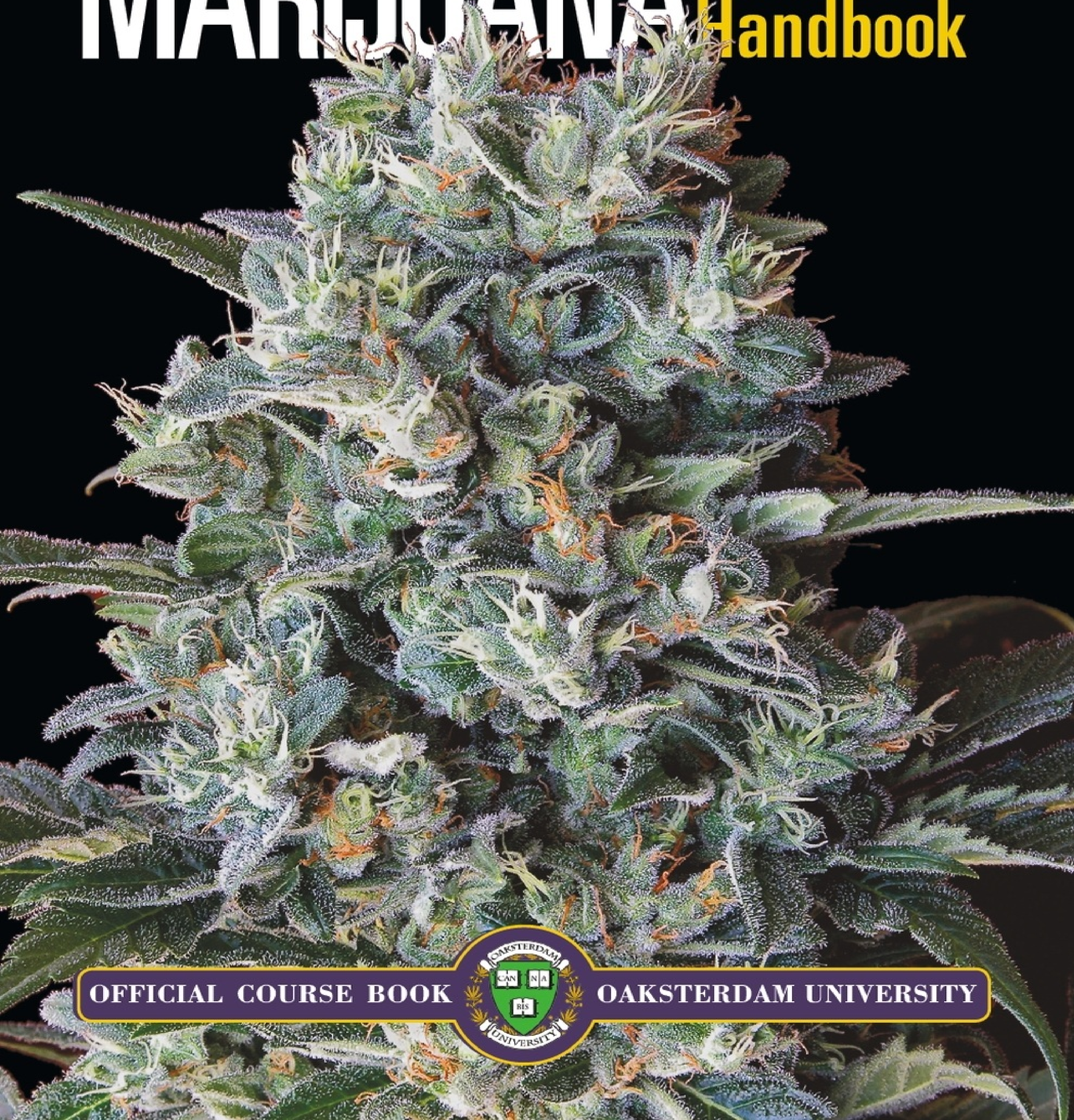
Ed Rosenthal's MARIJUANA GROWER'S Handbook



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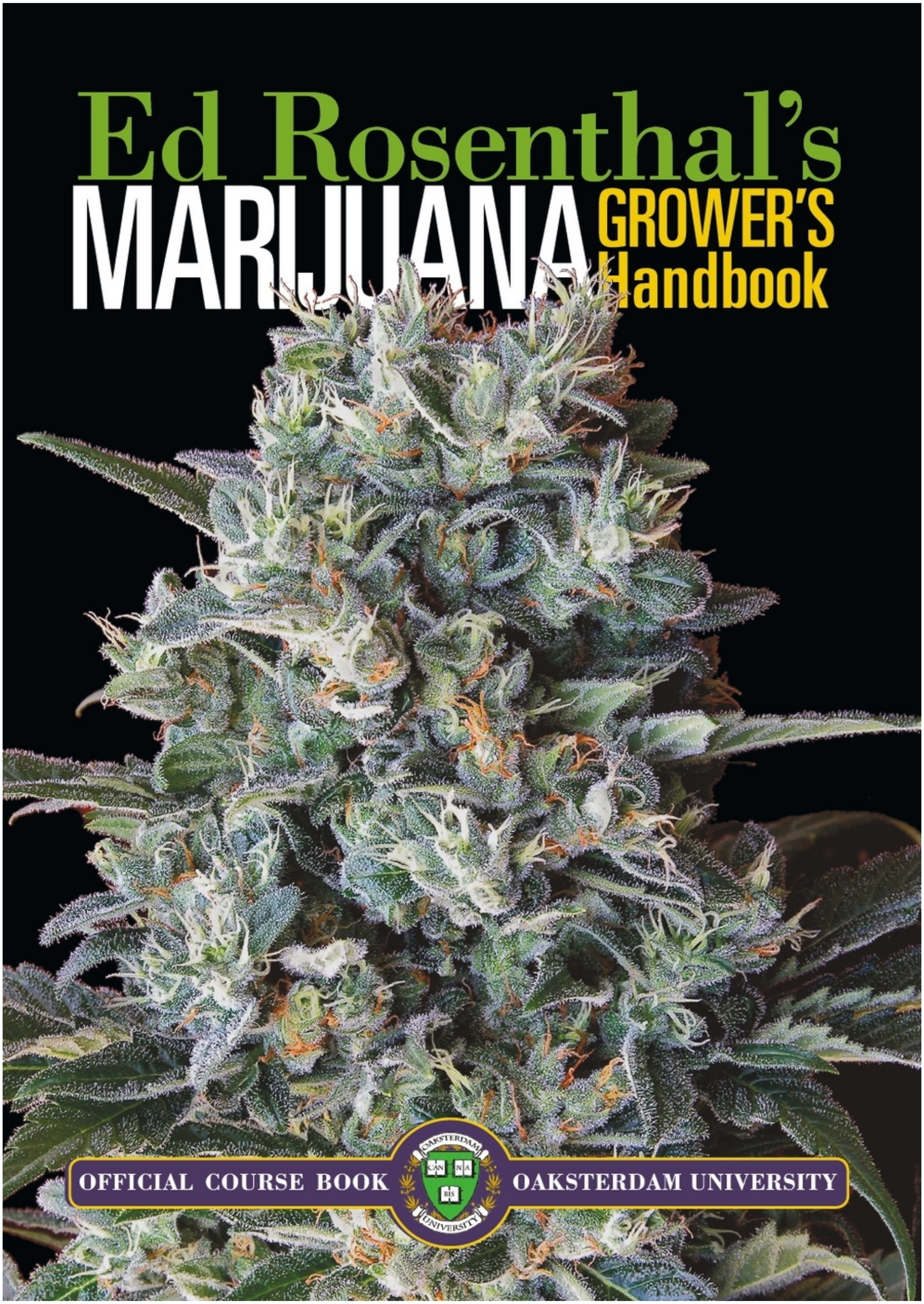
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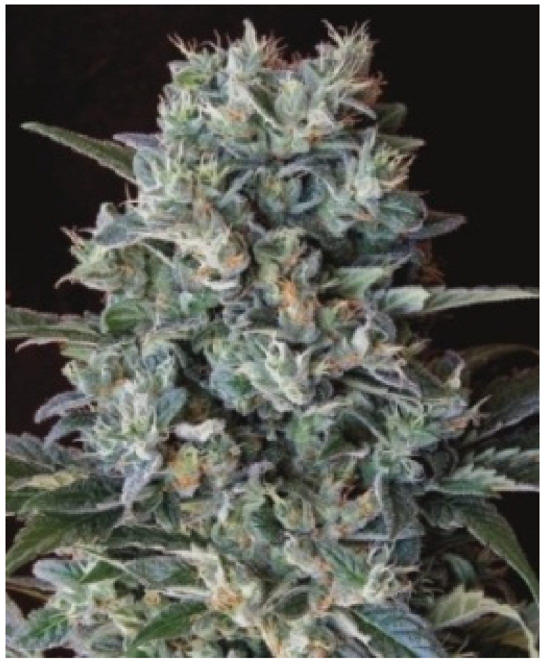

Ed Rosenthal

ASK ED© Edition Your Complete Guide for Medical & Personal Marijuana Cultivation

MARIJUANA GROWER'S HANDBOOK

Ask Ed Edition: Your Complete Guide for Medical & Personal Marijuana Cultivation Published by Quick American Publishing A division of Quick Trading Co.
Oakland, California

Print ISBN: 978-0-932551-46-7

eBook ISBN 978-0-932551-50-4

Cover photo: Mandala Seeds, Variety: White Satin Project Director: Jane Klein
Project Manager: Angela Bacca Chief Editor: William Dolphin Editors: Angela Bacca, Hera Lee, David Johnson-Igra Additional Editors: Laurel Hubert, Patricia Hernandez, Eve Cohen Cover and Interior Design: Hera Lee Design and Production: Hera Lee, Alvaro Villanueva, Renate Woodbury All photographs by Ed Rosenthal and Angela Bacca, except where noted.

Publisher's Cataloging-in-Publication (Provided by Quality Books, Inc.) Rosenthal, Ed.
Marijuana grower's handbook / Ed Rosenthal. -- Ask Ed ed.
p. cm.
Includes bibliographical references and index.
ISBN-13: 978-0-932551-46-7
ISBN-10: 0-932551-46-7

1. Cannabis. 2. Marijuana. I. Title.

SB295.C35R665 2010 633.7'9
QBI10-600030

The material offered in this book is presented as information that should be available to the public. The Publisher does not advocate breaking the law. However, we urge readers to support the secure passage of fair marijuana legislation.

MARIJUANA
Grower's Handbook
ASK ED© Edition

Ed Rosenthal

Dedication

This series is dedicated to Pete Seeger.

"God bless the grass that grows through the crack."

Malvina Reynolds, "God Bless the Grass"

This edition of Marijuana Grower's Handbook is dedicated to Jack Herer—keeping his promise to Edwin "Captain Ed" M. Adair III.

"Look out of any window, any morning, any evening, any day,
Maybe the sun is shining, birds are winging, no rain is falling from a heavy sky.
What do you want me to do, to do for you to see you through?
For this is all a dream we dreamed one afternoon long ago."
Lyrics: Robert Hunter and Phil Lesh, "Box of Rain"

ACKNOWLEDGEMENTS

Amerinada Dist., Sheldon Aberman, Al K., Arjan, Berkeley Patients Group, Ben Dronkers, Bill Graham, Bonnie and Clyde, Brian L., Brian M., Bubbleman and Diana P., Dennis Peron, Chris H., Current Culture, Doug Buddy, Elvis (not that one), Emerald Mountain Ministry, Etienne, G. Lee Ph.D. and DJ Sun Ph.D., Franco, George M., Harborside Health Center, Hugo Martinez, JD Petris, Jeff H., Jeff Nunes, John Sajo, Jonathon M., Jodi, John Lydon, June D., Kat, Keith Stroup, Kenny M., Kevin S., Kirk X., Larry B., Levi, Lydia D, Marc and Jodie Emery, Mark Lovinger, Mark Gray, Matt Q., Mike Aldrich, Mike D., Mila Jansen, Oaksterdam University, R&M Distribution/C.A.P. Controllers, Sensi Seed Bank, Green House Seed Co., Rachael Szmajda and Rick Pfrommer, Ram and Liz, Priv Doz., Dr. Habil Ewald Sieverding, T.A., Shawn B., Theo Tekstra, Tom Flowers, John Rosenwald, Corey X., Jerry, Vince, Tommy Chong, William Dolphin, Willie Nelson, Will and Anna Foster

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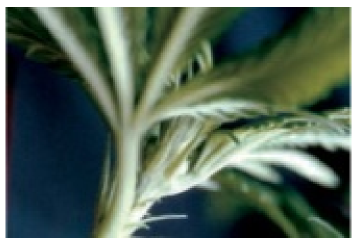
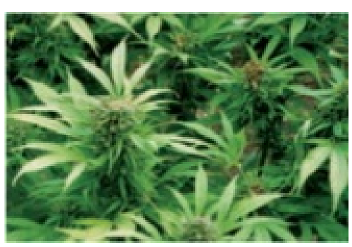
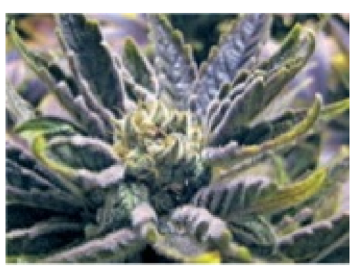






FOREWORD

by TOMMY CHONG

All my close friends are pot heads! And one of my close friends is not only a pot head he is the expert pot grower who holds the distinction of turning more people on to pot than Cheech and Chong.

I am talking about Ed Rosenthal, the pot-growing gardener whose *Ask Ed* column has helped keep the DEA busy chasing down the few hundred thousand or so pot gardens currently growing all over America. And not only is Ed a great gardener, he is also a great revolutionary, an “anti-establishment” hippie who likes to wear weird clothes and “out” the corrupt Federal officials who insist on enforcing America’s sadly outdated drug laws.

When I first met Ed, he was facing 10 years in Federal prison for doing pretty much what he has been doing for the past 30 or so years—growing pot. The Feds insisted Ed broke the law, and Ed would agree with them—and then explain, “It’s a terrible law!” Ed is also a writer of books, an occupation I have just recently been exposed to. Ed’s books are treated pretty much like the “pot bible” when it comes to combatting disease, thieves, and other pests that could waste an entire growing cycle. This is another reason why I admire and respect this man. Writing is hard; comedy is easy.

Writing is like masturbating when you have just masturbated. It's not fun. But it has to be done, or else people would not have anything to read while they sit on the toilet.

Now, notice how I headed right into the toilet when I called myself a writer? There must be a reason for that, eh? No, I am being modest about my talent as a writer but for good reasons, on the other hand, however (now I just made, what, three mistakes in this last sentence?), Ed is a writer. He is an excellent writer of how to do anything concerning pot. How to grow it. How to hide it. How to care for it. How to smoke it. How to stay out of jail while growing it. What to do while you are in jail for growing it. Ed has the whole field covered. Ask Ed.

And I do on occasion ask Ed. I ask him why he thinks pot has stayed illegal for so long. His was an interesting answer. A really surprising answer. And an intelligent answer. One I cannot divulge for reasons…well, to tell you the truth…I don't remember his answer because I was smoking at the time we had that conversation, and you know us pot heads! I'll remember the answer right after I stop writing this…whatever it is I am writing.

Anyway, Ed is probably one of the most intelligent men I know, and he does have the answer to quite a few problems facing Americans today. So, if you have the time and the inclination, check out Ed's writings. Read what he has to say. You may not be ready for him, but you are not alone. Even the United States Government had to back off when it came to arguing with Ed. They did back off, and I have to say that when the pot laws change and disappear, we all will have to take a moment before we light up that legal joint and say a silent, "Thanks, Ed Rosenthal," because he stood in front of the government tank and faced it down. And he was totally zonked out of his mind when he did it.

Thank you, Ed—

Tommy Chong

PREFACE

by R. KEITH STROUP, ESQ.

Ed Rosenthal, the best-known marijuana horticulturist in America, and the expert relied on by hundreds of thousands of marijuana growers when they want to learn the best marijuana cultivation techniques, is a friend and colleague whom I've known since the 1980s and '90s, when he wrote a monthly cultivation column, "Ask Ed," for *High Times* magazine.

We have, over the years, at times disagreed over style and tactics, but I have learned to appreciate Ed's significant contribution to the movement to legalize marijuana in this country. He has been a leader in bringing the best cultivation techniques to a mass audience, and he has shown the political courage to stand up to the full force of the federal government, and lived to tell about it.

As Americans first began to grow much of our own marijuana here at home—some with the goal of saving money, some to assure a high-quality product, and others to avoid dealing with the underground market—Ed clearly had a very positive impact on that movement. Any home gardener knows that although anyone can learn to be a successful grower, whether they grow vegetables, flowers, or herbs such as marijuana, gardening is not as simple as planting a seed and watering it occasionally.

It requires a lot of expertise that generally can only be gained from a good book or a more experienced friend. Ed has long been providing accurate and detailed instructions to wannabe farmers so they could turn a good intention into a good crop. And he continues to provide that expertise today, with the publication of the 25th anniversary edition of ***Marijuana Grower's Handbook***.

Personal cultivation is crucial. It protects consumers from the possibility, once marijuana is legalized, that big corporations take over the market. Tobacco companies, for instance, already have the land and processing plants available—but the marijuana they may offer could be too expensive, too weak, or otherwise not as high in quality as we have grown accustomed to during the Grow American Movement. Should that occur, we have the ultimate instrument in our hands: we can refuse to purchase their commercially produced marijuana and simply grow our own. Without the right to cultivate for personal use, consumers could end up with poor choices, poor marijuana, and no real alternatives.

Ed Rosenthal has also always been an out-front marijuana legalization advocate, someone willing to push the envelope, often at some personal risk, to achieve social change. He was arrested by the Feds in 2002 for managing a nursery that supplied medical patients with starter plants in Oakland, California. He and the city attorney thought he was legally cultivating medical marijuana as an officer of the City of Oakland. Ed faced a possible 20-year mandatory minimum prison sentence; he refused to discuss a plea agreement.

While that strategy might have seemed risky, in the end his courage was rewarded by the judge, who said Ed had justifiably relied on his status with the city, and sentenced him to only one day in jail, with credit for time already served. Ed had survived the best shot the Feds could take, and he is still standing.

Ed Rosenthal is the best-known cultivation expert in America. He has written more than a dozen books on the topic; he is politically active and testifies as an expert in state and federal criminal cases. He was the recipient of the *2007 NORML Lifetime Achievement Award* for advancing the cause of legal marijuana.

Over the years, Ed and I have developed a friendship based on mutual respect, and we stay in touch and see each other several times a year at marijuana-related events in different parts of the country. The friendship is largely based on our common appreciation and enjoyment of marijuana, and our shared belief in the importance of making it legal. But even more to the point, we both believe that legalizing the personal cultivation of marijuana, along the lines of what Ed likes to call the "tomato model," is the single most important provision we must achieve.

I am delighted to give my thanks to Ed Rosenthal for leading the home-grown consumer movement in America, and for bringing us all closer to full marijuana legalization.

R. Keith Stroup, Esq.
NORML Founder and Legal Counsel*

THE TOMATO MODEL

The model for what marijuana legalization should look like is already out there. It's tomatoes. More tomatoes are grown in America by home gardeners than are produced commercially. Yet there is a robust commercial market for tomatoes and tomato products of all types: canned, vine-ripened, organic, sauces, soups, ketchup, *etc.* At the same time, small-scale specialty cultivators do well selling their produce at farmers' markets, and home gardeners with extra tomatoes share the bounty with neighbors as gifts, in trade, or through informal sales. Marijuana could be handled in the same way. Commercial growers can thrive side-by-side with home and specialty cultivators.

Soma's Patio Garden

FREE LEGAL BACKYARD MARIJUANA: THE TIPPING POINT

by MICHAEL ALDRICH, Ph.D

"God grows pot, why can't we?"

We're very close to the tipping point in the marijuana legalization movement—"the moment of critical mass, the threshold, the boiling point," as Malcolm Gladwell defines it in his book by that name, which Ed Rosenthal turned me on to when it first came out. The momentum for change has become unstoppable, but the legalization movement has been pushing for reform for nearly 50 years. The subtitle of *The Tipping Point* is "How Little Things Can Make a Big Difference," and that's been the process. Gladwell borrows from epidemiology to identify key factors that determine whether a cultural trend will "tip" into widespread popularity. Gladwell says: "The success of any kind of social epidemic [movement] is heavily dependent on the involvement of people with a particular and rare set of social gifts." In the beginning, very few people may champion an idea, but they get it started. Gladwell describes them as Connectors, Mavens, and Salesmen, charismatic types who bring things together, disseminate information, and sell the idea to the public—that's us!

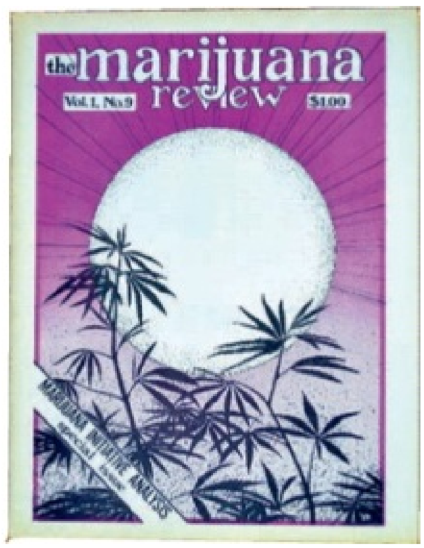
Margaret Mead once said, “Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has.” Dr. Mead was one of the first world-famous women to espouse legalization of marijuana, but the early days of the movement were quite male-dominated. In this essay, I’d like to reminisce a little about how the marijuana movement got to this tipping point, identify some early players, and look at the issue of personal cultivation. My account focuses on the first stages of reform, especially in California.

THE FIRST LEGALIZE-MARIJUANA ORGANIZATION, LEMAR (LEgalize MARijuana), sprouted up in San Francisco in August, 1964, when a brave young hippie named Lowell Eggemeier strolled into a police station, declared that putting people in jail for pot was ridiculous, and fired up a joint in front of the desk sergeant. His lawyer, James R. White III, drew up legal briefs showing the unconstitutionality of the felony marijuana laws, with quotes from investigative bodies such as the Indian Hemp Drugs Commission of 1894 and the LaGuardia Report of 1944, and published them in mimeo form as LEMAR Briefs. Eggemeier’s little act of civil disobedience started the whole movement, and how it grew!

The stage was set a few years earlier, in 1958, when beatnik Neal Cassady was busted in San Francisco for offering a joint to undercover narcs. Neal served two years in San Quentin for that, and Allen Ginsberg was infuriated. That anger fueled Ginsberg’s reaction to the *LEMAR Briefs* he read at his publisher, City Lights Bookstore. In 1965, Gins-burg founded NY LEMAR with Peter Orlovsky, Ed Sanders, William S. Burroughs, and Randy Wicker, who ran a little head shop in the East Village. The group held rallies and carried signs like *Pot Is Fun* and *Pot Is A Reality Kick* through the snow in front of the Women’s Prison. It made *TIME* magazine and linked us up with the world.

The universal fear of dope back then was so great that one would not talk openly in a bus…

THE BIGGEST OBSTACLE to public awareness of the issue was decades of relentless police propaganda against marijuana, backed up by always-negative “scientific” and “journalistic” articles about the herb. The multiple uses of the plant for medicine and fiber were forgotten. LEMAR hoped to correct that. As Ginsberg himself recalled, “The universal fear of dope back then was so great that one would not talk openly in a bus, for example, you couldn’t talk about changing the law, much less talk about smoking grass, for fear you'd be arrested." Ginsberg researched, got high, and scribed "The Great Marijuana Hoax: First Manifesto to End the Bringdown" for the *Atlantic Monthly* in 1966, it became the centerpiece of *The Marihuana Papers*. This compendium of historic articles, along with such books as *Pot: A Handbook of Marihuana, The Book of Grass*, and *1 in 7: Drugs on Campus* all contributed to public consciousness expansion.



LEMAR groups sprang up across the country. John and Leni Sinclair's in Detroit, DJ Levy's in Cleveland, and mine at SUNY-Buffalo in 1966, the first college chapter. The Detroit chapter became the most vital chapter in the Midwest, thanks to the organizing of John Sinclair, the brilliant poet and bluesman, and his wife Leni, a great music photographer. Leni Sinclair's photo of their 2-year-old daughter in front of a garden made the cover of *The Marijuana Review,* the magazine I started with Ed Sanders in 1968. *The Marijuana Review's* news stories and colorful features of cannabis culture circulated internationally through the Underground Press Syndicate, run by Tom Forcade, who later co-founded *High Times* a few years later with Ed Rosenthal. Once again, the idea was to control our own media, publish our own understanding, and get the word out. As this was happening, Ed and other New York activists such as Dana Beal and Aron Kay were committing flagrant acts of public inhalation at smoke-ins, be-ins, rallies, protests, poetry readings, midnight Reefer Madness shows, and debates with expert know-nothings.

IN FEBRUARY, 1969, I MET DR. TOD MIKURIYA at the New Worlds Drug Symposium in Buffalo. He was an example of Gladwell's

Connector, Maven, and Salesman all at once. A psychiatrist by training, he was something of an expert on cultivation as well as medicine, tramping off to Morocco to study kif cultivation in the Rif Mountains for his book Economic Botany. Not only was he one of the few who had actually read the Indian Hemp Drugs Commission report of 1894, he had just had them republished. A few years later, his Marijuana Medical Papers 1839-1972 would bring together the best articles in English about medical marijuana. As his hero, Dr. W. B. O'Shaughnessy, had done in 1839, Dr. Mikuriya re-introduced cannabis therapeutics to modern medicine.

IN 1970, I began a project with Blair Newman, a radical young genius with an extraordinary vision who I had met at the 1968 annual conference of the National Student Association Drug Studies Desk. Why not, he had proposed then, fund the marijuana movement by selling **hemp** products? We ran with the idea, and in 1970 set up Amorphia, The Cannabis Co-op—a nonprofit organization that manufactured and marketed hemp-rolling papers. Because hemp cultivation was illegal in the U.S., we ordered the papers from Spain. Amorphia sold Acapulco Gold rolling papers (made from rice, maize, chocolate, and hemp), with all the proceeds devoted to legalization, including funding the 1972 California Marijuana Initiative. Amorphia emphasized cultivation for personal use as part of any legalization plan, and we liked the idea of using grassroots political activism, including voter initiatives, to achieve our goals.

IN 1971, a bold young attorney named R. Keith Stroup got a tiny grant from Hugh Hefner and started the National Organization for Reform of Marijuana Laws (NORML). One of the main differences between Amorphia and NORML was that Stroup preferred a more traditional legislative approach to reform, working with politicians and suits rather than hippies, and hated initiatives because he was sure they would fail. The time was right for both groups, because the 1969 U.S. Supreme Court ruling in the Tim Leary case had made the 1937 Marihuana Tax Act unenforceable. In response, President Richard Nixon proposed a new federal law, the Controlled Substances Act of 1970. This new scheme created a system of schedules for dangerous drugs, with penalties dependent on which schedule the drug was in, but gave the U.S. Attorney General, John Mitchell, final power to designate the schedule for each drug. Marijuana, Mitchell decided, would go in Schedule I along with heroin, instead of Schedule II or III for drugs with recognized medical uses, such as cocaine and amphetamines. Pot was officially the drug of hippies, not doctors.

THE CONTROLLED SUBSTANCES ACT included another feature. At the insistence of then-Congressman and future New York City Mayor Ed Koch, the bill created the National Commission on Marihuana and Drug Abuse. Nixon appointed seven of its 13 members, including its chairman, Raymond Shafer, the former governor of Pennsylvania who was then a national Republican Party leader. We didn't have much faith in its credibility, but both NORML and Amorphia wrangled invitations to the Commission hearings in San Francisco in June 1971. I introduced Allen Ginsberg—clean-shaven, necktied, and wearing a porkpie hat—as "our spiritual and financial adviser." I presented the case for legalization with emphasis on cultivation, telling the Commission that, in the future, "Amorphia intends to engage in the production of legal marijuana on a nonprofit basis."

In March, 1972, to our astonishment, the Shafer Commission recommended that federal law be amended so that possession, use, or "casual distribution" of small amounts of marijuana by adults in private would no longer be a criminal offense. Possession or distribution in public would garner a $100 fine, while cultivation or sale of marijuana for profit would remain criminal, felony offenses. President Nixon rejected the Commission's report out of hand. In a taped Oval Office conversation with his chief of staff, H.R. "Bob" Haldeman, Nixon said, "I want a Goddamn strong statement on marijuana… that just tears the ass out of them… every one of those bastards that are out for legalizing marijuana is Jewish. What the Christ is the matter with the Jews, Bob, what is the matter with them? I suppose it's because most of them are psychiatrists, you know, there's so many, all the great psychiatrists are Jewish. We are going to hit the marijuana thing, and I want to hit it right square in the puss."

1972 WAS ALSO THE YEAR THAT AMORPHIA ran a statewide initiative campaign to legalize marijuana in California. With impetus from Foster City attorney Leo Paoli, we came up with an initiative that emphasized cultivation for personal use. CMI-72 was succinct, easily understandable, and appealing to volunteers. It said:

> **No person in the State of California 18 years of age or older shall be punished criminally, or be denied any right or privilege, by reason of such person's planting, cultivating, harvesting, drying, processing, otherwise preparing, transporting, or possessing marijuana for personal use, or by reason of that use.**
>
> **This provision shall in no way be construed to repeal existing legislation, or limit the enactment of future legislation, prohibiting persons under the influence of marijuana from engaging in conduct that endangers others.**

Although it lost by a wide margin, CMI-72 was a “tipping point” in the early days of the reform movement. It was the first time marijuana law reform was on the ballot anywhere in the world. It was the first time that sales of hemp (paper) funded an initiative. And it was the last time that a California initiative campaign was run entirely by volunteers, instead of paid signature gatherers. The marijuana movement grew from a handful of activists to a state full of supporters.

Many legendary Mavens, Connectors, and Salesmen cut their teeth in the CMI-72 campaign. Ed Rosenthal moved to San Francisco in 1972. He shared our vision of cultivation as the key to legalization and toured California encouraging growers to support the initiative, and offering advice to improve their crops. We took word of the campaign

The marijuana movement grew from a handful of activists to a state full of supporters.

to NORML’s first national conference in August 1972, where I met Michelle Cauble, who was working for the National Coordinating Council on Drug Education. I invited Michelle out to work on CMI, she showed up two weeks later, and we’ve been together ever since. Harvey Milk’s first political action in San Francisco was gathering signatures on the CMI petition by going door to door in the Castro district. In 1977, Milk won a seat on the San Francisco Board of Supervisors and became the first openly gay American to be elected to public office. Milk’s marijuana supplier was Dennis Peron, who would play key roles in future initiatives.

CMI received about 33% of the vote statewide; however, in Berkeley, CMI passed by 71.3%. Following that, Councilwoman Loni Hancock—who would later become mayor and serve in the state Assembly and Senate—sponsored a local ballot measure directing police to give lowest priority to marijuana law enforcement and to make no arrests for cultivation, possession or use.

VOTER SUPPORT FOR DECRIMINALIZATION also caught the attention of another hugely important player, a charismatic politician with powerful negotiation skills who made others want to agree with him, the type of person Gladwell calls a “Salesman:” George R. Moscone, who was at that time State Senate Majority Leader, representing San Francisco.

Senator Moscone held hearings in 1974 and worked with Gordon Brownell and me to craft a bill to reduce the penalties for possession of an ounce or less of marijuana from a felony to a citable misdemeanor with a maximum $100 fine. This bold move, passed by the legislature in 1975 as SB95, “The Moscone Act,” saved the state of California more than $100 million a year in enforcement costs. But it had a flaw: it didn’t decriminalize cultivation.

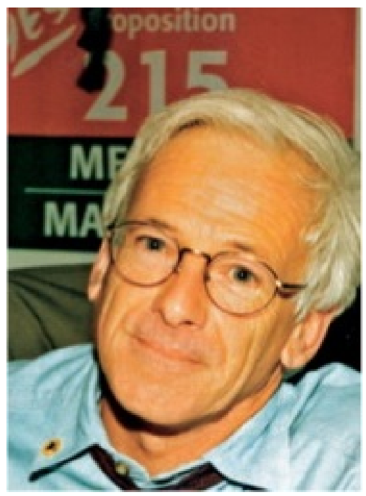
WE WERE CULTIVATING ANYWAY, of course. In 1974, Ed began his long publishing career when he co-authored the Indoor/Outdoor Highest Quality Marijuana Growers Guide, 94 pages of **sinsemilla** cultivation information available to homegrowers everywhere. By the late Seventies, California growers were producing exquisite strains of sinsemilla such as “Big Sur Holy Weed,” and genetics had replaced geographic origin as a way of identifying strains. We were growing it in the U.S. now, but it was still illegal as hell. Sinsemilla farms, indoor hydroponics included, spread throughout the U.S. in the 1980s in response to the border crackdowns of the “War on Drugs.”

“The goofy relaxant had become a critical medication.”

JACK HERER ENTERED THE MOVEMENT in 1972, soon after mustering out of the army, by volunteering to work for CMI. One day in the Los Angeles CMI office, I showed Jack some hemp paper. His response, best I remember, was: “You mean there’s something else you can do with hemp besides smoke it?” Jack sure grabbed that ball of twine and ran with it! He researched the history of hemp for more than a decade, and in 1985 published the first edition of *The Emperor Wears No Clothes* (Herer 1985). It has gone through many editions and may be the most popular hemp book of all time. In the 1980s, Jack was also attempting to remedy the problem of federal prohibition with a series of initiatives in Oregon and California to legalize hemp cultivation for all purposes, though none made the ballot.

IN 1973 BOB RANDALL discovered that marijuana helped his glaucoma better than prescription drugs. “The goofy relaxant had become a critical medication,” he wrote. Living in Washington, D.C., however, he couldn’t get through the droughts “when marijuana could not be bought for blood or money.” To provide his sight-saving remedy, he and his mate Alice O’Leary grew four little pot plants on their balcony, and promptly got busted by D.C. narcs. Bob pursued his medical necessity claim through the courts, and in 1976 became the first American in 40 years to gain legal access to marijuana for medical purposes. But where to get it? Would you believe free marijuana from the Feds?! Bob was the first patient in what the government calls a Compassionate Investigational New Drug program, receiving pre-rolled marijuana cigarettes from the National Institute on Drug Abuse (NIDA). Unfortunately, NIDA’s seedy, stemmy, low-grade pot remains some of the worst marijuana in the country. It is still the only legal source for federally approved researchers and the few remaining patients in the IND program that Bob’s case established. Bob and Alice’s Galen Press published the best early books on marijuana medicine, and in 1980 they founded the Alliance for Cannabis Therapeutics (ACT), the first group focused solely on the role of marijuana in medical treatment.

IN 1978, DENNIS PERON placed Proposition W on the San Francisco ballot, a measure which demanded that the district attorney and the chief of police “cease the arrest and prosecution of individuals involved in the cultivation, transfer or possession of marijuana." Prop. W passed, but just weeks later an assassin killed Harvey Milk and then-Mayor George Moscone. The new mayor, Dianne Fein-stein, now a U.S. Senator, refused to implement Proposition W. But Dennis wasn't done. He started the world's first Cannabis Buyers' Club in San Francisco, and by 1996 it had evolved into America's first medical pot emporium—a five-story building with one story devoted to cultivation. He never forgot the power of the initiative, and in 1996 he helped develop the wording and started the petition drive to put the Compassionate Use Act, Proposition 215, on the California state ballot. This "tipping point" initiative, which passed with 54%, enshrines in the state constitution the right of individual patients and their caregivers to grow marijuana, and pushed the movement forward at top speed. Since then, many other states have followed suit.



IN 1989, DEBBY GOLDSBERRY co-founded Cannabis Action Network (CAN) after several years on the "Hemp Tour" with Jack Herer and Ben Masel. Goldsberry wrote recently that CAN "instilled a more grassroots, female-oriented spirit into the then heavily male-dominated marijuana legalization movement." After Proposition 215 passed in 1996, she and Don Duncan opened the Berkeley Patients Group, one of the best medical cannabis dispensaries in the world.

IN 1995, MIKKI NORRIS mounted a remarkable photo exhibit, "Human Rights and the U.S. Drug War," that pioneered the movement to reduce the long sentences handed down for drugs. She and Chris Conrad also co-authored, along with Virginia Resner, the heartbreaking book Shattered Lives: Portraits from America's Drug War. Another activist on prison issues, Julia Stewart, organized Families Against Mandatory Minimums (FAMM) to fight the harsh sentences

Congress required judges to impose.

VALERIE AND MIKE CORRAL in Santa Cruz started the Wo/Men's Alliance for Medical Marijuana (WAMM) after getting busted for five plants in 1992. Valerie remembers, "As the first patient in the State of California to challenge existing law and based on a defense of necessity, I was ushered into the legal, political, and social foreground of this health issue." The DEA moved against WAMM in 2002. The city council then took it upon themselves to publicly distribute medicine to WAMM's patients on the steps of City Hall. Valerie and Mike's input also led to the inclusion of the rights of patients to collectively and cooperatively cultivate marijuana in the California legislature's Medical Marijuana Program Act of 2003 (SB420). This further legitimized the hundreds of medical cannabis dispensaries and cultivation collectives already operating in California under local ordinance.

TIMELINE	
1940	**Robert Mitchum busted**
1958	**Neal Cassady busted**
1964-1970	**LEMAR**
1970-1973	**Amorphia**
1970	**Controlled Substances Act**
1971	**NORML**
1971-1972	**The Shafer Commission**
1972	**CMI**
1975	**Moscone Act**
1976	**Investigational New Drug Program**
1978	**Prop W**
1989	**Cannabis Action Network (CAN)**
1995	**Marijuana Policy Project (MPP)**
1996	**Proposition 215**
1998	**Students for Sensible Drug Policy (SSDP)**
2002	**Americans for Safe Access (ASA)**
2002	**Green Aid**

IN 1995, NORML PROVIDED THE SPARK for what has become a leading marijuana reform organization, the Marijuana Policy Project (MPP). MPP was founded by two former NORML staffers, Rob Kampia and Chuck Thomas, who wanted to create a mainstream D.C. lobbying organization focused narrowly on changing public policy. That initial effort got off the ground with an aggressive membership drive and a modest grant from a philanthropic foundation funded by financier George Soros. By the end of that first year, MPP's work with the U.S. Sentencing Commission had helped change the federal sentencing guidelines, resulting in shorter sentences for people convicted of cultivating marijuana and the release of an estimated 950 federal marijuana prisoners. This early success attracted the support of another philanthropist, the insurance magnate Peter Lewis, who remains the organization's primary funder.

SINCE THEN, MPP HAS GROWN into one of the leading marijuana reform organizations in the U.S., claiming 25,000 members nationally and roughly three dozen full-time staff members spread between offices in Washington, D.C., and state campaigns around the country. MPP worked to pass a medical marijuana initiative in Washington, D.C. in 1998, and in 2000 MPP lobbying helped convince the Hawaii state legislature to become the first to enact protections for medical marijuana patients. That success was repeated in Maryland in 2003 when four years of lobbying resulted in the Republican governor signing legislation to reduce penalties for medical marijuana use. In 2004, litigation MPP funded established that state privacy protections that meant Alaskans 21 years or over may legally possess up to four ounces of marijuana in their homes. That same year, MPP helped pass a medical marijuana ballot initiative in Nevada and in 2008 it was instrumental in the passage of a medical marijuana initiative in Michigan. MPP continues to lobby for medical marijuana bills and legislation to end marijuana prohibition.

OUR MOVEMENT'S MEDICAL MARIJUANA VICTORIES have not come without a fight. In the early morning hours of February 12, 2002, federal agents began a series of coordinated raids on a San Francisco medical marijuana collective and the homes and businesses of the handful of people who were supplying it with medicine. As doors were being broken down, the head of the Drug Enforcement Administration, Asa Hutchison, was preparing the speech he was to give that evening at San Francisco's distinguished Commonwealth Club. He planned to announce a new front on the war on drugs—the arrest and aggressive prosecution of medical marijuana providers, including the "kingpin", Ed Rosenthal. But the Feds misjudged both their target and the patient community. Not only was Asa Hutchison shouted down by patient advocates at his speech, but the actions of his agents galvanized a grassroots response of patients.

Led by medical cannabis patient Steph Sherer and visionary entrepreneur Don Duncan, area activists formed Americans for Safe Access (ASA) to provide a voice for patients and resist federal interference in California's medical marijuana program. The acronym was not a coincidence. One of ASA's goals was to directly challenge and embarrass Asa Hutchison, the then-head of the DEA. As a grassroots organization of patients and activists, ASA began with protests around the trial of Ed Rosenthal in late 2002 and early 2003. Every day of Ed's trial, the large courtyard of the federal courthouse was filled with protestors organized by ASA. The strategic creativity of Steph Sherer's group was evident immediately, as protestors engaged in various forms of street theater to convey their message. One day, dozens of protestors stood motionless in rows with duct-taped mouths and medical placards, a silent demonstration of all that the jury was not being allowed to hear. On another, rainy day, protestors carried matching red umbrellas that had "Free Ed" spelled out in white tape, easily readable from the windows of the federal building above. When Ed's trial concluded with a guilty verdict on all counts, ASA activists were instrumental in providing the jurors with the full facts and convincing them to speak out about their experience. This led to the first jury revolt in a federal medical cannabis trial, with the majority of the panel appearing on *CNN*, *Dateline* and elsewhere to denounce the Rosenthal trial as a miscarriage of justice.

SINCE THEN, ASA HAS GROWN into the leading advocacy organization for medical cannabis. Based in Oakland, California with a national lobbying office in Washington, D.C., ASA reports that it currently has over 30,000 active members with chapters and affiliates in more than 40 states. ASA provides legal training and medical information, as well as court support and rapid response to law-enforcement raids. The ASA legal team has made a big impact, winning a suit against California Highway Patrol to make them comply with state medical cannabis law. Other landmark cases have helped establish the rights of patient collectives to organize in the state. ASA has even gone after the federal government's lies about the medical efficacy of cannabis by filing a suit against the federal department of Health and Human Services under a little-known law that requires federal agencies to rely on sound science in the information they disseminate. ASA is also working closely with federal policy makers to remove barriers to research and establish protections for patients everywhere in the country. The Truth in Trials Act, which would give patients a medical defense in federal trials, has been a key piece of that legislative effort.

ASA has also worked closely with state lawmakers in California and elsewhere to expand patient protections. Over the last six years, ASA has become a respected voice for medical cannabis patients.

THE OTHER MARIJUANA REFORM ORGANIZATION to come out of the arrest and prosecution of Ed Rosenthal was Green Aid: The Medical Marijuana Defense and Education Fund. This tax-exempt 501(c)3 organization was formed by activists and allies as a way of rallying support and directing resources to the legal defense of critical, tipping-point medical cannabis cases. Green Aid helped Ed put together a group of attorneys that he dubbed "The Green Team," including Bob Eye, a prominent attorney from Topeka, Kansas who had been a candidate for governor there; Bill Simpich, a leading civil-rights lawyer from Oakland, California; and Joe Elford, a young Yale-trained attorney who would become ASA's chief counsel and establish landmark legal precedents for patients in California. Among the things Green Aid quickly did in support of medical cannabis was establish a website for tax-deductible donations for Ed's case and other high-profile litigation. Green Aid also worked hard to publicize Ed's case and keep it on the front pages, publishing a daily diary of his trial on their website. The result was national television and radio coverage and more than 200 published articles internationally, including front-page stories and sympathetic editorials in the New York Times, San Francisco Chronicle, Oakland Tribune, and San Francisco Examiner.

ANNUAL CAUSES OF DEATH IN THE UNITED STATES

Tobacco	**435,000**
Poor Diet and Physical Inactivity	**365,000**
Alcohol	**85,000**
Microbial Agents	**75,000**
Toxic Agents	**55,000**

Prescription Drugs	**32,000**
Suicide	**30,622**
Incidents Involving Firearms	**29,000**
Motor Vehicle Crashes	**26,347**
Homicide	**20,308**
Sexual Behaviors	**20,000**
All Illicit Drug Use	**17,000**
Aspirin, Other Anti-Inflammatory Drugs	**7,600**
Marijuana	**0**

HTTP://DRUGWARFACTS.ORG

Thanks to Green Aid, Ed's case changed the tone of coverage on the issue. The scare quotes disappeared from "medical marijuana," and it would no longer be referred to as "so-called" medical use. Green Aid was also instrumental in helping Ed mount a successful appeal of his conviction and fight a now-expanded federal retrial in 2007. Tried under the same limited rules of evidence as the first trial, Ed was again convicted but not before exposing the pettiness of the government's attacks on patients. Today, Green Aid continues to assist with the legal defenses of prominent medical cannabis cases.

IN 1997, JEFF JONES founded the Oakland Cannabis Buyers Club (OCBC). To protect the OCBC from federal interference, Oakland city officials established growing and possession guidelines and declared the OCBC an agent of the city. Jeff's legal battle to provide medical-quality pot went all the way to the U.S. Supreme Court in 2001, but they shot him down. Then one of the patients he was supplying, Angel Raich and her attorney, Rob Raich, took her medical necessity defense to the high court, but they also ruled against her. Nonetheless, these two cases helped galvanize public opinion in favor of medical marijuana legalization.

IN 2007, RICHARD LEE, the operator of the Bulldog Café, a medical cannabis dispensary in Oakland, opened Oaksterdam University to offer courses in cultivation and dispensary management to the burgeoning cannabis industry. Since its establishment, Oaksterdam University has expanded to campuses in Los Angeles and Sebastopol, California, and Ann Arbor, Michigan. The main Oakland campus has become a focal point for both education and activism on marijuana.

THIS BRIEF HISTORY, which must leave out many important events and people, illustrates both how far we've come and how far we have to go. Thousands of articles have been written. Millions of people grow marijuana. Many decriminalization reforms have been passed by legislatures, but none have legalized cultivation for all. Omitting the underlying question of supply impedes all the modern laws attempting to regulate marijuana. Almost three decades ago, the International Cannabis Alliance for Reform met in Amsterdam to consider legalization plans and proposals, and came to the same conclusion. At a minimum, everyone should have the right to grow cannabis for personal use. This is the cornerstone of legalization, because it allows the consumer to opt out of the underground market. So to get to the real "tipping point," the legal cultivation of cannabis is the most important issue to be resolved. The personal right to cultivate cannabis is the crux of any successful legalization scheme. In California, at least, medical patients have the right to free, legal, backyard marijuana. The tipping point will have been reached when everyone has that right.


OVERGROWING THE GOVERNMENT!

ED'S INTRODUCTION

WARNING: Although using marijuana may not be addictive, growing it is.

Why grow marijuana? The reasons can be many, and varied. Perhaps you have never considered growing marijuana. Or, perhaps, you never tried because it felt like a difficult, risky undertaking. You may have even tried your hand at raising a young plant or two but abandoned the project when the plants failed to thrive or were overcome with mold or pests.

Despite any potential pitfalls, there are many compelling reasons to embark on this journey. First, there are practical benefits from being able to choose which strains to cultivate—selecting for height, grow time, aroma, taste, and the wide spectrum of the mental and bodily effects varieties offer. Also, many medical cannabis patients understandably prefer to have the control over their medicine that a personal garden allows, with the knowledge that it is grown safely and organically. Another factor can be cost: it is generally much less expensive to grow one's own than to pay for someone else's packaged product, and less risky than buying a bag from some unknown source.

As a plant, cannabis is similar to any other plant—it likes light, water, nutrients, and human attention. Yet it has some unique characteristics and a long history of interaction with the human species. Time, observation, and research have taught us the best ways to care for marijuana to achieve big, beautiful buds and amazing harvests. Any effort you make to learn how to cultivate this fascinating plant will be well rewarded, and this book will help demystify the process.

The most powerful reason to grow marijuana, in my experience, is the enjoyment and satisfaction that comes from forming a personal relationship with this fascinating plant. As I can attest, this is the only truly addicting aspect of marijuana.

Marijuana Grower's Handbook is designed to help you grow bountiful yields of high quality marijuana. Whether you are a beginner or an experienced grower, this book provides the information to help you grow a garden that will provide you good harvests, enjoyment, and an enriching pastime.

Most gardeners, myself included, have an anthropomorphic attachment to marijuana. They name their plants, develop a fondness for one or the other. There are some good reasons for this: unlike other annuals, marijuana has separate male and female plants. It has distinct life stages including growth and reproductive, and it takes between 50 and 80 days of "flowering" to ripen, each day of flowering comparable to a year in the life of a human.

The best part of gardening is that at the end of the journey you will harvest some of the best buds you have ever smoked, all ripened to perfection.

PRECAUTION: The legality of marijuana depends on who you are and where you are located. If you are living in a state where it is legal for medical marijuana patients or suppliers to grow, then you will have a different attitude about growing than someone who lives in the majority of states and countries where marijuana is illegal to use or grow.

Before you start to plan a garden you should have a clear understanding of the laws regarding cultivation of marijuana. With this information you can make a realistic assessment of the situation and decide whether gardening is for you. You should also begin to make contingency plans based on worst-case scenarios.

In states where medical patients are allowed to grow marijuana there are often strict limits on the number of plants or the amount of space that can be devoted to the garden. Marijuana cultivation is often considered a serious offense so it is imperative to take precautions to keep yourself free.

Some questions you might ask yourself before you commence this venture are:

Am I willing to take on the responsibilities and risks?
Can I afford a legal quagmire?
How do my roommates feel about it?
Do I really have a secure area?

Most marijuana arrests are the result of “accidents,” lovers’ spats, nosy neighbors or jealous friends. People who snitch to get out of trouble also appears in the statistics. It pays then, for marijuana growers to become nicer people than they might otherwise be. Don’t alienate others. Treat your friends better. Be nice and helpful to your neighbors. Let the harried driver cut in. Develop a broader perspective on life.

Marijuana Growers Handbook Website—www.mjgrowers.com

Writing this book I found myself constantly having to make choices about what should be included and at what level of detail. This book provides what is most necessary and relevant to your growing success. Fortunately, the Internet has provided us a way to make even more information available to you. At *www.MJGROWERS.com* you will find additional photos, research, and articles on a wide variety of topics. As changes occur in equipment and methods the website will keep the book, and you, up to date on the latest developments. Your password to this library: **MJReader**

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for updates and more info

HIMILAYAN GOLD | Photo: Green House Seed Co.

SPACE BOMB | Photo: Subcool

Part I

MARIJUANA THE PLANT

HOW MARIJUANA GETS YOU HIGH

by G. LEE, Ph.D and D.J. SUN, Ph.D

Photo: Sannie's Seeds

MARIJUANA AND THE BRAIN

In recent years, remarkable progress has been made in our understanding of cannabinoids and how they operate in the body. The study of cannabinoids has focused mainly on the brain, so first let us consider the cerebral effects of cannabis, starting with the obvious.

Marijuana influences mental perception. That much must have been immediately clear to the first people who started cultivating cannabis for its delta 9 THC (Δ9-THC) effects (as distinct from fiber hemp) over 2,000 years ago. And while those cognitive effects have been sought after, let's not be overly romantic about them. Sometimes they can feel stupefying, like a sacrifice of chronology and mental dialogue, or an impaired ability to follow conversation. Short-term memory can be interrupted and spatial orientation impaired, effects which can give way to a heightened sensory perception of the here and now.

At other times or simultaneously, marijuana can evoke a nebulous sense of well-being—the feeling of getting high, enhancing appreciation of a moment or hysterical irony, a melody or profound lyric. It can help you feel momentarily less concerned about societal and interpersonal pressures. These properties have been portrayed from opposing perspectives: as good or bad, uplifting or unsettling, habit-forming or not, anxiety relieving or promoting.

As with other hallucinogens, a person’s set (including individual psychological, physical and genetic dispositions) and setting play a role in particular mental experiences and outcomes, as do the chemical variations in the herb (see the discussion of terpenoids). It isn’t trivial to acknowledge that one person might feel calmed by smoking a joint, while someone else might experience outright panic hitting the same joint. Likewise, while exceedingly few people who experiment with marijuana develop a dependency, it does happen. These matters are complex and frequently oversimplified, but it is important to recognize that even if cannabis is kind to a great many people, it does not mean it is for everyone.

The various promises and warnings about how marijuana affects the brain are rooted in genuine human experiences. To determine which are accurate and supported by science calls for continuing objective research and a mature conversation about cannabis and our relationship to it.

Now consider some of the less “psychoactive” biological effects of Δ9-THC other cannabinoids:

- nausea goes away
- multiple kinds of pain are relieved
- inflammation is reduced
- muscles are relaxed
- seizures are sometimes brought under control

These are just some of the therapeutic effects of cannabis that have been described by healers since antiquity, and each addresses health problems that demand a huge amount of clinical attention.

For instance, millions of people lose quality of life to chronic pain. While scientists and physicians continue to get a better grasp of what physical pain is, doctors readily acknowledge that current prescription medications are fraught with side effects and do not work on all types of pain, particularly the neuropathic pain that can result from nerve injury and disease.

Thanks to modern medical marijuana initiatives and biomedical research, including an increasing number of gold-standard, randomized double-blind clinical trials using botanical cannabis and extracts, this ancient remedy can once again be discussed without apology. Not only does cannabis relieve pain on its own, it works in concert with other analgesics to improve their efficacy. Similarly, no one should feel shame recommending or trying marijuana to combat severe nausea—nausea control and appetite stimulation can be one of its downright life-saving properties for people undergoing toxic chemotherapy or suffering from wasting syndrome. It is appalling that a patient struggling for survival should have to risk their freedom for choosing marijuana as their medicine.

CANNABINOID RECEPTORS

Marijuana affects the body because its bioactive cannabinoid compounds, especially Δ9-THC and **cannabidiol** (CBD), bind to and activate cannabinoid receptors—tiny molecular ports encoded by our genes and expressed on the membranous surfaces of our cells. The diversity of physiological effects generated by marijuana is due to the many different cell and tissue types that express cannabinoid receptors.

Various areas of the brain and other nervous system tissues contain cannabinoid receptors called CB1. The neurological effects of marijuana depend on the particular brain areas and networks these cannabinoid-sensitive cells participate in (for example, the neuronal networks mediating short-term memory, anxiety, or compulsive behavior). The location of the receptors on the cell can alter how they operate. Most mental and perceptual effects of cannabis can be attributed to CB1 receptor activation.

A second receptor, called CB2, has been identified primarily in certain cells of the immune system. CB2 appears responsible for the ability of THC, CBD, and the terpenoid β-carophyllene to reduce inflammation and some kinds of pain, among other effects.

How do we know such things? There were early clues that a specific receptor system is involved in marijuana’s effects. To test this hypothesis experimentally, some of the cannabinoid drugs produced in the 1980’s were designed to be weakly radioactive. These “hot” drugs light up the cannabinoid receptors they bind to, allowing scientists to see which neurons in the brain are sensitive to THC.

This and other techniques have revealed that the brain is teeming with CB1 receptors, consistent with marijuana having wide-ranging influences on mental function. Some of the only regions of the brain where CB1 receptors are absent are areas controlling vital functions such as breathing. This is why cannabis poses no risk of fatal respiratory depression that can occur with overdoses of opiates and other nervous system depressants such as alcohol, and why labeling marijuana as a "deadly narcotic" is incorrect and irresponsible.

THE ENDOCANNABINOIDS

The natural physiological chemicals that drive CB1 and CB2 receptors are a family of molecules present not just in humans but all over the animal kingdom. These native molecules are called endogenous cannabinoids, or endocannabinoids, a name borrowed from the plant. Endocannabinoids (often abbreviated as eCBs) have been called the "marijuana of the brain," although this is a deceptive metaphor; eCBs are an integral part of our physiology and appeared much earlier in evolutionary history than the cannabis plant, as indicated by their presence in so many life forms, even very simple marine organisms. It is more accurate to say that the cannabis plant evolved to produce compounds that are remarkable biochemical mimics of the eCBs.

Marijuana provides therapeutic benefits across a startlingly broad range of conditions and has an unparalleled record of safety.

There are presently two well-studied and readily detectable eCBs: anandamide (a name derived from ananda, the Sanskrit word for bliss) and 2-AG (short for 2-arachidonylglycerol), each is generated in cells by specific enzymes in response to activation signals. In other words, cells generate and release anandamide or 2-AG when they receive particular signals to do so.

In the brain, for example, if one neuron (electrical cell of the brain) barrages another neuron with excitatory electrical activity, the target neuron may respond by generating and releasing eCBs from its cellular membrane.

The eCBs travel “backwards” across the synaptic cleft separating the two neurons, where they find CB1 receptors waiting. Through the molecular signaling of these strategically located CB1 receptors, the release of other, more principal neurotransmitters is momentarily paused. The eCBs act as a negative feedback, to say, “Whoa! That’s enough input, now slow down!” Because eCBs travel opposite the conventional neurotransmitter pathway across synapses, they have been dubbed “retrograde messengers.”

This fascinating, groundbreaking scientific discovery has revealed how a large number of brain cells appear to work: a given neuron releases eCBs in order to continuously regulate and tune its own synaptic inputs. This process, where synaptic connections between neurons are weakened or strengthened, is referred to as synaptic plasticity, a mechanism by which learning and memory occurs at the cellular level. The feedback mechanism of eCB-mediated synaptic plasticity is important not just for computational processes (how we think and feel and learn), but as a matter of cellular survival; too much excitation is deadly to cells. Thus, an apparently major function of eCBs, and a major effect of cannabinoids from marijuana, is neuroprotection—that is, protecting brain cells from too much excitation (known as excitotoxicity), which is a serious contributor to the brain damaging effects of stroke, epilepsy, and other neurological disorders.

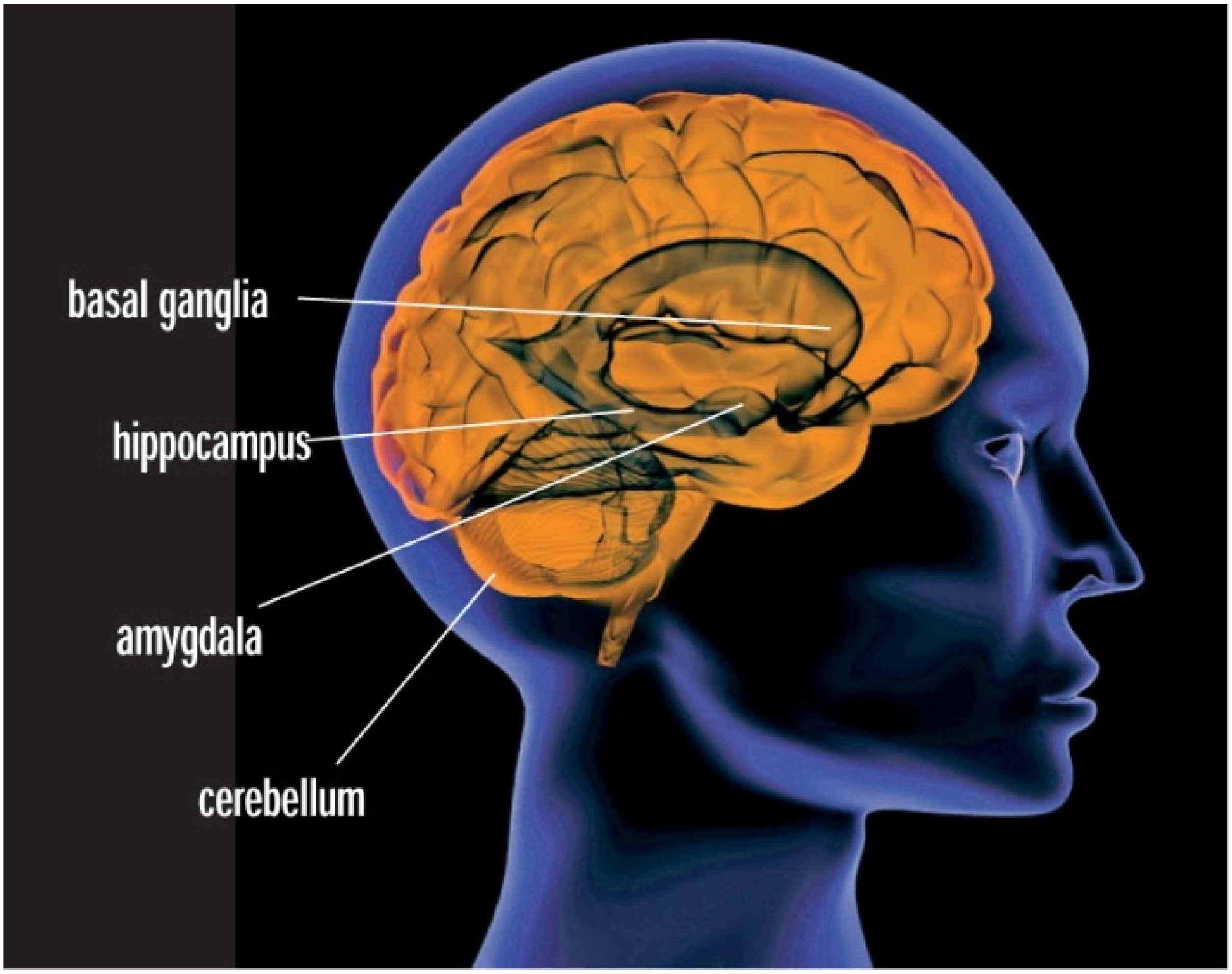
NEURONAL FREQUENCY & SYNCHRONY: SETTING TEMPO WITH ECBS

What we have just described is that eCBs are used by the brain to dampen patterns of neuronal electrical activity, and one of the therapeutic effects of cannabis is to mimic this property. Yet this is only half the story. The eCBs also work the opposite way, releasing the neuron to fire more freely, a process called disinhibition.

This is another way that eCB-mediated synaptic plasticity appears to be adaptive for healthy brain function, though its effects vary based on the area of the brain. In a brain area called the amygdala, eCBs purge the memory of fearful experiences, helping an individual move past emotional trauma. This action helps explain the apparent utility of cannabinoids (including herbal cannabis) as a treatment for some cases of post-traumatic stress disorder, or PTSD.

Large-scale population studies have failed to find any link between cannabis smoking and lung cancer or other respiratory ailments.

By contrast, in the area called the hip-pocampus, tightly controlled eCB signaling allows cells to fire in coordinated synchrony, setting up the brain rhythms that are important for orienting oneself in physical space. Marijuana is thought to interrupt spatial memory by simultaneously flooding all the cells in this rhythmic engine with THC…um, where did I put that pen that was just in my hand? Similarly, the so-called somatic symptoms of a marijuana high—feelings such as floating, sinking into your seat, or altered balance, are likely due to the THC-sensitive circuitry of yet another brain region, the cerebellum.



To summarize, eCBs can either inhibit neuronal activity by slowing down excitatory synapses onto that neuron, or they can disinhibit (excite) neuronal activity by slowing down inhibitory synapses. Both of these are physiological actions that contribute to normal brain function. The fact that CB1 receptors can orchestrate the tempo of brain cells in either direction—faster or slower—surely helps to explain how cannabis can have such wide ranging, even opposite, perceived effects in different individuals and circumstances.

The story of eCBs is not just about the brain, though. Important therapeutic properties of cannabinoids are mediated by the CB2 receptors on immune cells. Immune cells promote inflammation during the course of fighting an infection, an important adaptive property; however this action also can be a source of pain, tissue damage, and an obstacle to healing and well-being. Activation of CB2 receptors throughout the body (including the brain, where immune cells are called microglia), either by eCBs or the cannabinoids in marijuana, tells the immune cells to slow down releasing the chemicals that trigger inflammation.

This effect is directly analogous to what we described for the brain, where eCBs serve as a brake to the release of neurotransmitters. Clinically, the need to control swelling, itching, and pain is the reason why corticosteroids and non-steroidal anti-inflammatory drugs (NSAIDs) are such widely used medicines.

Cannabinoids offer a different molecular approach to these same problems. Recent research findings suggest that cannabinoids may be especially promising in reducing dangers of chronic inflammation in the brain, which is believed key to many serious neurodegenerative diseases ranging from Alzheimer's dementia to Parkinson's Disease and related motor disorders. The immune modulating effects of cannabinoids also appear to hold promise for the treatment of autoimmune diseases such as diabetes and multiple sclerosis.

The cannabinoid system appears to be primordial, since it exists in nearly all species of animals so far investigated, even very simple ones like microscopic hydra.

To date, the results of 79 controlled clinical trials on humans have been published, along with more than 15,000 peer-reviewed scientific articles on the chemistry and pharmacology of cannabis and cannabinoids, as well as more than 2,000 articles on the body's natural endocannabinoids.

These studies clearly show that the effects can be variable and difficult to predict with precision, but marijuana provides therapeutic benefits across a startlingly broad range of conditions and has an unparalleled record of safety.

HOW CANNABIS GETS YOU HIGH

How THC operates in our bodies is better understood with each new study. But marijuana is composed of over 400 compounds, including at least 88 cannabinoids other than THC.

Cannabis is used by inhalation (smoking or vaporization), ingestion (eating, drinking, or absorption through the mucus membranes of the mouth) or, more rarely, topical application (rubbing into the skin).

Inhalation is a considerably more rapid and efficient delivery method than ingestion, since the cannabinoids, terpenes and other chemicals pass readily across the lining of the lungs straight into the bloodstream. The effects and quality of the high are also somewhat different.

Vaporization (or ingestion) is safer for the respiratory tract than smoking and creates a far less telltale odor. Burning cannabis (or just about anything else for that matter) creates harmful chemicals, known as reactive oxygen species, that may damage the mouth, throat, and lungs. However, heating cannabis in a controlled manner to a temperature just below ignition of the plant material releases the lighter chemicals (including the cannabinoids) without actually burning anything or creating the reactive chemicals found in smoke.

Vaporization may also provide a different quality of high, since it may produce a different mixture of volatilized compounds. Interestingly, though prolonged smoking has been shown to damage the lungs and bronchial tubes, large-scale population studies have failed to find any link between cannabis smoking and lung cancer or other respiratory ailments.

Since the cannabinoids THC and cannabidiol (CBD) have both been shown to have cancer-fighting properties, scientists speculate that cannabinoids may have a prophylactic effect against damage that the tars and other potentially harmful chemicals present in cannabis smoke would otherwise cause.

As rapid as the onset of effects is when cannabis is inhaled, it is slow when eaten. When cannabis products are ingested, the cannabinoids pass first through the stomach then are absorbed across the lining of the intestines into the blood, which passes through the liver and changes most of the THC into 11-hydroxy-THC. While 11-hydroxy-THC is also psychoactive, it may create a different kind of high. Because absorption from the intestines is relatively inefficient and slow, larger doses must be taken if ingested rather than inhaled, and the effects last longer but are delayed for 30-90 minutes after ingestion. This delay can lead to inadvertent excess dosages, since you can’t tell how much you have on board, unlike inhalation, which allows for easy and immediate dosage adjustment.

Serious scientific studies have attempted to determine what factors affect how much THC is absorbed from a joint. Some found that longer “breath holding time” (scientifically known as BHT) was more important than the number of puffs taken or the “puff volume” (PV), while others found that BHT did not appear to affect blood levels of THC or how high the subjects got.

Another study found that the second half of the joint delivers more THC than the first half. Clearly, more research is needed on the question of how long to hold each hit (*so get to work!*). However, there is now a solid scientific basis for the practice of letting your buddies start a joint and getting your first hit after it comes back around to you.

The physiological workings of cannabis include some effects that we recognize as getting high, others that are medically beneficial, and some that are both. The effects include a temporary increase in heart rate and blood pressure, impaired memory and time dilation, slowed reaction time and impaired balance, inhibition of sensory gating (altered/enhanced perceptions), alteration in mood including decreased or increased anxiety/panic attacks (though increased anxiety is usually only seen in inexperienced users or in “overdose”), increased appetite, decreased activity of the intestines and decreased nausea, red eyes, dry mouth, analgesia (pain relief), and decreased muscle spasms.

Nearly all drugs (including over-the-counter medicines such as Tylenol and aspirin) are deadly if taken in overdose, so it is extraordinary that it is impossible to consume a lethal dose of THC. The effects of too much cannabis are generally restricted to severe memory impairment, possible paranoia or panic, near-certain overconsumption of snack foods, then sleep.

However, cannabinoids and the receptors that absorb them are not there just for humans to be able to get high. The cannabinoid system appears to be primordial, since it exists in nearly all species of animals so far investigated, even very simple ones like microscopic hydra.

The most likely reason that marijuana evolved to make cannabinoids like THC was to deter animals that would eat the plant (perhaps by preventing them from remembering where they found it). Many plants make substances that have biological effects in animals; humans have taken advantage of this to develop drugs derived from these substances, including morphine from poppies, aspirin from willow bark, and cancer drugs from periwinkle, to name a few.

Cannabis was used as medicine as early as 4,000 years ago in China and India, and preparations of cannabis were officially sanctioned medicines in the U.S. and other parts of the Western world from the 1800's until the late 1930's.

Today, the list of conditions for which cannabis has shown potential as treatment is a long one. As Michael Pollan describes in his book *The Botany of Desire*, the human-cannabinoid interaction has given marijuana an evolutionary survival advantage by persuading humans to plant it all over the world, something it could not have accomplished on its own.

"I'm in love with Mary Jane. She makes me feel alright. She makes my heart sing. Turns me on with her love. Takes me to paradise."

Lyrics: Rick James "Mary Jane"

MJGROWERS.COM

for updates and more info

Photo: Rachael Szmajda

Photo: Doobieduck

MARIJUANA: THE PLANT

CANNABIS evolved from plants native to the Himalayan foothills, but its origins are clouded by the plant's early symbiotic relationship with humans, a relationship at least 6,000 years old. The use of cannabis and its products spread quickly throughout the world and is now cultivated in climatic zones from the Arctic to the equator. Cannabis evolved on its own for hundreds of thousands of generations, but since its properties were discovered by humans, it has been bred intensively to optimize particular characteristics.

Cannabis is cultivated for one or more of three useful products—

- the nutritious seeds
- the fibrous stalks
- the resinous flowers

Cannabis seeds are rich in oil and protein and are used as a food and animal feed, as well as a source of oil for fuel and skincare products.

Cannabis fiber, produced from the stalks of the plant, is used to make tough cloth, paper, and rope. Though all cannabis plants are of the same species, the varieties typically cultivated for their seeds or fiber are known as hemp.

The third product, the flower and the resin that coats them, is used therapeutically and recreationally. Cannabis resin contains the group of substances collectively known as cannabinoids, of which Tetrahydro-cannabinol, usually referred to as **THC**, is the chief psychoactive component.

THC and the other 87 identified cannabinoids are unique to cannabis. No other plant produces them, although frankincense and cocoa may contain small amounts of compounds that bind to some of the same receptors. Plants grown for their THC content are commonly called marijuana.

The many uses of this multi-faceted plant have historically made it a valuable crop, and today there are collectively more breeding programs for marijuana than any other crop. Marijuana's breeding program is, at least in part, one of the unintended consequences of prohibition, as Michael Pollan points out in his book, *The Botany of Desire*. As the U.S. government escalated its War on Drugs and imposed tighter border controls to restrict the flow of marijuana from Mexico, resourceful American consumers became cultivators. Because of seed scarcity on the commercial market and the fact that cannabis is one of the few plants that casual farmers and breeders can easily grow from self-produced seed, many gardeners have become self-reliant and created their own seed stock.

Gardeners who take this path join an international breeding program as soon as they transfer some of their genetics (i.e. seeds) to someone else. In the 40 years of this modern cannabis breeding program, growers have developed diverse varieties and cultivation methods that are quite efficient at producing the desired product: large, dense buds of **sinsemilla**—that is, a profusion of unpollinated female flowers.

The desired product: large, dense buds of sinsemilla—that is, a profusion of unpollinated female flowers.

Marijuana varieties differ in many ways, including growth characteristics such as:

- height
- width
- branching traits
- leaf size and shape
- flowering time to yield
- potency
- taste
- type of high
- aroma

In choosing a variety, you should select for the quality of the high and the conditions in which you are growing.

Each variety flourishes best under particular environmental conditions. For the most part, potency is a factor of genetics.

Some plants have the genetic potential of producing high-grade marijuana and others do not. The goal of the cultivator is to nurture the high-THC plants so they can reach their full potential.

In nature, marijuana is a fast-growing annual plant, although some varieties in warm areas **over-winter,** going dormant as the days shorten and then returning to flowering the next summer. Marijuana does best in a well-drained, high-nutrient planting medium and requires long periods of bright, unobstructed light daily.

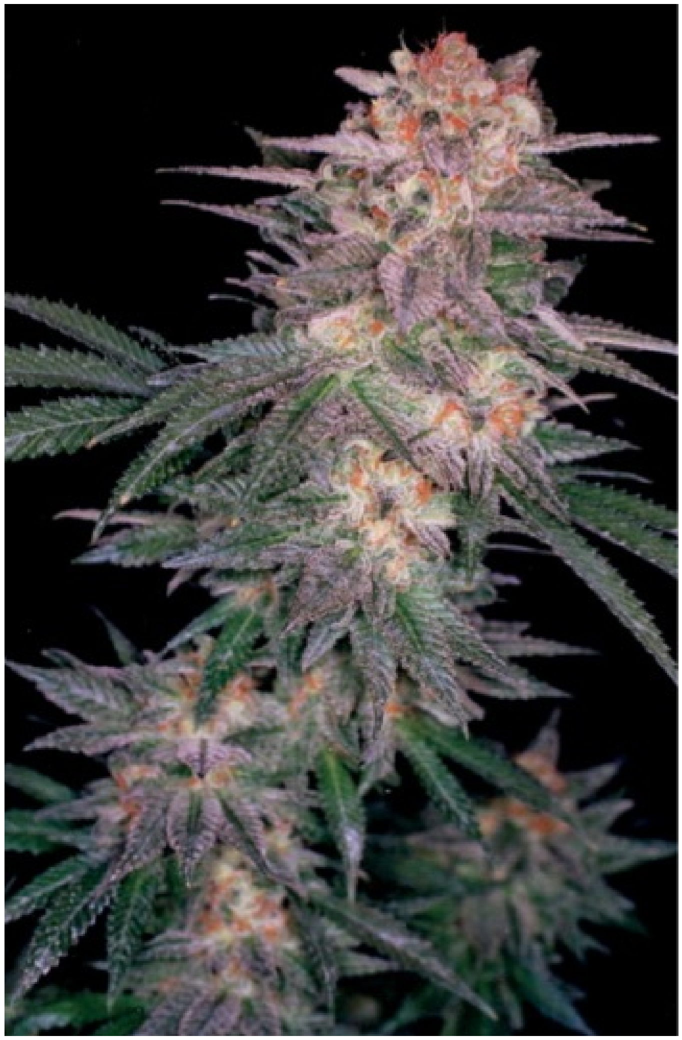
This book is about how to produce the best marijuana under controlled conditions, whether indoors, in the greenhouse, or even outdoors.

Marijuana is usually dioecious; i.e., plants are either male or female.

Occasionally monoecious plants, or **hermaphrodites**, appear and produce both male and female flowers. Such hermaphroditic plants are most common among some varieties native to south Asia, but can also result from environmental stress such as inadequate light or nutrition. Because they fertilize females just as a true male plant does, they are considered undesirable and are removed from the garden as soon as they appear.

Marijuana grown in the wild or with traditional methods outdoors has an annual cycle that begins with germination in the early spring. The plant grows vigorously for several months as the days lengthen and begins to flower when it reaches a critical time period in late summer or early fall.

Flowering depends on the variety’s native latitude but occurs in late summer as the night length increases. Varieties from high latitudes, such as most indicas, need less darkness to flower than those from lower latitude areas, such as most sativas. All varieties set seed in the fall as a result of changes in the weather—the seeds drop as the plant dies.



When growing indoors and in greenhouses, the cultivator has complete control of the environment. The grower determines when the plants are started and when they flower.

This book is about how to produce the best marijuana under controlled conditions, whether indoors, in the greenhouse, or even outdoors.

BOTANICAL DESCRIPTION: CANNABIS SATIVA L.

The word ***cannabis*** is an ancient one, dating back past Latin and Greek to Thracian or Scythian times. Scholars have even identified ancient Biblical references to a plant known as 'kaneh-bos' as early as the 15th century B.C.

As the contemporary name of a type of plant, *Cannabis Sativa Linnaeus (L.)*

was formally conferred in 1753 by Carolus Linnaeas in his famous taxonomy. Linnaeas, who devised the modern system for classifying and naming species, concluded that the genus Cannabis sativa had but one species, which bears the same botanical name. The genus is currently classified as belonging to the *Cannabaceae* family, which also includes hops (*Humulus sp.*). Modern phylogenetic studies and gene sequencing indicate that *Cannabis sativa L.* is more properly considered part of the *Celtidaceae* branch, which also includes the many species of Hackberrry tree, and that the two families should be merged to form a single group descended from a common ancestor. This would not be the first time that *Cannabis sativa L.* has been reclassified, as it was formerly categorized as part of the Nettle (*Urticaceae*) or Mulberry (*Moraceae*) family.

There has been a similar evolution of thinking on how many species of *Cannabis sativa L.* should be recognized. In 1785, soon after Linnaeus identified it as a single species, the influential biologist Jean-Baptiste de Lamarck claimed the plant he found in India should be classified as a separate species, which he named *Cannabis indica.* This name would be included in various pharmacopoeias to designate cannabis plants that are suitable for the manufacture of medicinal preparations.

In the 19th century, other botanists proposed separate species classifications for cannabis plants indigenous to China and Vietnam. But by the 20th century, difficulty with definitively distinguishing between any of them had led most botanists to conclude, as Linnaeus did, that all cannabis plants belong to a single species. Certainly all cannabis plants satisfy one of the chief criteria of a species: they can interbreed. There are different ways to define a species. Wide disparities in cannabis plants' geographic location and primary characteristics have led many to argue that three species should be recognized, based on whether they are cultivated primarily for fiber (sativa) or drugs (indica), or grow wild (ruderalis).

Cannabis ruderalis is probably the progenitor wild variety. The alleles or genetic traits of ruderlis are mostly dominant, indicating that the competing traits are probably mutations. For instance, flowering in ruderalis begins soon after germination and is not dependent on the length of daylight; this characteristic dominates crosses.

1. Male flower bract
2. Female flower bract
3. Male flower
4. Bunch of male flowers
5. Unfertilized female flower
6.-9. Maturing seed
10. Mature seed in perianth
11. Mature seed
12. Cutaway of seed showing embryo

SCIENTIFIC CLASSIFICATION

Kingdom: Plantae
Division: Magnoliophyta
Class: Magnoliopsida
Order: Rosales

Family: Cannabaceae
Genus: Cannabis

Formal Botanical Description

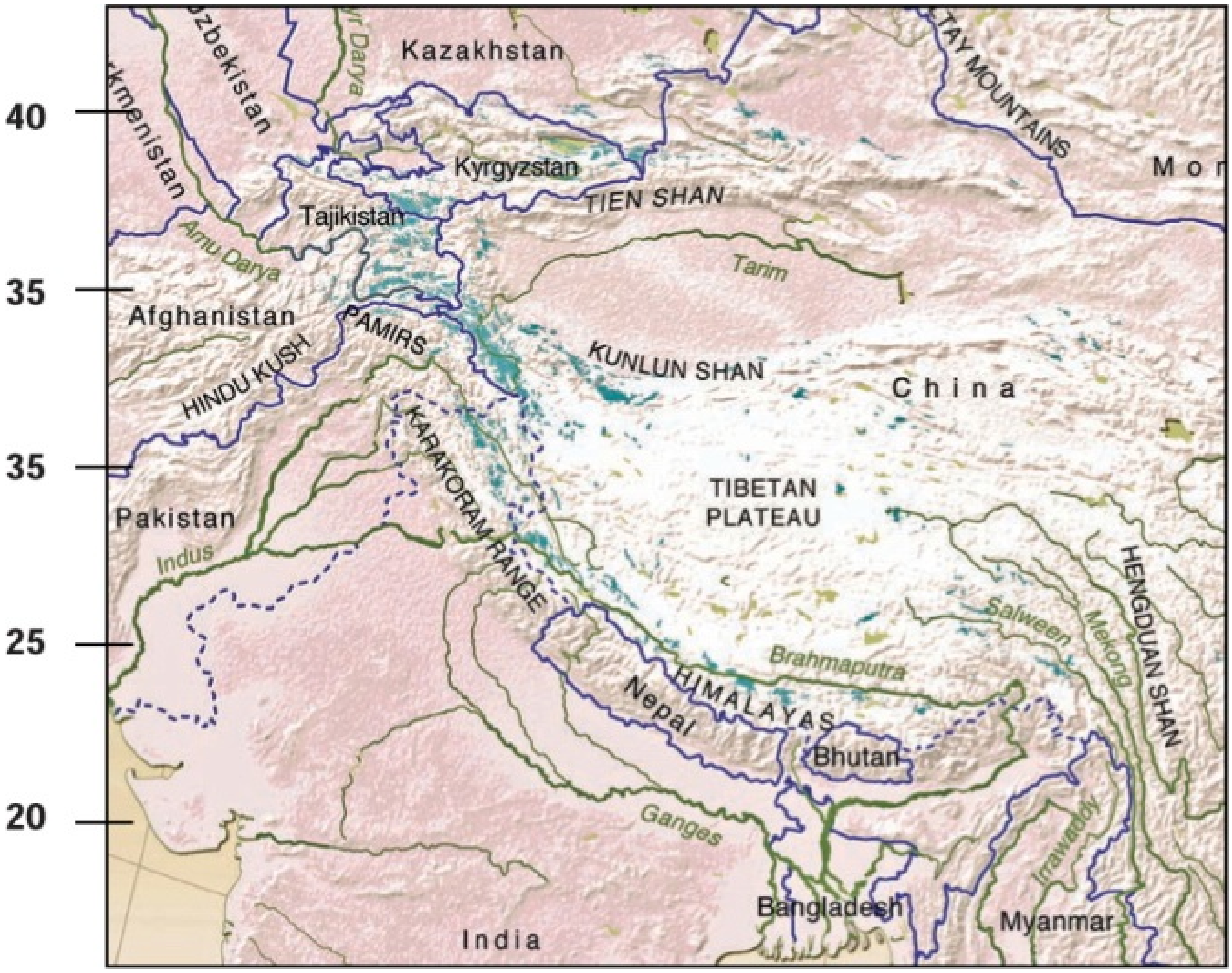
Cannabis is an annual, dioecious, flowering herb. The leaves have serrated leaflets. The first pair of leaves usually have a single leaflet, the number gradually increasing up to a maximum of about thirteen leaflets per leaf (usually seven or nine), depending on variety and growing conditions. At the top of a flowering plant, this number again diminishes to a single leaflet per leaf. The lower leaf pairs usually occur in an opposite leaf arrangement and the upper leaf pairs in an alternate arrangement on the main stem of a mature plant.

Cannabis normally has imperfect flowers, with staminate "male" and pistillate "female" flowers occurring on separate plants. Occasionally, individual plants bear both male and female flowers. Although monoecious plants are often referred to as "hermaphrodites," true hermaphrodites (which are less common) bear staminate and pistillate structures on individual flowers, whereas monoecious plants bear male and female flowers at different locations on the same plant.

Cannabis is wind-pollinated and produces "seeds" that are technically called achenes. Most strains of Cannabis are short day plants, with the possible exception of C. ruderalis and some equatorial C. sativa varieties that are commonly described as "auto-flowering" and may be day-neutral. Cannabis is diploid, having a chromosome complement of 2n=20. Polyploid individuals have been artificially produced. Cannabis plants produce a group of chemicals called cannabinoids, which are secreted by glandular trichomes that occur most abundantly on the floral calyxes and bracts of female plants.

The diversity of the cannabis plants' geography and morphology is considerable; they grow in very different ways and places. The stems grow to a height between from 3'-15' (0.9-4.5m) or more, and the plants range from thin and reedy to thick and bushy. While the plants are native to the Hindu Kush

Valley and the Himalayan foothills, it has migrated with humans throughout the world and can now be found growing wild on every continent but Antarctica. Since there are no laws prohibiting it in Antarctica where researchers from many countries work, it is safe to assume that cannabis has spread its roots there, too.



The Hindu-Kush region ranges through the Himalayan foothills and the southern stretch of the Tibetan Plateau which stretches thousands of miles from Kazakhstan through Tajikistan, Afghanistan, India, Nepal and Bhutan. South of the foothills, cannabis cultivation is practiced throughout India and Southeast Asia.

Cannabis sativa L. is the only dioecious annual—that is, each plant is distinctively either male or female—though hermaphrodite plants do occur, producing both male and female flowers. Also unusual is the fact that cannabis is an annual yet its closest botanical relative, hops, is a perennial. That, combined with the cannabis plant's ability in Nepal and similar climates to over winter or regenerate in spring, leads me to believe the plant's evolutionary path from being a perennial to an annual was relatively recent.

Even the plant's iconic leaves, instantly recognizable even to those who have never seen a plant growing, come in very different sizes and subtly different shapes. The palmate leaves can range from a spread of a few inches (approx 5cm) to more than a foot, while the five to seven sharply serrated leaflets vary from long and thin to broad and stubby. The cannabis plant's combination of extreme genetic variability and ease of interbreeding is part of what makes it so exciting to grow. The range of characteristics that selective breeding can produce is astonishing.

THE HIGH

The wide variety of looks, tastes, smells and highs of marijuana are no coincidence. The terrific subtleties of this plant allow gardeners with different goals to strive for their ideal plant. Marijuana enthusiasts have the pleasure of exploring the myriad effects, flavors, and odors that these varieties have to offer.

We often hear that varieties of marijuana have different tastes and highs because they contain varying ratios of cannabinoids, the chemicals specific to marijuana. However, testing of most modern marijuana shows a big spike in delta-9 THC (Δ9-THC), but in most varieties all the other 100-odd cannabinoids —including cannabinol (CBN), cannabidiol (CBD), cannabichromene (CBC) and cannabigerol (CBG)—are scarcely noted. The most popular strains show a substantial percentage of THC, generally registering 15% to 20% of bud weight. Most marijuana garden books talk about how the cannabinoid known as cannabidiol (CBD) somehow mediates the psychoactive qualities of THC. And some studies have indicated that CBD may affect THC uptake in such a way as to reduce some negative psychological effects, such as anxiety. But in 2005, scientists determined that CBD does not dock at the CB1 receptor sites in the brain that THC targets.

While the high is what most users notice, marijuana can have many other effects. Researchers have determined that the human body has a second type of cannabinoid receptor, named CB2, to which CBD binds. This may explain CBD's many apparent medicinal qualities. For example, clinical trials on pain control indicate that a 50-50 mix of THC and CBD produce the best analgesic effect. Similarly, the concentration of CB2 receptors in the human gut suggests that they may be responsible for marijuana’s well-documented ability to stimulate appetite, control nausea, and ease abdominal cramping. Much research remains to be done on the immune-modulating functions and other possible therapeutic applications of cannabinoids, including their possible role in fighting cancer tumors and controlling autoimmune malfunctions such as arthritis and Alzheimer’s.

Since plants are not mobile, they can’t outrun predators or pick up and relocate when competing plants move into the neighborhood. As a result, they have amassed other defenses against predators and competitors. One of their main strategies is chemical warfare. They produce oils and other chemicals designed to repel enemies. Others kill, sicken, delay maturation or affect their metabolism. Plants use other aromatics to attract either pollinators for reproduction or predators that attack the plants’ enemies. THC and the terpenes were developed as part of this arsenal.

If a recipe of cannabinoids doesn’t determine the personality of the high, what does? We can sniff out the answer. Experienced marijuana users often rate marijuana’s quality, before they ever use it, by simply smelling it. They may expect a certain kind of experience based on the odor. Interestingly enough, THC and the other cannabinoids are odorless. What these connoisseurs are smelling are terpenes, the essential oils of plants.

TERPENES

If cannabinoids, other than THC, are not contributing to the high, then we look at other ingredients in the smoke-stream.

Terpenes are major components of marijuana resin, just as they make up the largest percentage of aromatic essential oils contained in most plants. The scent of most flowers, herbs and spices are composed of these oils. When therapists use plant oils in aromatherapy, or when you use natural incense, perfume, or other scent to set the mood, you are inhaling various combinations of terpenes. They have the power to take you up or down, help you relax or focus, feel anxious or satisfied.

You recognize the presence of terpenes when you pinch that bud and take a whiff. Grapefruit, Silver Haze, Blueberry, Real Skunk—each of these odors brings a recognition of the type of high that the sample will explode into your brain.

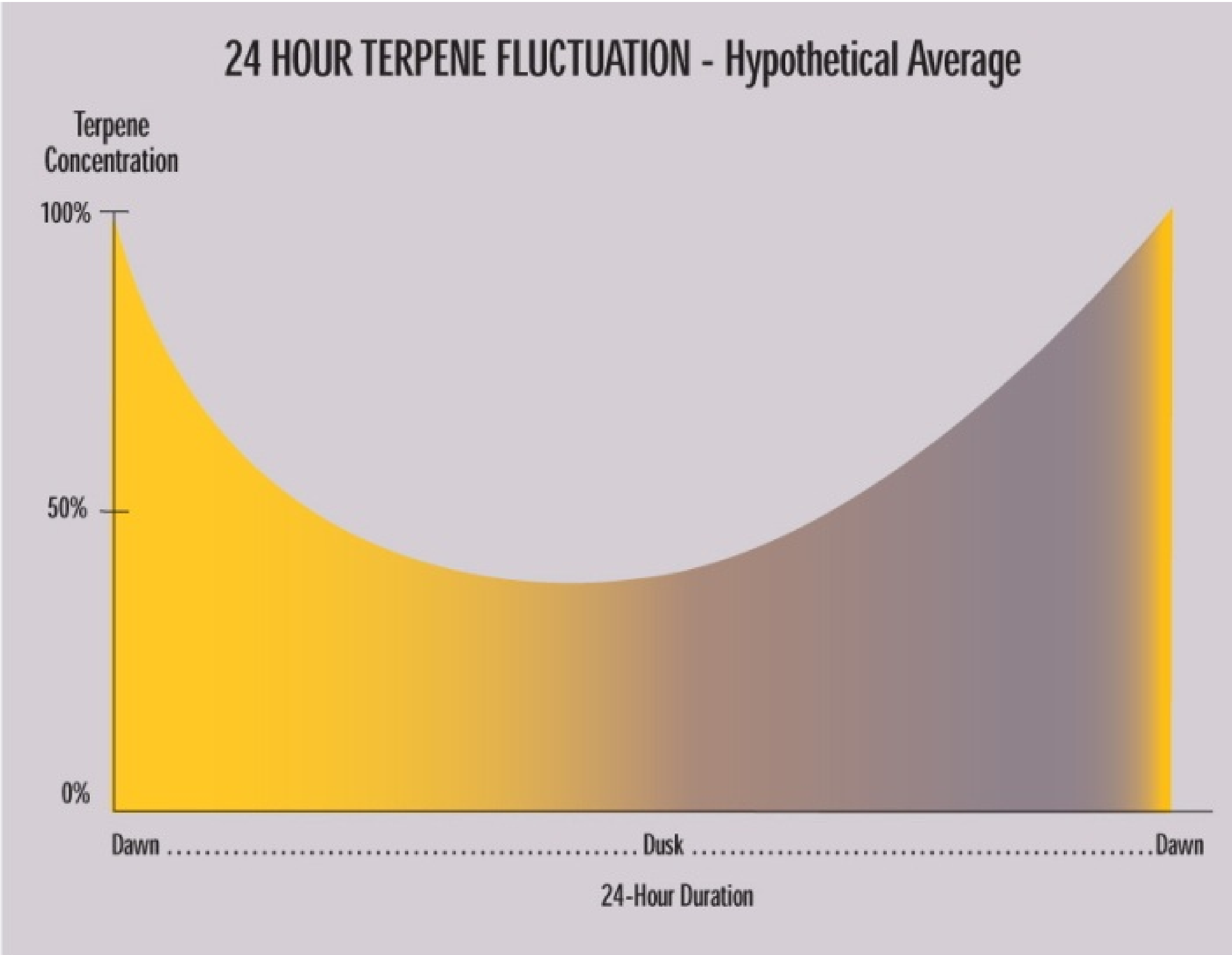
Plants produce terpenes for one of three reasons:

- to attract pollinators
- to repel or kill herbivores
- to attract predators of herbivores

These odor molecules, which are costly for the plant to produce, increase as the plant's investment in reproduction increases. Before flowering, the odors are faint. As flowering progresses and the plant is more invested in protecting it, the odor grows. As the bud ripens, whether seeded or sinsemilla (unpollinated), the odor increases substantially. Marijuana is wind pollinated, so it doesn't need to attract pollinators and outdoors it is resilient to insect predation as the odors are a signal to experienced mammals to stay away. This indicates that the odors deter animals that would eat the plant, including larger browsers.

By temporarily altering brain function, terpenes affect mood, sensitivity, and perceptions, including balance and pain.

Chemically speaking, terpenes are composed of repeating units of isoprene, which is a five-carbon unit chain or ring with eight hydrogen atoms attached (C_5H_8). Terpenes use the simple isoprene units as blocks to build molecules with 10, 15, 20, 30, and 40 carbon units; they also twist and turn the molecular structure to form simple chains or three-dimensional (polycyclic) structures. Most significantly for the marijuana plant, terpene pathways are key enzymatic steps in the plant's production of THC. In addition, terpenes can form bonds with other molecules which affect how animals and plants react to them. Depending on how terpenes stack against each other, they create different aromas.



As it matures sexually, marijuana produces terpenes in the glands that surround the flowers. Terpene levels increase during the dark period and reach their peak just before dawn. During the day they evaporate and fill the surrounding air with odor to warn predators. By the end of the day, at dusk, terpene (and cannabinoid) levels are at their lowest.

Most of the aromas that we associate with plants are the result of terpenes and flavonoids. Humans can smell and taste these compounds, but that is not the only way they affect us. Aromatherapy uses the inhalation of essential oils to regulate mood, sleep patterns, acuity, and healing processes. For example, lavender oil is a soothing agent and relaxant; rosemary is used to focus attention and provide a sense of satisfaction. These effects are a result of the combination of terpenes and other chemicals found in the oils of these plants. While terpenes affect the brain in their own way, they also modify the effect of THC within the brain, adding subtleties to the high. Some terpenes may affect the high because they lock into receptor sites in the brain and modify its chemical output. A few, such as thujone, one of the main terpenes in wormwood (which is used to make absinthe), bind weakly to the CB1 receptor. Others alter the permeability of cell membranes or the blood brain-barrier, allowing in either more or less THC. Others affect serotonin and dopamine chemistry by shutting off their production, affecting their movement, binding to their receptor sites, or slowing their natural destruction. **Dopamine** and **serotonin**, two of the main regulators of mood and attitude, are affected by some terpenes, as well as THC.

By temporarily altering brain function, terpenes can affect mood, sensitivity, and perceptions, including balance and pain. When terpenes are mixed, as they are in natural plant oils, they each play a role in affecting brain function. Some combinations may work synergistically and others antagonistically, but each "recipe" of terpenes affects moods and feelings in its own way.

Over 100 terpenes have been identified in marijuana. There are actually many more when one considers the multiple variations of each terpene. For instance, the characteristic citrus odor found in fruit rinds differs by type and even variety of fruit—oranges and lemons have different odors, and their terpenes, called **limonenes**, are mirror versions of each other. This is due to slight differences in the amounts of limonene, as well as other compounds that contribute to citrus elements.

About 10-30% of marijuana smoke resin is composed of assorted terpenes. Some terpenes appear only occasionally in marijuana, while others are found all the time. The percentage of particular terpenes and the ratios in which they are found vary by plant variety. You experience this yourself when you notice different varieties have specific smells, indicating their individual essential oil makeup. Interestingly, hops and both groups of cannabis (low-THC hemp and high-potency marijuana)—contain similar complements of terpenes. One researcher found that the oil of common black pepper (*piper nigrum*) also has a group of terpenes similar to cannabis. Terpenes are produced in the **trichomes**, the same glands where THC is produced.

Age, maturation, and the time of day can affect the amount, and perhaps ratios, of terpenes. One reason is their high evaporation rates at temperatures as low as 75° F (24° C). As plants mature, their odor gets more intense and sometimes changes as they ripen. Plants are constantly producing terpenes, but they evaporate under pressure from sunlight and rising temperatures. That means plants have more terpenes at the end of the dark period than after a full day of light. You can test this yourself—check a plant's odor early in the morning and at the end of a sunny day. You will find more pungency earlier in the morning.

Climate and weather also affect terpene and flavonoid production. The same variety of marijuana can produce different quantities and perhaps even different types of oils, depending on the type of soil in which it is grown or the fertilizers used. The terpenes described below are those generally most abundant in marijuana, though individual plants may differ widely both in total percentages of terpenes and in their ratios.

Hops and Lemongrass

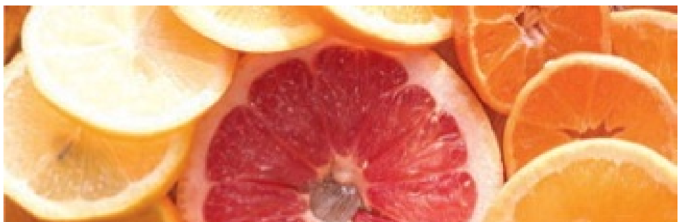
MYRCENE is the most prevalent terpene found in most varieties of marijuana but not found in hemp. It is also present in high amounts in hops, lemon grass, West Indian bay tree (used to make bay rum), verbena and the plant from which it derives its name, mercia. Myrcene also appears in small amounts in the essential oils of many other plants. Its odor is variously described as clove-like, earthy, nutty, green-vegetative, and citrus. The various odors are the result of slight differences in the overall essential-oil makeup. All of these flavors and odors are commonly used to describe cannabis.

Mango

Myrcene is a potent analgesic, anti-inflammatory and antibiotic. It blocks the actions of cytochrome, aflatoxin B and other pro-mutagens that are implicated in carcinogenesis. It is also present in small amounts in many essential oils associated with anti-depressive and uplifting effects. Myrcene and THC are likely synergists, meaning a combination of the two molecules create a stronger experience than either one alone. Myrcene may affect the permeability of the cell membrane, allowing more THC to reach brain cells.

Slightly overripe mangos contain large quantities of myrcene. Eating a mango 20-30 minutes before using marijuana gives the myrcene time to enter the bloodstream and start crossing the blood-brain barrier. Myrcene may help THC cross the barrier by opening the pathway or less likely, it might carry the molecule with it. The combination of THC and myrcene creates a stronger high, faster.

LIMONENE is found in the rind of citrus and many other fruits and flowers. Limonene is the second, third or fourth most prevalent terpene in cannabis resins, depending on the variety. Everyone is familiar with the odor of citrus resins—they explode into the air when a fruit is peeled. The exact odor is determined by the structure of the terpene. Plants use limonene to repulse predators. For instance, flies have a group of receptors wired directly to the fly brain that are similar in function to the taste buds on our tongues. One of them detects noxious chemicals and responds to limonene as a toxin.



Citrus

Limonene has anti-bacterial, anti-fungal and anti-cancer activities. It inhibits the Ras cancer gene cascade which promotes tumor growth. Since limonene is such a potent anti-fungal and anti-cancer agent, it is thought to protect against the Aspergillus fungi and carcinogens sometimes found in cannabis smoke streams. It synergistically promotes the absorption of other terpenes by penetrating cell membranes. In humans, limonene's design facilitates a direct response by quickly permeating the blood-brain barrier. The result is increased systolic blood pressure. In one test, participants reported an increase in alertness and restlessness. Various limonene analogs can cue the brain to sexuality, buoyancy or focused attention. Limonene sprays are used to treat depression.

B-CARYOPHYLLENE is a major terpene found in black pepper (15-25%), clove (10-20%) and cotton (15-25%). It is found in smaller percentages in several other herbs and spices. It has a sweet, woody, dry-clove odor and tastes pepper-spicy with camphor and astringent citrus backgrounds. It contributes to black pepper's spiciness and is used industrially to enhance tobacco flavor.

Black Pepper, Clove

B-Caryophyllene, ingested in large amounts, blocks calcium and potassium ion channels. As a result, it impedes the pressure exerted by heart muscles. Applied topically, it is an analgesic and is one of the active constituents of clove oil, a preferred treatment for toothache. It docks on the CB2 receptor site, the same site for which cannabidiol has an affinity. Thus it may help reduce inflammation. In a recent experiment, a group of experienced marijuana users smoked a joint with caryophyllene added. All but one reported good feelings and were slightly giddy. The other individual had positive feelings but was more contemplative. It added a slightly woody taste to the bouquet.

PINENE is the familiar odor associated with pine trees and their resins. It is the major component in turpentine and is found in many other plant essential oils in noticeable amounts; including rosemary, sage and eucalyptus. Many additional plant oils contain minute quantities of it. **Pinene** is used medically as an expectorant and topical antiseptic. It easily crosses the blood-brain barrier where it acts as an acetylcholinesterase inhibitor; that is, it inhibits activity of a chemical that destroys an information-transfer molecule. This results in better memory. Largely due to the presence of pinene, rosemary and sage are both considered "memory plants." Concoctions made from their leaves have been used for thousands of years in traditional medicine to retain and restore memory.

Pine

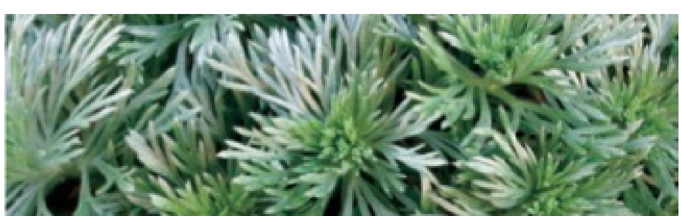
Rosemary, Sage

Pinene is likely to give the true skunk varieties, ones that stink like the animal, much of their odor. It is also a bronchodilator. The smoke seems to expand in your lungs and the high comes on very quickly since a high percentage of the substance will pass into the bloodstream and brain. It also increases focus, self-satisfaction, and energy. This might seem counterintuitive to experienced marijuana users because Afghani Skunk experiences are often calming or sedating. This is caused by the presence of terpineol, which is often found in combination with pinene. Pinene's intense odor camouflages terpineol. The hidden terpineol knocks you out, but because it's odor is undetected, the effect is attributed to the pinene. If you notice a sweet sensation in the skunky smell, there is a good chance that terpineol is present.

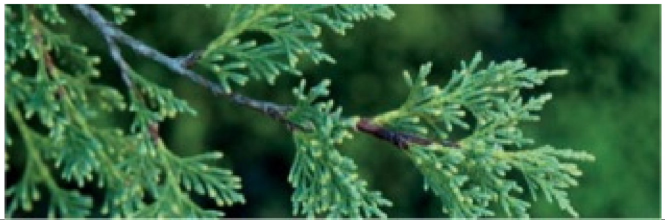
Lilac, Apple Blossoms

TERPINEOL has a lilac, citrus, or apple blossom/lime odor. It is a minor constituent of many plant essential oils. It is used in perfumes and soaps for fragrance. Terpineol is obtained commercially from processing other terpenes. It reduces motility, the capability for movement, by 45% in rat tests. This may account for the couchlock effects of some cannabis, although terpineol's odor is not usually associated with body highs. That may be explained by the fact that terpineol is often found in cannabis with high pinene levels, as mentioned above. Its odor is masked by the pungent woodsy aromas of pinene.

BORNEOL smells much like the menthol aroma of camphor and is easily converted into it. It is found in small quantities in many essential oils. Commercially, it is derived from artemisia plants such as wormwood and some species of cinnamon. It is considered a "calming sedative" in Chinese medicine. It is indicated for fatigue and recovery from illness and stress. The camphor-like overtones of Silver Haze varieties are unmistakable. The high of these varieties does have a calming effect, in addition to its psychedelic aspects. This indicates there may be a large amount of borneol present in these varieties.



Artemisia



Cedar

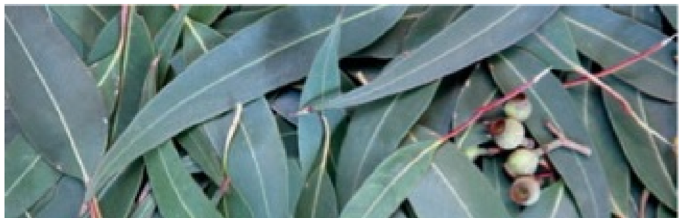
DELTA-3-CARENE has a sweet, pungent odor. It is a constituent of pine and cedar resin but is found in many other plants, including rosemary. In aromatherapy, cypress oil (high in Delta-3-Carene) is used to dry excess fluids, tears, running noses, excess menstrual flow and perspiration. It may contribute to the dry eye and dry mouth experienced by marijuana users.

Lavender, Lilly of the Valley

LINALOOL has a floral scent reminiscent of spring flowers such as lily of the valley, but with spicy overtones. It is refined from lavender, neroli and other essential oils. Humans can detect its odor in the air at rates as low as one part per million (ppm). Linalool is being tested now for treatment of several types of cancers. It is also a component of several sedating essential oils. In tests on humans who inhaled it, it caused severe sedation. In tests on rats, it reduced their activity by almost 75%.

Minty-Camphor

PULEGONE has a minty-camphor odor and flavor that is used in the candy industry. It is implicated in liver damage when used in very high dosages. It is found in tiny quantities in marijuana. Pulegone is an acetylcholinesterase inhibitor; that is, pulegone interferes with the action of the protein that destroys acetylcholine, the chemical the brain uses to store memory. Pulegone may counteract THC’s effect of lowering acetylcholine levels. The result is that you’d forget more on THC alone than THC accompanied by pulegone.



Eucalyptus

CINEOLE is the main ingredient in oil of eucalyptus. It has a camphor-minty odor similar to pulegone. It is also found in other fragrant plants and in minor amounts in marijuana. It is used to increase circulation, pain relief and has other topical uses. Cineole easily crosses the blood-brain barrier and triggers a fast olfactory reaction. Eucalyptus oil is considered centering, balancing, and stimulating. It is probably the stimulating and thought-provoking part of the cannabis smoke stream.

TERPENE INTERACTION

The way terpenes interact with one another and their resulting effect on brain activity provides fascinating territory for another level of exploration and creativity for seed breeders. By learning the odors of the terpenes, you may be able to predict the mind-altering properties each lends to a bud.

MAPPING THE POT PALATE | DJ SHORT

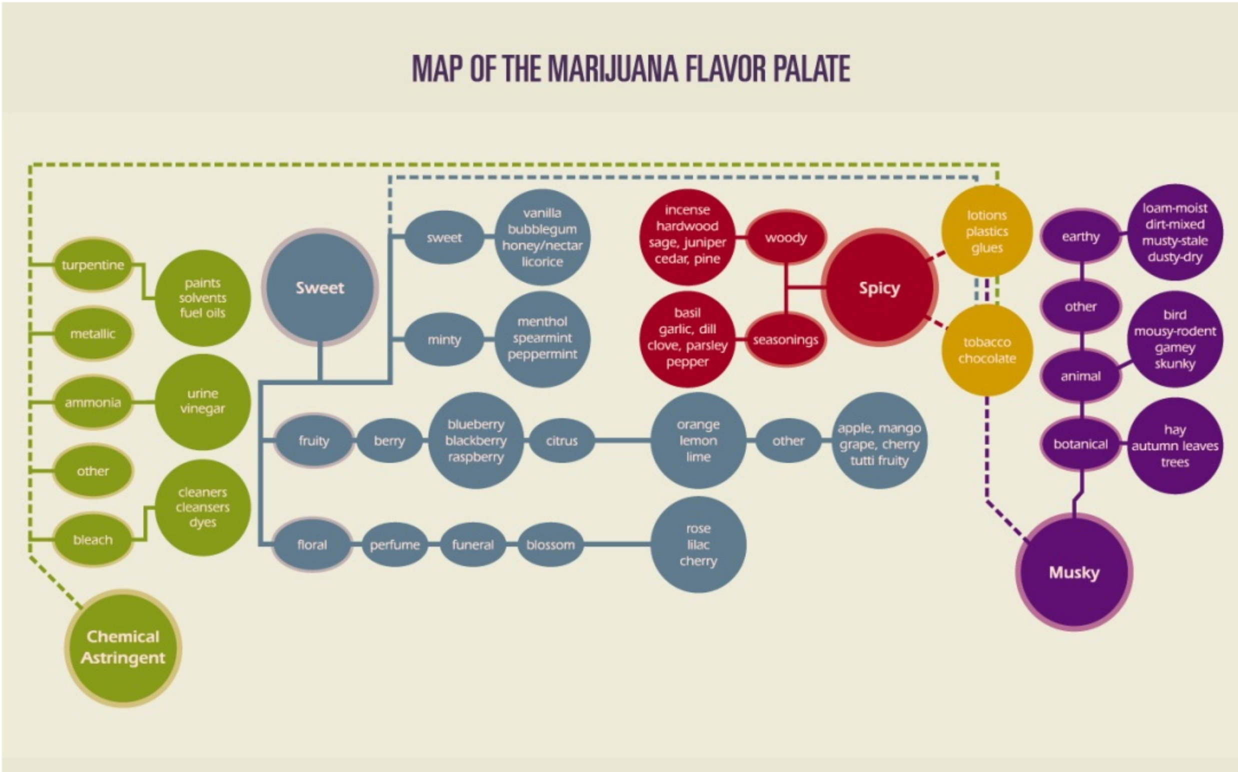
The breeding and production of fine cannabis is more art than science. A creative mind and sense of intuition are necessary to achieve success in this field. While some herb is strictly pleasing to the mental palate, taste can also be tantamount to the buzz for the cannabis connoisseur.

The range of flavors expressed by the genus cannabis is extraordinary. No other plant on the planet can equal the bouquet of

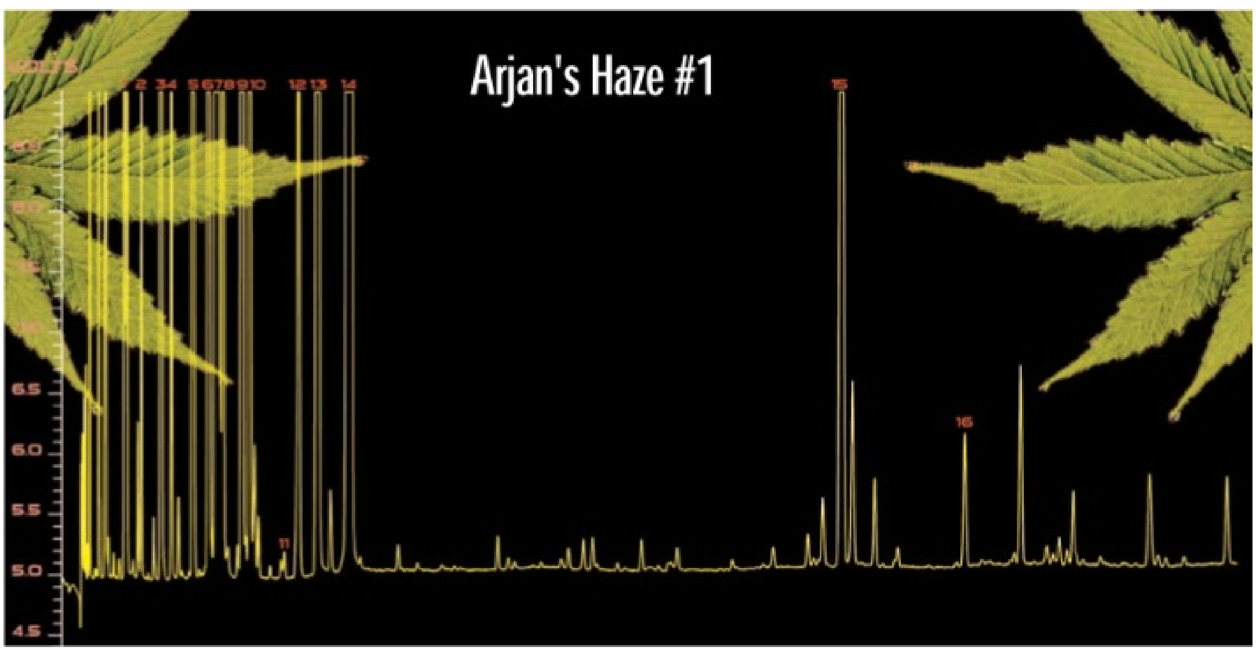
smells and tastes available from cannabis. The spectrum of possible smells and tastes a human can experience is large and complex. To date, no one has created a fully usable olfaction chart, although Ann Noble of the wine world has developed a nifty “aroma wheel” for that industry, which inspired me to develop a similar map for cannabis. Like its counterpart, categories branch out from the general to the more specific. For instance, a category like “fruity” will subdivide into “berry” and “citrus;” citrus divides further into the more distinct flavors of “lemon,” “lime” and “orange.”

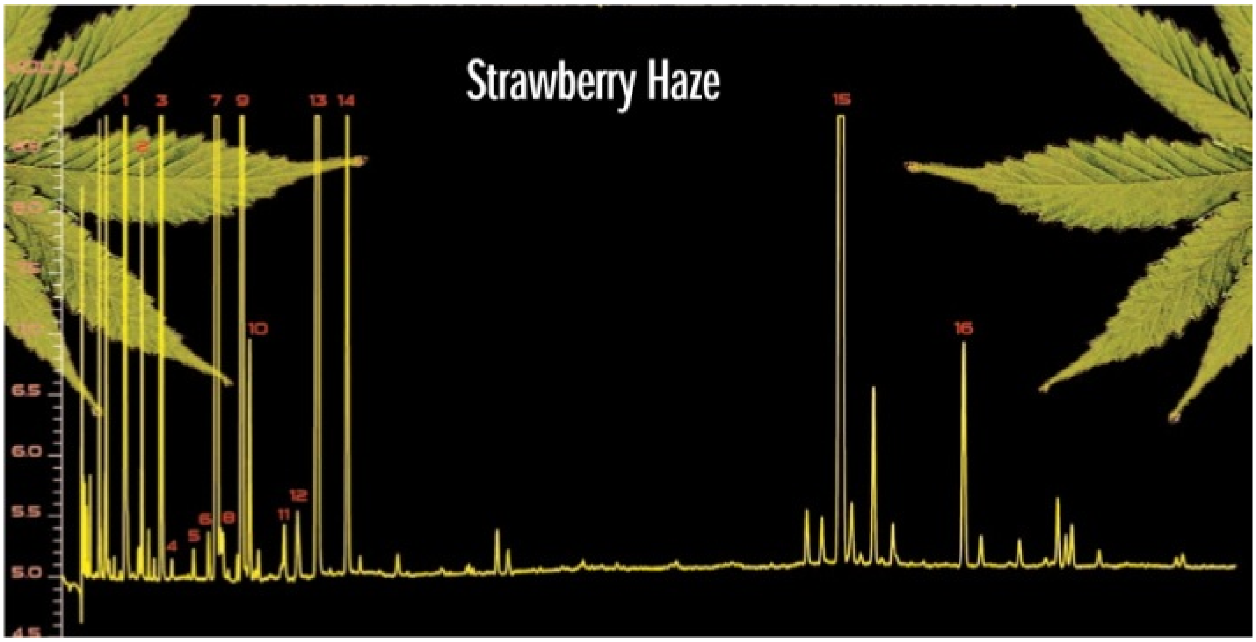
The range of aromas and flavors represented on the chart (next page) are all possible to achieve. Some of these are already well known and represented among widely available cannabis varieties, while others require some cross-breeding to achieve. Some of the most desirable bud bridges multiple categories, creating a complex sensory experience. Although the strength of smell and flavor may vary, many strains’ flavors were best expressed when they were grown outdoors in their region of origin. Note that aroma and flavor vary by growing method and also between various stages of the plant. The aroma of a live bud on the plant, a dried and cured bud, and the smoke on the inhale and exhale, may all be different from each other.

The physical palate of cannabis is a wondrous dimension, important in distinguishing the good from the superb in the weed world. Capable of being refined, one’s palate is best educated through experience. The map that follows is meant to aid the discriminating stoner in charting the territory. Happy travels.



The array of different flavors and aromas of marijuana fall in a range among these general categories: Chemical/Astringent, Sweet, Spicy, musky

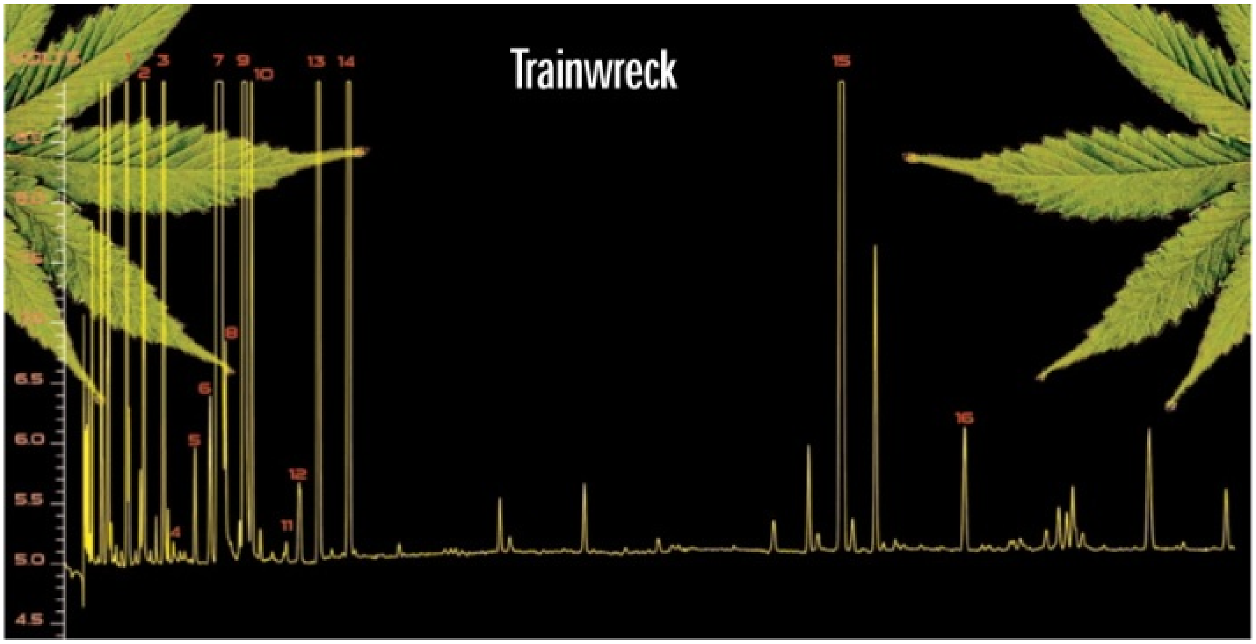


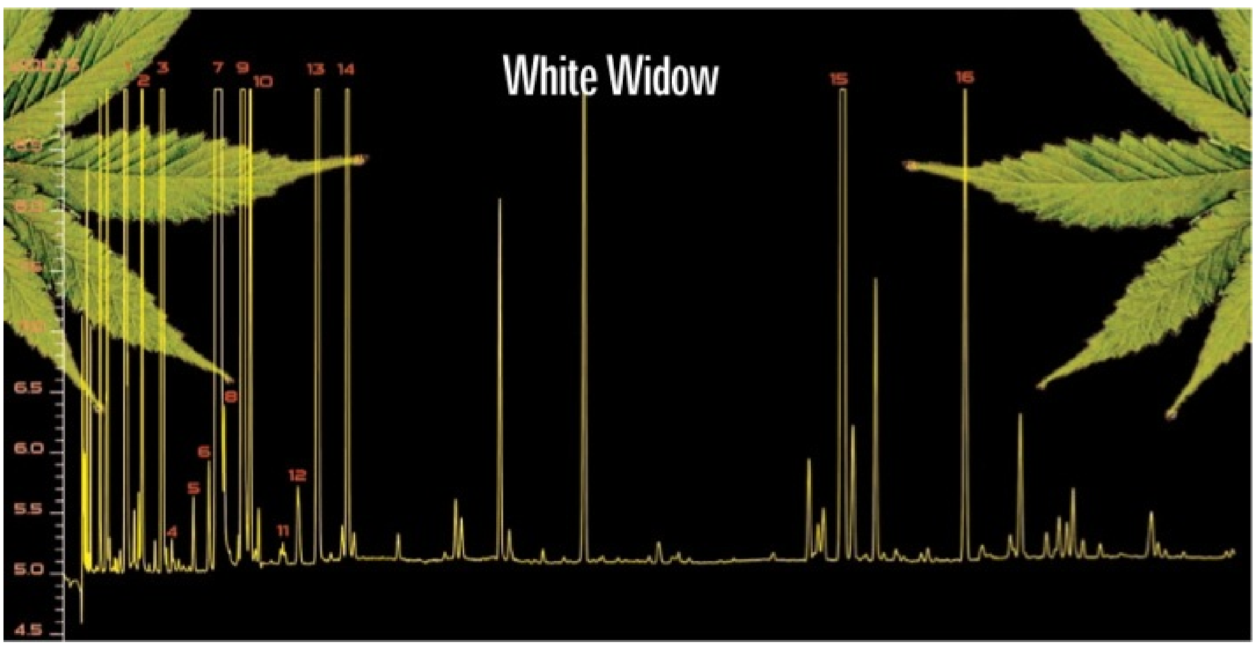


TERPENE KEY

THESE CHARTS SHOW LEVELS OF SPECIFIC TERPENES:

1–Alpha-pinene
2–Camphene
3–Beta-pinene
4–Sabinene
5–Delta-3 Carene
6–Alpha-Phellandrene
7–Beta-Myrcene
8–Alpha-Terpinene
9–Limonene
10–1.8-Cineole
11–Y-Terpinene
12–Cis-Ocimene
13–Trans-Ocimene
14–Alpha-Terpinolene
15–Trans-Caryophyllene
16–Alpha-Humulene


Trainwreck
VOLTS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
6.5
6.0
5.5
5.0
4.5


White Widow
VOLTS
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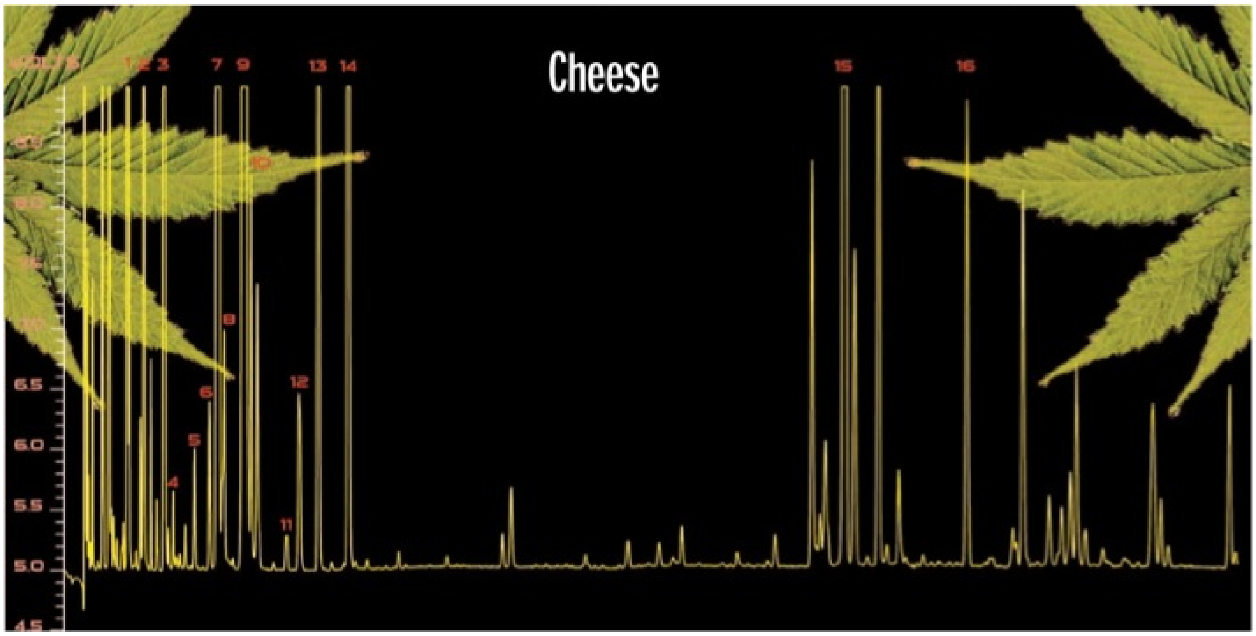
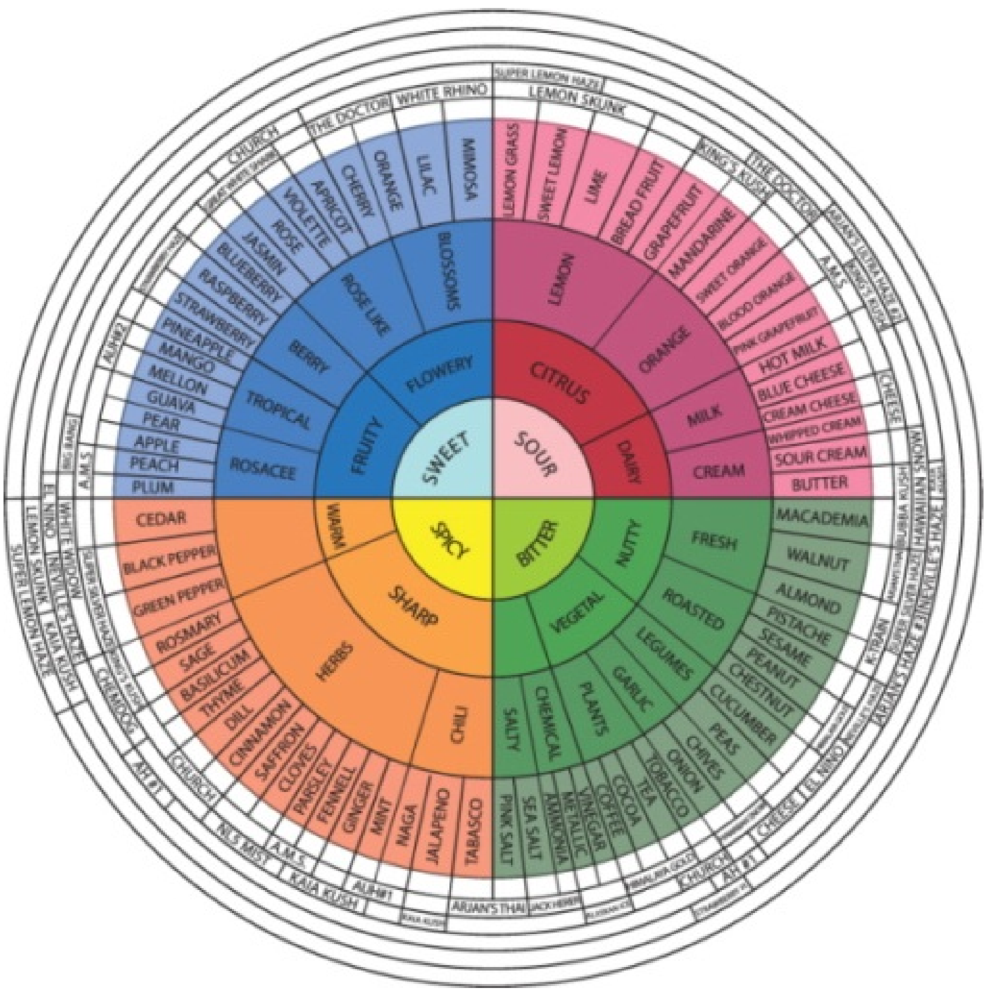




Green House Seeds developed this odor wheel to help classify their varieties.

THE TERPENE CHARTS

Green House Seeds has been testing for terpenes since 2008. This has allowed breeders, growers, and users to take a good look at the analysis of some of the bud they are growing and using. Still, this field requires more investigation.

Terpenes create the “personality” of the high, so the recipe, that is, the combination of terpenes in a bud, determines its direction. Each recipe produces a slightly different effect. Each is an adventure. Perhaps that’s why so many people are interested in breeding and even more people enjoy trying new varieties.

Here’s my interpretation of the results based on aromatherapy and researchers’ controlled experiments using essential oils individually or in combinations.

Tests were performed for sixteen terpenes. (See Terpene Key).

To simplify interpretation we can combine numbers 1 and 3-alpha and beta pinene, 8, 11 and 14-alpha and terpinene and terpinolene, and 13 and 14-cis and trans-ocimene. The pinene helps create the more acrid pungent odors, as does terpenine and terpinolene.

In addition to the terpenes that were identified in several of the varieties, Trainwreck and White Widow had similar unidentified spikes, which delineates a bit of their similarity. Cheese also contained terpenes not identified by the test. These terpenes have not been found in other varieties tested by Greenhouse. This may account for its unusual aroma and high.

Most of the varieties had high levels of 1, 2, 3, 7, 9, 10, 13, 14 and 15. It is interesting that White Widow and Trainwreck have wide bands at 7, beta-myrcene. Myrcene makes the blood-brain barrier more porous, allowing more THC to get to the brain faster. This results in a faster, more powerful initial experience and perhaps a more intense high.

Alpha-terpinolene, band 14, has a wide band in Arjan’s Haze #1 (AH #1) and a very narrow band in Arjan’s Strawberry Haze (ASH). Terpinolene and its cousin terpineol, which was not tested for, have sweet odors reminiscent of apple blossoms or lilac. They also are responsible for serious couchlock. One would assume from this that AH #1 is fairly laid-back, while ASH is more energetic. On the other hand ASH is lower in cineole than the others. Cineole helps THC pass through the blood-brain barrier, so it is slow to come on.

B-Caryophyllene (15) is anti-fungal and protects the body from fungi that may be present in the bud. All these varieties contain ample amounts.

Between 15 and 16 an unidentified terpene (A) appears on all the charts. It’s most prominent in Cheese, but is also significant in White Widow and Trainwreck. It is insignificant in the Hazes.

Humulene, #16, is the main essential oil in hops flowers, cannabis’ cousin. It imparts aroma to beer, but also has both anti-inflammatory effects and is used as a sedative and to relieve stress. Varieties containing high quantities may relieve pain, reduce inflammation, lower stress and induce better sleep. On the other hand, it might not be the best therapy for concentration or even socializing. Two varieties that are often used medically, White Widow and Cheese, both contain more of it than the other varieties do.

You can see the test results of other varieties on the Green House Seeds website.

SPEED QUEEN | Photo: Mandala Seeds

INDICA & SATIVA RUDERALIS & KUSH

Marijuana grown in the United States has been developed from the two potent sub-species or varieties: **indica** and **sativa**. Another sub-species, **ruderalis**, is also available and is used to create **auto-flowering** varieties that do not wait for shorter days to begin budding. The **kush** varieties, sometimes called Afghani, are a sub-group of indicas.

Plants of the same population from higher latitudes have a lot of variability. These include Southern Africans, Northern Mexicans, and indicas. Marijuana within these groups look slightly different from each other and have different maturities and potency. The ratio of THC (the psychoactive ingredient) also varies. The differences in native climate makes low-latitude populations more homogeneous and high-latitude populations heterogeneous.

Plant varieties originating in lower latitudes have less variation within their population. There is little change of weather in more tropical areas, where every year tends to resemble the last. In temperate climates, by contrast, there can be wide variability—one year may be cold and rainy, the next hot and dry.

The wide selection of characteristics in northern-latitude varieties means that some individual plants will thrive no matter what conditions occur in a particular season. Most varieties available today are hybrids of these types, and bred to have the best characteristics of each. Beginning in the 1970s, breeders crossed different landraces (varieties native to Afghanistan, India, Colombia, Mexico, Thailand and Vietnam and Equatorial Africa). The result was some of the first domesticated varieties, including Skunk #1, Big Bud, William’s Wonder, Haze, Northern Lights, and Afghani-Kush. A second generation of breeders included landraces from Brazil, South Africa and Burma.

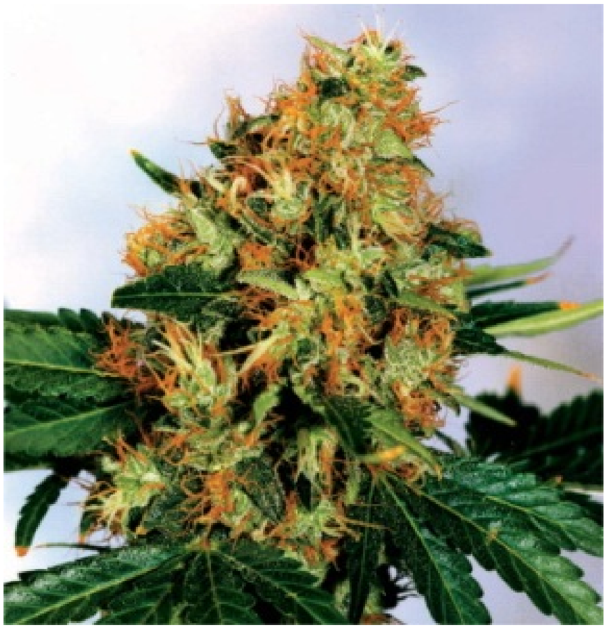
After 40 years of breeding, the marijuana plant has been substantially changed.

Within a few years, breeders started working with the resulting domesticated varieties, selecting for more sophisticated highs, faster ripening time, controlled odor and growth, bigger buds, and pest resistance. Most of the varieties offered today are many hybridizations away from the original landraces from which they started. They have been totally domesticated to modern standards.

INDICA

Indica plants developed in central Asia between the 25th and 35th latitudes, where the weather is changeable. Drought one year may be followed by cloudy, rainy or sunny weather. For the population to continue, the plant group needed different individuals that survive and even thrive under those specific conditions. Thus, in any season, no matter what the weather, some plants will do better than others.

Indicas, including Kush varieties, have broad general characteristics: they mature early, have compact short branches and wide, short leaves which are dark green, sometimes tinged purple. Their buds are usually tight, heavy, wide, and thick, rather than long. They smell “stinky,” “skunky,” or “pungent,” and their smoke is thick—a small toke can induce coughing.



MANGOLIAN INDICA: 100% Indica, Flowering 55-60 days, High: heavy body stone, sleepy, long lasting, Smell/Taste: fresh woodsy, mango citrus taste.

MAZAR: 100% Indica. Afghan x Skunk. The Afghani (Mazar-i-Shariff) part is a very short Christmastree-like plant. High: very “up.” Flowering: 8 - 9 weeks, early Nov. outdoors. Photo: Dutch Passion Seeds

HINDU KUSH: Original sativa from the Hindu Kush region, Flowering: 10-12 weeks, High: cerebral. Taste/Smell: musty, earthy, hash-like. Photo: Mel Frank

Indica plants were developed for resin content, which was removed from the flowers to make hashish. It is only after these varieties were introduced to the West that their buds were consumed. The best indicas have a relaxing "social high," which allow you to sense and feel the environment, without analyzing the experience.

Kush varieties are indicas that were developed in the Hindu-Kush valley that stretches through northern Afghanistan, Pakistan and India. They are a variant of indicas and have many of the same characteristics. Some growers look for extra-wide leaf blades. The difference between Kush varieties and other indicas is one of nuance, rather than distinct difference.

ARJAN'S ULTRA HAZE #1: Sativa, Neville's Haze x Cambodian/Laos, Flowering: 13 weeks, late Nov. outdoors. High: intense sativa high, psychedlic.

PLANT CHARACTERISTICS: INDICAS v. SATIVAS

	INDICA	SATIVA
Height	2' to 6' feet (60 to 180 cm)	5' to 25' (1.5 to 7.5 m)
Shape	Conical to bushy	Tall, Christmastree shape
Branching	Lots of side branching, usually wider	Moderate branching, wide at its base,

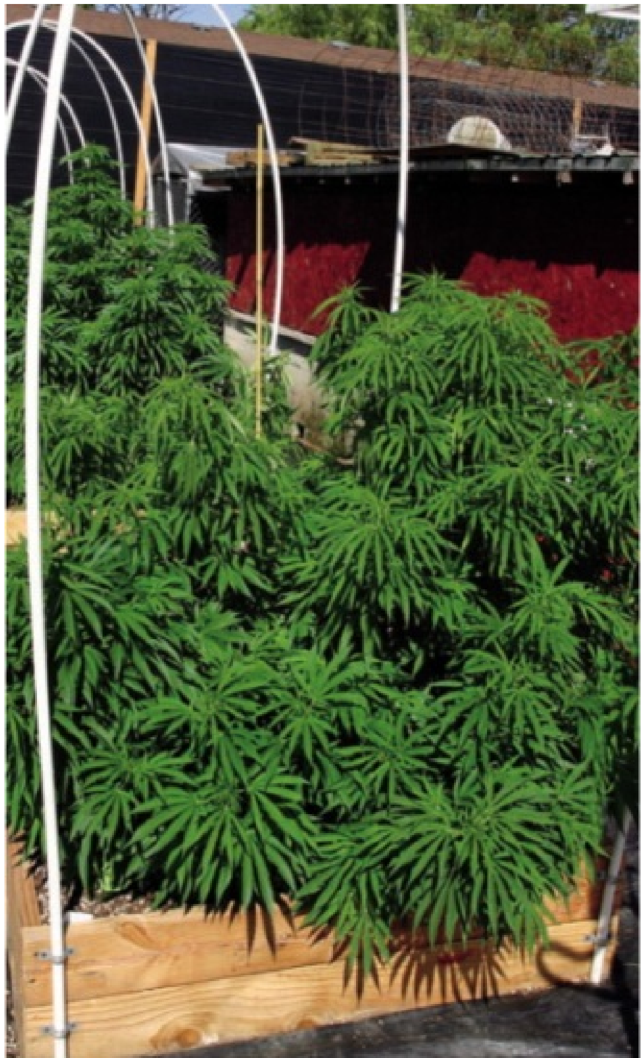
	than its height	single stem at top
Nodes	**Short stem length between leaves**	**Long stem length between leaves**
Leaves	**Wide short leaves, short wide blades**	**Long leaves, thin long blades**
Color	**Dark green to purple**	**Pale to medium green**
Flowers	**Wide, dense, bulky**	**Long sausage-shaped flowers**
Odor	**Pungent, sticky, or fruity**	**Sweet to spicy**
High	**Inertia, desensitizing**	**Psychedelic**
Flowering	**6 to 9 weeks**	**8 to 15 weeks**

SATIVA

INDICA

SATIVA/INDICA: Trainwreck

SATIVA/INDICA: Trainwreck



SATIVA/INDICA

SATIVA

Sativa plants are found throughout the world. Potent varieties such as Colombian, Panamanian, Mexican, Nigerian, Congolese, Indian and Thai are found in equatorial and sub/equatorial zones. These plants require a long time to mature because they originated in areas that have a long season. They are usually very potent, containing large quantities of THC. The highs they produce are described in such terms as psychedelic, dreamy, spacey, and creative. The buds usually smell sweet or tangy and the smoke is smooth, sometimes deceptively so.

Jamaican Sativa

Sativa plants grow in a conical, Christmastree form. The leaves have long, narrow serrated blades, wide spacing between branches, and vigorous growth. They often grow very tall outdoors and are difficult to control indoors.

Sativas have long, medium-thick buds when grown in full equatorial sun; under artificial light with inadequate intensity, or even under the temperate sun, the buds run, or are thinner, longer and don’t fill out completely. In areas with short growing seasons, the buds often don’t mature before frost.

Sativa (top) and Indica (bottom)

At this point, marijuana is the most intensively bred plant using classical techniques. There are several reasons for this:

One is that pollen, because it is produced on male plants, can easily be either removed from or introduced to the females, facilitating controlled breeding.

The more important reason is non-botanical: prohibition has limited commerce in seed. Most people cannot go to the store to pick up a pack of White Widow seeds; thus necessity led to growers producing their own seed.

RUDERALIS

Ruderalis is a wild or feral variety of auto-flowering marijuana. A few weeks after germination, the plants begin to produce flowers while continuing to grow. They tend to be short, between 1'-3' (0.3-0.9 m), and varieties differ in flowering growth. The seed bank tried using a Romanian variety that grew flowers along its new growth. In the early summer, the flowers were apparent, but they didn't form any heads or colas. In the fall, the plants continued to grow and formed small, but the flowers didn't produce heavy glandular development as they matured. Some varieties that are available commercially are more determinate. They produce flowers as the plants grow larger and when a critical time period occurs, they quickly stop growing vegetatively and form a bud. These varieties include the LowRyder series.

If indica and sativa varieties are considered opposite ends of a spectrum, most marijuana plants today fall between the two ends. Because of marijuana's long symbiotic relationship with humans, whether for potent flowers or strong fibers, seeds have constantly been procured or traded across borders so that virtually all existing plant populations have been mixed with foreign varieties at one time or another. Since the 1980s, seeds from the Dutch and other seed companies have been introduced in traditional marijuana growing areas all over the world including Mexico, Jamaica, and Thailand.

After 40 years of breeding, the marijuana plant has been substantially changed. Breeders began with landraces then widened the selection. Now thousands of varieties are available from countries all over the world. Hybrids, hybrids of hybrids, stabilized crosses, and remarkable "cuttings-only" varieties propagated only by cloning are all widely available.

Even in traditional cannabis-growing countries, the marijuana found there is often the result of several crossed lines. For example, Jamaican ganja is probably the result of crosses between hemp, which the English cultivated for rope, and Indian ganja, which arrived with the Indian immigrants who came to the country.

The term for marijuana in Jamaica is *ganja*—the same as in India. The traditional Jamaican term for the best weed is *Kali*, which is the name of the Hindu goddess of destruction. However, tourists in Jamaica today are likely to be solicited with terms such as Kush or Purple; it is very difficult to find the original landraces there.

LOWRYDER

RUDERALIS x SKUNK.

Since the heyday of hemp in the 18th and 19th centuries, when it was the preferred material for rope, paper, and cloth, marijuana has been re-domesticated for western cultivation. Gardeners today have thousands of seed choices—among these, you are sure to find seeds or clones that fit your needs.

ASK ED: Marijuana Questions

LONG FLOWERING SATIVA

I am planning to grow a long flowering (landrace) sativa. Should I try *to mimic its original environment or will it adapt well to normal methods of indoor gardening?*

Equatorial indicas need lots of light, space and time. For these reasons they are not popular with indoor growers or with high latitude outdoor growers.

The intensity of sunlight declines from the equator to higher latitudes because the sun hits the equator at a direct perpendicular angle. As the latitude increases the sun's angle becomes more oblique. Landraces from equatorial areas have adapted genetically to the intense sun. To grow well, they need more intense light than most indoor plants receive. Typically, gardeners use a 1000w HPS lamp over a 4' x 4' (1.2 m x 1.2 m) space, 16 sq ft (1.44 sq m), with an input of about 60 watts per square foot. With the sativas, increase the light to a 1000w lamp over a 3' x 3' (0.9 m x 0.9 m) space, 9 sq ft (0.81 sq m).

Equatorial plants are fast growing and have large stem spaces (internodes) between the leaves. They are not the tight hybrids that gardeners are accustomed to, but their wilder cousins must gain height and canopy space quickly to survive. Indicas, on the other hand, adapted to a far less habitable environment. They didn't need height; they just had to tough out uncertain weather and drought, short summers and poor soil. A compact thick-leaved plant is better equipped for the windy Himalayan foothills than a tall lanky one.

Provide sativas twice to four times the space that you give indicas. You can control height somewhat using early flowering, pruning, bending and super-budding. Still, these are going to be tall plants. Treating them at the end of the day with a strong blue light of at least 20 watts per square foot (220 watts per square meter) of 6,500-7,000 Kelvin or higher, aquarium light actinic blue) may control the height a bit. The lights should go on shortly before the other lights are turned off and stay on for about an hour. The light should be moveable so the light is "sprayed" all over the plants and reaches most tissue. Cooling the plants by lowering the temperature 10 degrees for an hour before the lights go on also controls stem growth.

Place fans in the room to create a strong draft shakes the plants to the point where the stems bend results in shorter, stouter stems.

Time waits for no one, but you must wait for sativas. They often ripen in November, December or January outdoors. Indoors they have a 10 to 16 week ripening time. Unfortunately, sativas don’t do well in freezing weather or under snow. Indoors, they should never receive more than 12 hours of light. Ripening is hastened a bit by lowering the light duration to 10 hours as soon as the plants germinate. Even when flowering, young sativas also continue to grow vegetatively.

Outdoors, the plants are well suited for the southern tier of the U.S. One of the best strategies for growing these plants is to start them outdoors in September in an area where plants can be grown in winter. The short days induce flowering and keep the plants relatively short.

Landrace Varieties at a Glance

Variety	Maturity	Outdoor Size: Height	Width	Branching Pattern	Bud Type	Aroma	High	Buds Density	Flower Color	Comments
Afghani & Kush	mid-Sept. to Oct.	4′- 8′	3′- 6′	squat, compact, short side branches, thick webbed leaves	thick, dense, short, rounded	heavy pungent, skunky-fruity	heavy, tiring, stupefying	rounded, dense	dark green, purple population.	The standard commercial plant. Quality varies within
Colombian	late Nov. to Jan	7′-12′	4′-7′	conical, Christmas tree, long branches at bottom, tapering at the top, thin long leaves	med. thick, 4"- 8" long, light to medium density	sweet, fruity, light	spacy, thought-provoking, strong	tends to run long flower stem, sparse flowered	green, some red	Rarely seen commercially. Needs lots of light and warmth to develop thick colas
Indian (Central)	mid-Nov. to mid-Dec.	8′-12′	4′-6′	long internodes, big leaves, strong firm branches, elongated conical shape	big, thick, 7½" long; light-wt. flowers on tiny cola branches	med. fruity-skunky	strong, active, social	large fluffy buds	light green, red pistils	Will run without intense light. Susceptible to fusarium wilt
Jamaican	late Oct. to Dec.	6′-10′	3′-6′	conical, but squatter than Col. med.. leaves, medium branching	long thin colas w/buds 1½" - 3" long	light, sweet, musky	medium, active, social	thin, long runs under low light	light green	Adaptable, good weather resistance. Susceptible to fusarium wilt
Mexican (Northern)	Oct. to early Nov.	8′-15′	4½'- 9'	elongated Christmas tree, long branches, medium-sized leaves	long, thin 12"- 24" colas	light, sweet perfume, spicy	weak, slightly heavy, sleepy	long thin mature well	light green, red	Vigorous plants, fast starters. Some cold-resistance.
Mexican (Southern)	Nov. to Dec.	8'-14'	4½'- 9'	shorter than northern	long thin 12"-18" colas	sweet	comes on quick; intense, soaring	long, thin, may run a little	very light colored, red hairs	Hybridizes well with Afghani

Moroccan	Aug. to Sept.	4' - 9'	2½' - 5'	some side branching, but most effort in tops	thick, rounded, 3"- 6" long	med. sweet to skunky	weak, buzzy	thin buds mature easily	dark green	Good breeding material, lots of variation
Nigerian	mid-Nov. to mid-Dec.	6' - 12'	4' - 7'	Xmas tree with strong side branches; long, highly serrated fingers	med. thick, dense; runs in low light	dry sweet, perfume musk	very strong, bell-ringing, paralyzing	thick, med. length, may run; needs lots of light	medium green	Vigorous warm-weather plant. Needs light to mature
Thai	Dec. to Jan. and	5' - 9'	4' - 8'	asymmetrical, long branches seek open space	dense, under high light runs otherwise	medium, dry-sweet, spicy	strong druggy, has energy	fluffy, mature se-quentially over months	medium green	Many hermaphodites make growing hard. Buds ripen but plant sends out new flowers
Southern African	Aug. to Oct.	5' - 9'	4' - 6'	elongated conical lower branches angle up sharply; thin-bladed leaves often heavily serrated	med. thick, may be somewhat loose & leafy	heavy sweet to spicy	uplifting, social	thin buds mature easily	light green	Very variable. Good breeding material

All of the descriptions are guidelines. Growth is affected by cultivation technique, microenvironmental conditions, variations in climate, available nutrients, latitude and other factors. Other, several distinctive varieties can be found in the same areas. The most common varieties are described.

HINDU-KUSH. The branches are short and stay close to the main stem. The center bud is very prominent. The plant uses relatively little space and has a heavy yield. This is a typical Indica plant. From Marijuana Botany© 1981 by R.C. Clarke, published by And/Or Pres, Inc.

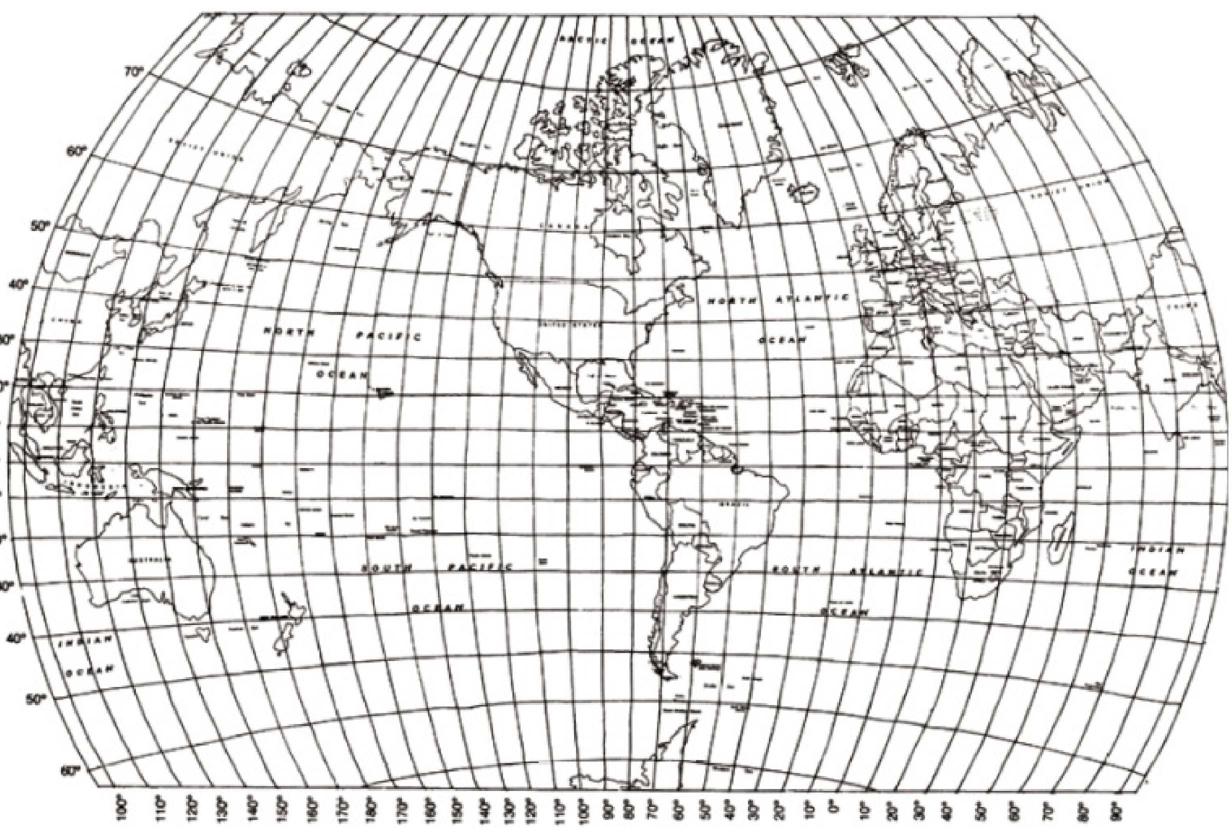
MEXICAN SATIVA. The plants have long spreading branches with thin, long buds. The plant uses a large space for a moderate yield. This is typical of a Sativa plant. From Marijuana Botany© 1981 by R.C. Clarke, published by And/Or Pres, Inc.

L to R: White Rhino (Green House Seed Co.) 90% Indica; Wappa (Paradise Seeds) 100% Indica, Soma A+ (Soma Seeds) mostly Indica.

Fruit of the Gods (Delta 9 Labs) mostly Sativa; BC Sweet Tooth (BC Buds) 90% Indica; Arjan’s Ultra Haze #2 (Green House Seed Co.) 90% Sativa.

Malawi Gold (African Seeds) mostly Sativa, Cinderella (Wally Duck) mostly Sativa, Haze Mist (Flying Dutchmen) mostly Sativa.

Most modern varieties are many hybridizations away from the original landraces. They have been domesticated to produce more higher quality buds in less time.



The sun's rays reach the earth at varying intensities. The equator, where large tree-like sativas originated, consistently gets the brightest, most intense light. Indicas developed in the regions north or south of the equator. The latitude of the region you plan to grow should be taken into account when choosing what variety to grow outdoors.

VARIETIES

Photo: BC BUD DEPOT

There are a bewildering number of commercially available varieties offered by seed banks in Europe and North America. Some varieties are clone only, reproduced by rooting cuttings of one particular unique plant. *(See Getting Started.)* Friends who are growing a variety can often provide you with clones, and in medical states patients often have access to them through dispensaries. Whether you use seeds or clones, choosing the right variety is extremely important because varieties differ not only in their effects but also in how they grow. Outdoor varieties need more light than indoor. Some varieties spread out and others grow more compactly. They differ in height, time to maturity, and yield. So choosing varieties can be a daunting, but thoroughly pleasurable task. Use your own taste and circumstance to choose what you grow. If you prefer certain varieties or types, select a variety that provides that and is adapted to grow in your garden.

CHOOSING VARIETIES

Your choice of marijuana variety is probably the most important decision you will make in your garden. First, you want a plant that will do well in the environment that you are going to provide. Second, you want to grow varieties whose qualities you like; the high, taste, aroma and personality of the bud all play a role in the decision making process. Each variety has its own genetic blueprint that determines how the plant reacts within its environment. A complex interplay between nature and nurture controls everything from maturation time to the size and shape of all the plant parts—not to mention the color, taste, potency, high, and yield of your crop. You can think of nature as the genetic potential of the plant under ideal conditions and nurture as providing the conditions to realize that potential.

New varieties are the result of intense competition among seed breeders, and the popularity of varieties tend to wax and wane with the seasonality of couture fashion. The upshot of this, as far as you are concerned, is that you can try new varieties each crop while sticking with the varieties that you like. Gardeners can grow a garden with only one or two varieties or a potpourri—each style of growing has its advantages. Seeds for different varieties are available in stores throughout many countries, including Canada, Great Britain, Holland, and Spain. In the U.S., seeds and clones are typically available in states with medical dispensaries, but anyone can obtain seeds via the Internet or mail-order.

Commercial growers prefer homogeneous gardens. To assure uniformity, they usually use clones (rooted cuttings) from one plant or one variety so that the garden is genetically identical, or at least closely related. Using clones from the same plant allows commercial growers to maximize their crop, because the plants grow identically, thrive under the same conditions, mature at the same time, and provide predictable potency. Commercial growers also typically choose fast-maturing plants for a quick turnaround.

Home growers are usually more concerned with quality than with fast maturity or maximum yield. They often grow mixed groups of plants so they harvest at different times and can choose from a selection of potencies, qualities of high, and tastes. The mix of varieties and maturation times in a heterogeneous garden typically results in lower yields, when compared to homogeneous gardens. Heterogeneous gardens also take more individualized care because the plants grow at different rates, have different shapes, and require varying amounts of space. If you are growing indoors, make sure that the varieties you choose are suitable for indoor cultivation and meet your garden’s criteria; they shouldn’t grow too tall, or do best in conditions you cannot provide.

VARIETIES BY SEED COMPANIES

Breeding is not easy. It requires a keen eye, an acute sense of taste, and most importantly, an ability to discern a plant with outstanding potency. Not many people have this ability—a sort of perfect pitch in the area of THC and cannabis. In addition to skill, an inspired breeder has an intuitive ability to choose the right one.

Seed breeding has socially redeeming values. It helps us change not what we think, but how we think it. From ruderalis type progenitors thousands of years ago, successions of breeders coaxed and twisted the plant's genes to produce the wonderful sensations we experience today using marijuana.

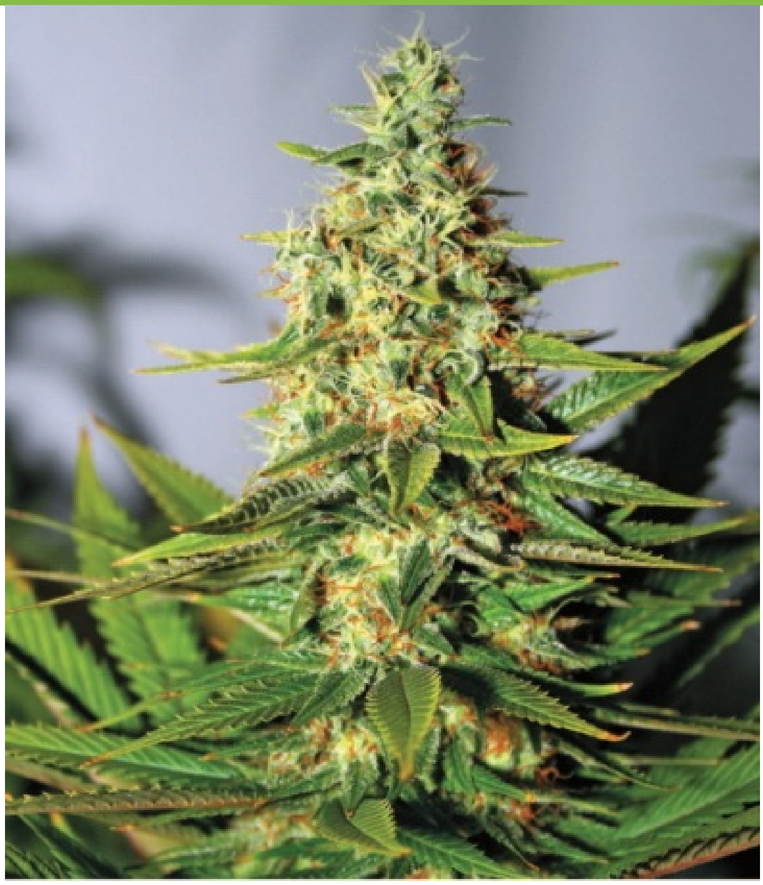
The plant has developed a wonderful symbiotic relationship with humans. Its decision has had an enormous effect on our development, as we have had on its fortunes. From its start in the Himalayan foothills, the plant has traveled the world. Humans carried it to every climate and every continent and helped it fit into its new homes. In return, Cannabis has helped societies progress time and time again, over thousands of years. The experience of the two species in the last 50 years has been just another turn on the spiral of their coexistence. Two things are certain as this journey continues: the species will continue to travel together, and the journey will continue to cover new areas of the spiral.

The following pages show some of the breeding done by seed companies around the world.

MARIJUANA GROWER'S HANDBOOK CONNECTS YOU TO THE WORLD'S GREAT SEED BREEDERS

BARNEY'S FARM SEED CO. www.barneysfarm.com
CERES SEEDS www.ceresseeds.com
DJ SHORT *varieties available at seedsman seed bank:*
www.seedsman.com/en/cannabis-seeds/dj-short
DNA GENETICS www.dnagenetics.com
DUTCH PASSION SEED CO. www.dutch-passion.nl
GREEN HOUSE SEED CO. www.greenhouseseeds.nl/shop
KC BRAINS www.kcbrains.com
MANDALA SEEDS www.mandalaseeds.com
MINISTRY OF CANNABIS www.ministryofcannabis.com
NIRVANA www.nirvana.nl
PARADISE SEEDS www.paradise-seeds.com
ROYAL QUEEN SEEDS www.royalqueenseeds.com
SAGAMARTHA www.highestseeds.com
SANNIE'S SEEDS www.canniesshop.com
SEEDS OF LIFE www.seedsoflife.eu
SENSI SEED BANK www.sensiseeds.com
SERIOUS SEEDS www.seriousseeds.com
SOCAL SEED CO. www.socalseedco.com
SOMA SEEDS www.somaseeds.com
TGA SEEDS www.tgagenetics.com

BARNEY’S FARM SEED CO.



BARNEY’S FARM G-13 HAZE

G13 x Hawaiian, **Indica/Sativa:** mainly Sativa; **Flowering:** 70-80 days, mid-to end-Oct. outdoors; **High:** powerful, cerebral; **Smell/Taste:** fruit and spice.

LSD

Skunk #1 x Mazar, **Indica/Sativa**: mainly Indica; **Flowering:** 60-65 days, mid-Sept. outdoors; **High:** euphoric, psychedelic, super trippy, powerful; **Smell/Taste:** earthy chestnut, sweet musk.

BARNEY’S FARM SEED CO.

DR. GRINSPOON

Heirloom Sativa; **100% Sativa**; **Flowering:** 100-105 days; **High:** strong, energetic, cerebral; **Smell/Taste:** citrus, tropical fruit, whisper of pine.

BARNEY’S FARM SEED CO.

VANILLA KUSH

Kashmir x Afghan, **Indica/Sativa:** mainly Indica; **Flowering:** 60-65 days, late Sept. outdoors; **High:** strong, body **High**; **Smell/Taste:** wild vanilla, lavender, accents of lemon and orange peel.

CERES SEEDS

PURPLE

Feminized, **Indica/Sativa:** 50/50; **Flowering:** 50-60 days, early Oct. outdoors; **High:** purple haze, all in my brain.

CERES SEEDS

SKUNK HAZE

Feminized, **Indica/Sativa:** mostly Sativa; **Flowering:** 65-75 days; **High:** uplifting, dreamy; **Smell/Taste:** spicy-sweet.

FRUITY THAI

Thai Sativa x Dutch Indica, **Indica/Sativa:** 50/50, **Flowering:** 55-65 days; **High:** active, sensual, talkative; **Smell/Taste:** lemon, melon, sweet.

WHITE PANTHER

Original White Dwarf, **Indica/Sativa**: 50/50; **Flowering:** 45-55 days, mid-Oct. outdoors; **High:** pleasant, dreamy, sensual.

DJ SHORT

VANILLUNA

Blueberry Sativa x Original Blueberry, **Indica/Sativa:** mostly Indica; **Flowering:** 55-60 days; **High:** smooth, dreamy, calming; **Smell/Taste:** creamy, vanilla/honey with hint of floral and melon musk.

DJ SHORT

COCOA KUSH

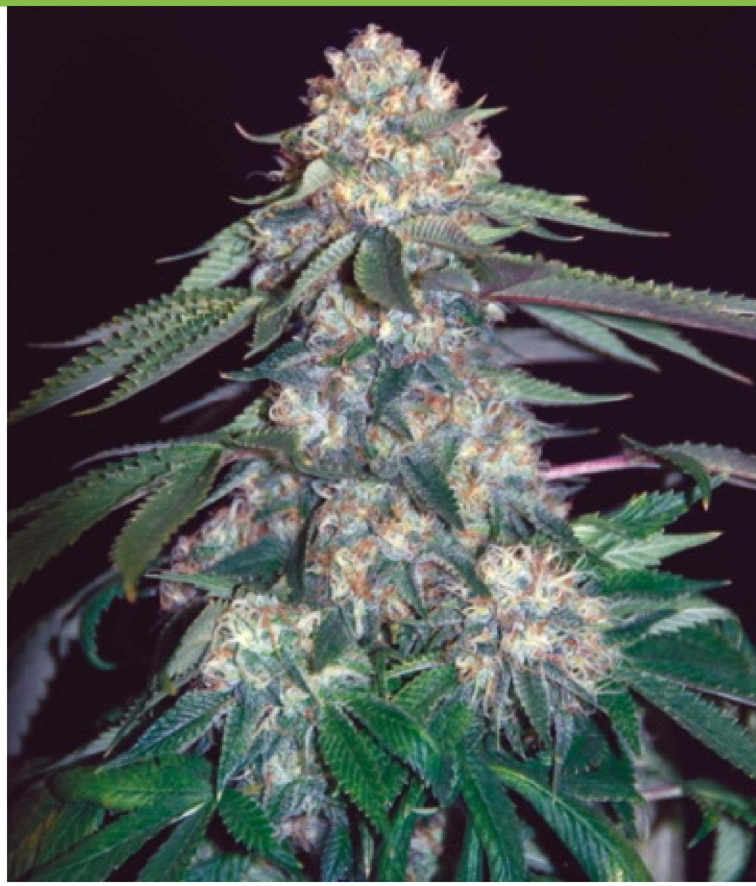
Blueberry Sativa x Original Blueberry, **Indica/Sativa:** 40/60; **Flowering:** 55-60 days; **High:** take-your-breath-away power blending to a sleepy/dreamy finish; **Smell/Taste:** nutty, licorice, chocolate, tobacco with creamy, floral, fruity background.

DNA GENETICS

KANDY KUSH

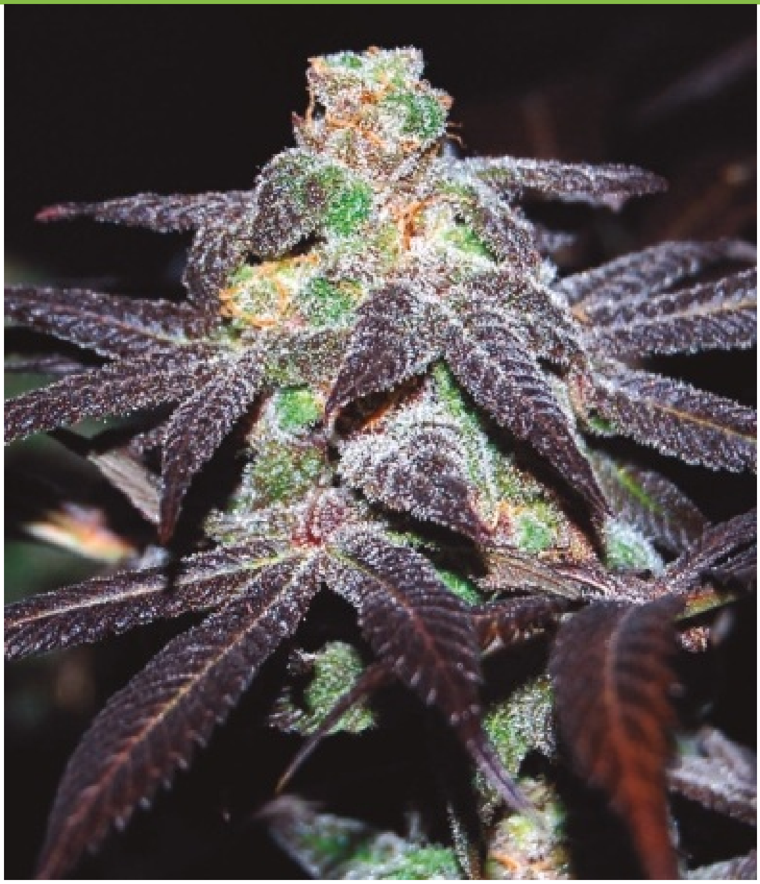
Feminized: OG Kush x Trainwreck (T4), **Indica/Sativa:** 40/60; **Flowering:** 9-10 weeks indoors; **Smell/Taste:** lemon, citrus-sweet; **High:** body, stoney.

DNA GENETICS



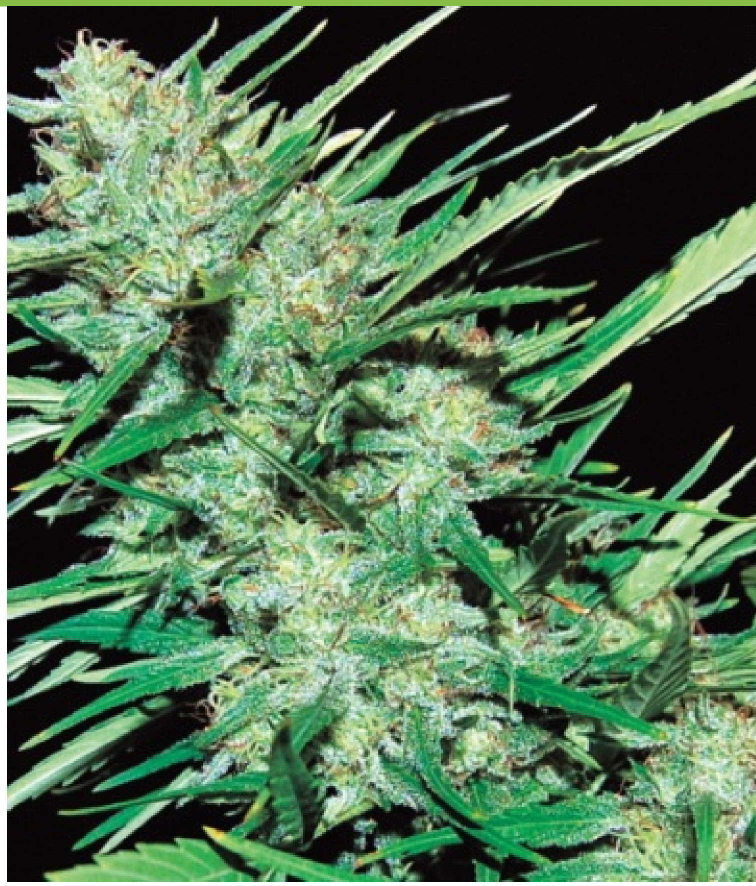
OG KUSH

Parentage: bag of seeds from a Grateful Dead show (Chem Dawg); **Flowering:** 8-9 weeks; **Smell/Taste**: fuel.



PURPLE WRECK

Purple Urkel x Trainwreck (T4), **Indica/Sativa:** 60/40; **Flowering:** 8-9 weeks; **Smell/Taste:** fruity, sweet.



CHOCOLOPE

OG Chocolate Thai x Cannalope Haze (Feminized & Unfeminized), **Indica/Sativa:** 5/95; **Flowering:** 8-9 weeks; **High:** old school; **Smell/Taste:** chocolate.

DUTCH PASSION SEED CO.

AUTOBLUEBERRY

Blueberry phenotype; Feminized, AutoFlowering; **Indica/Sativa/Ruderalis**: 60/20/20; **Flowering:** 10 weeks; **High:** euphoric, long lasting; **Small/Taste**: berry, fruity, incense, sweet.

FREDDY’S BEST

Chocolope x Dutch Haze x unnamed Sativa bred by Freddy; **Indica/Sativa:** Sativa; **High:** clear, long lasting; **Smell/Taste:** chocolate, earthy, spicy, sweet.

DUTCH PASSION SEED CO.

NIGHT QUEEN

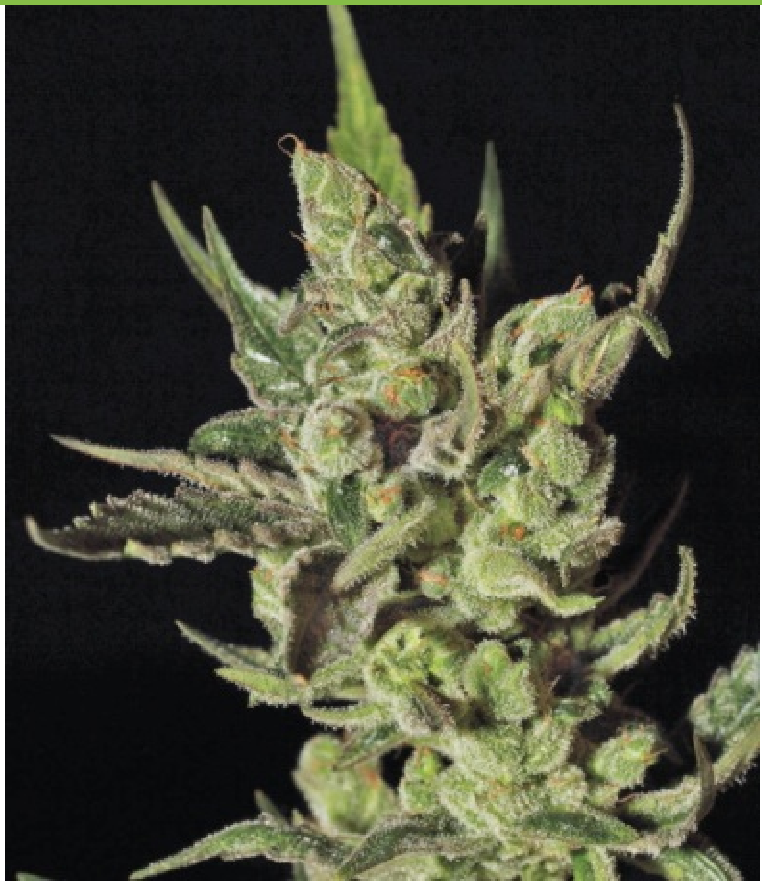
Afghani Indica; Feminized; **Indica/Sativa**: 95/5; **Flowering:** 55-70 days; **High:** body relaxing, physical, stoney; **Smell/Taste:** earthy, spicy.

DUTCH PASSION SEED CO.

THINK DIFFERENT

Feminized, AutoFlowering; **Indica/Sativa/Ruderalis:** 20/60/20; **Flowering:** 9 weeks; **High:** couchlock, heady, intense, long lasting; **Smell/Taste:** incense, skunk, sweet.

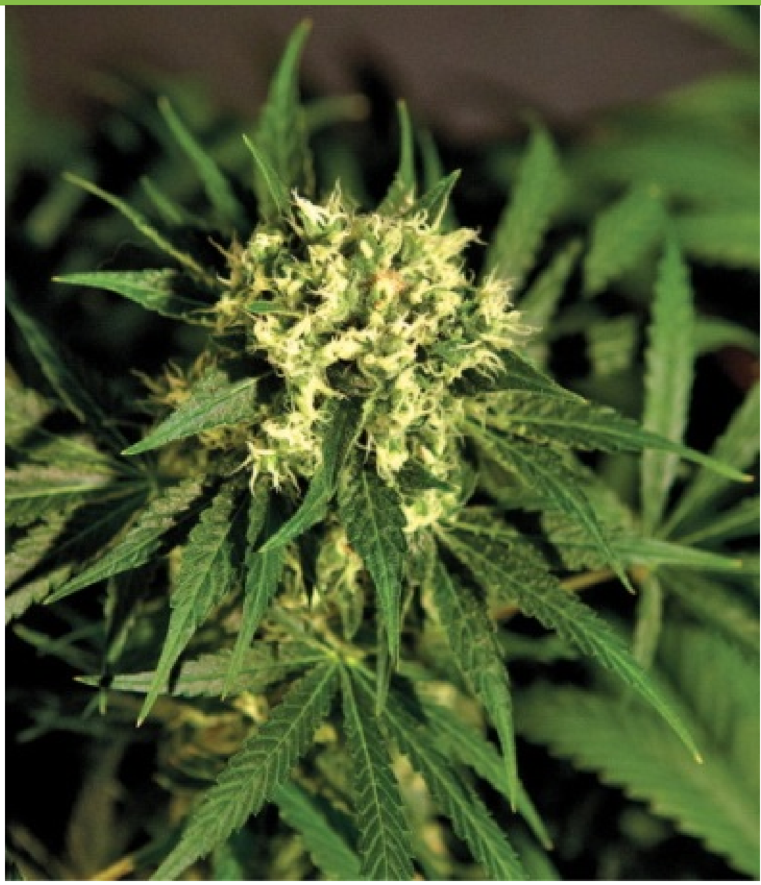
GREEN HOUSE SEED CO.



EXODUS CHEESE

Skunk #1 x clone-only strain, UK; Feminized; **Indica/Sativa**: mainly Indica, **Flowering**: 50-60 days; **High**: body relaxing, electric, giggly, happy, playful; **Smell/Taste**: dark, floral, musky, skunk, woodsy.

GREEN HOUSE SEED CO.



KALASHNIKOVA

AK47 x White Widow, Feminized; **Indica/Sativa:** Indica, **Flowering**: 50-60 days; **High**: body relaxing, clear, dreamy, physical, longlasting, **Smell/Taste**: acrid, grapefruit, metal, orange, pepper, spicy.

GREEN HOUSE SEED CO.

KALASHNIKOVA-AUTOFLOWERING

Kalashnikova x Green-O-Matic; Feminized, AutoFlowering; **Ruderalis**; **Flowering**: 50-60 days; **High**: clear, creeper, energetic, thoughtful, uplifting; **Taste/Smell:** acrid, berry, fruity, herbal, pungent, spicy.

K-TRAIN

Trainwreck x OG Kush, Feminized, **Indica/Sativa**: 50/50; **Flowering**: 50-60 days; **High**: body relaxing, dreamy, euphoric, longlasting; **Taste/Smell**: candy, earthy, Jamaican bread fruit.

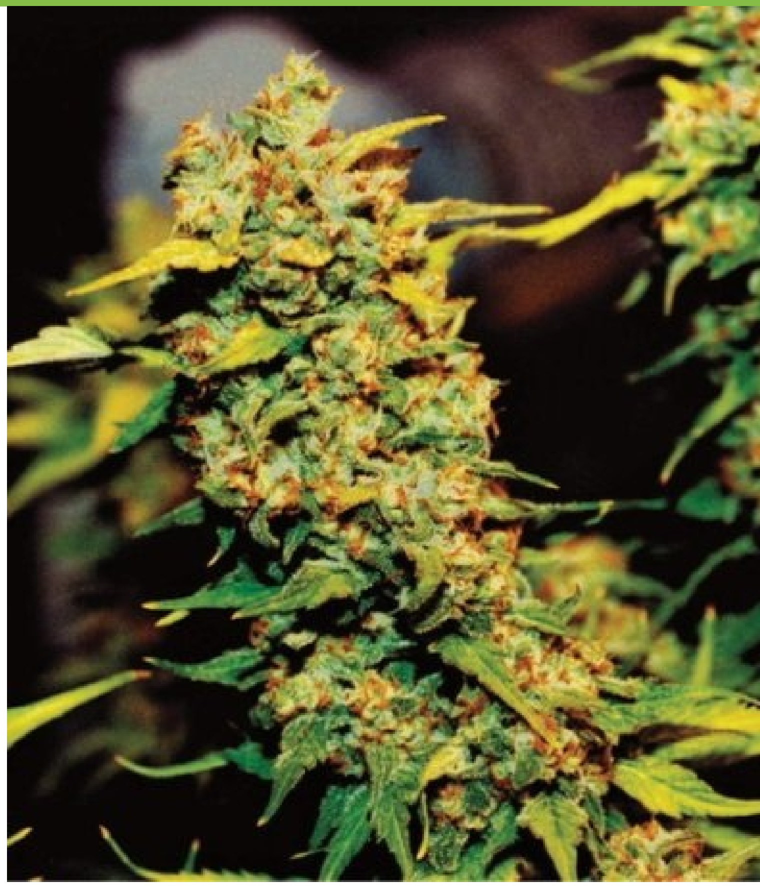
KC 42

New Zealand x KC 639, **Indica/Sativa:** mostly Sativa; **Flowering:** 63-84 days; **High:** Haze, **Smell/Taste:** lemon.

KC 36

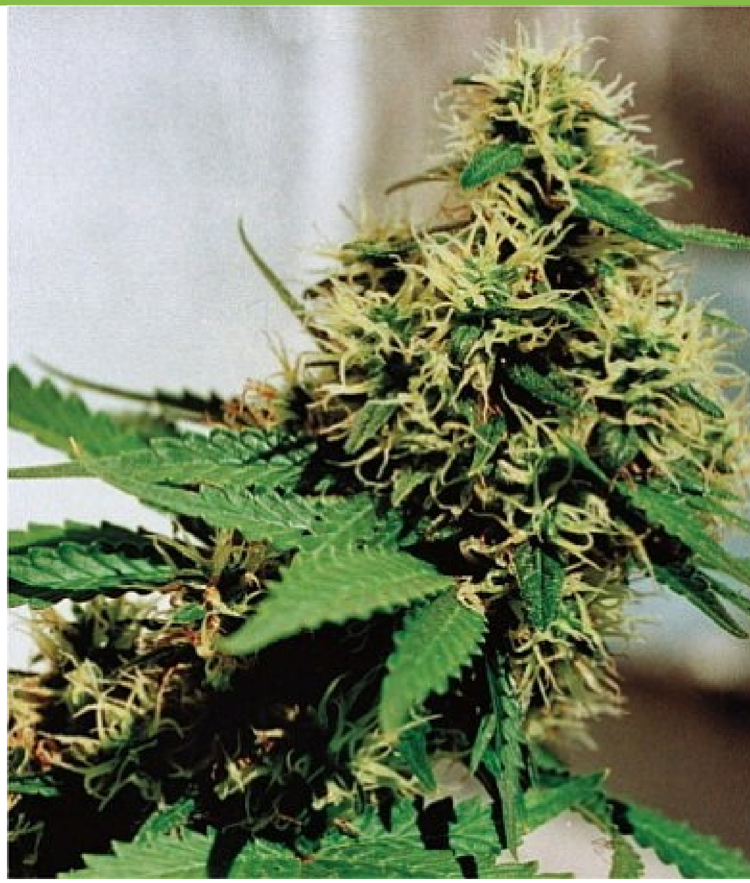
White Widow x KC 606, **Indica/Sativa:** 85/15; **Flowering:** 56-70 days, late Sept. outdoors; **High:** cozy, body stone; **Smell/Taste:** floral.

KC BRAINS



LEDO UNO

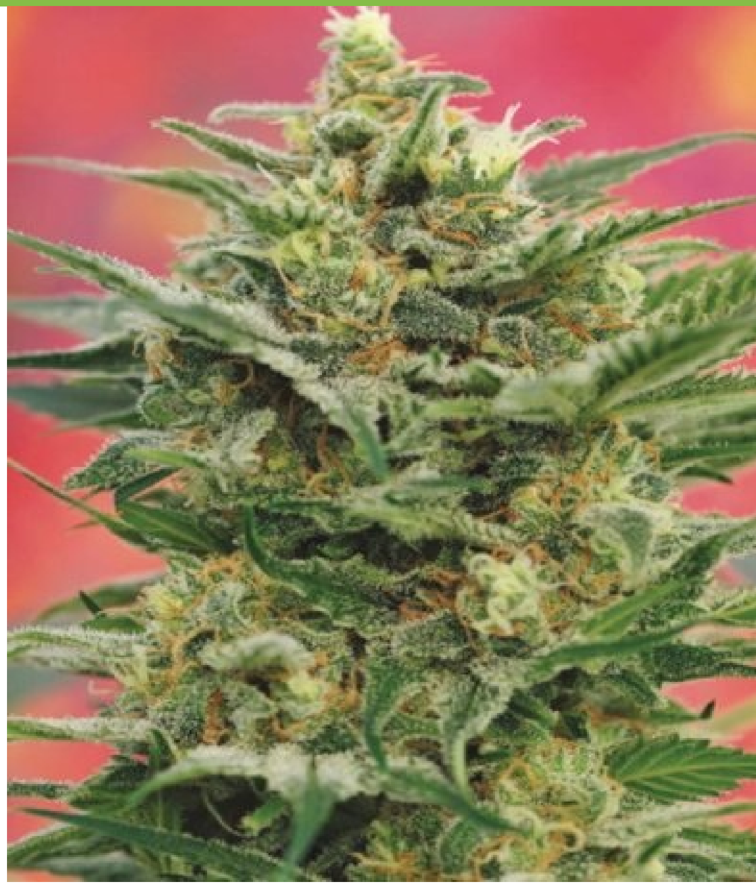
Brazilian x Thai and KC 606 x Ledo Uno, **Indica/Sativa:** 40/60; **Flowering**: 49-63 days, mid-Sept. outdoors; **High**: body stone, giggle; **Smell/Taste**: citrus, lemon.



KC 33

Afghani Haze x Ukrainian strain, **Indica/Sativa:** 60/40; **Flowering**: 63-77 days, Aug. to mid-Oct. outdoors; **High**: cerebral, **Smell/Taste**: lemon, citrus.

MANDALA SEEDS



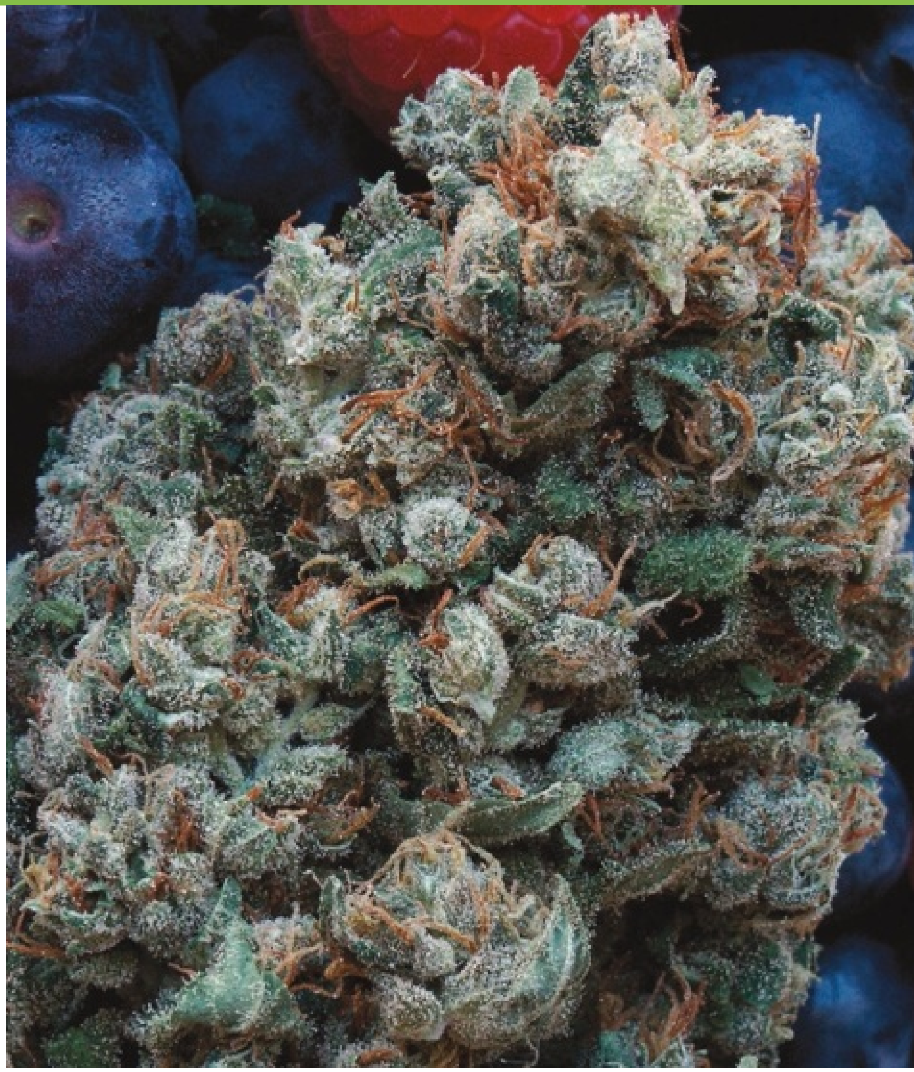
8 MILES HIGH

African x North Indian, **Indica/Sativa:** 50/50; **Flowering:** 60-65 days; **High:** uplifting, alert, fiery-energetic; **Smell/Taste:** sweet-fruity, strawberry-melon, pine, hashy.

MANDALA SEEDS

GANESH

Uttarkhand, N.India - Afghanistan, **Indica/Sativa:** 50/50; **Flowering:** 60 days; **High:** laid back, sensual relaxing; **Smell/Taste:** skunky-pungent, earthy, chocolate.



HASHBERRY

California Indica x Kashmir/N. India landraces, **Indica/Sativa:** mostly Indica; **Flowering**: 60-65 days; **High**: relaxing, head/body balance; **Smell/Taste**: black currant jam, hashy, fruity.

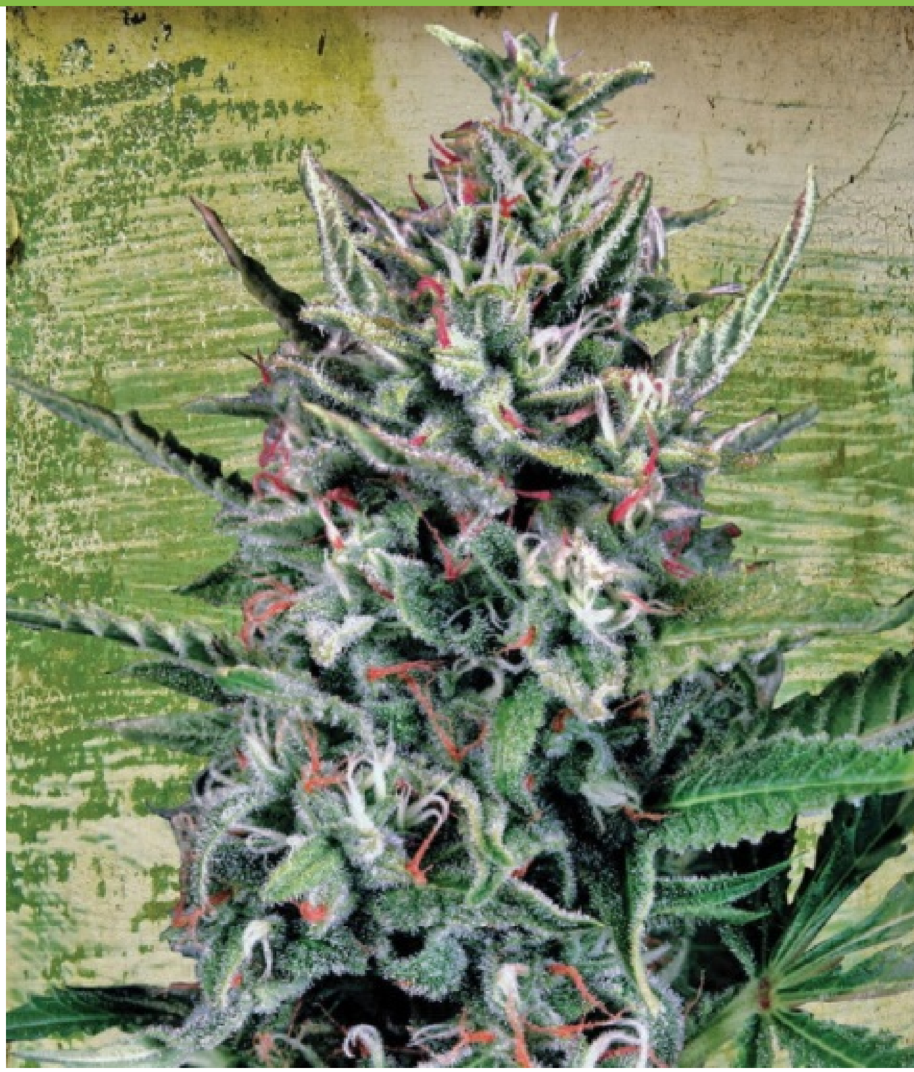
MANDALA SEEDS

SATORI

Lucid Dreams x unnamed Sativa hybrid, **Indica/Sativa:** 50/50; **Flowering**: 70-75 days;**High**: blissful, spiritual; **Smell/Taste:** herbal, honey.

AUTO BLUE AMNESIA

BlueberryxAutoFlowering x AmnesiaxAutoFlowering; Feminized, AutoFlowering; **Ruderalis**; **Flowering:** 40-50 days; **High:** active, energetic, long lasting, playful, positive, social; **Smell/Taste:** bubblegum, floral, sweet.



AUTO SILVER BULLET

Silver Haze x AutoFlowering; Feminized, AutoFlowering; **Ruderalis**; **Flowering:** 40-50 days; **High:** clear, happy, lucid, social; **Smell/Taste:** citrus, incense, woodsy.

CRISTAL-CLOUD

Silver Haze/MexicanxSilver Haze/MexicanxBlack Domina; Feminized; mainly Sativa; **Flowering:** 60 days; **High:** energetic, playful; **Smell/Taste:** citrus, floral, haze.

MANDALAY

Burma x BurmaxChronic; Feminized; mainly Sativa; **Flowering:** 60 days; **High:** calm, intense, long lasting, psychedelic, wandering mind; **Smell/Taste:** licorice, vanilla.

URBAN POSION

Durban Poison x Northern Lights, **Indica/Sativa:** 40/60; **Flowering**: 9-11 weeks, Oct. outdoors; **High**: cerebral; **Smell/Taste**: pine, fresh, floral, licorice, sweet.

SWISS CHEESE

Swiss Miss x Skunk #1, **Indica/Sativa:** 30/70, **Flowering:** 7-8 weeks, Sept. outdoors, **High:** stoney buzz, **Smell/Taste:** earthy, musky, sweet, candy

NIRVANA

SWEET TOOTH

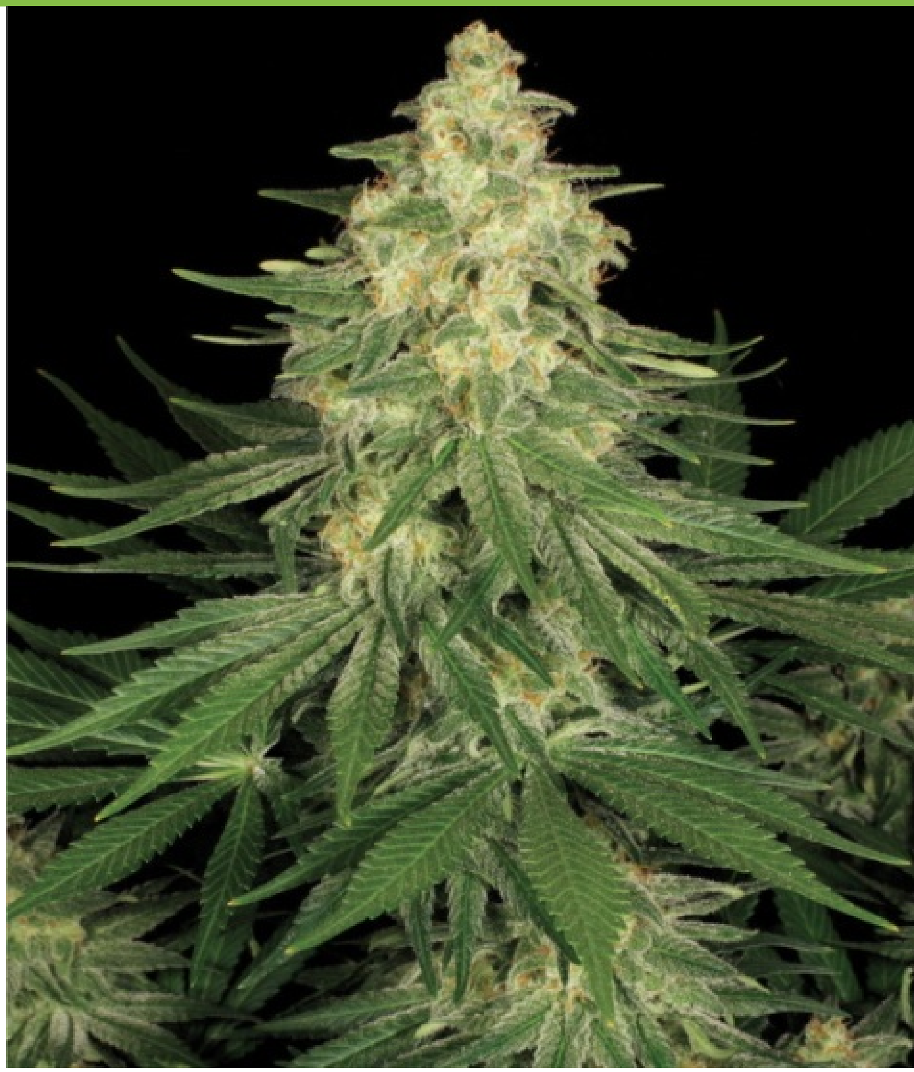
Sweet Pink Grapefruit x Resinous Blueberry x Grapefruit, **Indica/Sativa:** mostly Indica; **Flowering:** 7-8 weeks; **High:** long lasting relaxation; **Smell/Taste:** sweet, berry, pineapple.

NIRVANA

OG KUSH SVC

Orange or Lemon Thai x Petrol Skunk Afghani Kush, **Indica/Sativa:** mostly Sativa; **Flowering:** 9 weeks; **High:** heady; **Smell/Taste:** piney, lemon, slightly sour.

PARADISE SEEDS



ALL KUSH

Kush x Kush•Thai, Feminized; **Indica/Sativa:** mostly Indica; **Flowering**: 7-8 weeks; **High:** body relaxing, couchlock, intense, long lasting, playful, sedative; **Smell/Taste:** musky, sweet.

PANDORA

Afghani • Ruderalis x AfghanixSkunk, Feminized, AutoFlowering; **Indica/Sativa:** 50/50; **Flowering**: 40-50 days; **High:** body relaxing, calm, intense, medicinal; **Smell/Taste:** floral, pungent, spicy, sweet.

SENSI STAR

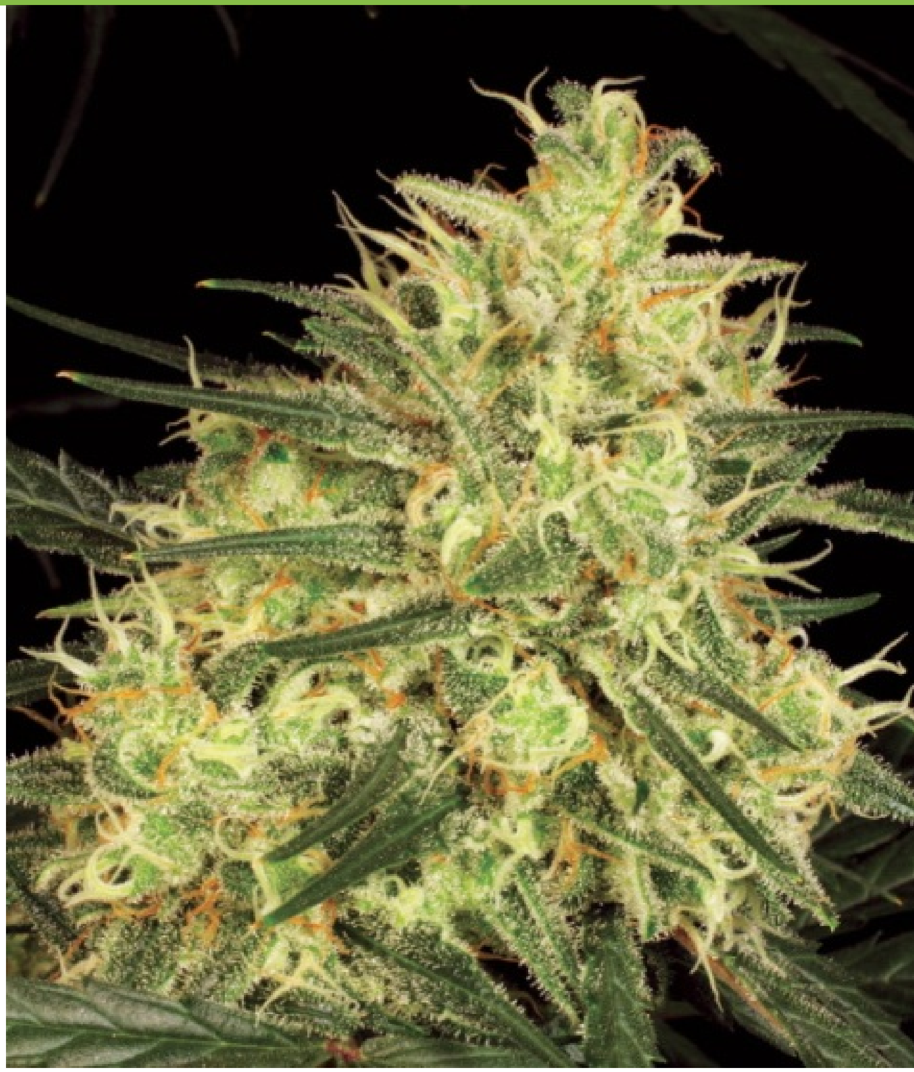
Parentage unrevealed, Feminized; **Indica**; **Flowering**: 50-60 days; **High:** blissful, body relaxing, electric; **Smell/Taste:** fresh, hash, lemon, metal, pineapple.

PARADISE SEEDS

WHITEBERRY

Blueberry x White WidowxAfghani, Feminized; **Indica/Sativa:** 50/50; **Flowering**: 50-60 days; **High:** body relaxing, happy, heady, lucid, positive, stoney; **Smell/Taste:** berry, hash, pungent, sweet.

PARADISE SEEDS



ANATOMICAL HAZE

Colombian/Mexico x Afghan, Feminized, **Indica/Sativa:** Sativa; **Flowering:** 9 weeks; **High:** active, clear, energetic, euphoric, lucid, soaring, uplifting; **Smell/Taste:** sweet, spicy, haze, fruity, citrus, kiwi.

ROYAL QUEEN SEEDS

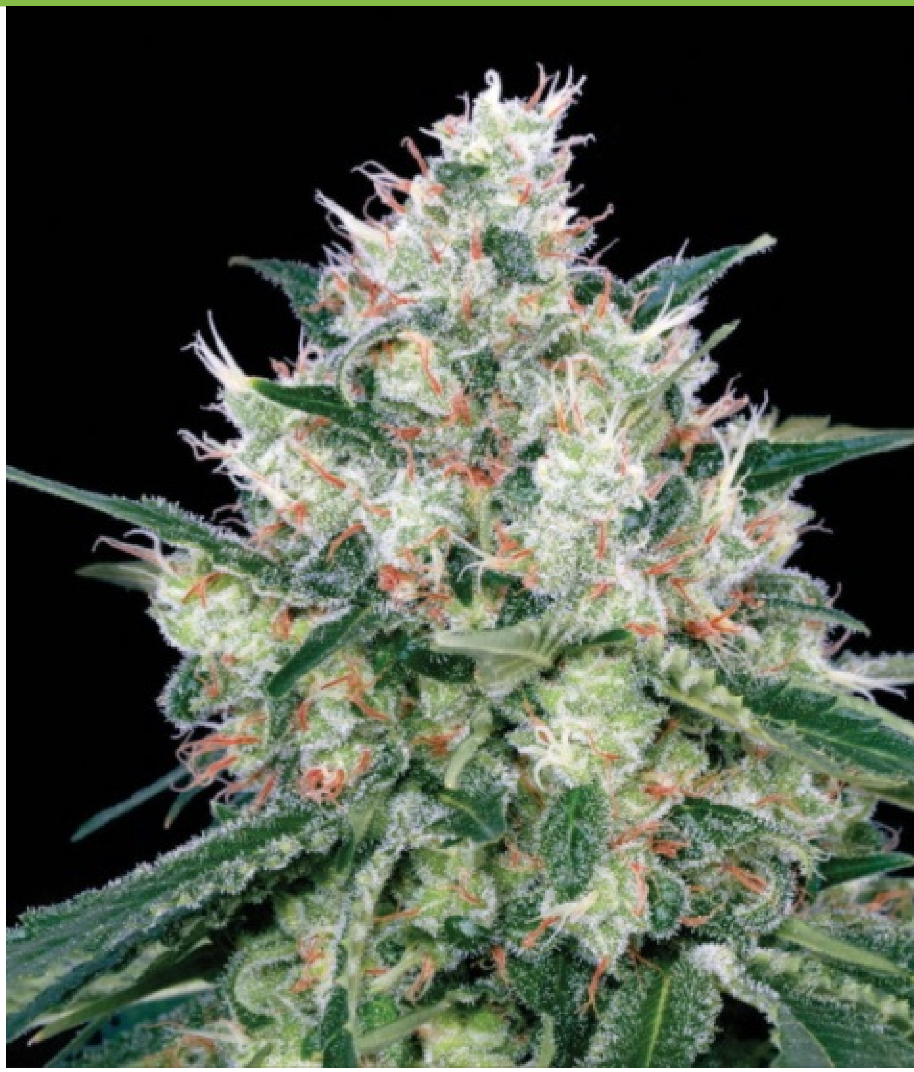
DANCE WORLD

Dancehall 20 x Juanita La Lagrimosa, **Indica/Sativa**: 25/75; **Flowering**: 8 weeks; **High**: inspiring, motivating; **Smell/Taste**: complex mix of earthy aromas and spicy, almost fruity flavour.

ROYAL QUEEN SEEDS

JACK HERER AUTOMATIC

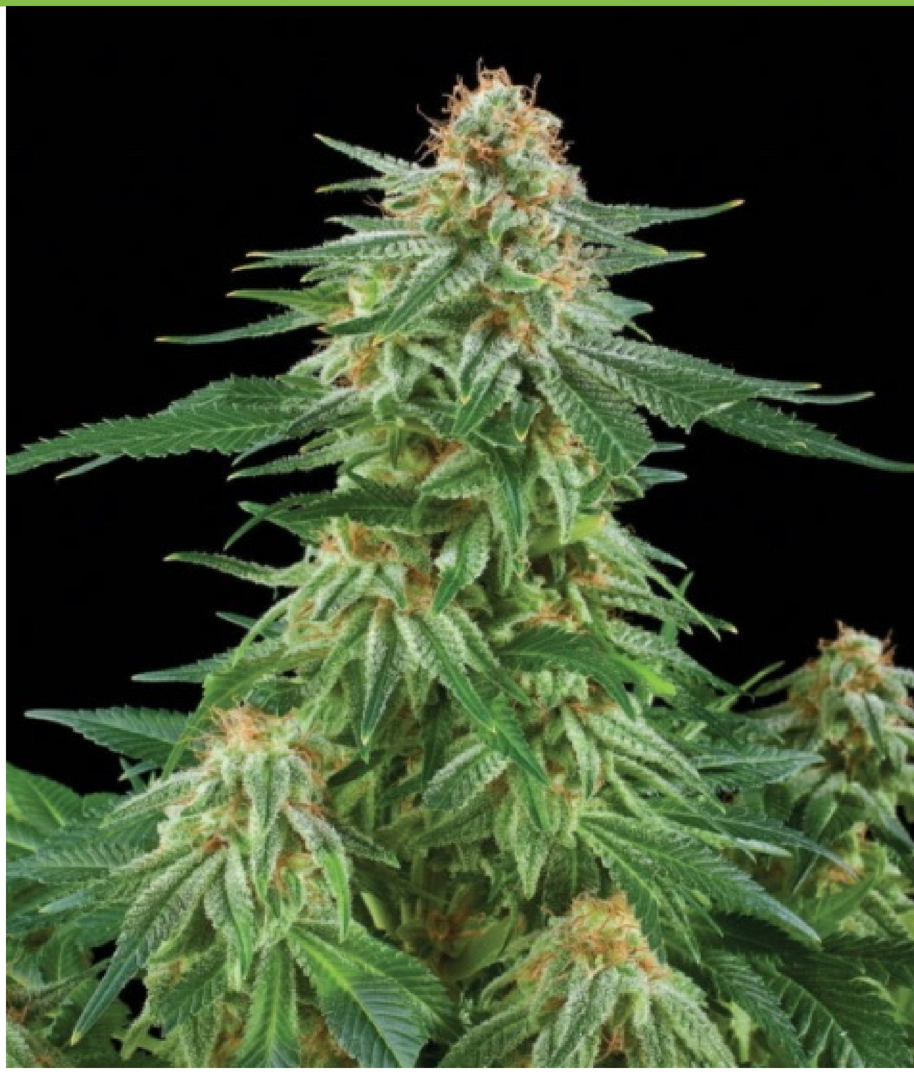
Jack Herer x Ruderalis, **Indica/Sativa/Ruderalis**: 30/40/30; **Flowering**: 70-75 days; **High**: Sativa spiritual; **Smell/Taste**: Haze-like, peppery.



ROYAL CARAMEL

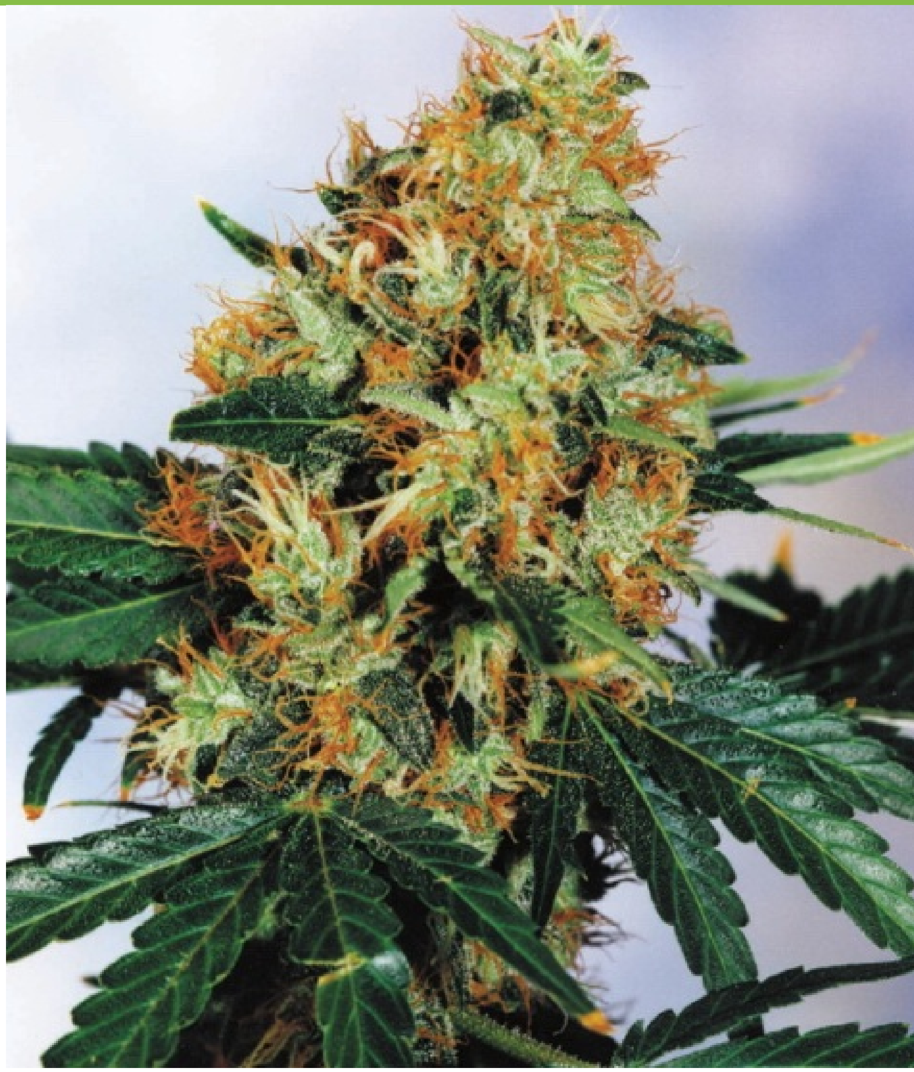
BlueBlack x Maple Leaf Indica x White Rhino, **Indica/Sativa**: 50/50; **Flowering**: 55-60 days; **High**: narcotic, physical; **Smell/Taste**: intense, sweet sugary, caramel.

ROYAL QUEEN SEEDS



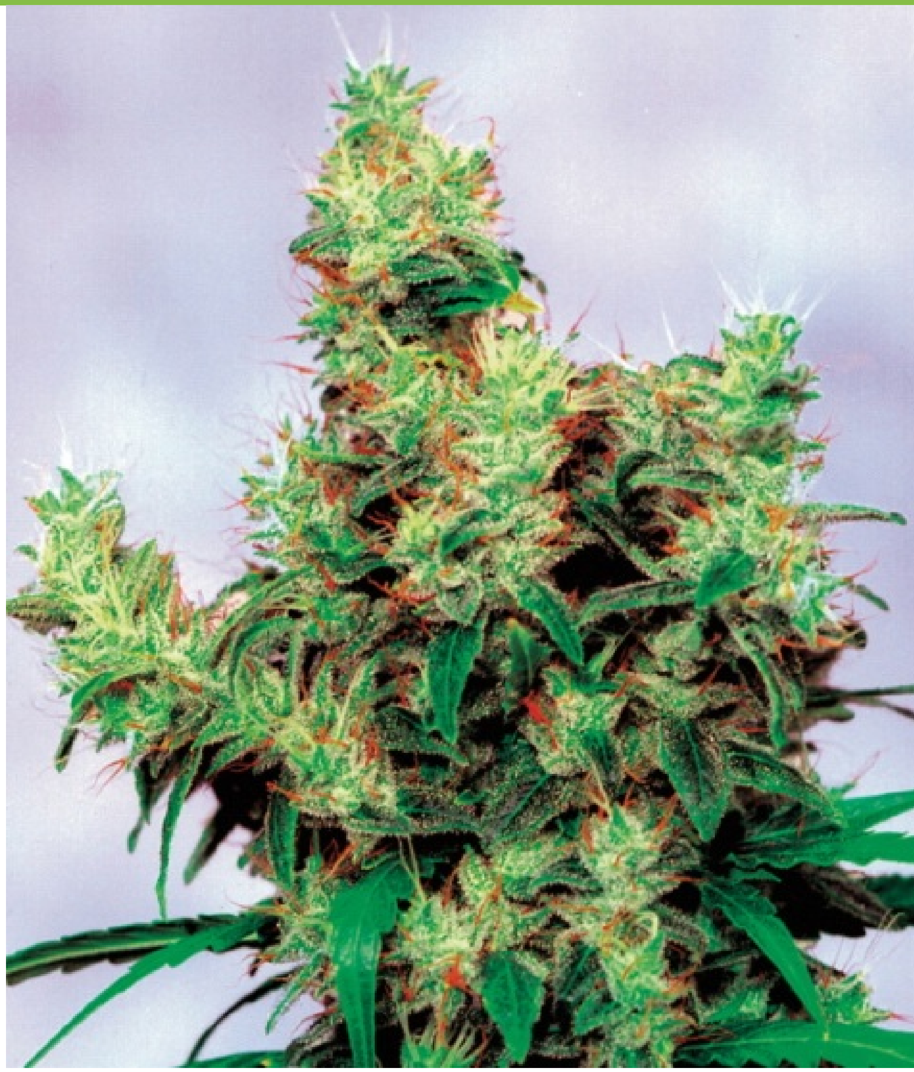
WHITE WIDOW AUTOMATIC

Royal Critical Automatic x White Widow, **Indica/Sativa/Ruderalis**: 40/40/20; **Flowering**: 75 days, **High**: physical; **Smell/Taste**: sweet and sour, citrus.



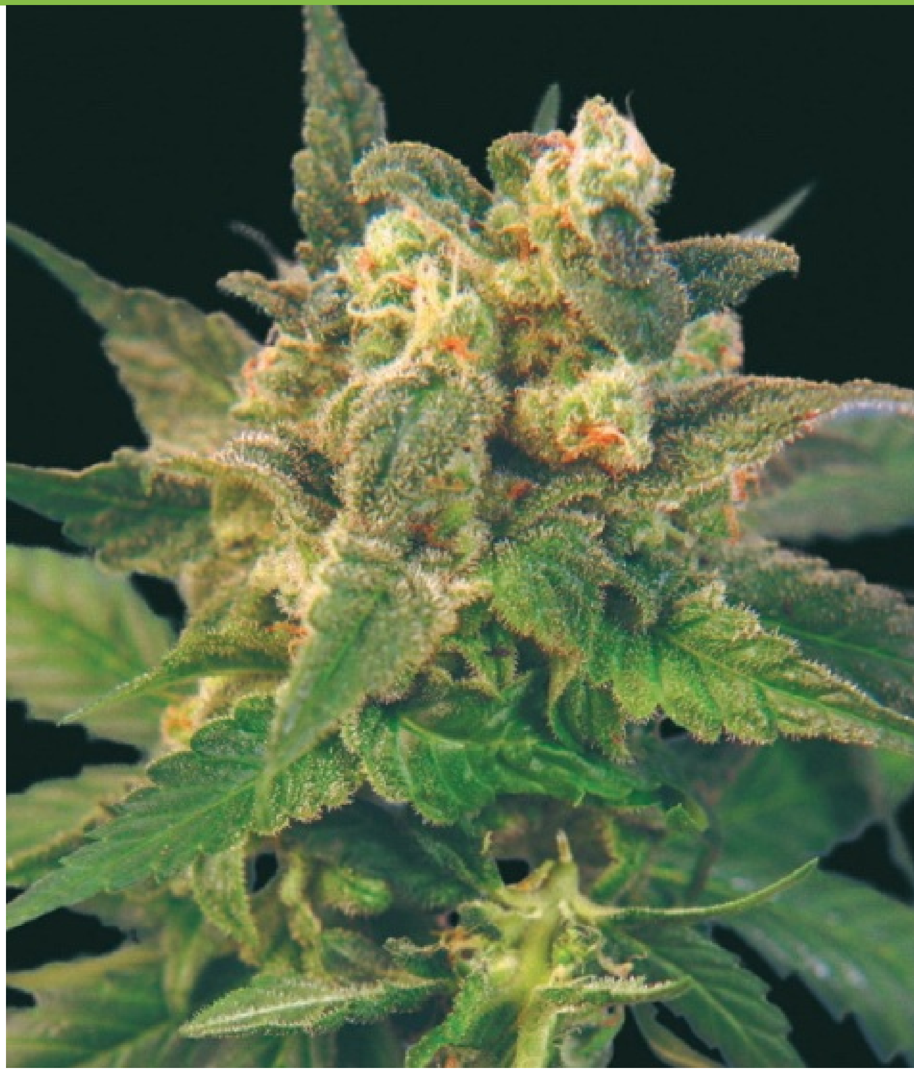
MONGOLIAN INDICA

Afghani Skunk x Afghani x Northern Lights, **Indica/Sativa**: mostly Indica; **Flowering**: 55-60 days; **High**: sleepy, physical; **Smell/Taste**: fresh, woodsy, mango, citrus.



STONEHEDGE

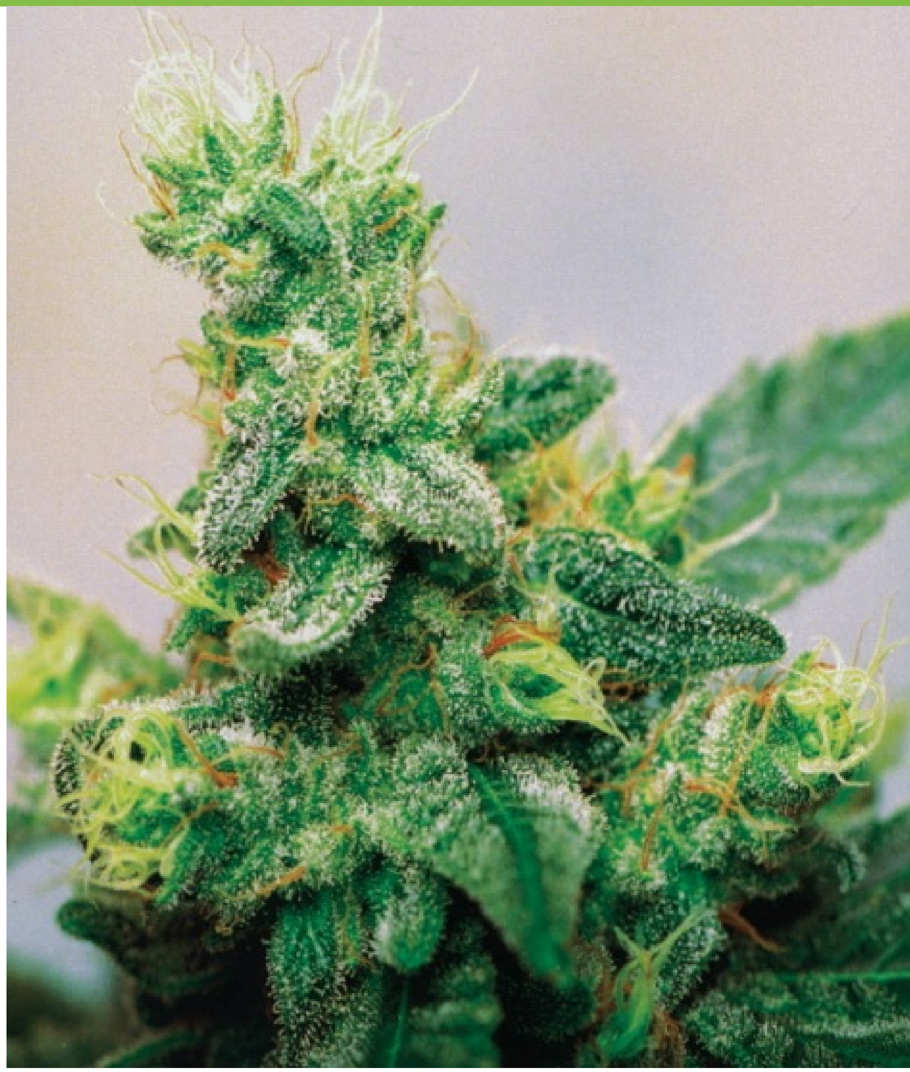
Cambodian CA x Western Winds, **Indica/Sativa**: 50/50; **Flowering**: 65 days indoors, mid-October outdoors; **High**: mellow body **High**; **Smell/Taste**: spicy, sweet.



MATANUSKA MINK

Matanuska Tundra x Grey Mist, **Indica/Sativa**: 50/50; **Flowering**: 65 days; **High**: positive, social; **Smell/Taste**: minty.

SAGAMARTHA



YUMBOLDT

Humboldt, CA Origins, **Indica/Sativa**: mostly Indica; **Flowering**: 65 days; **High**: relaxing; **Smell/Taste**: woodsy, reminiscent of 70’s California sinsemilla.

KILLING FIELDS

Sannie's The One x Sannie's Jack F4, **Indica/Sativa:** mostly Sativa; **Flowering**: 11-13 weeks; **High:** active, long lasting; **Smell/Taste:** berry, candy, citrus, spicy, fruity.

SANNIE'S HERIJUANA

M Killer New Haven Strain x F Petrolia Headstash, **Indica/Sativa:** 50/50; **Flowering**: 7-8 weeks; **High:** narcotic, deep stone; **Smell/Taste:** fuel, sandalwood, coffee.

K.O. KUSH

Killa Kush x Herijuana, **Indica/Sativa:** mostly Indica; **Flowering**: 7-8 weeks; **High:** extremely stoney; **Smell/Taste:** pine, sandalwood, earthy, kushy.

SANNIE’S SEEDS

ANESTHESIA F1

Skunk/AfghanxSannie’s Herijuana; **Indica/Sativa**: mostly Indica; **Flowering**: 9-10 weeks; **High:** dark, potent, flavorful medical; **Smell/Taste:** old school. (Breeder: Whazzup)

THE BIG LOW

Big Low (F3); Giant AutoFlowering, Feminized; **Indica/Sativa:** 70/30; **Flowering**: 35-40 days; **High:** medical**; Smell/Taste**: fruity, aromatic, strong.

SEEDS OF LIFE

HINDIANA

Big Low x Hindu Kush Original, Giant AutoFlowering, Feminized; **Indica/Sativa:** 80/20; **Flowering**: 30-35 days; **High:** medical**; Smell/Taste**: resinous, strong.

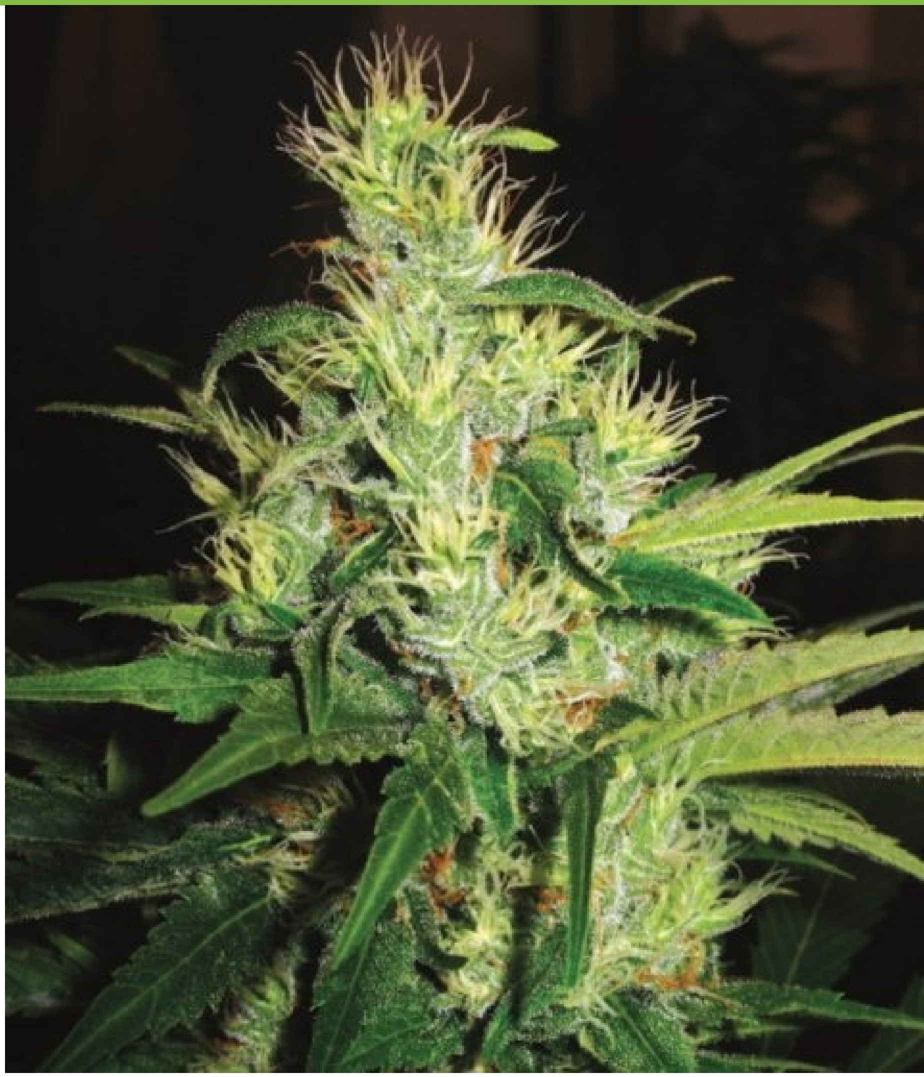
THE KABALA

Big Low x AK4 (F1), Giant AutoFlowering, Feminized; **Indica/Sativa**: 30/70; **Flowering**: 40-45 days; **High:** medical**; Smell/Taste**: full-bodied, intense.

NORDIKA

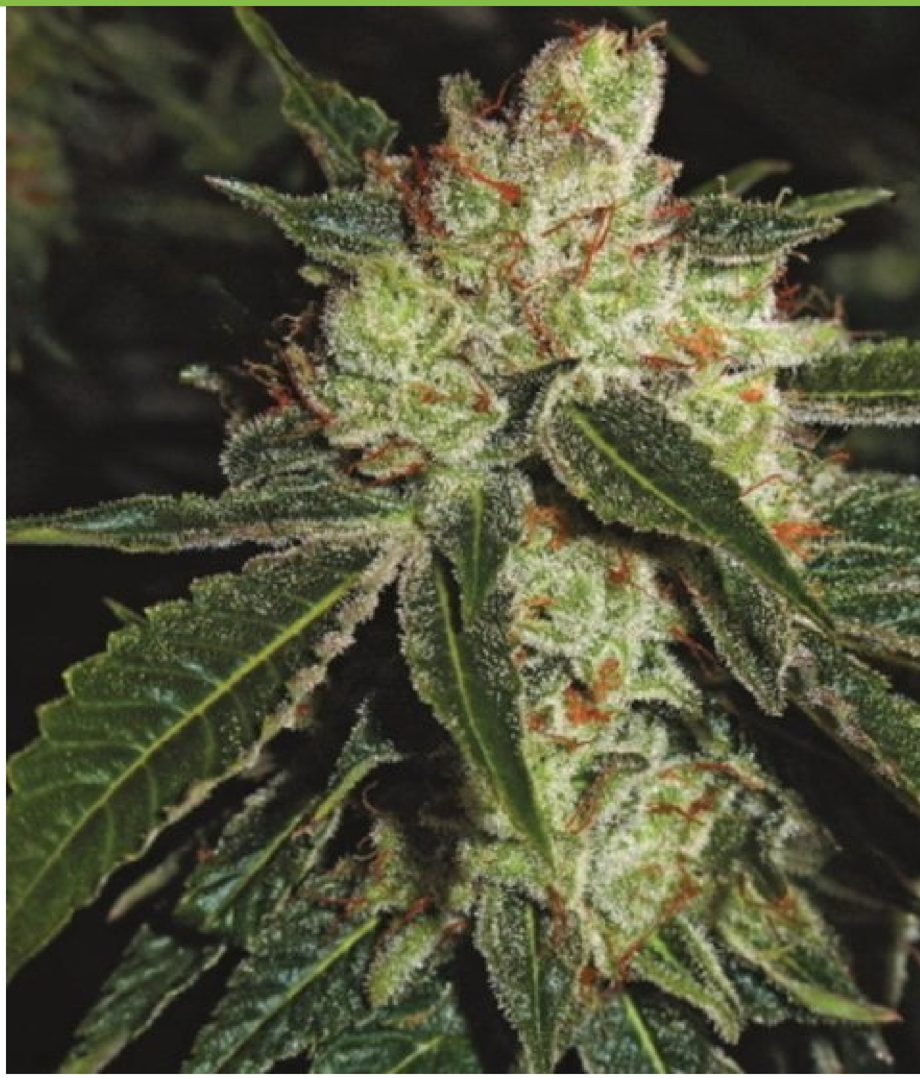
Kabala x Sativa (N. Europe); Giant AutoFlowering, Feminized; **Indica/Sativa**: 20/80; **Flowering**: 45-50 days; **High**: sativa, productive; **Smell/Taste:** enchanting.

SENSI SEED BANK



JACK FLASH

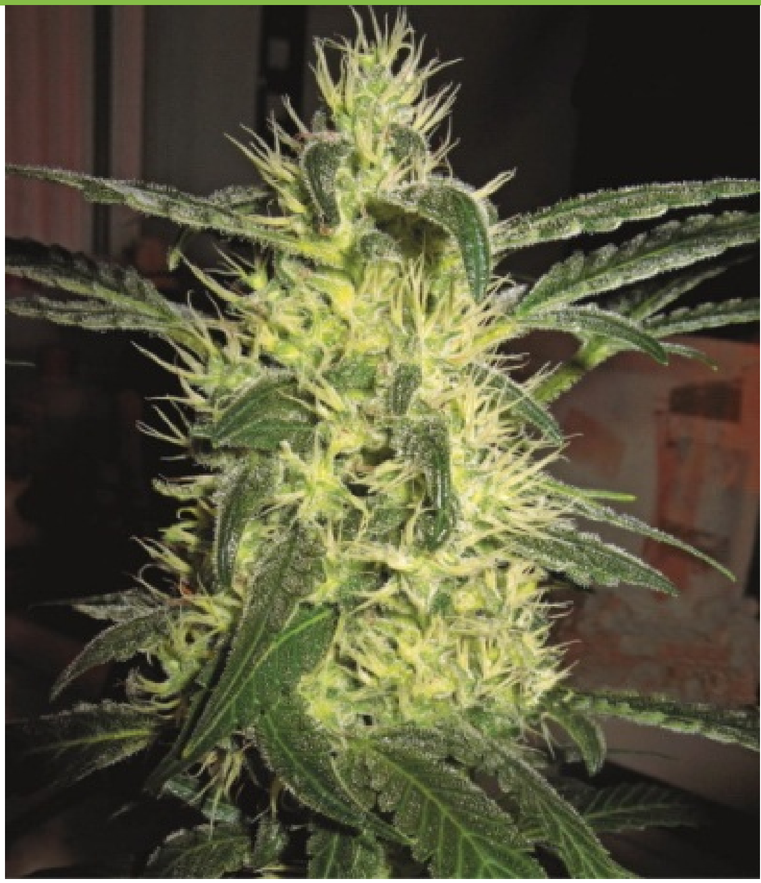
(Feminized/unfeminized) Northern LIghts #5 x SKC1 ROOD x SK 1 8.5 F3A, **Indica/Sativa:** 55/45; **Flowering:** 50-70 days; **High:** relaxing, then warm & cerebral; **Smell/Taste:** fruity, acrid, hint of pungency.



SHIVA SKUNK

(Feminized/unfeminized) NL#5 x SK#1, **Indica/Sativa:** mostly Indica; **Flowering:** 45-55 days; **High:** giggly, adventurous, contemplative; **Smell/Taste:** Musky, dank, sweet citrus, creamy.

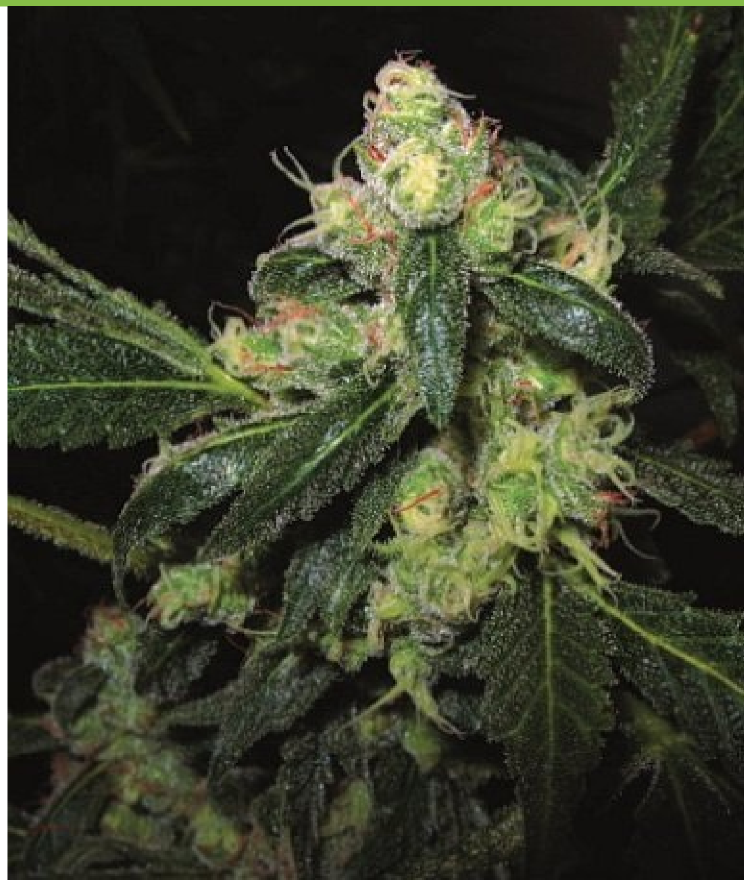
SENSI SEED BANK



SILVER HAZE

(Feminized/unfeminized) Central American, South Indian, Thai; **Flowering**: 65-76 days; **High**: soaring.

SENSI SEED BANK



SUPER SKUNK

(Feminized/unfeminized) Skunk #1 x Afghani Hash Plant, **Indica/Sativa:** mostly Indica; **Flowering**: 45-50 days.

SERIOUS SEEDS

BIDDY EARLY

Early Pearl/Skunk x Warlock; Feminized; **Sativa/Indica**: mainly Sativa; **Flowering**: 50-60 days; **High**: even/body high, happy, intense, soaring; **Smell/Taste**: candy, caramel, earthy, fresh, sweet.

SERIOUS SEEDS

MOTAVATION

Starwarz/Medizin Power x Warlock; Feminized; **Indica/Sativa**: mainly Indica; **Flowering**: 50-60 days; **High**: body relaxing, couchlock, dreamy, long lasting, thoughtful; **Smell/Taste**: floral, fresh, fuel, sweet.

SERIOUS SEEDS

WARLOCK

Skunk x Skunk/Afghani; Feminized; **Indica/Sativa**: Indica; **Flowering**: 55-60 days; **High**: dreamy, even/body high, functional, intense, munchies, positive; **Smell/Taste**: fresh, fruity, pungent, sweet.

SERIOUS SEEDS

WHITE RUSSIAN

White Widow x AK47; Feminized; **Indica/Sativa**: mainly Indica; **Flowering**: 56-63 days; **High**: happy, intense, more cerebral than sedative; **Smell/Taste**: foral, fresh, note of sandalwood.

SERIOUS SEEDS

AK-47

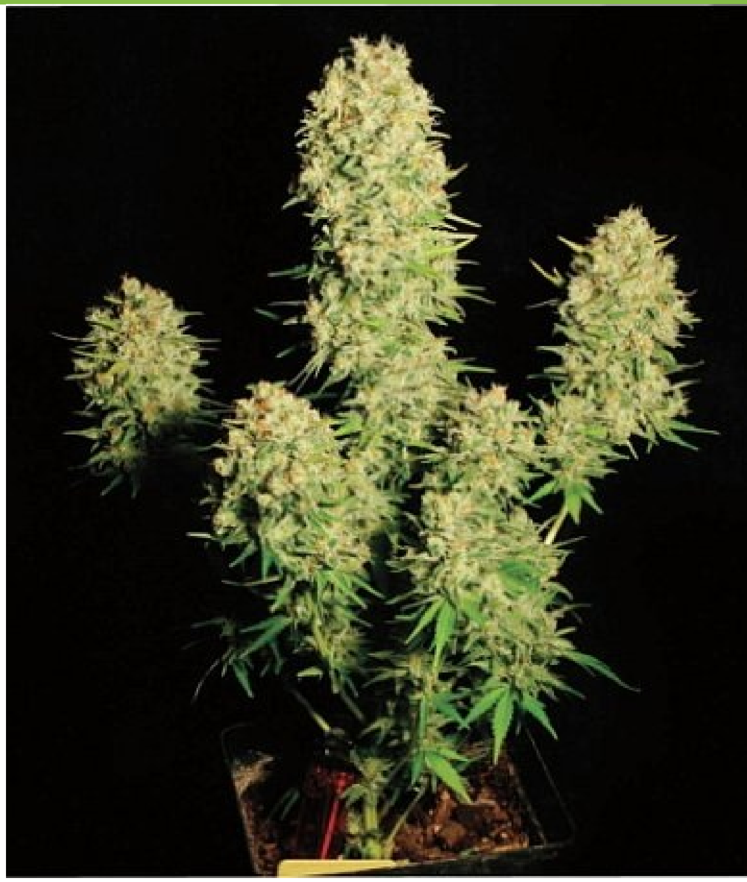
Columbian, Afghani, Mexican, **Indica/Sativa:** 40/60; **Flowering**: 56-63 days; **High**: strong cerebral turning to strong body stone; **Smell/Taste**: sweet and fruity, spicy-sweet with sandalwood undertone.

SERIOUS SEEDS

BUBBLE GUM

Acalpulco Gold x Mexican mixed with Afghani, **Indica/Sativa:** 50/50; **Flowering**: 56-63 days; **High**: strong cerebral, euphoric and stoney; **Smell/Taste**: Bazooka Joe Bubblegum™, fruity sweet.

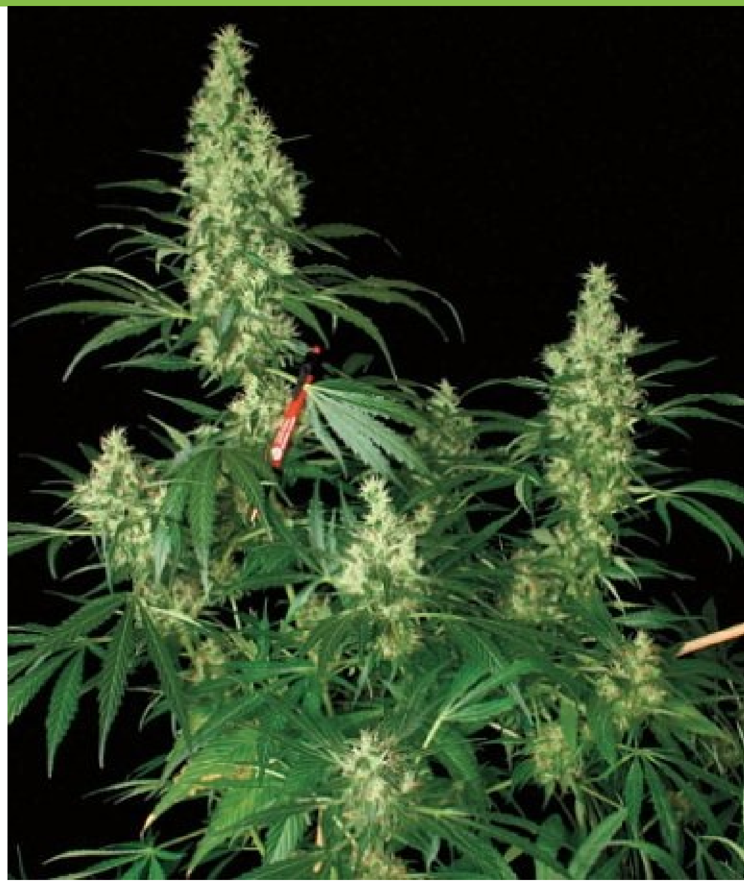
SERIOUS SEEDS



CHRONIC

Northern Lights, Skunk, AK-47, **Indica/Sativa:** 50/50; **Flowering**: 56-67 days; **High**: longlasting, uplifting, stoney; **Smell/Taste**: sweet wildflower.

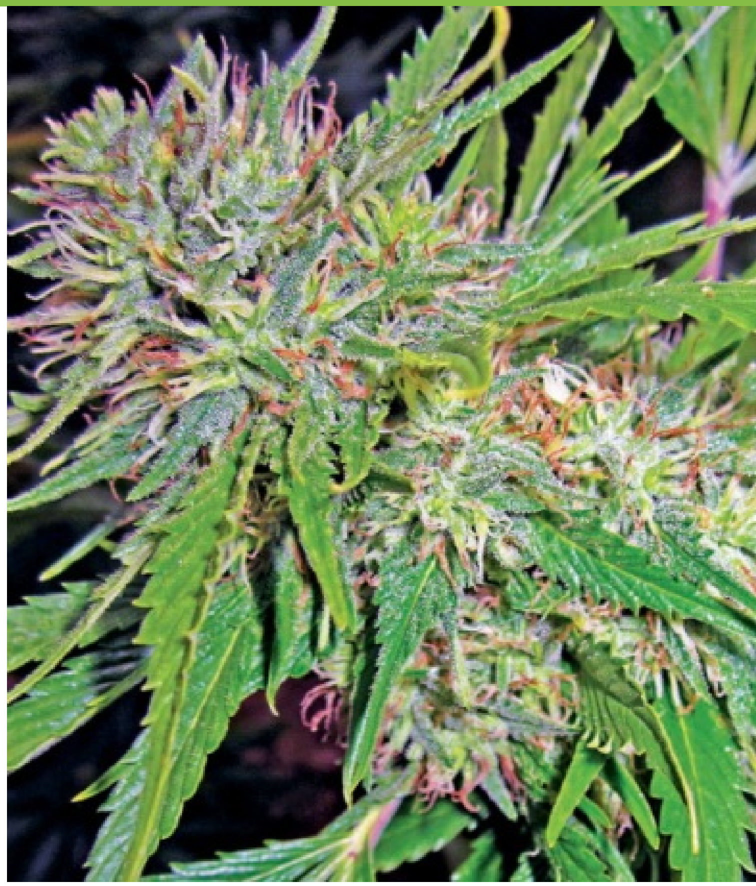
SERIOUS SEEDS



KALI MIST

Cambodian, Malawian x Columbian, Afghani, **Indica/Sativa:** 10/90; **Flowering**: 70-77 days, **High**: energizing, meditative; **Smell/Taste**: spicy-sweet.

SOCAL SEED CO.



BIG SUR HOLY WEED

Big Sur Holy Weed Indy x Sativa Pheno; **Indica/Sativa:** 50/50 Hybrid; **Flowering:** 8-9 weeks; **High:** soaring; **Smell/Taste:** fruity and sweet.

DAWG GOO

Afgooey x ChemD Male; **Indica/Sativa:** 65/35; **Flowering:** 8-10 weeks; **High:** clear, functional, mellow; **Smell/Taste:** earthy, herbal, sweet.

SOCAL SEED CO.

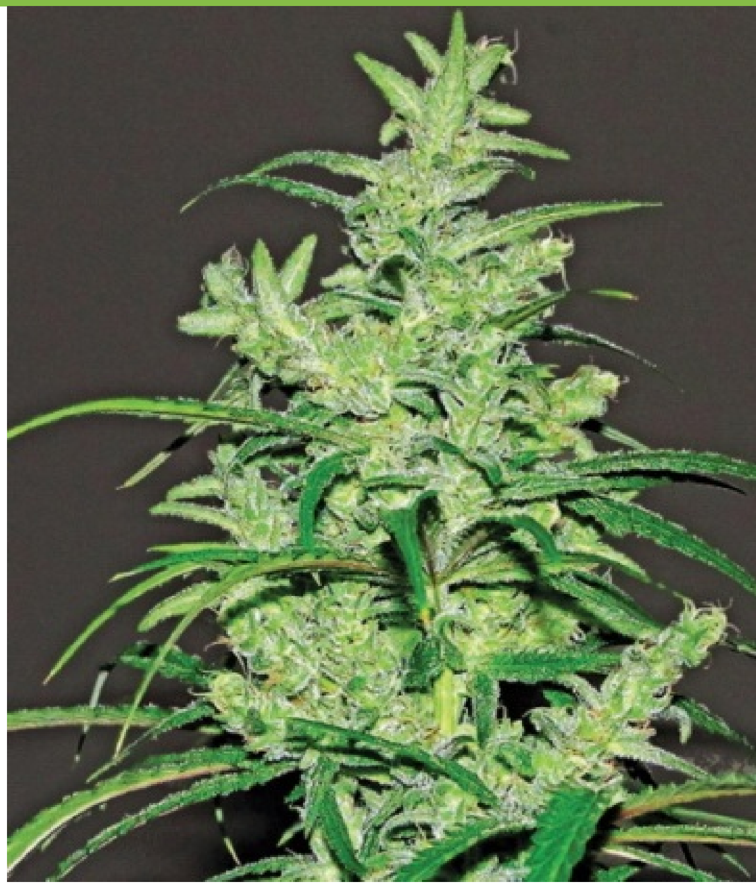
DAWGTOWN DAZE

Pure California Haze x ChemD Male; **Indica/Sativa:** 20/80; **Flowering:** 10-12, up to 16 weeks; **High:** blissful, clear, euphoric; **Smell/Taste:** fuel, haze, pepper.

SOCAL SEED CO.

FIRE HEADBAND

Fire Diesel x VGH OG; **Indica/Sativa:** 50/50; **Flowering:** 9-10 weeks; **High:** even/body **High**, intense; **Smell/Taste:** pungent, sour.



PURE E-32 (IX6 BX3)

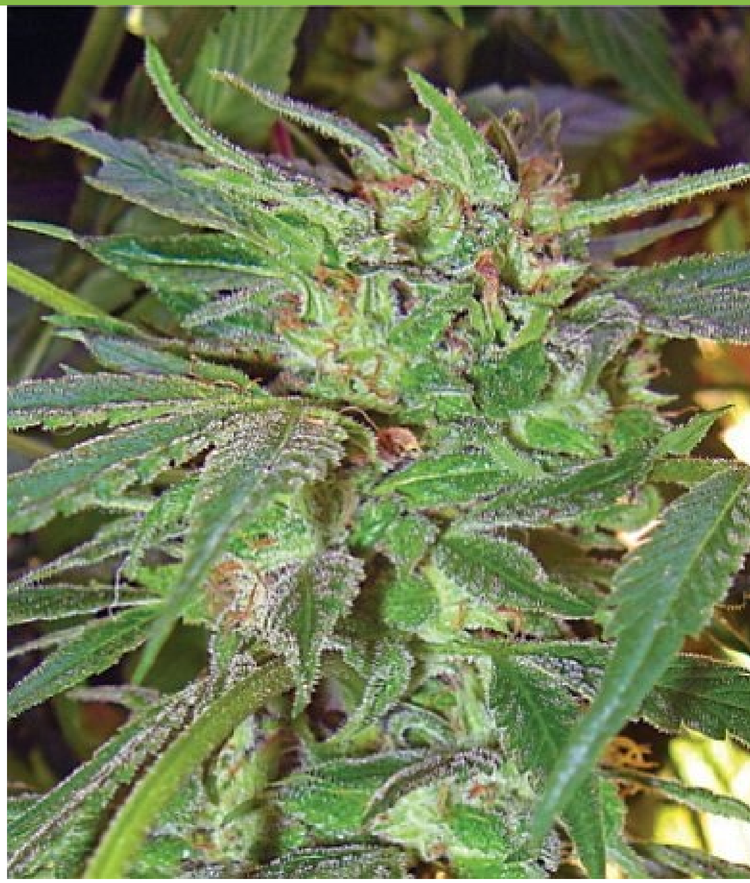
e-32 Trainwreck x AToA Trainwreck (e-32 IX6 BX2); **Indica/Sativa:** 20/80; **Flowering:** 10-12 weeks; **High:** active, electric; **Smell/Taste:** foresty, pine.

SOCAL SEED CO.

PURPLE SUICIDE

BOG Sour Bubble x Elite Genetics Twisted Purple OGK; **Indica/Sativa**: 70/30; **Flowering:** 8-9 weeks; **High:** couchlock, eyedroop, stoney; **Smell/Taste:** herbal, musky, sweet.

SOCAL SEED CO.



SOCAL DAWG

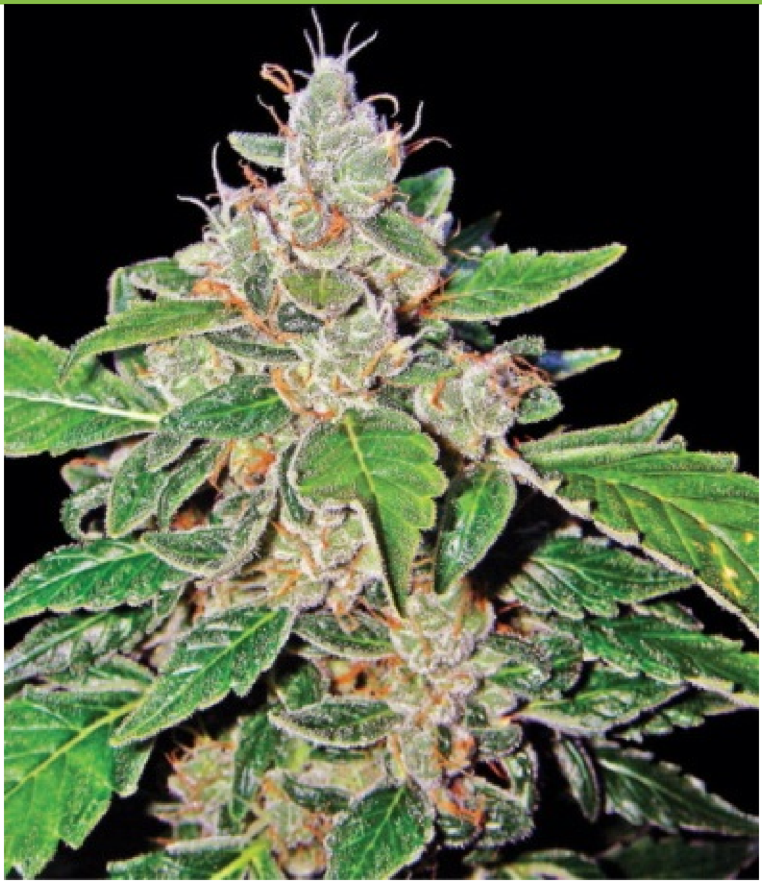
ChemD Clone x ChemD Male; **Indica/Sativa:** 40/60; **Flowering:** 8-10 weeks; **High:** heady, mellow, social; **Smell/Taste:** Chemdawg, fuel, pungent.

SOCAL SEED CO.

SOCAL GIESEL

Massachusetts Super Skunk x ChemD Male; **Indica/Sativa:** 45/55; Sativa; **Flowering:** 8-10 weeks; **High:** heady, mellow, social; **Smell/Taste:** musky, pungent, skunk.

SOCAL SEED CO.



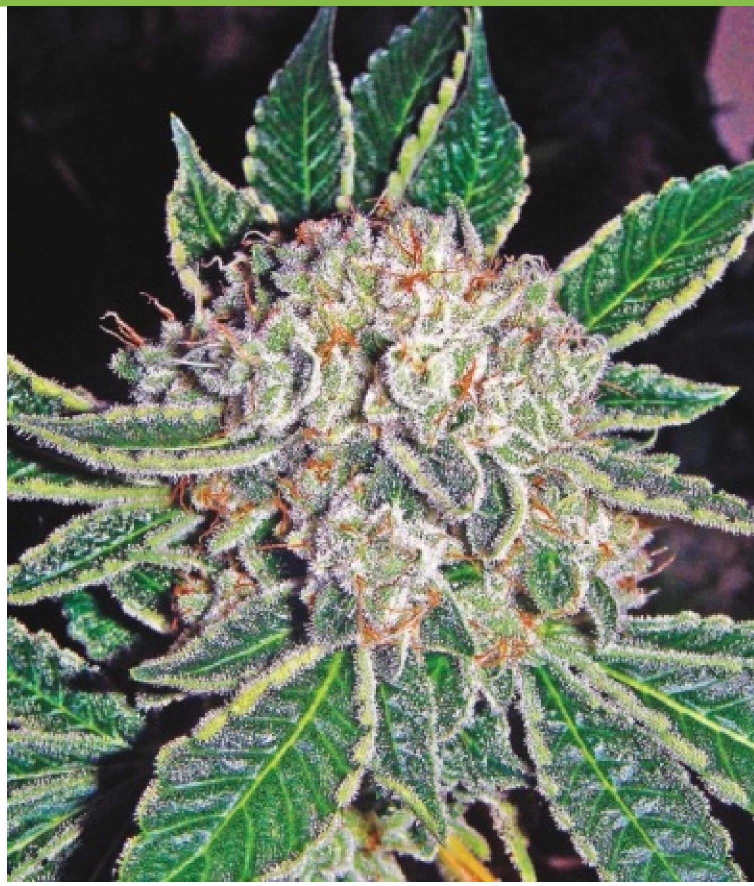
SOCAL ORIGINAL DIESEL

Original Diesel x ChemD Male; **Indica/Sativa**: 70/30; **Flowering:** 10 weeks; **High:** body relaxing, heady, stoney; **Smell/Taste:** fuel, pungent, sweet.

SOCAL WHITE LIGHTENING

The White x ChemD Male; **Indica/Sativa:** 80/20; **Flowering:** 8-9 weeks; **High:** stoney; **Smell/Taste:** earthy, pungent, woodsy.

SOCAL SEED CO.



TRIPLE PLATINUM

Double Platinum x ChemD Male; **Indica/Sativa:** 75/25; **Flowering:** 9-10 weeks; **High:** functional, sedative, stoney; **Smell/Taste:** earthy, musky, pungent

SOCAL SEED CO.

VGH OG

Tahoe OG x ChemD Male; **Indica/Sativa**: 60/40; **Flowering:** 8-10 weeks; **High:** eyedroop, heady, stoney; **Smell/Taste:** banana pheno, fuel, pungent.

SOMA SEEDS

NY CITY DIESEL

Sour Diesel x Afghani-Hawaiian, **Indica/Sativa:** 40/60; **Flowering**: 70 days; early Nov. outdoors; **High**: uplifting, creative, smooth; **Smell/Taste:** ruby grapefruit.

TGA SEEDS

SPACE BOMB

Romulan x Cindy 99, **Indica/Sativa:** 40/60; **Flowering**: 45-55 days; **High**: up, motivating, happy, pain relief; **Smell/Taste**: sour candy, fruity, also semi-rotting.

PART I QUICK POINTS: MARIJUANA THE PLANT

CANNABIS

Since humans discovered its properties cannabis has been bred intensively to optimize particular characteristics.

Though all cannabis plants are of the same species, the varieties typically cultivated for their seeds or fiber are known as hemp. Plants grown for their THC content are commonly called marijuana. Cannabis resin contains the group of substances collectively known as cannabinoids, of which tetrahydrocannabinol, usually referred to as THC, is the chief psychoactive component.

Marijuana varieties differ in many ways, including growth characteristics such as height, width, branching traits, leaf size and shape, flowering time to yield, as well as potency, taste, type of high, and aroma. In choosing a variety, you should select for both the quality of the high and the conditions in which you are growing. Cannabis is the only dioecious annual—that is, each plant is distinctively either male or female—though some individual plants may be or become hermaphrodites, producing both male and female flowers.

In nature, marijuana is a fast growing annual plant, although some varieties in warm areas over-winter, or go dormant as the days shorten and return to flowering the next summer. When grown outdoors, marijuana has an annual cycle that begins with germination in the early spring. The plant grows vigorously for several months as the days lengthen and begins to flower when it reaches a critical time period in late summer or early fall. When growing indoors and in greenhouses, the cultivator has complete control of the environment.

Most aromas we associate with plants are the result of terpenes. Terpenes are major components of marijuana resin as well as make up the largest percentage of aromatic oils contained in most plants. Many plants, including marijuana, are used in different forms of therapy including but not limited to pain management, moods, and aromatherapy. While terpenes affect the brain in their own way, they also modify the effect of THC within the brain, adding subtleties to the high. Age, maturation, and the time of day can affect the amount, and perhaps ratios, of terpenes.

Things to Know

- The three most common uses of cannabis are as a food, a fiber, and a resinous flower. Cannabis seeds are rich in oil and protein and are used as a food and animal feed, as well as a source of oil or fuel and skin care products. Cannabis fiber, produced from the stalk of the plant is used to make tough cloth, paper, and rope. The flowers and the resin that coats them are used therapeutically and recreationally.
- Plants are rooted into the ground and are immobile. They have evolved protection mechanisms such as the production of terpenes. Plants produce terpenes for one of three reasons; to attract pollinators, to repel or kill herbivores, and to attract predators of herbivores.

VARIETIES

Marijuana has been developed from two potent sub-species or varieties: indica and sativa. Most marijuana plants today fall between the two ends.

Indicas, which include kush varieties (sometimes called Afghan), generally mature early, have compact short branches and wide, short leaves which are dark green, sometimes tinged purple. Their buds are usually tight, heavy, wide, and thick rather than long. They smell “stinky”, “skunky”, or “pungent,” and their smoke is thick—a small toke can induce coughing.

Sativas require a long time to mature because they originated in areas that have a long season. They are usually very potent, containing large quantities of THC. The highs they produce are described in such terms as psychedelic, dreamy, spacey, and creative. The buds usually smell sweet or tangy and the smoke is smooth, sometimes deceptively so.

Ruderalis is a wild or feral variety of auto-flowering marijuana, which does not wait for shorter days to begin budding. A few weeks after germination, the plants begin to produce flowers while continuing to grow.

Feminized seeds are now the standard for most seed companies, these are seeds that have been treated to produce only female plants and are an ideal choice for marijuana cultivation. The qualities of the useable marijuana produced by feminized seed plants—its taste, flavor, and potency—is better than buds produced by either regular seed plants or clones.

However, some varieties are clone only, which means they are reproduced by rooting cuttings of one particular unique plant and propagating them.

Things to Know

- The best way to choose which variety to grow is to start by evaluating the environment you will be growing it in. Are their height or security restrictions? The second factor in determining which variety to choose is your personal preference: what type of high, taste and aroma you desire?
- Seed banks carry a large variety of strains from many excellent breeders. Seedsman is offering *Marijuana Grower's Handbook* readers a 10% discount when you enter the following code at checkout:
  EDROSENTHAL
  www.seedsman.com

Part II

WHAT ARE PLANTS AND WHAT DO THEY WANT?

MARIJUANA PLANT LIFE CYCLE

Within minutes of coming in contact with water, the marijuana seed reacts. Inside the seed shell, a tiny embryo that has been in a state of suspended animation begins to produce a set of three chemicals that induce growth: **auxin**, **cytokinin**, and **gibberellin**. Auxin is found in the growing tips of both the roots and the stem. It directs orderly new growth and develops the shape of the plant by inhibiting growth of the lower branches. Cytokinins promote lateral growth and cell division. Gibberellin directs stem and leaf growth. Together, these plant chemicals induce germination.

Left: Mature seeds are dark tan to dark brown. Light tan, green or broken seeds are not viable. Center: Seedling with the cotyledons (embryonic leaves), and first set of true leaves. Right: Seedlings transplanted to 3-gallon (13 l) containers using a coir medium.

Within a short time—typically one to five days, depending on temperature and the seed's age—the root tip breaks through the surface of the seed shell. The root continues to grow and absorb water, but it still depends on the nutrients packed in the seed with the embryo.

Then from the other end of the soon-to-be main stem, a pair of embryonic leaves (**cotyledons**) emerge. Sensing gravity, the plant orients itself so the roots point down and the leaves grow upward. Once the initial shoot emerges from the growing medium, plant growth follows the source of light. The cotyledons unfold and spread out to face the light, sometimes with pieces of the cracked seed shell still attached to them. The cotylydons immediately start producing sugars using the process of **photosynthesis**.

Seedlings grow fast with proper nurturing. Seedlings started in peat pots are transplanted, pot and all. Roots quickly grow through the fiber. After three weeks the plants are ready to transplant.

The roots continue to gather water and nutrients as they grow farther into the planting medium. They send the water and nutrient solution to the leaves, which the leaves convert to sugar to ship to the roots. The top-most new growth, known as the **apical meristem**, emerges from between the cotyledons where it was hidden and grows more prominent. It soon becomes apparent that another pair of leaves, the first true pair, is emerging. Within a few days, the leaves have unfolded and reached their full size, while a new set of leaves emerge from the growing tip. The second pair typically consists of three-bladed leaves. The following pair may be five-bladed.

As the plant continues to produce new leaves from its apical meristem, branches begin to grow at the nodes, the site where the stem meets the leaf **petiole**, the small stalk that attaches the leaf blade to the stem. These branches continue to grow as new ones appear further up the stem. Then new branches may appear on the **nodes** of the side (lateral) branches. Left untrimmed, plants take one of several characteristic shapes, ranging from Christmas or fir tree to bushy or single stem with little branching, or even an asymmetrical shape.

The plant continues to grow vegetatively—that is, it grows a main stem, branches, and leaves, but no flowers—until it receives environmental cues. Shortening light periods prompt it to respond by beginning to flower.

FLOWERING

Cannabis is considered a **short-day plant** that flowers in the fall. It regulates its growth and flowering stages by measuring the hours of uninterrupted darkness to determine when to flower. The plant produces a hormone called **phytochrome** (Pr) beginning at germination. The red spectrum of light, which is found in both daylight and lamp light, turns the chemical Pr to its inactive form, Pfr.

Under long dark periods, in the absence of red light, Pr builds to a critical level. During the late spring and early summer, there are significantly more hours of outdoor light than darkness, and Pr does not build up to a critical level.

FLOWERING WEEK BY WEEK

Within three or four days of initiation to a daily dark period of 10-11 hours, marijuana changes its growth pattern from vegetative to flowering. After that it is on a course that ends with bud ripening. Most modern plants take seven to nine weeks, although some sativas take longer. The plants shown here were all ready within eight weeks.

WEEK 1: **The plant slows down its growth.**

WEEK 2: **The first flowers appear at the nodes.**

WEEK 3: **Vegetative growth continues as the plant grows a total of between 25–50% larger than when flowering started.**

WEEK 4: **Vegetative growth has ended and the plants concentrate more of their energy into flowering. Odor becomes more noticeable as the plants start to produce capitate**

trichomes.

WEEK 5: Flower growth proliferates quickly. The flowers become thicker in areas where they have previously grown and they appear in new places along the top of the branch. The odor increases as more trichomes are noticeable and the odor intensifies a little.

WEEK 6: Flower growth continues in varieties that take longer to mature. It slows and then stops in seven-week varieties as the plants begin to ripen. The calyx behind the stigmas begins to swell. The odors of the seven-week varieties intensify.

WEEK 7: The calyxes in the seven-week varieties swell to near bursting as THC is produced in the glands. At the end of the week they will be ready. The trichomes stand more erect and the caps swell with newly produced resin. At the end of the week the flowers reach the peak zone. The odor is intense and the glands, filled with resin, fluoresce. Growth stops in the eight-week varieties as the flowers start to mature.

WEEK 8: The flowers are ripe by the end of the week, and reach the peak zone in the last 72 hours. After that, they will start to deteriorate if they aren't harvested.

FLOWERING WEEK BY WEEK—F13

Photos: Rachael Szmajda, Courtesy: Harborside Health Center

FLOWERING WEEK BY WEEK—PURPLE DIESEL

Photos: Rachael Szmajda, Courtesy: Harborside Health Center

FLOWERING WEEK BY WEEK—CHEM'S SISTER

Photos: Rachael Szmajda, Courtesy: Harborside Health Center

However, as the days grow shorter and there are longer periods of uninterrupted darkness during late summer, Pr reaches a critical level each evening. When this happens for about five days, the plants transition from vegetative growth to flowering. Pr is changed back to its inactive state in the presence of even a few moments of light, which is why uninterrupted darkness is so important to flowering.

In the Northern Hemisphere, the days get shorter after June 22. When the dark period reaches between 9 and 11 hours—usually in late July or August depending on latitude—the critical time period is reached. This triggers the plant to start flowering, rather than continue to grow vegetatively.

Indoors, the gardener controls flowering time by regulating the light cycle. While the plant is growing under continuous light or a long-day regimen of a minimum of 18 hours, plants continue to grow vegetatively, producing only leaves, stems, and roots, bu no flowers. When the light cycle is turned down to 12 hours on and 12 hours off, Pr reaches a critical level each dark period, and the plant is triggered to flower.

Watching a plant grow from a vegetative state to flowering is a surreal experience. Indoors, during the long-light period of vegetative growth, the plants have lightly filled the canopy, with their leaves barely touching. Then, when the light period is changed to a flowering regimen, the plants receive a daily long uninterrupted dark period. After about five days, vegetative growth slows or stops. Now the plants concentrate their energy on producing reproductive organs: flowers. During the second week, the first flowers appear along the nodes. During the third week, the number of flowers increases, and the area that they cover increases as well.

Flowering and ripening times differ by variety. Thanks to careful breeding, modern varieties grow far faster and ripen more quickly than their predecessors. Buds typically grow and ripen in six to ten weeks. The growth trajectory of the bud after the third week of flowering depends on how long the variety takes to mature. Two or three weeks before maturity, the bud starts its descent into ripening. While it continues to grow and fill out, the stigmas—small protrusions of the female flower that it uses to pollinate—turn brown.

The trichomes—where cannabinoids and terpenes are produced and stored—become more prominent. The trichomes stand erect from the plant tissue, and each has a cap that looks something like a mushroom head. As the bud matures, the trichomes continue to fill with THC and terpenes until the cap on top of the gland is so full that the oil-filled membrane looks like a balloon about to burst.

At maturity, trichomes cover the whole reproductive area. They fluoresce and sparkle when light shines on them, creating an appearance of white crystals. The stigmas have all turned brown. In most varieties, the ovary, where the seed would grow if the flower had been fertilized, swells in a sort of false pregnancy. The entire bud seems to vibrate.

The smell of the plant also changes. During the vegetative stage, the plant has some odor. As the bud grows, the odor remains the same, but its intensity increases dramatically. As the bud matures, its odor becomes more pungent and pervasive. At maturity, the smell can become overpowering, seeping through plastic bags and contaminating entire structures. Of course, this doesn’t happen with all varieties, and lighting affects the intensity of the aroma, too.

One of the factors indoor marijuana breeders select for is fast finishing, meaning flowering happens quickly. The gene for this is linked to the critical number of hours of darkness a plant needs in order to switch from vegetative growth to flowering. The faster the variety, the fewer hours of darkness it requires to flower.

Indoors, the plants’ growth stage is regulated with the flick of a switch. Nevertheless, the plants respond to the artificial light cycle in the same way that they do to the natural seasonal cycles. If you become familiar with the critical time period of the variety in mono-crop gardens (those with a single variety) or that of the slowest-ripening variety of a garden containing several strains, you can increase the light period closer to the critical time period. The more light the better, so long as the plant still flowers strongly.

The potency of marijuana is based on, for the most part, first its genetics and then the maturity of the bud. The plant's age has no bearing on potency. Mature flowers of genetically identical three-month and six-month-old plants have the same potency.

PHOTOSYNTHESIS

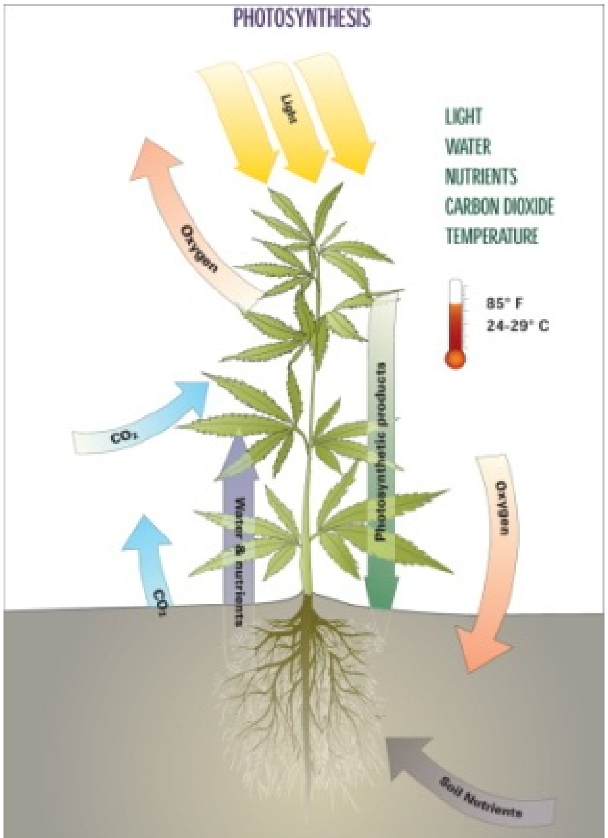
Photosynthesis is the process in which plants capture the energy from light and use it to power a series of biochemical reactions. Carbon dioxide from air and water are combined to produce sugar and release oxygen to the atmosphere. Sugar is used by the plant as a tissue building block to power metabolism—i.e., energy for life processes.

Photosynthesis started between 3.5 and 2.5 billion years ago when cyanobacteria, also known as blue-green algae, first evolved the use of photoreceptors to capture and utilize the energy from sunlight. The oxygen generated by this process radically altered the early atmosphere of the Earth, raising the concentration of oxygen from an estimated 1% to today's 21%, and changing the composition of the dissolved solutes in the world's oceans.

The biochemical process of photosynthesis in green plants takes place in an inner cellular **organelle** called the **chloroplast**, which captures the energy of sunlight and converts it to electrical charges used to make sugar. It is thought that chloroplasts which developed as cyanobacteria established an endosymbiotic relationship with their hosts.

According to this theory, chloroplasts were separate organisms that were taken inside the plant cell, just as proteobacteria were incorporated to become mitochondria, the cells' energy center. In fact, chloroplasts, like their counterparts the endosymbiotic mitochondria, still maintain enough of their original DNA genome to code for around 200 different proteins. These genes are inherited separately from the cell genome. But photosynthesis requires an additional 1,000 compounds, blueprints which are encoded in the DNA of the plant's nucleus.

The chloroplast is surrounded by an outer, permeable membrane and a second, relatively impermeable inner membrane. The stroma are inside this double barrier. Another membrane holds the thylakoid membranes that surround the innermost compartment, the lumen. The light-harvesting mechanism for photosynthesis is found in the area where the thylakoid membrane separates the stroma from the lumen.



Plants capture the energy from light and use it to fuel a complex set of processes in which they capture carbon dioxide (CO_2) from the air, break apart water (H_2O), and then attach the hydrogen (H) atoms that are released to the CO_2 to form sugar. The overall formula is: Light + 6(H_2O) + 6(CO_2) $=C_6H_{12}O_6 + 6O_2$.

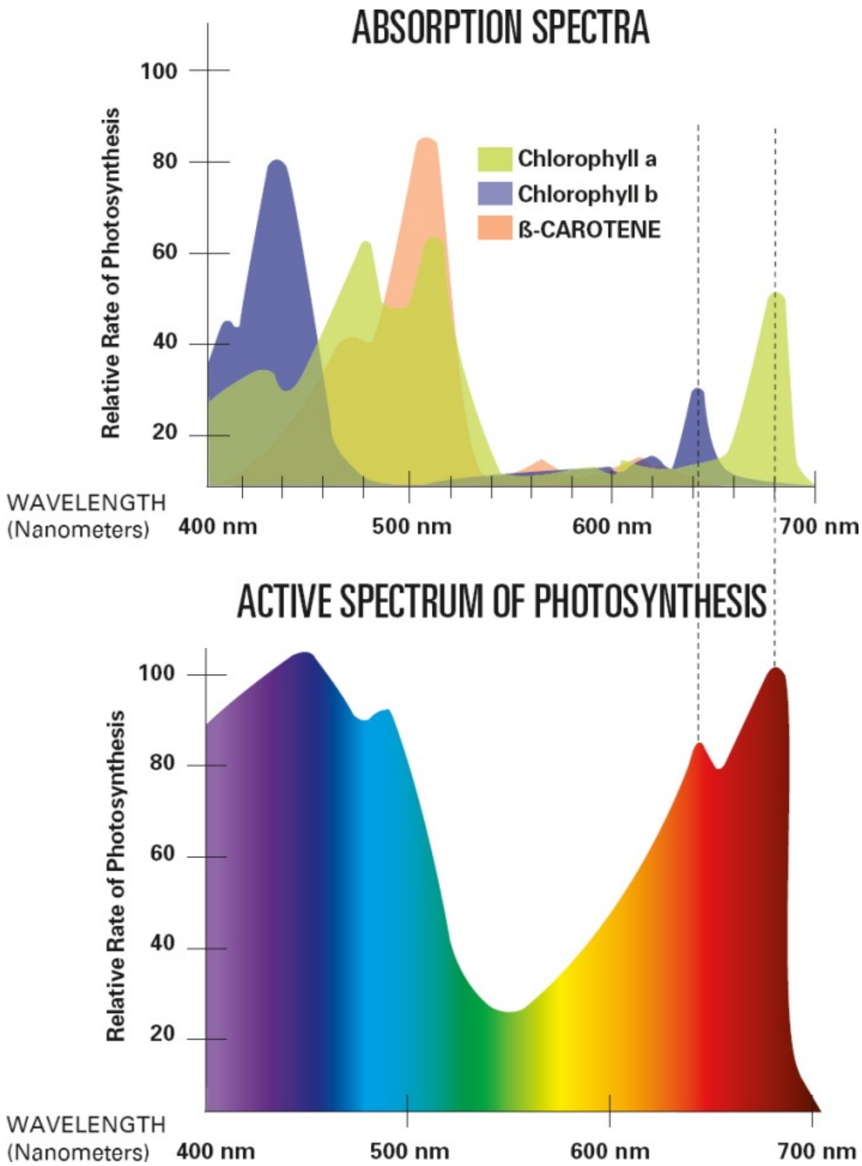
PROPORTION OF TOTAL LIGHT within each waveband under direct sun or leaf shade

	Irradiance 400-800 nm	Blue 400-500 nm	Green 500-600 nm	Red 600-700 nm	Far-Red 700-800 nm
Direct Sunlight	1700 (100%)	23%	26%	26%	25%
Leaf Shade	60 (100%)	4%	15%	11%	70%

Plants absorb or reflect most wavelengths of light. Far-Red light passes through; therefore there is a higher ratio of Far-Red to Red light in the shade. Plants use the Far-Red ratio to detect being in the shade; they grow longer stems to try to reach the light. Notice the peak of green in the visible spectrum of the canopy light; since green light more than other visible colors is reflected or passes through leaves, plants appear green.

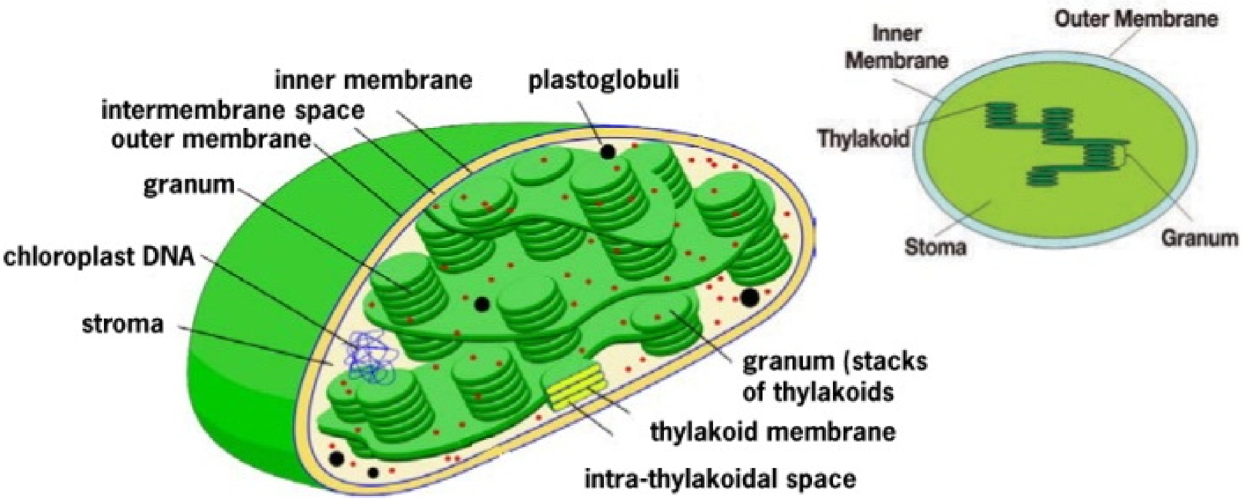
Chloroplasts contain a number of photoreceptors, including the principal pigment **chlorophyll**, as well as beta carotene. These pigments allow the chloroplast to absorb light over most of the visible spectrum, though most of these receptors absorb more red and blue light and reflect the green, which gives plants their characteristic color. These pigment molecules are arranged in large symmetrical protein structures called light-harvesting complexes. These complexes serve as antennae and channel the light-excited electrons to a chlorophyll molecule at the main reaction center, where photosynthesis occurs.

The “light” reactions take place in two distinct stages in protein complexes associated with the thylakoid membrane: Photosystems I and II. (Because the photosystems were named in their order of discovery, not function, the first set of photosynthesis reactions takes place in Photosystem II, not I.)

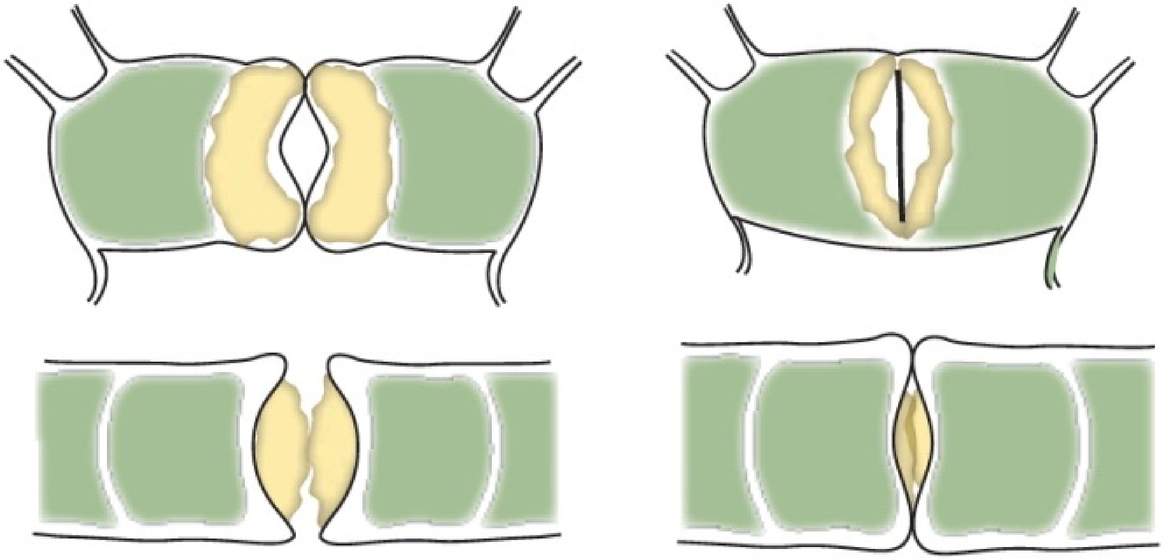


PIGMENT ABSORPTION SPECTRUM (top): The three pigments that capture most of the light used for photosynthesis are two forms of chlorophyll, A and B and Beta-Carotene. They are most efficient at capturing light in various wavelengths of the red and blue bands. They are not efficient at using green and yellow light.

ACTIVE PHOTOSYNTHESIS SPECTRUMS (bottom): The active photosynthetic spectrum gets most of its energy in the red and blue light. However the drop-off of efficiency of use of light for photosynthesis in the orange, yellow and green bands is not as great as would be expected if only chlorophyll and carotene were considered. Light in these wavelengths is harvested by other pigments (called accessory pigments) that transfer the energy to chlorophyll.



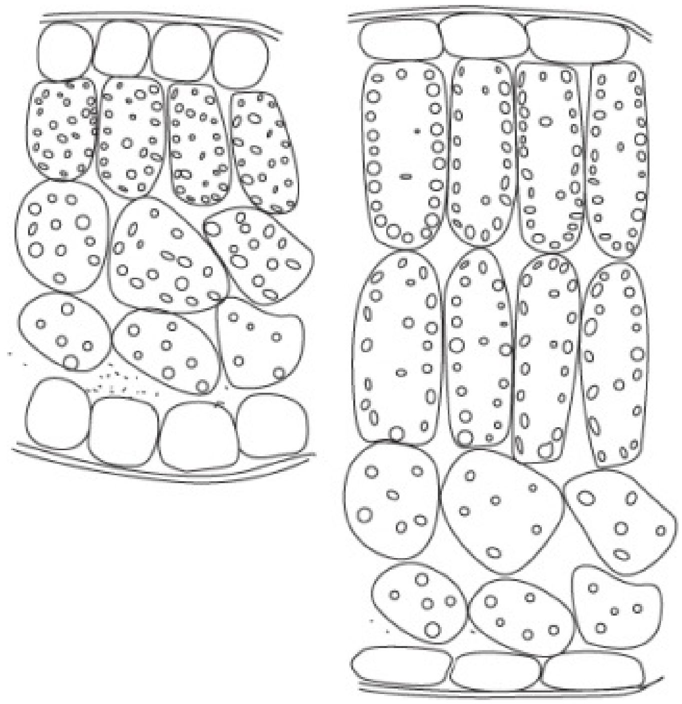
Chloroplasts contain the pigment chlorophyll. They are held in structures called thylakoids. They are extremely efficient at converting captured light to energy, which powers photosynthesis. Each photosystem contains hundreds of chlorophyll A, chlorophyll B and carotenoid molecules packed together and integrated into the thylakoid membrane. There are hundreds of these photosystems in each chloroplast and there are dozens of chloroplasts per cell and hundreds, if not thousands, of cells per leaf. The chances for absorption of photons is enormous. The absorption spectra for purified chlorophylls A and B (in vitro), have peaks only in the red and blue portions of the spectrum. In the leaf the dense packing of photo-active molecules and the transfer of electrons between the molecules allows photosynthesis to function across the spectrum, including in the green portion, where absorption is minimal. It also explains how minimally absorbed wavelengths are able to affect photosynthesis. Far-red light between 700 and 800nm is able to enhance the rates of photosynthesis under low light conditions by altering the distribution of PSI and PS2 leading to increased grana stacking and a closer association between the photosystems.



STOMATA: Shown open and cross-section (below)

STOMATA: Shown closed and cross-section (below)

The plant stomata regulate the exchange of gasses and liquids to and from the leaf. They function sort of like human pores. In their open position they absorb carbon dioxide as well as moisture and nutrients. In the closed position they retain water. Plants regulate water content and temperature using the stomata. When they transpire water, it cools the plant in much the same way that sweating helps us.



Photosynthesis relies on the microscopic photosystems found in plant leaves. Each photosystem contains hundreds of chlorophyll A, chlorophyll B and carotenoid molecules, which are packed together in the thylakoid membrane of the leaf. Since there are hundreds of these photosystems in each chloroplast, dozens of chloroplasts per cell, and hundreds if not thousands of cells per leaf, plants have an enormous number of chances to absorb light photons. The quantity of light chlorophylls A and B will absorb in laboratory tests peaks only in the red and blue portions of the spectrum, but the dense packing of photo-active molecules in the leaf allows photosynthesis to function across the spectrum, even at wavelengths that are only minimally absorbed. For instance, far-red light between 700 and 800nm enhances the rates of photosynthesis under low light conditions by altering the distribution of Photosystem I and Photosystem 2 to increase thylakoid stacks in chloroplasts and more closely associate the photosystems.

When Photosystem II absorbs light, it passes high-energy electrons along to the next stage, but it then needs additional electrons to return to its previous state. These electrons are supplied by the oxygen-evolving center (OEC) which separates electrons from water molecules in a process that leaves behind protons and oxygen. This very rapid reaction can produce as many as 50 oxygen molecules per second for every Photosystem II complex. This generates most of the Earth's breathable oxygen.

After the OEC has separated oxygen and protons from the water molecule, the extra electron is transferred in a process that removes protons from the stroma and adds them to the lumen. The electron is then passed to a water-soluble protein that delivers it to Photosystem I.

Photosystem I uses a higher wavelength of light than Photosystem II to re-excite the electron. It is used to produce **ATP** (***adenosine triphosphate***).

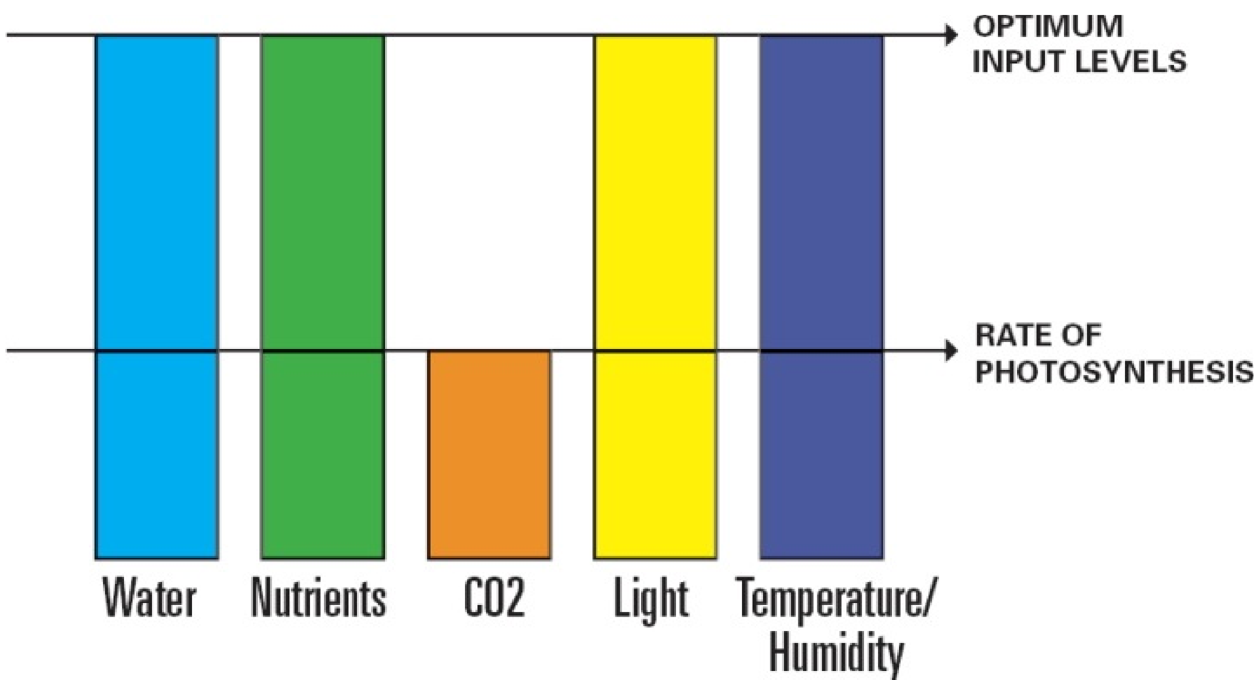
The energy generated by the "light" reactions power the "dark" reactions of photosynthesis that take place in the chloroplast stroma. There, an enzyme complex known as RUBISCO (*ribulose bisphosphate carboxylase/oxygenase*) uses CO_2 as the base to combine with hydrogen to make starches and sugars, including amino acids and carbohydrates. The sugars generated this way are processed further and stored in the plant as glucose polymers called starches for use later. They become the building blocks for tissue building and are used to power metabolism.

THE LIMITING FACTORS

Marijuana plants are dependent on their environment for materials and energy. There are five essential factors that affect marijuana growth: light, carbon dioxide (CO_2), nutrients, water, and temperature.

Each of these inputs is required for photosynthesis and growth, and they must all be available in adequate amounts for a plant to reach its potential. For example, as the intensity of light increases, the plant's ability to utilize it depends upon the availability of the other four factors. For this reason the five are called "limiting factors".

FIVE LIMITING FACTORS: NECESSARY COMPONENTS IN PLANT GROWTH



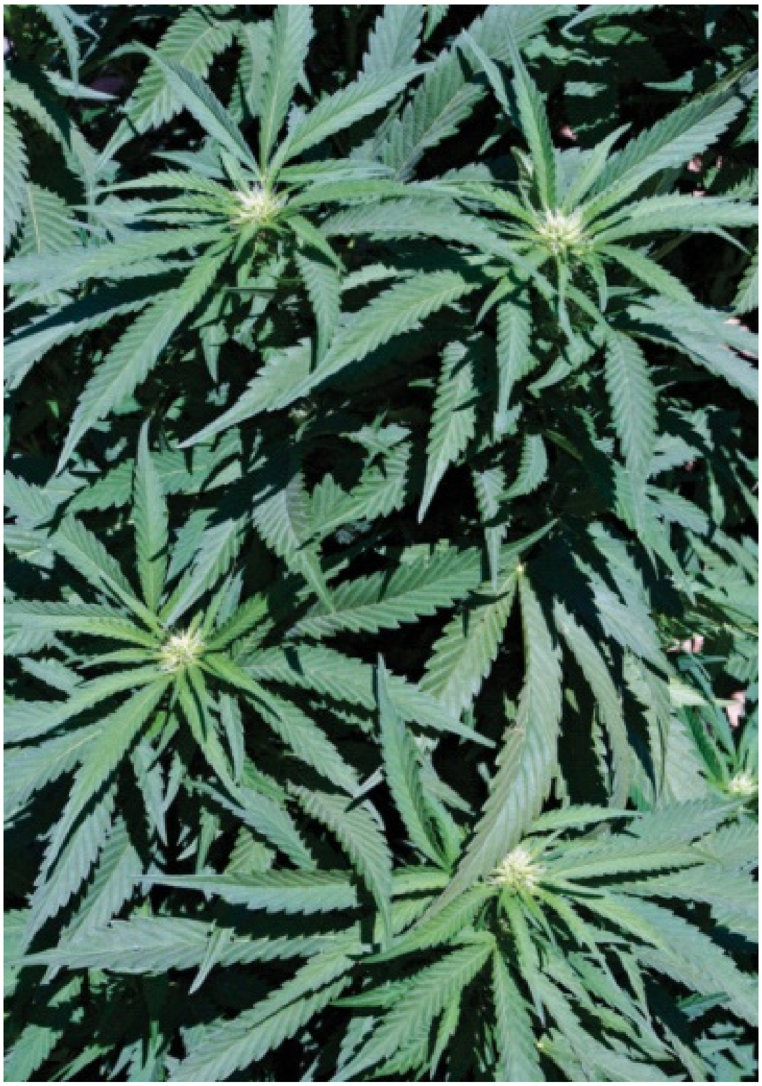
A deficiency of any single factor limits growth to the level that factor supplies. No matter how well other factors are supplied they cannot be utilized. For example, insufficient amounts of CO_2 limit the use of light, water, nutrients and temperature/humidity. If light is limited, lower the nutrient, CO_2 and temperature levels

The limiting factor—that is, the factor that is not supplied adequately—determines the rate of growth. Insufficient supplies of any one factor slows or stops growth.

It is unlikely that either water or nutrients are limiting factors in an indoor garden, since they are easily supplied. Oxygen, which is required by the roots and sometimes absorbed by the leaves, comprises 21% of the air, so leaves have easy access. Oxygenating the water and using porous mediums keep the roots supplied. That leaves three factors that are likely to limit plant growth: light, CO_2, and temperature.

Cannabis' metabolic rate—how fast it functions on a cellular level—is determined by temperature. Warm-blooded animals, such as humans, maintain a steady metabolic rate by regulating their temperature internally. Almost all other life forms' metabolic rates are dependent on their environment. In cool weather they function slowly, and their metabolism speeds up as it warms.

For this reason, all the factors in the garden must be considered in relation to each other. As the amount (intensity) of light increases, cannabis requires more CO_2 to use as raw material for photosynthesis.



LIGHT

Plants use light for several purposes, including the regulation of life processes such as the initiation of flowering. But the most amazing thing that they do with light is photosynthesis, the process that provides the foundation for most of life on Earth. Plants use photosynthesis to power the process of making sugar ($C_6H_{12}O_6$) from water (H_2O) and carbon dioxide (CO_2). Plants also use it to convert the sugars they make into starches and then into complex molecules such as cellulose. Add some nitrogen atoms, and you get nucleic acids and amino acids, the building blocks of all proteins.

Plants draw the energy they need from light across a spectrum broader than the human eye can see, from 400 nm (blue light) to 730 nm (red). Plants do different things with different wavelengths of light. Understanding the differences can help the careful cultivator ensure that the plants are getting everything they need to thrive.

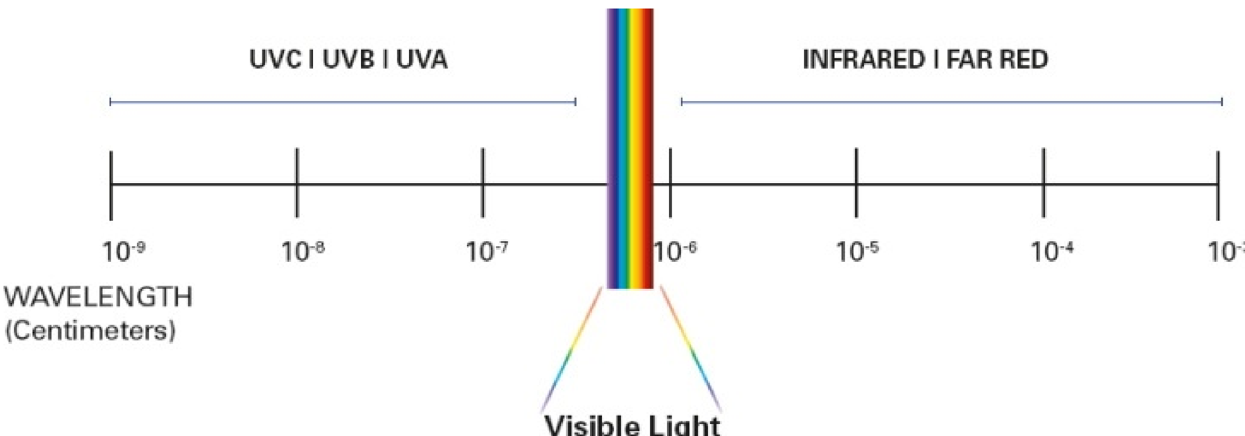
For photosynthesis, light energy is captured by chlorophylls A and B primarily from the red and blue portion of the spectrums. Light absorption by chlorophyll A peaks at 430 nm in the blue band and 662nm in the red, and chlorophyll B peaks at 453 nm in the blue and 642 nm in the orange-red bands. Chlorophyll synthesis peaks at 435 nm and 445 nm in the blue spectrum and 640 and 675 nm in the red wavelengths.

Chlorophyll is not the only light-sensitive part of the plant. Carotenoids, are a group of orange pigments that capture light in the blue portion of the spectrum, primarily at about 450 nm in the blue spectrum and 475 nm in the blue-green range. Carotenoids not only contribute to photosynthesis but also protect the chlorophyll frm excess light that could have destructive effects.

Anthocyanin and other flavinoid pigments also absorb blue and UV light to protect chlorophyll from photo-destruction.

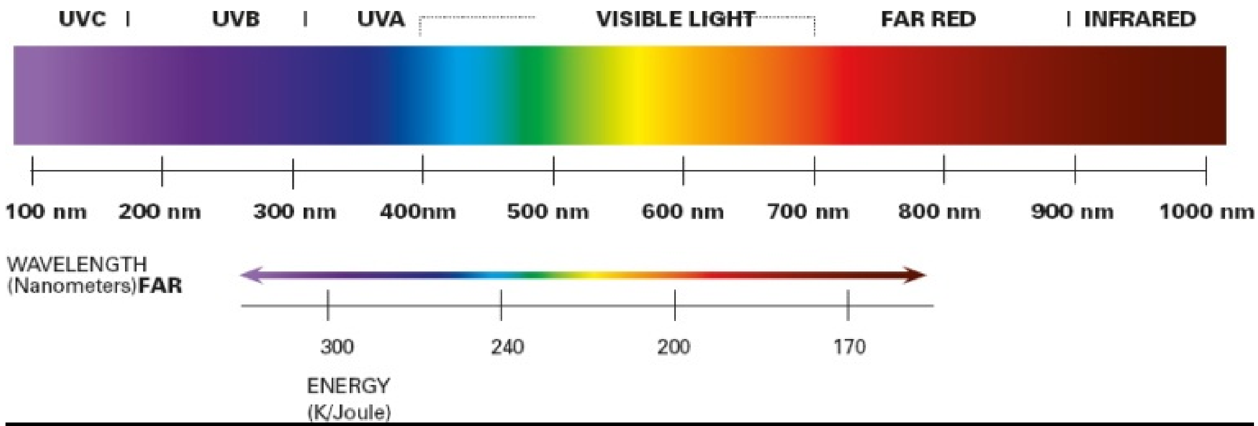
Another pigment that appears to play a role in plant health is xanthophyll. This yellow pigment captures light in the range from 400-530 nm, but is usually hidden from our view by the green of chlorophyll. If a leaf loses its chlorophyll—because of a nitrogen deficiency, for instance—xanthophyll's bright yellow color becomes apparent. Xanthophyll has several functions. First, it acts as a light and heat regulator. At dawn, it is in its low-energy form, violaxanthin, which has peak reactions to light at 480 nm and 648 nm. As the light increases to levels that might hurt the thylakoids and lead to photo-oxidation of the chlorophyll molecules, violaxanthin siphons off the excess energy of photons, using them to create its high-energy form, zeaxanthin. When light intensity decreases, the zeaxanthin returns to its low energy state, violaxanthin, in a cycle that can take anywhere from a few minutes to several hours. These chemical processes enable plants to cool themselves during lighted periods and to stay warm during cool nights. Plants bank energy during the day and release it at night by shifting xanthophyll to its low-energy form, releasing heat. During the day, some of the light energy may also be transferred to chlorophyll by releasing an electron to be used for photosynthesis. Other plant pigments also gather energy from spectrums not used by chlorophyll. Neoxanthin, lutein, and zeaxanthin each transfer more than half the energy they gather to chlorophyll.

ELECTROMAGNETIC RADIATION SPECTRUM



Visible light is a small portion of the electromagnetic radiation reaching Earth. Plants use a portion of that light to power photosynthesis.

VISIBLE & NEAR-VISIBLE LIGHT SPECTRUM



Plants use light from the visible spectrum for photosynthesis. They use red and blue light most efficiently, but use light from other spectrums as well. Blue light contains more energy than red light and more electricity is used to produce it than red light. However, plants obtain the same amount of energy no matter the spectrum. This is one reason why it is more cost effective to provide plants with mostly red rather than blue light.

MEASURING LIGHT

When considering lighting for your garden, you will see various terms used to describe the output of different lamps. Understanding the relationship between such things as a lamp's wattage and its output in lumens can help make meaningful comparisons between products.

The basic principles of how light is measured are also helpful for planning how to deploy lamps for maximum effectiveness and checking how much light your plants are getting. As anyone who has purchased a lightbulb is aware, bulbs are sold by wattage. But a quick comparison between fluorescent and incandescent bulbs, for instance, reveals that a 20w fluorescent may produce as much light as a 75w incandescent.

Watts only measure how much power a given bulb draws; output depends on the bulb technology. Light output or intensity is measured in several different units, including candelas, foot-candles,

lumens, lux, and moles. Many of these units are based on each other, and some are more commonly used than others. They measure three basic things:

- the amount of visible light emitted (candelas, lumens);
- the amount of light that reaches a defined area (foot-candles, lux); and
- the total number of light particles (moles).

The candela (or candle or candle-power) is the most basic international unit for measuring emitted light and is defined as the illumination created by a common candle. While that once meant an actual candle with a burning wick, scientists devised more precise and replicable standards over the years, but all aimed at maintaining the basic unit.

Lumens (lm) measure the visible light or "luminous flux" emitted in a defined beam. A single candela light source that radiates equally in all directions produces exactly 4π (12.6) lumens; a 23w compact fluorescent emits about 1600 lumens.

The foot-candle (fc) is a closely linked unit of measure, defined as the amount of light at a distance of one foot from a single-candle light source.

The lux is similar to the foot-candle in that it measures the visible light intensity (luminous flux) that reaches a particular area, defined as one lumen per square meter. So 100 lumens concentrated in an area of one square meter equals 100 lux; if that same 100 lumens is spread over a space ten square meters, you have 10 lux.

Moles: All of these ways of quantifying light intensity measure the amount of light at one instant in time. When measuring the light reaching a garden, growers are concerned with the amount of light the plants get over the entire lit period. For indoor setups where the light output is constant, knowing a lamp's lumens or the lux at the canopy works well enough because the total for the lit period is easily calculated. But for outside or in greenhouses, the light intensity varies depending on the time of day and season of the year. For them, an integrated light measure that adds up the amount of light throughout the day is more meaningful, and moles per day is a common way of expressing that.

Not to be confused with skin spots or burrowing rodents, moles measure the number of light photons (one mole = 6.02×10^{23} photons) and are frequently combined with units of area and time to

give you moles per meter per day.

An advantage of using moles or micromoles (millionths of a mole) is that the light quanta measured is not just the spectrum of light visible to the human eye, which is all candelas, foot-candles, lumens, and lux measure. Plants use far more of the light spectrum for photosynthesis than humans can see. In fact, the light we see best is some of the least useful to plants.

PAR: The light that plants use is known as Photosynthetically Active Radiation, or PAR. Humans see light best in the the yellow-green wavelengths around 550 nm, but PAR ranges from 400 to 700 nm, and plants make most use of light in the red and blue spectrums. Since PAR is usually expressed in moles, which measure light quanta (photons), PAR is also called quantum light. Measuring quantum light is the only way to be certain your plants are getting all the usable light they need.

DLI: The day's total of quantum light received is called the Daily Light Integral (DLI).The DLI for outdoor gardens varies considerably depending on latitude, season, and weather. For example, in the middle latitudes of the U.S. a sunny summer day will produce a DLI of roughly 26 moles/day; if it's cloudy, the DLI drops to about 12 moles/day. In the winter, a sunny day yields a DLI of approximately 9 moles/day, and cloudy conditions will reduce that to a mere 3 moles/day.

LIGHT UNIT CONVERSIONS

UNIT	Type of Measurement	Used In	COMPARED WITH 1 fc: Sunlight	High Pressure Sodium	Metal Halide	Cool-white Fluorescent	Incandescent 100w
FOOT-CANDLES [fc]	Visible (human eye)	Industry (U.S.)	1	1	1	1	1
LUX	Visible (human eye)	Industry (Europe)	10.76	10.76	10.76	10.76	10.76
$\mu mol \cdot m^{2} \cdot s^{-1}$ of PAR (400-700 nm)	Quanta of light	Horticulture in PAR range	0.20 research	0.13	0.15	0.15	0.22
$mol \cdot m^{-2} \cdot d^{-1}$ of PAR (or moles/day)	"daily light integral" accumulated PAR light during an entire day	Horticulture research	fc x .000718 x hours of light	fc x .000473 hours of light	fc x .000546 x hours of light	fc x .000524 x hours of light	fc x .000775 hours of light
$W \cdot m^{-2}$ (PAR)	Energy in PAR rang	Engineers, research	0.044	0.026	0.033	0.032	0.043
$W \cdot m^{-2}$ (PAR)	Total Energy	Engineers, research, heat loads	0.101	0.073	0.089	0.081	0.567

In addition to using light for energy, plants use it to regulate growth.

Plants use blue light to determine what direction to grow, an effect called phototropism and heliotropism (solar tracking).

Whether stems are elongated or stout is also determined by light. Far-red promotes elongation; red and blue promote stout stems.

Red and far-red light play a role in controlling flowering and other developmental processes red light at 680 nm stops plants from flowering. Far-red light at 730 nm just beyond visible red on the spectrum, promotes flowering in the absence of red light.

UVA light is at the wavelength of the invisible portion of emissions from black-lights. It helps reverse damage done to plant DNA by UVB light, as well as stimulating the production of anthocyanin and other flavonoids.

UVB light affects the potency of high-quality plants. The amount of THC a plant produces increases as it receives more UVB light. This light can be provided to indoor plants with proper lighting. Outdoors, the amount of UVB light is highest at the beginning of summer. By late September, the amount is a fraction of summer levels. (*For more information on using UVB light to increase potency, see Flowering.*) In humans, UVB causes tanning and sunburn.

Visible and near visible light ranges from about 200 nm in the UVC region to about 800 nm in the far-red region, with human vision able to detect light from about 400 nm in the blue-violet to about 730 nm in the far-red, with a peak sensitivity at 550 nm in the green region. Ozone in the atmosphere filters out the very high-energy photons coming from the sun in the UVC region below 200 nm to 290 nm. UVB from 290 nm to 320 nm penetrates the atmosphere and, while it causes sunburn and skin cancer, it is useful to plants that use it to produce flavonoids and terpenes, including THC in cannabis. UVA from 320 nm to 400 nm is also very important for plant growth and is able to contribute to photosynthesis as well as other responses such as phototropism.

The most important region of the light spectrum for plant growth is what is known as Photosynthetically Active Radiation (PAR), between 400 nm and 700 nm. PAR is typically measured in terms of how many total photons reach an area. The units for measuring it are typically expressed in millionths of a mole per square meter per second (μmol/sq m/s), with full sunlight registering at about 2,000 μmol/sq m/s, depending on latitude and season.

When a photon is absorbed by a chlorophyll molecule, its energy is transferred to an electron and it ceases to exist. Several things can happen to this excited electron. The energy absorbed can be lost either as heat, when the excited electron drops back to its ground state, or as light, causing fluorescence at longer wavelengths. Most importantly, it can be transferred to another molecule in close proximity causing a chemical reaction that results in photosynthesis.

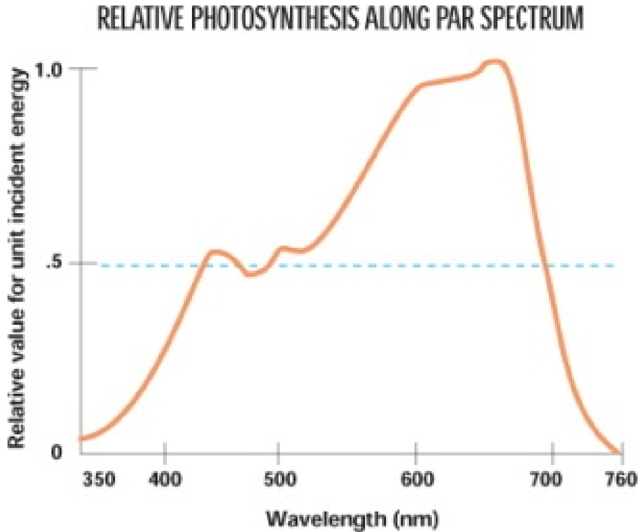


Chart shows photosynthesis results at each wavelength along the PAR spectrum

A light meter reads the foot-candles in the space; there are sensors atop the meter that detect and measure the light. Be sure to take measurements at canopy level, where your plants should be getting the most light possible.

UVC is germicidal; the sterilizing light is used in some hydroponic systems (*see Hydroponics*). It is harmful to humans and other animals.

Since lumens, **lux**, candles, and foot-candles are all measures of light in the narrow range of human sensitivity, they don't accurately measure all the light to which plants are sensitive.

The better measure of light in relationship to its usefulness to plants is Photosynthetically Active Radiation (**PAR**), which includes the range from 400-700 nm. PAR is typically measured in terms of how many total photons reach an area. The units for measuring it are typically expressed in millionths of a mole per square meter per second (µmol/sqmsq m/s), with full sunlight registering at about 2,000 µmol/sq m/s, depending on latitude and season.

Nonetheless, PAR measurements do not measure far-red and UV light. Nor do they take into account the differences in how plants absorb and use various wavelengths. For example, plants use light in the red range almost as efficiently as blue light, though blue light is more expensive to produce. Still, PAR is a more meaningful measure than the others.

LIGHT METERS

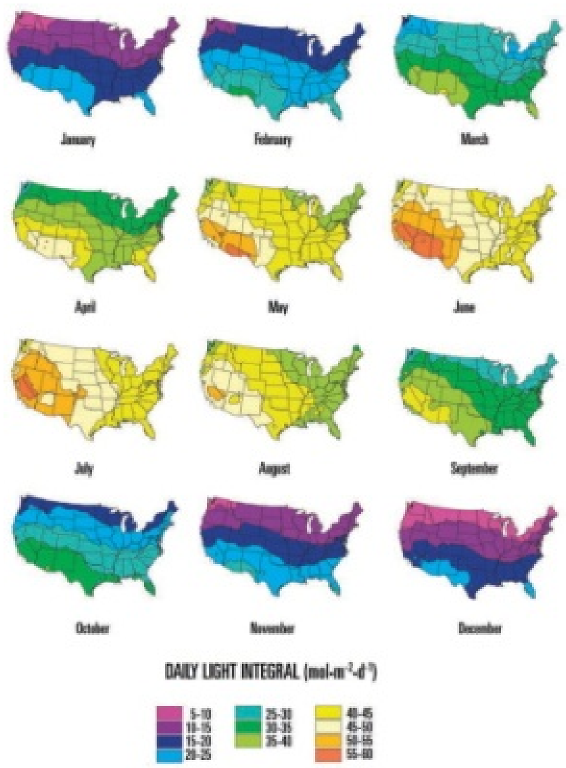
Most gardeners probably will not purchase a meter because a great garden with excellent buds can be grown just by calculating the watt input of the particular garden lights you use. But foot-candle and quantum light meters are a great source of information and come in very handy. Rather than guesstimating the light reaching the garden, the meters provide you with an accurate reading. A light meter lets you double-check your calculations and helps you ensure that you have set up a garden with light distributed evenly throughout.

OUTDOOR GROWING

The best source of light is the sun. It requires no expense, no electricity, and its bright beams do not draw suspicion. During the summer, the sun is brighter than artificial lighting and is self-regulating. Outdoors, on a clear day at the beginning of summer, when sunlight hits Earth at the most direct angle, the light's intensity can reach 15,000 **foot-candles** (161,000 lux) at noon, the brightest part of the day. Plants may not be able to process all the light at its peak, since marijuana plants are probably not able to use more than 7,000-7,500 fc (75,000-80,000 lux). Measured throughout the day from dawn to dusk, the average intensity is much less, probably 1,000-2,000 fc (10,700-21,500 lux). Of that, only about 20% of sunlight is PAR. The rest of the light spectrum is not used by plants. The excess light is converted into heat and then dissipated through **transpiration**, re-radiated as infrared heat, or dissipated using biochemical processes.

Marijuana is a sun-loving plant. It grows fastest and is most potent when it gets unobstructed light all day. Plants in containers can be moved back into bright light when they become shaded.

These plants were given enough room to grow into giants. They were grown with 6’ (1.82 m) of space between plants. Sailcloth was used to diffuse the sunlight.



This chart shows how much light plants receive daily over the course of a year. During the fall and winter the amount of light is based mostly on latitude. Notice that light levels drop dramatically during September, just as the plants are ripening. By October light has dropped in half as compared with June. By December it is down by nearly two-thirds. During the summer light intensity varies more by longitude. For example, the western half of the United States receives 50% more light than the eastern half. The eastern portion receives the least light, while intensity is higher in the Midwest and even more intense in the west. The southern portion of California and Nevada receive the most light.

Marijuana plants do best under full light all day. Gardeners can use the sun as the primary source of light if they have a garden, greenhouse, terrace, patio, roof, or skylights or even a directly lit window. Bright spaces that are lit from unobstructed sunlight at least five hours a day usually need no supplemental light during the summer.

Autumn light can be more problematic. If the garden continues to receive direct sunlight, there is usually enough light for the buds to mature. However, if the light changes in the fall so the plants get little direct sun, they will need artificial light to supplement the weak sunlight, overcast conditions, and oblique angles that create shadows. Without the additional light, buds do not develop properly. They grow loose and airy, and not particularly potent. Natural light can be supplemented using the same kinds of lights gardeners use for indoor gardens.

To find out exactly how much your plants are getting, use a light meter. If the light is close to 4,500 fc (48,375 lux) for five hours or more, the space is bright enough. Lower light levels result in less growth and slower ripening, and lower yield and quality.

USING A CAMERA LIGHT METER

You don't have to use a special meter to measure foot-candles. The light meter in a 35mm camera will work, too—provided it's a camera with adjustable settings. All you need is a large sheet of white paper or cardboard. To calculate the number of foot-candles of light reaching your garden, prop the paper or cardboard at a 45-degree angle at the height of the plant canopy. Set the camera's ASA (film

speed) dial at 100 and the shutter speed at 1/15 of a second. Then adjust the f-stop for proper exposure, as if you were taking a photo. The f-stop reading correlates to foot-candles, as listed below.

AT ASA 100 AND 1/15 SECOND:

f4	**=**	**10 fc**
f5.6	**=**	**20 fc**
f8	**=**	**40 fc**
f1	**=**	**80 fc**
f16	**=**	**160 fc**

If you've got more light than that, use higher settings on your camera. With the ASA speed set to 200 and the shutter speed at 1/125, the f-stop for proper exposure foot-candles are as follows:

AT ASA 400 AND 1/125 SECOND:

f4	**=**	**128 fc**
f5.6	**=**	**256 fc**
f8	**=**	**512 fc**
f11	**=**	**1024 fc**
f16	**=**	**2048 fc**
f22	**=**	**4096 fc**
f32	**=**	**8192 fc**

In higher latitudes, plants must be harvested early in the fall to accommodate climactic conditions. Unfortunately, during autumn, when the plants are finishing flower growth and ripening, both the length and intensity of light diminishes. This reduces yield from its potential. There are three possible solutions: force the plants early, supplement the sunlight with electric lighting, or grow early-maturing plants.

In the Daily Light Integral (DLI) chart you can see how much the moles per day changes from August through October. In August, the DLI ranges from 35 moles per day in the eastern U.S., to 45-50 in the west. In October the patterns change between north and south. The southwest receives 35-40 moles per day, but the rest of the country, except for the far north, receives only 20-30 moles per day. In addition to the low light levels, the sun delivers very little UVB light by mid-autumn.

To convert µmol/sq m/s to daily light integrals in µmol/sq m/day multiply by the number of seconds of light applied. For example, if you are growing plants in a garden with 1,000 µmol/sq m/s under continuous light (24h), you would have 1,000 x 3,600 s/h (seconds in an hour) x 24 hours or 86.4 µmol/sq m/day. For a 12-hour photoperiod, this would be 43.2 µmol/sq m/day. What could be easier? It should be noted that the average daily light integral in the summer in Arizona is about 65 µmol/sq m/day, while in New York during the winter it is only about 25 µmol/sq m/day.

Sunlight at noon on a clear early summer day produces about 2,000 µmol/sq m/s (10,000 fc or about 110,000 lux) at latitude 39˚ in Maryland, which lies in a middle latitude of the U.S. At higher latitudes, the light is weaker; at lower latitudes, it is stronger. It is stronger west of the Mississippi River in North America than east of the river.

HPS lamps’ amber color reflecting from a white wall.

Most gardens with MH or HPS lamps produce about 1,000 µmol/sq m/s (5000 fc, 55,000 lux) at the top of the canopy.

Gardens with fluorescent lamps seldom produce more than about 300-500 µmol/sqmsq m/s (1500 fc, 15 lux).

During autumn, gardens located in windows and terraces may receive direct light as the light comes from a more oblique angle. If they receive direct sunlight, the plants are probably getting enough light. Sometimes window spaces that are shaded in the summer get direct light in the fall as the sun's angle changes seasonally. If plants get only indirect light, even bright light, they require supplemental lighting. Using artificial lights to supply light to plants on a patio or terrace, or in a greenhouse or a window, need not cause suspicion. Use a metal halide (MH) lamp, which emits a clear light that blends in with natural light.

One rule of thumb is to supplement autumn's low light levels with about 20-30 watts per square foot (215-320 w/m) for about five hours a day during daylight. A 1000w lamp enhances the light of a square with 6-7 foot (7.8-2.1 m) sides. If the lights are on during the brightest part of the day, their light will go unnoticed by passersby, but not the plants. You can safely use metal halide lamps or fluorescent tubes designed for reptiles to provide UVB spectrum light. HPS lamps are available in many wattages and are very efficient. However, they should be used with caution because they emit a distinctive amber light that may be noticed by neighbors or passersby. MH lamps produce a "white" light that is less noticeable and also contains helpful UVB light. The lights also supply heat to the plant, which can be helpful in autumn.

INDOORS

Plants in indoor gardens require very bright light to grow well and yield a good crop. However, varieties differ in the amount of light they require to support fast growth and high performance flower development. Sativas require the most light, followed by sativaindica hybrids, indica-sativa hybrids, then indicas.

Yield and quality increase—and ripening time decreases—when plants are grown under bright lights and provided with their other needs.

Sativas require the most light. They evolved below the 30th parallel, near the equator, and are adapted to long periods of intense sun.

Sativaindica hybrids need less intense light than sativas, but still do best with light on the high range.

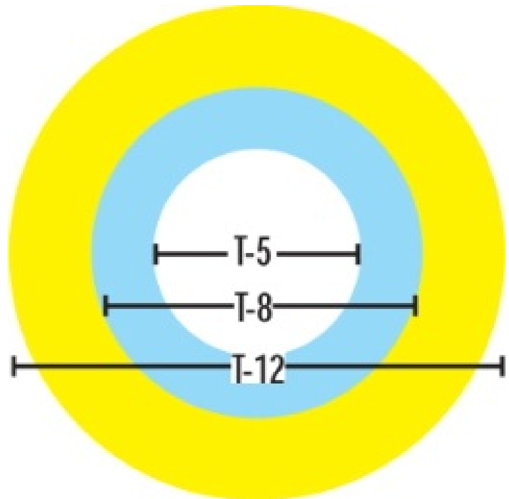
Indica-sativa hybrids are more light-forgiving than sativa-based plants. They can function in the mid-to-low light range.

Indicas need the least intense light of any of the varieties. They evolved in northern latitudes and are the best bet for low-light gardens.

During the growth cycle, most varieties will do well with 2000-2500 fc, (21,500-27,000 lux, 400-500 µmol/sq m/s) although the plants can efficiently use 5000fc (54,000 lux, 1000 µmol/sq m/s) or more. The more light they receive during vegetative growth, the faster their growth and the sturdier their stems. When grown under low light, or under a leafy canopy or when shaded by trees or other tall plants, all varieties develop long internodes (spaces on the stem between the leaves) due to the enhanced far-red light; plants with equatorial genetics are more affected by this.

Equatorial sativas need intense light and do best with between 70-80 watts per square foot (w/sq ft) (750-860 watts per square meter (w/sq m)). With less light the buds will be loose and lanky.

Sativaindica hybrids require bright light. They will produce luscious buds when illuminated with as little as 60 w/sq ft (640 w/sq m).



T-12 fluorescents are tubes that have a diameter of 1.5” (4 cm) are the least efficient. They will soon be phased out. T-8 tubes are 1” (2.5 cm) in diameter. T-5 tubes are 5.8” (15 cm) in diameter and are the most efficient fluorescents.

Fluorescent bulbs are classified according to the size of the tube. The diameter is listed as its “T” number, such as T-5, T-8, or T-12, with the number signifying how many eighths of an inch they are. So T-5 tubes are ⅝ inch; T-8 are 1 inch (8⁄8”); and T-12s are 1½ inches (12⁄8”). One problem with T-8 and T-12 fluorescent tubes is that their large diameters prevent them from being spaced as closely as T-5s, so it is difficult to get the light intensity necessary to produce the highest-quality bud.

Indica-sativa hybrids require less light and can produce very good buds using about 50-60 w/sq ft (535-640 w/sq m).

Indicas need the least amount of light to thrive. Some indicas produce well starting at about 40 w/sq ft (430 w/sq m), though others need 50 w/sq ft (535 w/sq m) to produce nice, tight buds. More light, 60 w/sq ft (640 w/sq m) doesn’t hurt; at 60 w/sq ft (60 w/sq m), the buds will be larger, tighter, and more potent.

Gardeners have a wide selection of lights to choose from. These include fluorescents, metal halides lamps, high-pressure sodium lamps, and LEDs. Cultivators rarely use incandescent or quartz halogen lights. These lamps are inefficient, converting only about 10%–20% of the energy they use to light and wasting the rest creating heat. If you are planning to use an incandescent lamp to light a “dark spot,” don’t. Use a compact fluorescent or LED instead.

FLUORESCENT LIGHTS

Growers have used fluorescent tubes to provide light since the early years of indoor cultivation in the 1960’s. They are inexpensive, easy to set up, and are fairly efficient, though they do require special fixtures and ballasts. Plants grow and bud adequately under them. However, fluorescents do not create the intensity of light emitted high-pressure sodium (HPS) lamps, so they usually don’t produce the large, tight buds the more powerful lamps do.

Fluorescents come with various spectral outputs, which are determined by the type of phosphor used to coat the surface of the tube. Each phosphor type emits a different set of light colors, identified as “warm white,” “cool white,” and “daylight” or “natural white.” These names signify the kind of light the tube produces, with daylight or natural white coming closest to approximating the sun’s spectrum. Lamps of different spectrums can use the same fixtures.

Vegetative garden growing under fluorescents. The tubes were installed in two light fixtures. Three tubes lit each foot (30 cm) of width of the garden.

Fluorescents are excellent tubes to use for cloning because the light is delivered evenly over a long space and the tubes don't produce too much heat.

Cool white fluorescents emit more blue light than warm white. They are useful during the vegetative stage of marijuana growth because the blue light promotes stout, compact stem growth.

Fluorescents are three to four times more efficient than incandescent lights. For instance, you might see 20w fluorescents advertised as delivering the equivalent light output as a 75w bulb. The lamps they are being compared to are incandescents. But fluorescents are only 50-75% as efficient as high-pressure sodium (HPS) lamps. Even that comparison is not as exact as it seems because of other factors, including emitted light spectrums (some lights produce more PAR than others) and lamp placement requirements (cooler fluorescents can be kept closer to the canopy than hot HPS lamps).

Warm whites emit more red light than cool whites and are used during flowering because the red spectrum promotes flower growth. All of these lamps are readily available.

Several brands of special “Plant Growth” lamps are available. They concentrate their light emissions in the red and blue spectrums to provide plants with the more energy in wavelengths the chlorophyll can use. However, they produce less total light.

High Output (HO) fluorescents are supercharged fluorescents Use almost twice the power of standard fluorescent lamps. They can illuminate a garden very brightly and are an alternative light source to using a high-intensity discharge lamp. They are readily available in both T-5 and T-8 tube sizes. They make it a lot easier than adding more fluorescent fixtures to increase the intensity of light that gets to the plants.

T-8 STRAIGHT LENGTH TUBES

T-8 tubes are one-inch wide and come in lengths of 2, 4, 6, or 8 feet (0.6, 1.2, 1.8 or 2.4 m). They are typically mounted in standard reflectors. Conventional T-8 tubes use about eight watts per linear foot and produce approximately 650-700 lumens per foot (0.3 m). T-8 fluorescents emit about 15% more light per watt than T-12s. Their diameter makes it hard to place more than four of these tubes per foot (0.3 m), even without individual reflectors. Although reflectors maximize the light coming from each tube, it is difficult to place more than three per foot (0.3 m). These lamps are best suited for rooting clones and adding supplemental light to the garden. More useful are the HO T-8 fluorescents, which use about 12-14 watts per square foot (0.09 sq m) and produce 1,000-1,250 lumens per foot (0.3 m), so they can deliver more light to the plant.

T-5 STRAIGHT LENGTH TUBES

T-5 tubes are 5⁄8 inches (1.5 cm) wide and also come in a variety of lengths. A more recent introduction to North America, they use different ballasts and fixtures than the T-8 tubes. T-5 tubes emit almost 30% more light per watt than T-8s. Their more compact size means it is possible to fit four T-5 tubes in each foot of width. T-5 tubes are available in HO models, which are the ones usually sold in shops. A 4-foot HO tube uses 54 watts and emits roughly 5,000 lumens, almost twice as much output as a conventional T-5. A bank of eight, four-foot T-5 HO tubes emits 40,000 lumens and uses about 435 watts, as compared to a 400w HPS that actually uses 440w and produces about 50,000 lumens. Placed over a 4’x4’ area (16 sq ft or 1.5 sq m) the intensity is 2,500 foot-candles. T-5 HO fluorescents use about 60% more electricity than regular T-5s.

T-5 fluorescent lamps are very efficient sources of light. The tubes are thinner than other fluorescents, so they can be placed closer together. The reflectors have baffles that reflect the light so little is lost to the garden.

COMPACT FLUORESCENTS (CFLs)

Compact fluorescents are often the most convenient lamps to use in small gardens. Unlike other fluorescent bulbs, they have ballasts built into the bulb assembly, so they can screw into standard incandescent sockets. They are available as floodlights, twisted tubes, straight mini-tubes, and as 8-or 12-inch diameter circular fluorescent tubes. U-shaped screw-in fluorescents are also available. Another advantage of CFLs is that they deliver a lot of light from a small point. Unlike tube fluorescents that deliver their light over a large area, often spanning several feet, the compacts “point of light” emissions make it easier to increase light intensity by grouping them close to each other. Large-wattage CFL lamps are available in sizes of 25, 50, 100, 150, 200, and 250 watts.

The light emitted from CFL lamps is undirected. Since any light that doesn’t reach the plants is wasted, use reflectors to get the lights to the garden. Inexpensive clamp-on light fixtures with bowl reflectors and screw sockets make it easy to position the lamps.

To maintain a fast growing garden, a minimum of 30 watts of fluorescent light per square foot is required during the vegetative growth period. More light—up to 40-60 watts per square foot—produces more high-quality growth. As long as the plants’ other needs are met, the more light that the plants receive, the faster and bushier they will grow.

Compact fluorescents come in many wattages, up to about 200 watts. They’re not as efficient as HPS lamps, but are easier to set up.

You can use fluorescent lights in innovative ways to supplement the main source of light. Mixing light sources such as fluorescents or LEDs with High Intensity Discharge (HID) lamps helps the garden because together they provide more light and can fill in partially shaded areas. Fluorescent lights can be mounted along the sides of the garden or placed in the midst of it. Fluorescent light wands or work lights can be hung vertically in the midst of the garden or horizontally between rows. No reflector is needed for mid-garden applications, because the tube can shine on the plants from every angle.

Both fluorescent and LED lights should be placed about 2-10 inches from the tops of the plants. Don’t let the leaves touch them, because they will be burned.

Use bowl reflectors with CFLs.

CFLs emit the most light when they are positioned with the base up; base down they emit less. Horizontally placed lamps work least efficiently.

METAL HALIDE LAMPS (MH)

MH lamps are the type of lamp used outdoors to illuminate sports events because they emit a white light. They were originally promoted as the light to use during the vegetative stage of plant growth, before the plants are forced to flower. But now it is generally recognized that plants grow as well vegetatively under HPS lamps as under MH, so they are not used that much because they emit less total light than HPS lamps and produce lower yields.

MH lamps, like fluorescents, come in many spectrums. This is a very important factor in figuring how effective your lamp is. In general, 15% of the energy used by MH lamps is emitted as PAR, as compared with 13% for HPS. But the crisp white light emitted by standard MH lamps is low in the red spectrum. Since plants need red spectrum light for photosynthesis and flowering, its absence is felt. Nonetheless, under metal halides, plants grow quickly and flowering is profuse, with heavier budding than under fluorescents. The brighter light penetrates a bit deeper into the canopy.

These plants are growing well under high power CFL fluorescents. The fluorescents supply intense light to the garden producing much less heat than exotics.

MH lamps may be the solution to plant lighting problems indoors and out. These are ideal lights for a garden where the amber light spectrum of an HPS would be indiscreet. During the fall, metal halide lamps can be used in backyard gardens to supply the extra energy boost needed to ripen. Run the lights during the day to supplement the ambient light. Although the light they emit is very bright, it is white, not the unusual amber color emitted by HPS lamps, so it is not as likely to cause suspicion.

MH lamps come in 250-, 400-and 1000-watt sizes. The 250w lamp can light a garden 2’ x 2’ (60 x 60 cm). The 400w lamps can easily illuminate a small garden 3’ x 3’ (90 x 90 cm) or smaller. The 1000w lamp can illuminate a garden of about 4’ x 4’ (120 x 120 cm).

The lamps are convenient to use. The complete unit consists of a lamp (bulb), fixture (reflector) and long cord that plugs into a remote ballast. The fixture and lamp are lightweight and are easy to hang. A chain or rope is used to suspend the fixture, which takes up little space, making it easy to gain access to the garden.

ASK ED: Marijuana Questions

BROKEN METAL HALIDE BULB

I recently saw a warning about UV emissions. The author stated that if the protective glass around a metal halide were to break, you should unplug it immediately because without this glass, the metal halide would emit harmful levels of UV radiation. Since reading in your ASK ED book about increased UVB increasing the THC production, I have been looking for a good source of UVB supplementation. Have you ever heard of anyone removing the glass from a MH to increase UVB? How much increased UVB would you receive? Or, is it truly unsafe to do so?

It is unsafe to use a MH with a broken outer bulb. Not only does it emit large amounts of harmful UVB rays, which cause sunburns. It also releases UVC light, which is deadly to most life forms. Broken MH lamps are not something you want to tinker with.

METAL HALIDES & ULTRAVIOLET LIGHT (UV)

Ultraviolet (UV) light, as discussed above, is composed of spectrums beyond blue that are invisible to humans but are visible to many animals. UV light is divided into three bands—UVA, UVB, and UVC. UVB is critical to the development of THC. The potency of marijuana is dependant on the amount of UVB light it receives. Metal halides emit UV light and can be used for this purpose.

Even if plants are being grown under HPS lamps, potency—that is, THC content—will increase significantly if they are replaced with metal halides during the last two weeks of flowering. Just be aware that the protective glass in air-cooled MH fixtures absorbs UV light before it gets to your garden. So the only way to benefit from the UV output is to remove the glass and take other steps to cool the light.

HIGH PRESSURE SODIUM VAPOR LAMPS (HPS)

High-pressure sodium (HPS) vapor lamps emit an orange or amber-looking light. HPS lamps are commonly used as streetlights. Their spectrum is heavily concentrated in the yellow, orange, and red spectrums with only a small amount of blue. HPS lights are usually used for flowering because they supply more orange and red light than MH lamps. The increased red and yellow light seems to promote more flower production.

Gardeners usually use HPS sizes of 150, 250, 400, 600, 750 or 1000 watts, all of which are sold in indoor garden shops. They produce about 15% more light than MH and use the same configuration: lamp, reflector, and remote ballast. The 600-and 750w HPS lamps are about 7% more efficient than the other sizes.

Small watt HPS lamps are available in hardware stores. They are used for outdoor lighting. They can be used to light tiny gardens and for brightening shaded or dark areas of the garden or to extend the canopy when plants bush out.

Space HPS lamps so they provide an even light throughout the garden. Placing the lights about a meter (about 3’) apart provides an input of approximately 60 watts per sq ft (660 watts per sq m).

HPS lamps emit 13% of the energy they use as PAR. The 250w lamp can light a garden 2’ x 2’ (60 x 60 cm). The 400w lamps can easily illuminate a small garden 3’ x 3’ (90 x 90 cm) or smaller. The 600w lamp illuminates a garden about 3.5’ x 3.5’, the 1000w lamp can illuminate a garden of about 4’ x 4’ (120 x 120 cm).

HPS lamps support fast growth during both vegetative and flowering stages. They need no supplemental lighting during any stage of growth. HPS lamp brands and models differ in both the amount of light emitted per watt and in the spectrum that is emitted.

Some HPS lamps emit enhanced levels of blue light, which encourages stout short stems and branches. Since light of particular spectrum is processed differently by plants, some lamps produce more growth and flowering than others. For more about the differences between HPS bulbs, see the website for the results of our tests of many of the most popular brands.

AGING HID LAMPS

How can I tell when a working HPS or metal halide bulb is ready for retirement? I've read that the bulbs emit less light over time. If the amount of light declines gradually, I might not notice the light decline. Should I mark the bulbs with the date I put them into service? How long do the bulbs last?

Lights become dimmer as they age. To check a lamp use a light meter or compare the old lamp with a new one. Bulbs should be replaced after about 8 or 9 months if they are being used for flowering, or after five months if the lamp is on continuously. Their light production diminishes with time and use.

Gardeners often combine HPS and MH lamps because they think blue light from the MH lamps keeps the stems stouter and shorter. But any benefit is likely to be far less than they would suppose. The red light of HPS lamps does not cause plants to stretch. **Stretching** is caused by far-red light, and HPS lamps don't emit light in those wavelengths. Confusion about this stems from how similar the light from incandescent lamps and HPS lamps look. Both emit visible light primarily in the yellow, orange and red spectrums, so gardeners confuse the spectrums of the two lamps. But incandescent bulbs emit more far-red than visible light, and HPS lamps don't.

BALLASTS

Each MH and HPS lamp has an electrical system that requires conversion to higher voltage than is delivered through the electrical grid. The ballast converts house current to the appropriate voltage. Ballasts used to power garden lights are usually remote from the light, connected by a long electrical cord. The convenience of this is that the heavy ballasts are not hanging from the ceiling, only the much lighter and less cumbersome reflector and bulb are stationed above the plant canopy.

Old-style magnetic ballasts are dedicated to a particular type and watt lamp and a single grid voltage, such as 110 or 220. Most digital ballasts can be used for both MH and HPS lamps of the same wattage and can be used with both 110 and 220 voltage. Some can power different wattage lamps.

Digital ballasts are the most efficient way to power indoor lights. Quantium Ballasts are equipped with a dimmer switch that allows the grower to regulate the energy output and intensity of the lights. Lamps powered by digital ballasts emit 15-20% more light than a standard electromagnetic core ballast.

Compared to magnetic ballasts, digital ballasts are more convenient to use for several other reasons:

- Magnetic ballasts use 20% more electricity than the bulb is rated to convert the electricity to an appropriate form. Digital ballasts use about 10%, half the current of a magnetic. As a result a 1000w lamp and magnetic ballast consume 1,200+ watts.

- Magnetic ballasts contain an iron magnetic core so they are heavy. A ballast for a 1000w lamp weighs between 35 lbs (16 kg) (MH), 44 lbs (20 kg) (HPS), and up to 54 lbs (24.5 kg) for a MH/HPS convertible unit. Digital ballasts weigh much less, only 8-12 lbs and most often ignite both MH and HPS bulbs.
- All magnetic ballasts hum. Digital ballasts are silent.
- Digital ballasts are gentler on the bulb during start-up.
- Digital ballasts regulate currency more precisely. The bulb receives a more even electrical flow so it is stressed less. It lasts longer, emits a brighter light, and doesn't flicker.
- Digital ballasts are "smart". They recognize the type and size of bulb that they are powering, so a single ballast can be used for either a HPS or MH bulb.
- Digital ballasts turn themselves off if they encounter any kind of problem.
- Magnetic ballasts emit a lot of heat. Digital ballasts produce a lot less.
- Digital ballasts are more expensive than magnetic ballasts, but they save electricity, labor, and effort while producing more light, resulting in more bud.

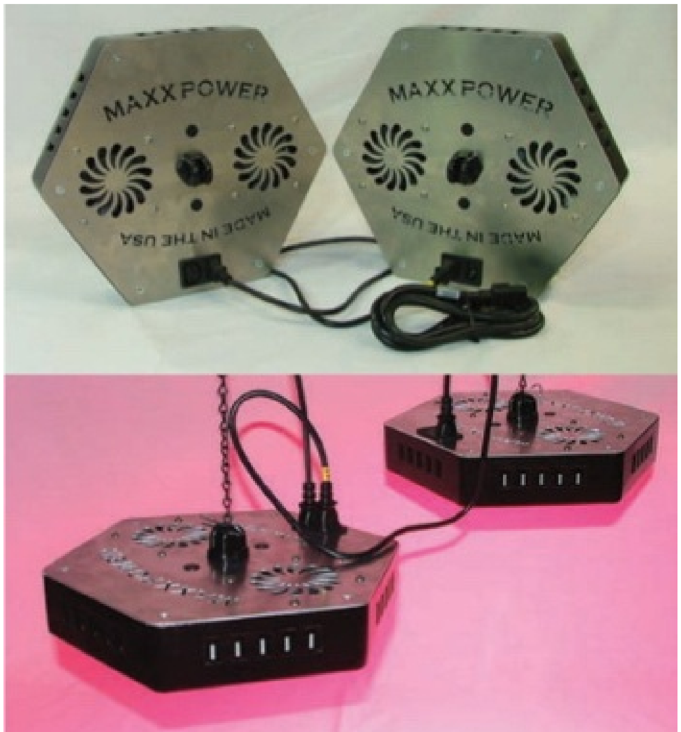
Digital ballasts have many advantages over electromagenetic ballasts, they are quieter and more efficient, and operate at a higher frequency, minimizing the wear and increasing lamp life. The Global Greenhouse Ballast is lightweight, creates very little heat, and works with both MH and HPS lamps.

LED LIGHTS

The latest addition to indoor lighting options is lamps made from Light Emitting Diodes (LEDs). LEDs come in many configurations, including flood lights, panels, bars, circles, and rectangular fixtures. LEDs create little heat, and fixtures are only three or four inches deep, so they make great lamps for closet cultivation or other spaces where height is an issue. LEDs are also highly efficient, using less electricity than HIDs and even fluorescents.

LEDs are unique among lighting systems because each diode emits light in an unusually narrow spectrum. The minerals used to make it determine the spectrum the diode emits. HID lamps emit most of their light in spectrums that are not very useful to the plant. With LEDs, fixtures can be designed to provide the plants with exactly the spectrum that they need for maximum growth.

LED lights emit light in a narrow portion of the light spectrum. Light output is concentrated in the light bands that plants use most efficiently, red and blue. The Supernova LED by HidHut features adjustable lighting controls that allow the grower to determine the ratio of blue to red light it projects. Fans are built into the equipment so very little heat is produced.



LEDs emit very little heat and can be placed very close to the plants. The light spreads at a 120° angle. This LED from Maxx Power has a built in digital driver that monitors the power going to the bulbs 100 times a second and adjusts accordingly to ensure that maximum output is being achieved.

By tailoring the diodes' light spectrum to plant requirements, LEDs can be more efficient PAR producers. HPS lamps deliver more total light per watt of input, but LEDs are twice as efficient in PAR light per watt as HPS lamps. That means a 200w LED lamp can be substituted for a 400w HPS lamp, and the 300w LED lamps can be substituted for 600w HPS lamps. The first generations of LED lamps did not emit an intense-enough light to support either active vegetative growth or flowering, but modern fixtures, which use higher-capacity diodes, have solved those early problems.

LEDs are lightweight, highly efficient light producers and emit far less heat than HPS lamps. They are also easy to install. The Stealth LED™ grow light has a 50,000 hour lifetime and reduces energy consumption as compared with HPS or MH systems by 60-70%.

LED fixtures cost more than HID lights, but save money in the long run:

- **LED lamps use less than half the electricity of HIDs per unit of PAR light produced. At $.10 a kilowatt, LEDs will save $215 per year when compared to the cost of running a 1000w HID twelve hours a day.**
- **LEDs last longer than HID bulbs.**
- **LEDs need little to no cooling equipment; HIDs require air or water cooling, ventilation systems, or air conditioners.**

Higher quality systems use mostly red light along with some blue. Just as with any other product, manufacturers' standards differ. A few manufacturers add the green light NASA has shown to be effective with plants, and amber is also sometimes added. Most manufacturers include a few white light emitters in their units. These diodes actually emit a combination of red, green, and blue spectrums, which combine to appear white. White lights help to both supply useful wavelengths for the plants and soften the eerie purple color generated by the combination of red and blue light. Luckily, the spectrum range is usually wider than the band that is guaranteed for each emitter.

Apache Tech LEDs are scientifically designed to enhance plant growth. Red and blue peaks power photosynthesis. Other spectrums required are supplied using white LEDs. The high-output LEDs are very efficient so they save electricity, operate at about 90° F (32° C), eliminating excess heat, and last 50,000 hours for low maintenance. Photo lower left: El Eddy, photo right: Rylar Sonwil

LEDs are powered by either a transformer or a digital driver. Transformers are similar to old-style magnetic ballasts for HID units; they use more energy than digital controllers and produce heat that may need to be dissipated. This is a small consideration compared to the heat HPS lamps produce, which has to be vented. LED lamps emit virtually no heat, so they can be placed very close to the garden and are not encumbered with tubes for air or water cooling, heavy ventilation, or any of the other problems or inconveniences of HID lamps.

Light from LEDs can be combined with HPS and MH lamps, so there is no reason to scrap your digital HID lamp. Adding LEDs to your other lights increases the amount of light delivered to the garden. For instance, a garden using a 400w HPS can be increased to the equivalent of 600 watts using 100 watts of LEDs. Adding 300 watts of LEDs creates the equivalent of a 1000w HID system.

An advantage of using a combination of HPS and LED lights is that you can ensure that you are providing all the spectrums that plants need to thrive. If more HID lamps rather than LEDs are used, they add PAR light, but most of the increase is in the yellow spectrum. Adding red and blue LEDs instead increases PAR light, but not in the yellow spectrum. Excess yellow light forces the plants' xanthophyll to absorb the heat created by the less useable light falling on the leaf surface. Red and blue LEDs put no additional stress on that pigment. LEDs can be used to amend the light spectrum during flowering. Adding red spectrum during the last half of flowering increases the size and density of the buds and shortens flowering time.

T-5 lights, such as these HID T-5 lights from Amerinada, are the most efficient fluorescent lights available.

LIGHT ACCESSORIES AND LIGHT REFLECTORS

Light doesn't become weaker or disappear with distance. It appears to dim as the light beam widens over a larger area. As it spreads, its intensity dissipates. Just think of a flashlight. If you can keep the beam tightly focused, it will have the same intensity at the focus point as it had at the point of emission. The larger an area of the garden that a lamp illuminates, the less intense the light that plants receive.

Reflectors are a way to keep the light from your lamps focused where you need it. The three types of lamps discussed—fluorescents, MH, and HPS—all emit light in all directions. Only a portion of the light shines directly on the garden. Unless it is redirected, the light illuminates wall and ceiling.

Any light emitted by the lamps that doesn't reach the plants is wasted and might as well not have been produced. There are many solutions, and all but a few involve the use of light reflectors.

FLUORESCENT LIGHT REFLECTORS

The shape of your fluorescent reflector determines, to a great extent, how much light the plants receive. Use the best reflector available. Many fixtures with reflectors place the tubes too close to each other, so that only about 60% of the light is actually transmitted out of the unit. The rest is trapped between the tubes or bounces back and forth between the tubes and the reflector. This light may as well not be emitted, since it is doing no good.

Look for reflectors that have small mini-reflectors or baffles between the tubes. They are angled to reflect the light downward and to separate the light from the different tubes so that it is not lost bouncing between them. These reflectors are available on the Internet if not locally. A good reflector pays for itself over a short period because increased light results in increased yield.

Wing reflectors like this LumeWing by C.A.P. Controllers are designed to guide the heat up to the top of the room and direct light down to the garden.

HPS lamps with air-cooled reflectors are standard lights used for commercial marijuana gardens. Reflectors are essential in maximizing the efficiency of your lamps. The light is directed to the canopy rather than the ceiling, floors, and walls. Lumenaire by C.A.P. Controllers reflectors fit a variety of bulbs.

Like other fluorescents, CFL bulbs emit light in all directions. Inexpensive clamp-on fixtures with bowl reflectors help direct the light to the garden. Commercial reflectors are available for larger size CFLs. Good reflectors can double the light intensity the garden receives from CFLs.

MH AND HPS REFLECTORS

Both MH and HPS bulbs emit most of the light along their length, so it comes out of the sides of the bulb. Many fixtures orient the bulb horizontally to take advantage of this. The reflector must direct the rest of the light downward.

There are many reflector models, but they can be classified into two general types, depending on which position the bulb is held, horizontally or vertically. For most gardens, horizontally held lamps are preferred.

HORIZONTAL REFLECTORS

Horizontal lamps deliver more light directly to the garden because of the position of the bulb and the direction that light is emitted. Manufacturers have created many designs and each leaves its own illumination footprint. Some focus light in a small area; others are designed to distribute it over a large space. The best reflector for a particular garden depends on the garden’s dimensions and design.

Small one-light or two-light gardens do better with focused reflectors. The light is directed downward, so most of it goes directly to the garden. Focused beam reflectors minimize the light that goes off to the sides. Larger gardens grow more vigorously when the reflectors in the center spread the light over a larger area. The plants receive light coming from different directions, minimizing shadows and giving a larger portion of the plant the opportunity to actively photosynthesize. Reflectors closer to the perimeter should still be close focused so that light remains in the garden.

Tube reflectors spread the light over a wide area and are especially useful in large gardens. They can also be positioned vertically in Coliseum type gardens.

Tube reflectors are very convenient in a large garden because they spread the light over a wide area. When used together, they diffuse light in many directions, reducing the amount of foliage in shadow.

VERTICAL REFLECTORS

When a bulb is held vertically, almost all of the light comes out the side and follows a horizontal path to the walls. This light must be directed down to the garden. None of the commercial vertical reflectors I have seen are well designed. The light they redirect is broadcast over a very wide area. Some reflectors have adjustable bulb positioning so the light is controlled somewhat, but most reflectors are too shallow and miss a large portion of light, so it is lost to the garden. Because of their poor design, vertical reflectors are very inefficient at directing light to the garden.

AIR-COOLED LIGHTS

MH and HPS lamps emit a lot of heat. You should figure each 1,000 watts of light input creates about 3,414 BTUs of heat. Just three of these lamps release the same amount of heat as two electric space heaters. If all of this heat is released into a room temperature garden, it has to be removed either through ventilation or air-cooling.

Air-cooled light reflectors solve part of the problem by removing the hot air before it gets into the room. The fixtures have a bottom glass so the lamp is totally enclosed. A six-or eight-inch inline fan is attached to a six-or eight-inch accordion air hose outside of the garden area. It leads to a small pipe extending from one of the short sides of the reflector and supplies it with cool air. Another hose attached to the other side of the reflector leads out of the room. The cooling air travels through the tube and never has contact with the air in the garden. It picks up the lamps' heat but absolutely no odor from the room. The air can be safely exhausted from the structure or used to heat interior space.

Depending on the quality of the air-cooled reflector, between 60 and 90% of the lamp's heat is removed from the room, simplifying temperature management. The one problem with air-cooled lights is that the bottom glass in the fixture absorbs UV-B light and 8% of other spectrums, so the advantage of using MH lamps is eliminated.

Another strategy is to use air-cooled lights with no enclosing glass. Air is drawn from the garden space through the tubing and then cleaned of odor using an in-line carbon filter so it can be exhausted or used for heating. Air above the canopy is pulled up into the reflector, drawing the heat with it. This keeps the canopy cool.

WATER-COOLED REFLECTORS

Water-cooled reflectors work in much the same way as air-cooled reflectors except that, instead of air, water is used. The water is circulated in a closed system in which the water flows across the hot glass of the bulb and is cooled outside the garden. The water exchanges virtually all the heat the lamp emits and then removes it from the room.

There is a natural aversion to the thought of mixing electricity and water. Put those thoughts aside. The water moving inside the tube touches only the glass portion of the bulb. These systems have been available commercially for many years. I have never heard first hand of an accident occurring with them, and the manufacturers are still in business, which also attests to their safety.

The water absorbs about 10% of the light. Unfortunately, more than 10% of the red light is removed because it is the weakest and is absorbed first. UVB light passes through the water, but not the glass.

Air-cooled lights make it easy to keep the garden cool. The circulating air is odorless, so it can be used to heat other areas.

This air-cooled reflector removes most of the heat emitted from the lamp. The lamp produces a lot of heat, about 3400 BTU's.

LIGHT MOVERS

No matter what kind of light reflector you use, it delivers light in an uneven pattern. Usually the center area, directly under the lamp, receives the most light. The intensity of the light tapers off as the distance from the center increases. Moving the lights helps eliminate differences in light intensity. Light shuttles move metal halide and sodium vapor lamps so that the angle of light changes. As the lamps move, each plant section comes directly under the light repeatedly. Instead of plants in the center receiving more light than those on the edge, the light is distributed more equally throughout the garden.

Water-cooled lights and reflectors allow the grower to maximize the light available to the canopy without over-heating the room or burning the plants. They are safe because water never comes in contact with the current. The Fresca Sol light above removes 93% of the heat created by the bulb. From the light, the water goes to a reservoir and sometimes to a heat exchanger located outside of the garden space. After the water is cooled it recirculates back to the lights. With a large enough reservoir such as a hot tub, you can easily cool 8 lamps.

The water removes so much heat that you can touch the reflector without discomfort.

These units increase the efficiency of the light and garden in several ways:

Moving lamps distribute light evenly, so there are no hot spots to create uneven growth. With movers, plants grow more uniformly. Clones from a single variety grow to the same size and ripen at the same time.

Lights can be placed closer to the plants so they receive more intense light with less directed outside the plant area.

Total garden growth and yield increases. Getting light to the formerly light-deprived areas of the garden increases their growth more than less light decreases growth in the formerly favored sections. Expect a 10-20% increase in yield using **light movers**.

Shuttles move lights in one of two ways. Linear models move lights back and forth in a straight line. Circular models move the lights in an arc.

Linear movers have a standard-issue 6-foot movement area. However, some models have shorter lengths, and the distance they travel can be adjusted. Even if you're only moving a single light one foot, the angle of light to the plant changes. Areas that were in constant shadow see the light and respond with increased growth.

Using accessories, light movers can move several fixtures at the same time. The accordion tubing attached to air-cooled lights moves with them.

Lamp movers that travel in a circle are convenient to use with gardens that are square. Some revolve the lights in one direction and then re-trace the journey.

Most of these can be used with air-cooled lights. Rotating movers perform the same function as the linear movers, providing an even source of light throughout the garden.

Spinners are light movers that rotate lights much faster than other light movers. They come in various sizes and hold one to four lamps. Because of the fast speed at which they spin, plants receive a more continuous blast of light. Since the increased airflow generated by the spinning keeps the lamps cooler, the whole unit can be lowered closer to the plants. Although the lamps stay cool, the lamps still spread the heat they emit throughout the room.

Choose a light mover model that is appropriate to use in your garden—linear for a rectangular space, rotating for a square or circular one.

PHOTOPERIODISM IN MARIJUANA

The term short-day is something of a misnomer; what marijuana needs is a sufficiently long night.

Marijuana flowers only if it has been kept in the dark for at least 9-11.5 hours depending on variety, this critical light period occurs for 5-7 days consecutively.

The lights travel in a circle revolving about 270˚ in one direction and then traveling back. Three to five lights can be attached, depending on model. This system is an excellent choice for square gardens that are 8’ x 8’ (240 x 240 cm).

This light mover carries the lamp back and forth over a fixed length, usually 5-6’ (152-162 cm). Photo: SeeMoreBuds

Interruption of an otherwise long night by red light (666 nm) prevents flowering unless it is followed by irradiation with far-red (730 nm) light.

An intense exposure to far-red light at the start of the night reduces the dark requirement by two hours. These responses are mediated by phytochrome.

Phytochromes exist in two interconvertible forms—

- Pr because it absorbs red (R; 660 nm) light;
- Pfr because it absorbs far-red (FR; 730 nm) light.

These are the relationships:

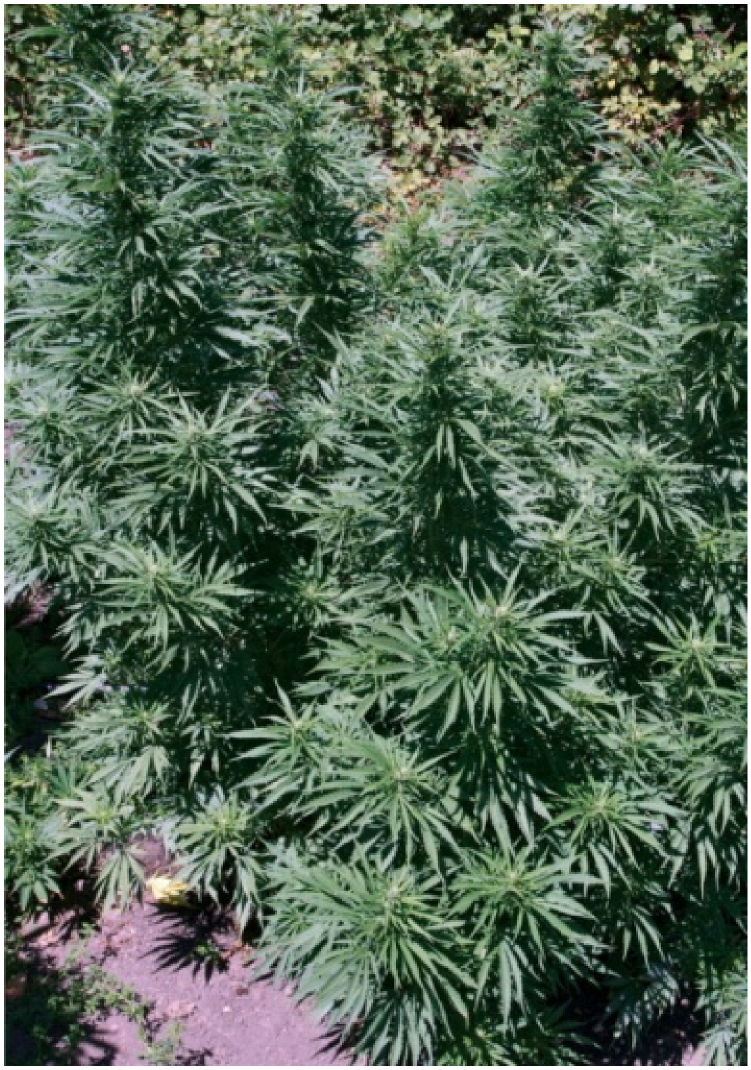
- Absorption of red light by Pr converts it into Pfr.
- Absorption of far-red light by Pfr converts it into Pr.
- In the dark, Pfr spontaneously converts back to Pr over a two hour time period.
- Sunlight is richer in red (660 nm) than far-red (730 nm) light, so at sundown all the phytochrome is Pfr.
- During the night, the Pfr converts back to Pr.
- The Pr form is needed for the release of the flowering signal.

Therefore, marijuana needs 9-11.5 hours of darkness for several days of this regimen in which it converts the Pfr present at sundown into Pr to carry out the supplementary reactions leading to the release of the flowering signal.

If this process is interrupted by a flash of 660 nm light, the Pr is immediately reconverted to Pfr and the night's work is undone.

A subsequent exposure to far-red (730 nm) light converts the pigment back to Pr and the steps leading to the release of "florigen" can be completed.

Exposure to intense far-red light at the beginning of the night sets the clock ahead about two hours or so by eliminating the need for the spontaneous conversion of Pfr.



MANGO

CARBON DIOXIDE

CARBON DIOXIDE (CO_2) is a gas which comprises about 0.038% or 380 parts per million (ppm) of the earth's atmosphere.

CO_2 is one of the two raw materials required for plant photosynthesis. (Water is the other.)

Cannabis uses CO_2 only in the presence of light. Photosynthesis occurs immediately after the plant receives light. The plant starts mining CO_2 from the air by opening its stomata, tiny organs found on the leaf surface, primarily on the underside. They function much like pores in the skin. They regulate the absorption of water, gas, oxygen, (O_2), and CO_2 into the plant, as well as the evacuation of water and O_2 from the plant.

Once CO_2 is absorbed into the plant, it is directed to the chloroplasts—the plant organelles that contain light-absorbing chlorophylls—where photosynthesis takes place.

Photosynthesis consists of a complex series of reactions in which light energy is used to convert carbon dioxide and water to sugar, releasing oxygen as a byproduct.

The amount of CO_2 in the air has a profound effect on the rate of photosynthesis and plant growth. Photosynthesis speeds up as the amount of CO_2 in the air increases, as long as there is enough light to power it. Conversely, as the CO_2 content of the air falls, photosynthesis slows to a crawl and virtually stops at a CO_2 concentration of around 200 ppm, no matter what the other conditions. Lacking CO_2, plants continue respiration and growth for a short time, until their sugars are used up; then they slow down their metabolism to conserve energy. Only when more CO_2 is available can the plant processes continue.

Outdoors, breezes and the exchange of gasses in the air constantly replace the CO_2 that plants consume. This provides enough CO_2 for vigorous growth, and outdoor growers rarely think of the gas as a limiting factor, even though growth of some plants, including cannabis, is not maximized in the Earth's present atmosphere. In fact, the 380 ppm of CO_2 found in earth's atmosphere is on the low end of the continuum of most plants' ability to use it as fuel for photosynthesis.

Outdoor plants growing in the bright light of summer grow heavier and faster when supplemented with CO_2. Raising the level of CO_2 up to 0.15% (1500 ppm), or a little more than four times the amount usually found in the atmosphere, increases plant growth rate significantly. Enhancing growth outdoors using increased CO_2 is discussed in the supplementation section.

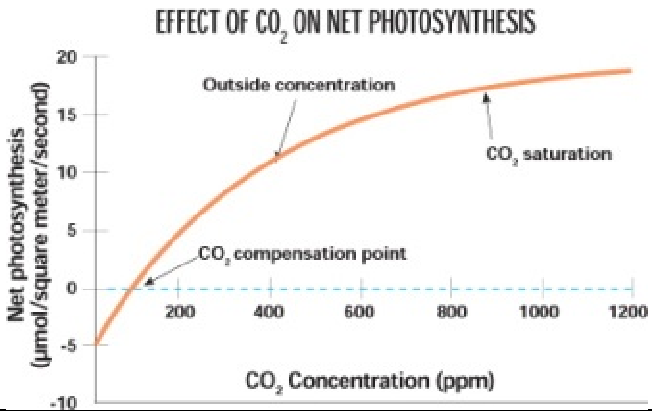
CO_2 is not dangerous. It is a nonflammable gas. It is non-toxic at the low levels growers employ. CO_2 can pose health risks in extreme concentrations (above 50,000 ppm), but this level is more than 30 times the maximum plants find useful.

When plants are growing in an enclosed area, there is a limited amount of CO_2 for them to use. Under bright lights, CO_2 is used up quickly. Enclosed gardens with no ventilation are also rapidly depleted to the point where the photosynthesis rate slows to a virtual stop at 200 ppm. Only when more CO_2 is added to the mix does photosynthesis resume.

A closed closet or other small gardening space can be recharged with CO_2 simply by opening the door or curtain to let in fresh air. This increases the CO_2 content of the closet passively, as air naturally equalizes the concentrations of oxygen (O_2) and CO_2 inside and outside the growing space, exchanging the higher O_2 levels with CO_2. Adding a small fan expedites the air exchange.

The rate of photosynthesis has the greatest increase as the CO_2 level climbs from 0-200. Under low-light conditions (150 mols or 1150 fc) (12,330 lux), the rate of photosyntheses increases as CO_2 rises to 400 ppm. Increasing the CO_2 concentration beyond that without increasing light intensity does not result in a higher rate of photosynthesis. The plant cannot take advantage of higher CO_2

levels until the light intensity increases.



Light level, temperature and CO_2 level must all increase for the plant to utilize resources most efficiently. At less than 100 ppm of CO_2 photosynthesis does not take place and plants suffer a net loss of sugar due to respiration. At 100 ppm CO_2 respiration and photosynthesis are equal so there is no net loss or gain. Photosynthesis increases quickly as the CO_2 levels climb to 400 ppm. The increase in photosynthesis is more moderate as the CO_2 concentration climbs to 800 ppm. The increase is more moderate, but significant between 800 and 1200 ppm.

At a light intensity of 600 mol (4600 fc) (49,310 lux), the photosynthesis rate increases more as CO_2 concentrations are increased to 400 ppm. The rate of increase declines a bit after that, but the photosynthesis rate continues to increase as CO_2 levels reach 600 ppm. Above 600 ppm of CO_2, the photosynthesis rate continues to climb but at an even slower rate, until the rate increase levels off at about 1200 ppm.

PHOTOSYNTHESIS BRIEFLY

Chlorophyll pigments absorb light and convert it to electro-chemical energy. This energy is used to cleave water and combine the H with CO_2 to form suger and release oxygen.

$$6(H_2O) + 6(CO_2) + \text{LIGHT} \Rightarrow C_6H_{12}O_6 + 6O_2$$

COMMON MYTHS ABOUT CO_2 DEBUNKED

- **CO_2 enrichment is like chocolate cake for your plants—you can't give it to them all the time.**
- **Your plant can overdose on CO_2.**
- **All you need is good ventilation—extra CO_2 will not help.**
- **Plants need fresh air, keeping them in a closed system is imprisonment.**
- **The only time plants need CO_2 is when other conditions aren't right.**
- **Plants grow immune to CO_2.**

ALL FALSE!

By increasing the light intensity, you encourage your plants to absorb even more CO_2 which increases growth and yield. When the plants receive between 4500-5500 fc (48,240 lux) of light, they can utilize between 1200-1300 ppm of CO_2. While very few gardens are supplied with more than 7500 fc (80,400 lux) of light, at that intensity the plants can use up to 1500 ppm of CO_2, the enrichment rate recommended by some manufacturers.

Marijuana uses CO_2 only when it is receiving light. Enrichment during the dark period has no effect.

You can supply CO_2 to your plants easily and cheaply. The most convenient way to do this is by using a meter, regulator, and tank kit. There are other ways, too. Instead of using a tank, you can use a meter that regulates a CO_2 generator that burns propane or natural gas. You can also use metabolic and chemical processes to produce CO_2, or obtain dry ice, which sheds CO_2 as it evaporates.

CO_2 TANKS

The easiest way to supply the gas is to use a CO_2 tank kit. The kit consists of a CO_2 meter, pressure regulator, and a solenoid valve. For most gardeners, 20 or 50 pound tanks (the weight of the gas), are the most convenient. Tanks can be bought or rented. Steel tanks weigh twice as much as aluminum tanks, so a steel tank that holds 20 lbs. of CO_2 has a gross weight of 50 lbs., and an aluminum tank weighs about 40 lbs. filled. The 50 pound tanks weigh respectively 170 and 110 lbs. when filled.

A 20 lb (9 kg) aluminum tank weighs about 35 lbs (16 kg).

CO_2 regulators attach to CO_2 tanks and allow the grower to pre-set and adjust the amount of CO_2 being released into the room. This CO_2 regulator is adjustable from 0.5-15 cubic feet (0.014-0.42 cubic meters) per hour and is available from C.A.P. Controllers. The pressure regulator, flow rate valve and solenoid switch which opens and closes the valve are all regulated by the ppm meter.

You can calculate how much CO_2 is needed to bring a growing area to 1,000 ppm by multiplying the cubic area of the growing room (length x width x height) by .001. The total represents the number of square feet of gas required to reach optimum CO_2 range. For instance, a room 13' x 18' x 12' contains 2808 cubic feet: 2808 x .001 equals 2.8 cubic feet of CO_2 required. A room 3 x 4 x 3 meters contains 36 cubic meters and would require .036 cubic meters of CO_2.

Although CO_2 tanks are a bit cumbersome to lug around and are more expensive than other methods of supplying CO_2, they are still the best solution for most gardeners. The reason is that they don't run the risk of degrading the garden environment, as compared with CO_2 generators. Tanks release nothing but cool CO_2, while CO_2 generators also release heat and water vapor, neither of which is helpful in most gardens.

CO_2 tank systems use a regulator/emitter system to control the amount of gas being released, and consequently, the concentration of CO_2 in the garden.

- A regulator that standardizes the pressure.
- An adjustable CO_2 flow meter that controls the amount of gas released over a given time period.
- A solenoid valve that shuts the gas flow on or off.

All systems include a CO_2 controller. The best units have a sensor that constantly measures the ppm of CO_2 in the air and turns the flow on or off to maintain a ppm you set. These systems keep an accurate gauge of the CO_2 in the air, eliminating guesswork and unwanted fluctuations.

The yield of your indoor harvest is dependent on the limiting factors. Many products automatically measure and regulate the climate of the room, freeing up the grower’s time. The Harvest Master can be set to control the light cycle, exhaust fans, CO_2, temperature and humidity.

Another type of controller injects CO_2 into the room on a timed basis. These units aren’t as helpful because they are set and release CO_2 according to your guesstimates, not accurate measurement of conditions. Some units coordinate release with ventilation fans and lights so the whole system works automatically.

CO_2 SYSTEM SET-UP

In most tank systems, CO_2 should be released just above the plants. The gas is heavier and cooler than the air so it sinks. As it flows downward, it reaches the top of the canopy first. This is where most of the light touches the leaves and where most of the plants' CO_2-consuming photosynthesis takes place. A good way to disperse the gas is by using inexpensive "soaker hoses" sold in plant nurseries and gardening stores. These soaker hoses have tiny holes along their length that disperse the gas.

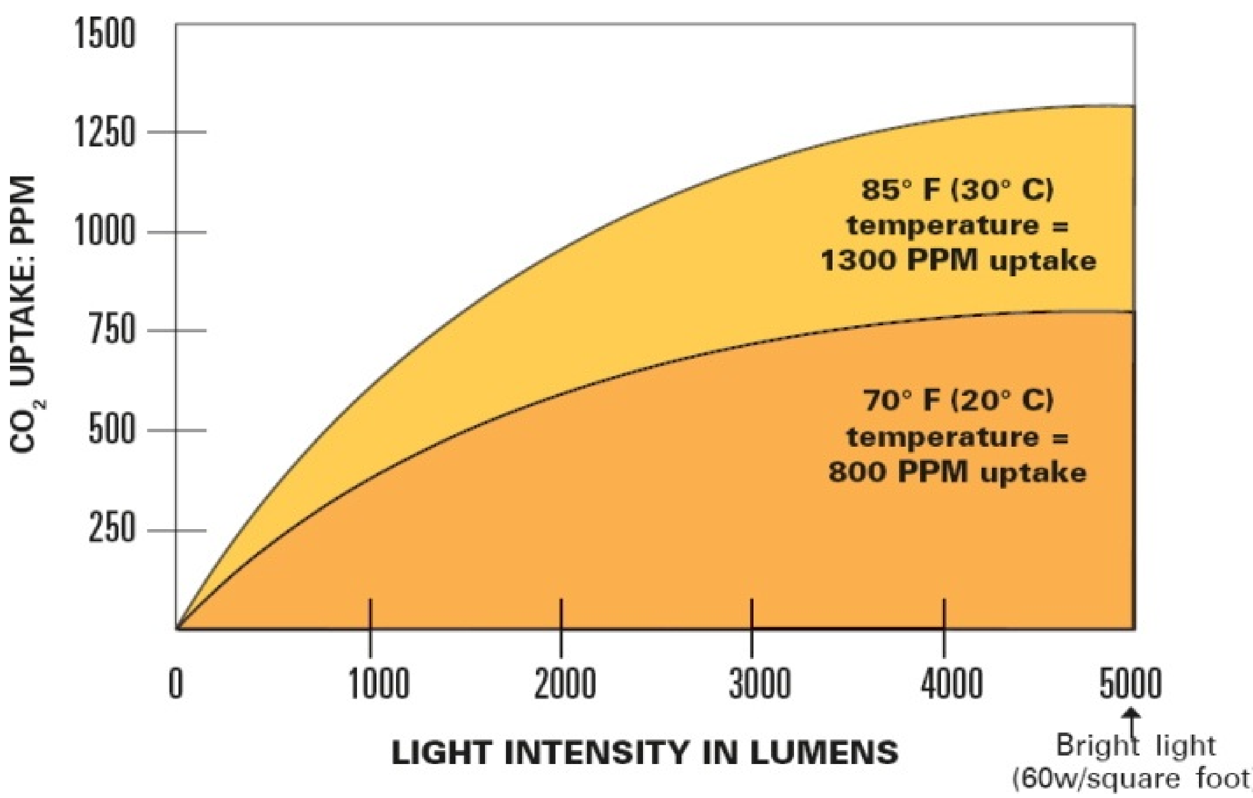
Some models of premade grow cabinets come with CO_2 equipment.

www.actechwi.com

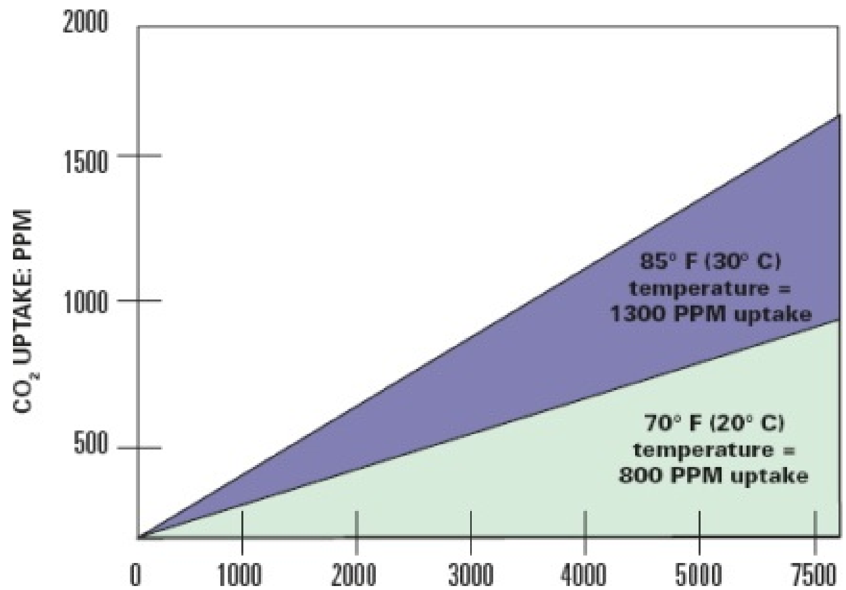
In this garden air is enriched as it passes through the tubes. The reflectors, with no bottom glass, draw in air as it exits through a carbon filter.

Some systems circulate air through the plant canopy, drawing it up towards the ceiling. In this kind of system, the CO_2 should flow from the tube just below the canopy, so it is pulled up to the top. Another method of enriching a space with CO_2 is to add it to the air intake, so all new air is enriched. This is especially useful when a space has constant or frequent ventilation. Whichever set up you choose, place the tank where it can be replaced easily.

CO_2 REQUIRED FOR LIGHT USAGE



CO_2 UPTAKE WITH SUPERCHARGING AND NO LIMITING RESOURCES



CO_2 REQUIRED FOR LIGHT USAGE: The amount of light, CO_2 and nutrients required for fast growth rise in direct ratio to each other. CO_2 UPTAKE WITH NO LIMITING FACTORS: As the intensity of light increases the plant requires higher temperature and higher concentration of CO_2.

1 pound of CO_2 (0.45 kg) = 8.7 cubic feet (0.246 cubic m)

MANUAL CO_2 CONTROL

Before CO_2 meters and controllers were available, growers had to guesstimate the amount of CO_2 required by figuring the cubic area of the space, then estimating the depletion of the gas over time. From this, they would calculate the flow rate adjustment and set a timer used to control the solenoid valve. While this method is not as efficient as exact measurement with a meter, and the CO_2 levels will vary, affecting growth, this type of equipment is still available.

If you’re using such a system, the ratio of gas to space depends on the ppm of gas desired:

- **600 ppm is 1:666 (multiply cubic area by .0006)** A room of 1,000 cubic feet (28 cubic meters) requires 0.6 cubic feet (.0168 cubic m) of CO_2.
- **1000 ppm is 1:1,000 (multiply cubic area by .001)** A room of 1,000 cubic feet requires 1 cubic foot (0.028 cubic m) of CO_2.
- **1200 ppm is :1,000,000 (multiply cubic area by .0012)** A 1,000 cubic foot (28.8 cubic m) room requires 1.2 cubic feet (0.033 cubic m) of CO_2.

To calculate how long the valve should remain open to reach that level of CO_2 concentration in the room, divide the number of cubic feet of gas required by the flow rate of the tank's valve. For instance, if the tank's flow rate is 50 cubic feet per hour, 2.8÷50 gives us 0.024 hours or 1.44 minutes (0.024 hours x 60 minutes = 1.44 minutes).

In a warm, well-lit room with no outside ventilation, the gas should be replenished every 10 minutes when the plants have filled out the canopy. When the plants are smaller or in a moderately lit room, they do not use the CO_2 as fast. The gas should also be replenished each time after the room is ventilated or opened, since the enriched air will have evacuated.

GENERATORS

CO_2 generators are much less expensive to operate than bottled CO_2 injection systems. They create carbon dioxide inexpensively by burning either natural gas or propane. They are safe to be around and burn cleanly and completely, leaving no toxic residues and creating no carbon monoxide (a colorless, odorless, poisonous gas).

Generators emit CO_2, water, and heat. Each pound of natural gas or propane burned produces about three pounds (1.36 kg) of CO_2, one pound (0.45 kg) of water, and about 21,800 British Thermal Units (BTUs) of heat. Other gasses and fuels produce different amounts of energy, per unit burned.

If your growing area is cool or cold, the heat from a CO_2 generator can be useful in keeping the space warm, as well as supplying CO_2 and humidity to the garden. In a warm space, the generator's heat must be dissipated to maintain the moderate temperature levels necessary for optimal growth. Some CO_2 generators use water-cooling to absorb the heat. The heated water is cooled outside the garden area, eliminating the temperature problem. However, the CO_2 enriched air still contains the moisture that was created.

Nursery supply houses sell large CO_2 generators especially designed for greenhouses. Indoor garden centers typically sell smaller generators more appropriate for indoor gardens. Even a small generator unit can raise CO_2 levels very quickly.

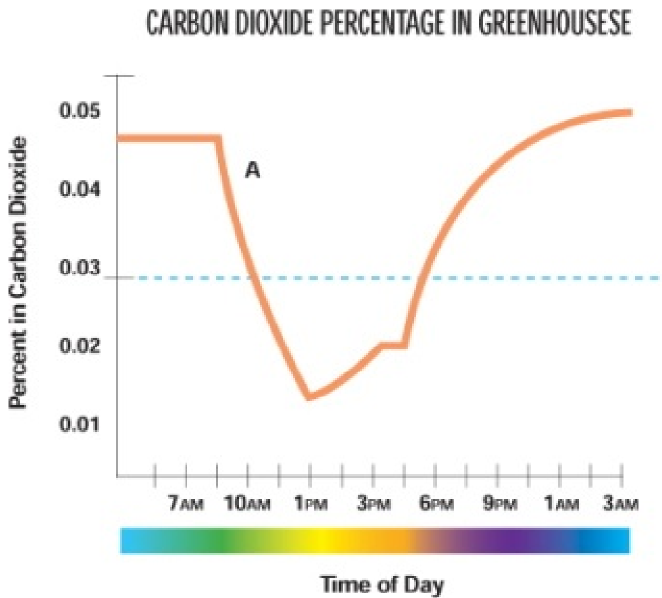
OTHER METHODS TO ENRICH AIR WITH CO_2

There are other ways of bringing CO_2 into the garden space. They include water heaters and other gas appliances, dry ice, chemical reactions, and biological processes such as composting, fermentation, and animal respiration.

GAS APPLIANCES

Like CO_2 generators, water heaters and other gas appliances produce CO_2 as they burn natural gas or propane. If the water heater is in the garden space—or if its exhaust is vented into the room—it enriches the garden with CO_2 whenever the gas turns on. Although the gas may be produced irregularly rather than on a schedule, each time the garden air is enriched, the photosynthesis and growth rate spurts. Other appliances that create CO_2 output are gas-powered furnaces, clothes dryers, and stoves.

This is a single plant. A water heater (seen in lower photo) intermittently provided CO_2 to the plant. Notice the difference in growth between the enriched and unenriched side. The plant grew 20’ high and 30’ wide.



A. During a sunny day in the winter period
B. As compared to outside air: CO_2 concentration is too low for healthy plant growth.

ASK ED: Marijuana Questions

CAR FUMES FOR PLANTS

The only decent outdoor spots around here are near the highway. There's a lot of traffic—four lanes each way. Since a portion of the fumes from vehicles contains CO_2 would planting near a highway be beneficial or bad for my plants? I've been growing along the highway for the last few years. Some plants grew only a few feet (approx 0.9 m) tall, but others grew to a height of almost ten feet (3 m).

Car fumes are not good for plants or humans. The exhaust from clean burning cars contain carbon dioxide (CO_2); carbon monoxide (CO), which is toxic; carcinogenic alkenes and polycyclic *hydrocarbons*; various lung damaging acids, such as nitric oxide (which is what comprises smog); heavy metals, and other harmful gasses and particles.

Diesel vehicles produce even more poisons than gasoline engines. Every so often a broken, old or poorly maintained vehicle passes by, releasing considerably more toxins into the air. Plants absorb these particles through the stomata. When the exhaust fumes are in the air they absorb them, too. Some hydrocarbons and small particles wind up as a coating on top of the soil, or get washed into the ground and are drawn into the plant by the roots.

Plants growing beside a well-used highway should not be ingested or smoked. In the interest of harm reduction, I have some tips for people who insist on growing by the side of the road:

If there is a prevailing wind, plant upstream from the highway rather than downstream. That way, the pollution moves away from the plants.

Plant as far away from the highway as possible. Pollution at 25 ft (8 m) is much worse than at 50 feet (16 m) from the road.

Plant in an area with a physical barrier. A good place to plant would be an area that is protected from the road by some barrier such as trees, brush or a wall.

Plant on a flat rather than hilly part of the road. Even accounting for the lack of gas used going down hill, cars use more gas in hilly terrain. When more gas is used, more pollution is generated. Also, engines under more stress as they navigate hills are more likely to emit pollutants.

Plant uphill from the road. Pollutants are more likely to travel downhill rather than uphill.

Still, your plants and you will both be happier and healthier if you choose to garden away from such toxic influence.

DRY ICE

Dry ice is CO_2 that has been cooled to -109˚ F (43˚ C), the temperature at which it becomes a solid. Each pound (0.45 kg) of the ice evaporates to 8.7 cubic feet (0.25 cubic m) of gas. Dry ice usually comes in 30 pound (13k kg) blocks and costs about the same as CO_2 in tanks. Dry ice evaporates CO_2 at different rates, depending on the temperature of the surrounding air—about 7% a day when kept in a freezer and considerably faster at room temperatures. Since it is hard to control the rate of evaporation, and dry ice is inconvenient, even dangerous to handle, most growers conclude there are easier ways to provide a garden with CO_2.

One cubic foot (0.028 cubic m) of gas increases the percentage of gas in a 1,000-cubic-foot (28.3 cubic m) room (10 x 10 x 10) by 1,000 ppm.

CO_2 Boost uses organic matter as food for bacteria that digests it, and releases oxygen. Everything is contained in the kit. It produces a steady stream of CO_2 for about two weeks. Then the organic matter is replaced.

SELTZER SPRAYS

Plants can be supplied with CO_2 by spraying them periodically with carbonated water or seltzer (salt-free soda water). CO_2 enriched sprays are especially convenient to use with small plants, such as seedlings, rooted clones and small plants. This method is a bit expensive if you are buying soda water for large plants. Gardeners can lower the cost significantly by make their own soda spray by carbonating water using a kit.

VINEGAR AND BAKING SODA

When vinegar and baking soda are combined, they make a salt and release CO_2.

The best method for creating a controlled release of CO_2 is to drip vinegar into a solution made of baking soda and water. As the vinegar combines with the solution, CO_2 is released. Regulating the frequency of the drip controls the amount of CO_2 generated. This is not a cheap way to make CO_2 in a mid-large size garden, because baking soda and vinegar are expensive to purchase in the quantities needed to create significant amounts of CO_2.

To generate one cubic foot of CO_2, combine 3 quarts of 5% vinegar with 3.7 ounces of baking soda. Generating one cubic meter of CO_2 requires 101 liters of 5% vinegar and 3.7 kilos of baking soda.

This system is costly to operate and is only feasible for a small garden.

FERMENTATION

Fermentation is the process used to brew beer and make wine. To ferment alcohol and make CO_2, all that is required is a jug or container, malt or another source of sugar, and yeast. Yeast are single-cell microorganisms that have been used in baking and fermenting alcoholic beverages for thousands of years. In fermentation, yeast digest sugar and release alcohol and CO_2. A gross simplification of this process is:

$\mathbf{C_6H_{12}O_6 \Rightarrow 2(CH_3CH_2OH) + 2(CO_2)}$ (Sugar => Alcohol + Carbon Dioxide)

One kilogram of CO_2 equals 0.546 cubic meter of gas.

As yeast feast on the sugars, they release about half the weight of the sugar as CO_2, so one pound (0.45 k) of sugar yields about half a pound (0.23 kg), or 4.35 cubic feet (0.12 m3), of gas. The yeast complete their meal in about four days. Then the solution must be replaced.

BEER MAKING KIT

Yeast have a hard time processing sugar as the alcohol content climbs. Most beer yeast slow down as the liquid approaches about 5-8% alcohol. The maximum amount of sugar that yeast can process well is about 1⁄10 of the weight of the water. A gallon of water weighs 8 pounds (3.6 kg), so about 13 ounces (0.381 l) of sugar can be used. A liter of water weighs 1,000 grams, so use 80 grams of sugar.

ANIMAL RESPIRATION

Humans and other mammals, birds, and, to lesser extent, reptiles, produce a large amount of CO_2 each day. The effect of each breath they take is CO_2 released into the atmosphere. A human (150 lbs., 68 kg) produces an average of 0.9 kilograms CO_2 per day. In an hour a human releases .326 cubic feet of the gas (0.0092 cubic m).

When placed near a garden, animals such as pet rabbits use the oxygen the plants produce and complete the cycle by returning CO_2 to them. A precautionary note on keeping animals around plants: animals are constantly shedding and creating dander. Much of this material becomes airborne and easily attaches to sticky plant parts. Any garden air in proximity to animals should be filtered.

Green Pad CO_2 Generators are made with a combination of carbons and acids and are activated when sprayed with water or when the humidity of the room rises above 35% (your room should already be well above this level). They last for a week and can be used to provide CO_2 to grow rooms and clone domes.

USING CO_2 OUTDOORS

Even plants grown outdoors can benefit from CO_2 supplementation. They will grow bigger, sturdier, and produce higher yield. Plants grown in tunnels or in greenhouses also benefit from CO_2 supplementation because they rapidly deplete the air of CO_2 as they photosynthesize, so air enrichment is very effective at increasing their growth.

To enrich the air around a plant outdoors, run a CO_2 line from a tank up the stem of the plant so that the gas disperses around the canopy. This works best when there is at most only a gentle breeze.

COMPOST PILES

Compost piles produce considerable CO_2 and can be placed in the center of a densely planted outdoor garden. As the CO_2 is emitted by the pile, breezes will carry it through the plants. A small compost container can be placed under a large plant. Because compost piles generate heat, the emerging gas will be warmer than the surrounding air and drift up through the plant's canopy. Moist organic mulches or thin layers of compost can also be placed over the soil. When they are provided with a bit of nitrogen, the microorganisms they hold become very active and release extra CO_2. Their activity is regulated by temperature, so they produce more CO_2 during the warmer daylight hours, rather than at night.

Compost can be used to increase the CO_2 content of both outdoor and greenhouse gardens. It is not necessarily smelly and yields a large amount of CO_2. Using compost or vermicompost (compost with worms) to generate CO_2 is environmentally friendly. When it is ripe, the compost can be used to enrich the soil or to make compost tea.

About ⅙ to ¼ of the compost pile's starting wet weight is converted to CO_2, so a 100 pound pile contributes 33-50 pounds (15-22 kg) of carbon to the gas. Carbon makes up about 27% of the weight and volume of the gas and oxygen makes up 73%, so that the total amount of CO_2 created is 61 to 93 pounds (27.6 kg-42 kg), produced over a 30-day period. That comes to two to three pounds (0.9-1.3 m) or 16-25 cubic feet (0.45-0.7 cubic m) a day. Similarly, for each 100 kilograms of starting matter, the pile releases 60-90 kilograms of CO_2 over a 30-day period. The gas is supplied both day and night, so much of it is produced when the plants won't utilize it.

ASK ED: Marijuana Questions

CO_2 OXYGEN DISPLACEMENT

You recommend CO_2 as a boon to plant production when growing under indoor lights. You also mention that CO_2 is not good for the root zone as it displaces the needed O_2 used by the roots to "burn" the sugars and build the roots. So is there a conflict with upping the CO_2 content of a room and promoting healthy root development? Would a supplementary system of oxygen distribution (with tanks) be of benefit in such an instance?

The amount of CO_2 found in the air is about 375 parts per million (ppm), or .0375%, almost 4/100 of 1%. A CO_2 enriched garden might have a CO_2 content of 1500 ppm, or .15%. In contrast, oxygen comprises about 21% of air's volume. The increased amount of CO_2 in the air has little if any effect on the amount of oxygen absorbed from the water.

At the air-water surface, water releases CO_2 to the air and picks up oxygen. That is why it's recommended that reservoirs (and fish tanks) keep the water circulating. The more the water circulates and comes in contact with air, the more it releases CO_2 and holds oxygen. Even in a CO_2-enriched room, the water releases CO_2 in favor of O_2.

Adding O_2 to the roots using a tank is a good idea. Enriching the water or the soil helps maintain a healthful environment for the roots. Roots enriched with oxygen are healthier, grow faster and are more efficient at absorbing nutrients.

Adding a heavy layer of organic compost or mulch on top of the soil provides both a bit a warmth and protection from the elements and at the same time increasing the CO_2 content around the plants as microorganisms feed on it, releasing the gas.

CO_2 AND ROOTS

Roots do not use CO_2 because they don't photosynthesize, so they have no use for it. Plants obtain CO_2 for photosynthesis through the leaf stomata. In fact, CO_2 in the soil or water can pose a problem, because it can drive out much-needed oxygen.

CO_2 and O_2 both dissolve in water and compete for a place in the solution. In this respect, gardeners and aquarium enthusiasts face a similar problem. In fish tanks, pumps keep the water circulating so that the water at the surface releases the excess CO_2 produced by the fish and dissolves free O_2, maintaining the dynamic balance of oxygen saturation that the fish need to survive.

When soil, planting mix, and such hydroponic mediums as rockwool or coir are watered with CO_2 water (seltzer), the dissolved CO_2 eventually returns to its gas form and forces oxygen from the soil's air spaces. Then the roots are starved of oxygen, which they need for respiration.

Some gardens are divided to create a room of vegetating plants and a room of flowering plants. The GroZone Dual Zone Controller allows the gardener to control two different spaces at the same time and includes settings for low and high CO_2.

OXYGEN

Oxygen is not just a byproduct of photosynthesis; it is also used by the plant. The mitochondria, the cells' energy centers, use oxygen as they burn sugar to power growth and flowering, which produces water and CO_2 as byproducts.

A plant has three sources of oxygen: the oxygen it releases during photosynthesis but holds in its structure, the oxygen in the atmosphere, and oxygen dissolved in water, which the plant roots absorb. Oxygen comprises about 21% of the air solution, so plant parts above ground rarely experience a shortage of it.

Another way of supplying plant roots with oxygen is by producing it using electrolysis. Electrolysis is the process of separating water into its component parts: hydrogen and oxygen by running an electric current through it.

Roots require oxygen for respiration. They obtain it from air spaces in the soil or from oxygen that is dissolved in water. When roots don't have enough oxygen, they deteriorate in various ways. They cannot draw up water and nutrients effectively, so root growth and respiration stops. They lose their stamina and become susceptible to pathogens. Anaerobic (oxygen-free) conditions also promote growth of harmful anaerobic bacteria that thrive in oxygen-free environments. They produce ammonia, which is toxic to plants at high levels. An ammonia smell is a sure sign of anaerobic conditions.

For roots to have adequate oxygen supplies, the planting medium must not be packed too tightly and must have porosity, so that it has space to hold air as well as water.

In hydroponic systems water should be circulated and aerated to remove the CO_2 and replace it with oxygen. Water can be supplemented with oxygen by adding a small amount of hydrogen peroxide (H_2O_2) to the water.

Warm water holds much less oxygen than cool or cold water, as discussed in the the Temperature, Humidity and Air Quality chapter.

Porous soil that allows air to circulate through the root area is not the only way your plants can get the oxygen they need to thrive. Some gardeners supplement the water they use with extra oxygen to deliver the maximum amount to roots. How much oxygen roots can use is not certain, but experiments with both cuttings and rooted plants of several types all demonstrate that an oxygen-enriched environment makes a big difference in plant vigor—in the range of 50-60% more growth for cuttings and 30% for rooted plants. Conversely, water with a low dissolved-oxygen concentration inhibits growth. Temperature affects the oxygen level of the water. The warmer the water, the less oxygen it can dissolve.

Water can be enriched with oxygen in several ways. The best source of naturally enriched water is immediately downstream from a waterfall. This could be the drop of water into the reservoir from a table. An inexpensive aquarium air bubbler or a submersible pump circulates the water in reservoirs and water tanks so new water is constantly coming to the surface to exchange gasses with the air.

Indoors and out, hydrogen peroxide (H_2O_2) can be used as an oxygenating supplement. Add one part of 3% hydrogen peroxide (H_2O_2) (drugstore strength) for every ten parts of water. The extra oxygen will dissipate in 72 hours or less. At a higher concentration H_2O_2 kills bacteria and fungi in the water and soil, and is useful if you are combating pathogenic fungi or bacteria, but remember that healthy soil contains many helpful bacteria, too.

SOUR DIESEL

WATER

Not all water is created equal. When we drink different waters, we experience their distinctive qualities as different flavors. The mineral, carbon dioxide, and oxygen content of water vary substantially, and affect your plants. Three key measures of water composition are its alkalinity, its pH (alkaline-acid level), and its content of dissolved minerals. Mineral content is often referred to as dissolved solids, which are expressed as parts per million (ppm) and can be tested approximately by measuring the electrical conductivity (EC) of the water.

Alkalinity is the ability of the water to buffer acids. When water contains dissolved solids, usually calcium (Ca) and magnesium (Mg), its pH is not affected as much by the addition of acidic substances, such as a soluble fertilizer. The Ca and Mg buffer the acid/alkaline balance so that small additions of fertilizers don't create dramatic changes in pH. When water is very pure and contains no minerals, it is called soft water and has little or no buffering ability, so its pH is very changeable. Adding a small amount of an acidic substance has extreme effects on soft water's pH.

Waters from different areas vary dramatically in the amount of dissolved solids they contain and, consequently, in their buffering ability. For example, tapwater in San Francisco, California contains about 65 ppm of dissolved salts. It has very little buffering ability. By contrast, water in Los Angeles, California contains about 450 ppm. This "hard water" has very strong buffering ability, so it takes a large amount of pH adjuster to have much of an effect.

Water districts and companies continuously test the water they supply you. The test results are public records and are available from the water district or company. The results may be sent to customers annually or posted on the Internet. If not, they can be obtained by communicating with the water supplier.

In addition to measures of alkalinity, dissolved solids, and pH, the report shows contaminants.

A reading of 125-150 ppm for your water is a good starting point because it represents some buffering ability, but not so much that large amounts of minerals have to be added to adjust pH. To increase the reading use Cal-Mag, which contains a solution of calcium and magnesium, or alternatively, calcium nitrate (CaNO3). To lower the mineral level in the water, use a reverse osmosis system or a charcoal/chemical de-ionizer. The high-mineral water can be mixed with the purified water to get to the desired 125 ppm.

pH

The pH is a measure of acid-alkalinity balance. Technically, it represents the concentration of hydrogen or hydroxyl ions in a solution. pH is measured on a scale of 0-14, with 0 the most acid, 7 neutral (an equal concentration of hydrogen and hydroxyl ions), and 14 pure alkali. This is a logarithmic scale, so every one point increase or decrease in pH reflects a 10-fold change in acidity or alkalinity. For example, a pH 5 solution is 10 times more acidic than a pH 6, while a pH of 4 is whopping 100 times more acidic than pH 6! Most nutrients the plants use are soluble only in a limited range of acidity, from about 5.5 to about 6.5 in mineral soil and 5.6 to 6.4 in a hydroponic medium. Solubility also depends to some extent on the type of soil, planting mix, or hydroponic medium.

Should the water or the water-solution in the soil become too acid or alkaline, the nutrients dissolved in the water precipitate and become unavailable to the plants. When the nutrients are locked up, plant growth is slowed. Typically, a plant growing in an acidic environment with a low pH is very small, often growing only a few inches (approx 7.5 cm) in several months. Plants growing in a high-pH environment look pale and sickly and also have stunted growth.

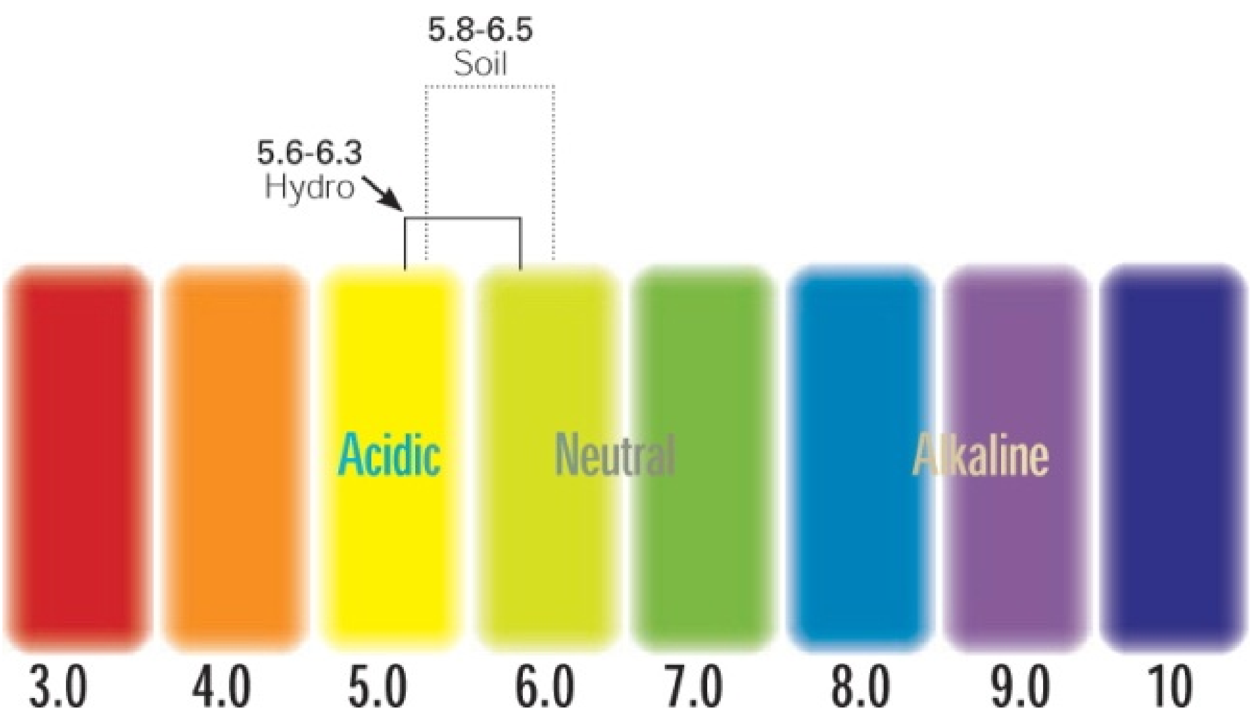
The pH of tap water may change seasonally. Test it regularly. The pH of tap water changes when your local water company flushes its system, so it is a good idea to check it every time.

The pH of water can change for many reasons. Plants affect the pH of the water solution as they remove various nutrients. Microbes growing in the medium also change the pH. Addition of nutrients by the grower changes pH, as well. For this reason, growers check and adjust the pH frequently.

For absolute control of a planting medium system, test the pH weekly. Carbon seed mediums have a lot of buffering ability and adjust to pH changes.

Plants growing in hydroponic systems have more effect on the pH of the water/nutrient solution, so it should be checked every day or two. Adjust pH after nutrients are added, since they affect its balance. Measure the pH of water using a pH meter or chemical reagent test kit designed for aquariums or gardens. Meters are the easiest to use.

Once the water is tested, it should be adjusted if it does not fall within the pH range of 5.8-6.3. Adjust the water using small increments of chemicals. Once there is a standard measure of how much chemical is needed to adjust the water, the process becomes fast and easy to do. Hydroponic supply companies sell measured adjusters, pH UP and pH DOWN, that are very convenient and highly recommended. The water-nutrient solution can also be adjusted using common household chemicals. Water that is too acidic can alternatively be neutralized using potassium bicarbonate, or wood ash. Water that is too alkaline can be adjusted using nitric acid, sulfuric acid, citric acid (Vitamin C), kombucha tea or vinegar.



Optimum water pH in a hydroponic system is 5.6-6.3. In a soil system the pH should be between 5.8-6.5. Different nutrients can require a different pH, so you should always check the bottle.

Chlorine is added to water systems to kill infectious agents, but when the water is used for irrigation, the chlorine kills some of the beneficial microorganisms in the **rhizosphere**, the area surrounding the roots. To protect the micro-life, remove the chlorine from the water.

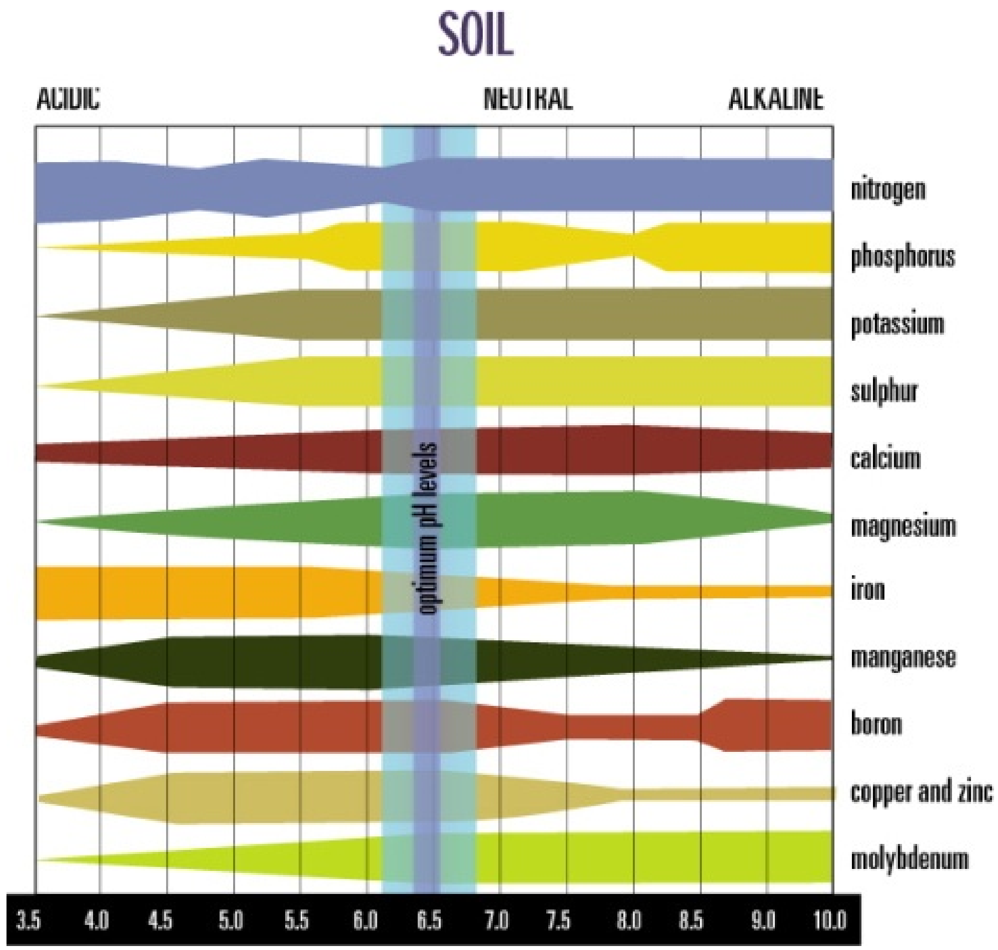
In the past, water was treated with a chlorine compound that had a characteristic odor and taste. This chlorine evaporates when tap water sits for a day or two. Now, most water systems use chloramine, which doesn't evaporate. Instead, it has to be removed.

Aquarium hobbyists face the same problem because the chemical also affects fish. They use an additive that removes not just chlorine but the ammonia which is produced by the chemical reaction.

Chloramine can also be removed from water by adding a gram of vitamin C (ascorbic acid) per 75 gallons (285 l) of water. Adding ascorbic acid to the water is safe for both the plants and you.

WATER ALKALINITY

The pH of pure distilled water is very unstable and has no buffering ability. The addition of a tiny amount of an acid makes it very acidic and a small amount of a base makes it alkaline. Our tap water contains minerals that it has picked up while percolating through the earth or hanging out in a reservoir. These minerals affect water's alkalinity. Alkalinity is a measure of water's ability to buffer acid, that is, resist change in pH when acid is added to it. The presence of Ca and other alkaline minerals such as potassium (K), buffers the water by neutralizing acids when they are added to it. Water with a small amount of Ca or other alkaline minerals has little buffering ability. As the alkaline mineral content increases so does its buffering ability. When there is too much buffer present alkalinity increases and large amounts of acids are required to change the pH.



Acceptable pH range for soil gardens: 5.5–6.5. Optimum pH levels are 6.0-6.3.

Alkalinity is tested by measuring the ppm of your water before adding nutrients or pH adjuster. Water with a ppm of 125-175 generally has enough Ca to act as a buffer, without having so much alkalinity that the water is hard to adjust.

Water that has a low Ca content can be adjusted by using Cal-Mag, available from many fertilizer companies. First add the Cal-Mag if needed; then adjust the pH. Then add fertilizers to the water if needed; then adjust the pH.

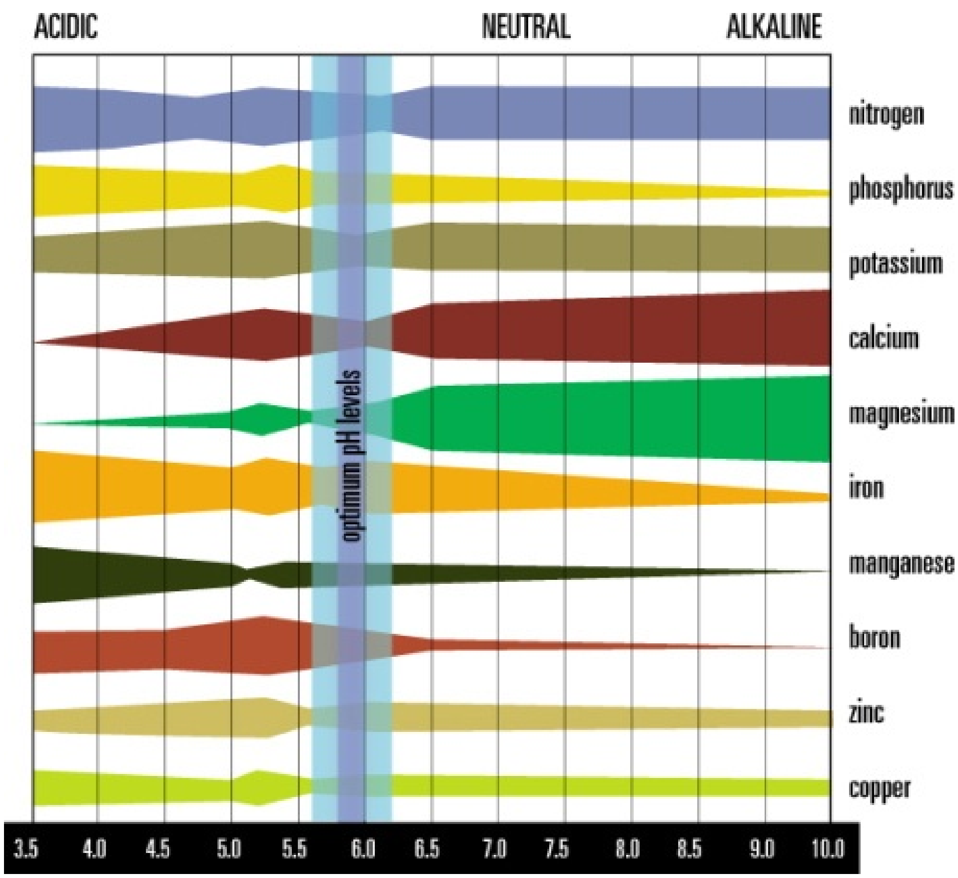
Every water district provides an annual water report. Below is the portion that concerns calcium (Ca), magnesium (Mg), potassium (K), alkalinity and pH. Other portions list contaminants, pollutants and other aspects of water quality.

The symbol mg/L is an abbreviation for milligrams per liter. There are 1,000 grams in a liter and 1,000 milligrams in a gram. Therefore, one mg/L also represents 1 ppm. (It’s a pretty convenient system. The United States should try it some time.)

Let's examine the water coming from the Orinda reservoir, which services Berkeley, Oakland and several other cities in the San Francisco, California, East Bay Area (See Water Quality Annual Report, next page).

CO_2 dissolved in the water lowers its pH. CO_2 forms carbonic acid when it is in solution with water.

HYDRO-WATER SYSTEM



Acceptable pH range for hydro systems: 5.6–6.4. Optimum pH levels are 5.8–6.2.

Bicarbonate and carbonate equivalents: The first two categories, totaled together, show the total alkalinity. Ca, K and sodium (Na) all raise the alkalinity.

Calcium: levels vary between 4-20 ppm. This is too low a concentration for healthy plant growth and must be raised by increasing the ppm to 125-175 using Cal-Mag or calcium nitrate ($CaNO_3$). $CaNO_3$ is dissolved easily. It contains nitrogen (N), so it should not be used during flowering. Decrease other N fertilization when using it in the vegetative cycle.

Hardness: Hard water has high mineral content, usually mostly Ca and Mg, as compared with soft water. In this water, however, the K and other minerals play an important role. Sometimes iron (Fe) is also present, but not in this water.

Excessive calcium in the water is a leading contributor to nutrient lockout. Reverse osmosis systems purify water and neutralize pH. Aqua Engineering Reverse Osmosis systems have a membrane with a 98% rejection rate, which maximizes the plant's potential to absorb nutrients.

A PPM/EC meter determines if the water is too hard which can make nutrients unavailable to the roots. PPM and pH meters are essential gardening tools. This one by Hanna (above left) is convenient because it measures pH, EC, and PPM. It recalibrates easily. Without a meter, water and nutrient decisions are guesswork. Right: Add pH Down to a solution that is too base, such as this filtered water.

Moisture meters and pH test kits allow the gardener to maximize the efficiency of the nutrient uptake of the plant.

One way to “test” the water is to use soap. It lathers easily in soft water but not in hard. Use a “simple” soap. “Modern” soaps often contain water-softening agents.

There are a number of factors that determine water hardness including temperature and pH, but generally speaking, water hardness corresponds with mineral content. Here are the ranges:

- VERY SOFT: 0-70 ppm—Much too little Ca/mineral content (EBMUD water falls into this category.)
- SOFT: 70-140 ppm—This falls in the low end of an ideal level. Add Ca to the water.
- SLIGHTLY HARD: 140-210 ppm—OK
- MODERATELY HARD: 210-320 ppm—the lower end of this spectrum is OK; however, the high end has too much buffering activity.
- HARD: 320-530 ppm—Mineral content must be lowered or accounted for in formulating fertilizers.
- VERY HARD: >530 ppm—Mineral content must be lowered or accounted for in formulating fertilizers.

There are several ways to handle high mineral content:

- Configure fertilizer to use nutrients that are found in the water and have raised its alkaline content as well as its total ppm.
- Reverse osmosis. This filters water clean by driving it through a tiny membrane. Osmosis water can be combined with tap or source water to create a mix that has a ppm of about 150.

East Bay Municipal Utility District Annual Report 2009

OTHER WATER QUALITY PARAMETERS	Orinda
Alkalinity, bicarbonate (mg/L as CaC03)	**20.2-36.4**
Alkalinity, carbonate (mg/L as CaC03)	**0.5-0.6**
Calcium (mg/L)	**4-20**
Hardness (mg/L as CaC03)	**15-78**
Magnesium (mg/L)	**0.8-5.6**
pH (pH units)	**8.2-9.3**
Potassium (mg/L)	**0.5-1.3**
Silica (mg/L)	**8.3-11**
Sodium (mg/L)	**5.5-19**

The table above provides useful information for certain industrial and home applications. Information on water hardness in “grains per gallon”can help improve the function of cooling equipment and other process applications. To convert the hardness values into grains per gallon, divide the values shown in the tables in milligrams per liter by 17. For example, water hardness in areas served by the Orinda Water Treatment Plant had a range from 15 to 78 mg/L or 0.9 to 4.6 grains per gallon.

- Heat the water. Sometimes the calcium and other minerals are held as a carbonate or bicarbonate. In either case part of the carbonate portion of the molecule contains carbon dioxide. As water temperature increases it holds fewer gasses so the CO_2 evaporates, leaving the Ca in the water. The calcium is no longer soluble so it precipitates, forming scale on the container. If white or tan chalky deposits form when you boil water or appear over a period of time, it is an especially good candidate for this treatment. Immediately pour the water from the container because as it cools it absorbs more CO_2, which again combines with the minerals, dissolving them.
- Specialized non-chemical hard-water treatment systems.

Magnesium (Mg): Magnesium is dissolved as water traverses Ca bearing rocks and soil that also hold Mg. Notice that it ranges from 0.8-5.6 ppm. This is only a fraction of the plant’s needs so it must be supplemented.

When you irrigate the plants make sure that you don’t shock the roots with water that is either too cold or too warm. Make sure that the water is in the temperature range of 65-75° F (18-24° C).

pH: The pH is very alkaline because of the Ca in the water. However, since it contains few minerals its pH is sensitive to the addition of acids. A little pH Down goes a long way

Potassium (K): The amount of K dissolved in the water has hardly any effect on plant nutrition. However, it does slightly affect pH and alkalinity.

Silica: Plants readily absorb dissolved silica and hold it between their cells. It toughens the plant, strengthens the stem, and makes them more resistant to environmental stresses and insects.

Sodium (Na): Sodium is a portion of table salt, NaCl. It is dissolved in tap water as a result of geologic conditions and human interaction. It varies seasonally. This is a low number. Sodium, K and Ca dance in a chemical minuet regarding plant uptake. When levels get too high it affects uptake of these salts.

ASK ED: Marijuana Questions

USING BOTTLED WATER

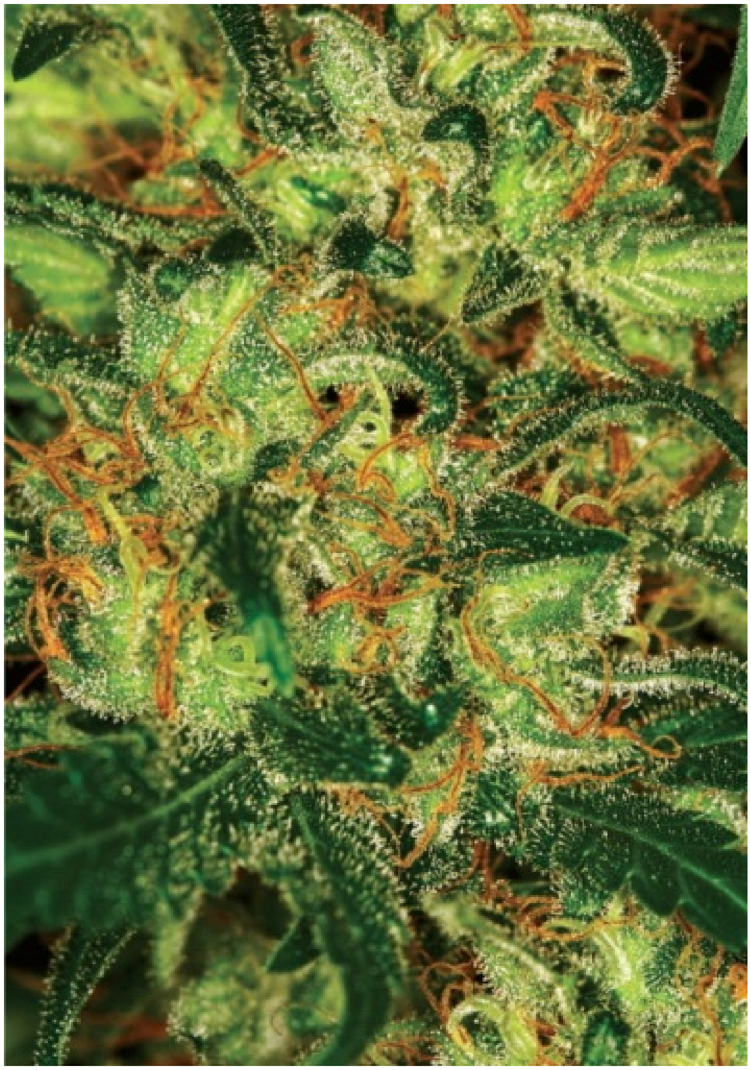
If price isn't an issue would you recommend using bottled water like Aquafina or would you stick with tap water?

To make an intelligent decision regarding irrigation water, obtain a report from your local water department. It will detail the water's pH, dissolved solids and pollutants. Then you can determine whether the water is suitable for the plants or if it should be treated or substituted with water from another source. One element to examine is calcium. Some hydroponic fertilizers don't contain much of it. If the water also has only small amounts you may need a calcium booster.

If you fed your plants Aquafina you might be supplying them with the same water they were receiving from your tap. Aquafina bottling plants use filtered tapwater, so the qualities of the waters, that is, the dissolved solids, pH and pollutants, vary by region. The brand is owned by Pep-siCo. Coca-Cola's brand from the tap is Dasani. If the water says drinking water, rather than mountain spring, rest assured it comes from the tap. Unlike municipal water that you can obtain a report on, the bottled waters don't list the water's contents. To find out what's in them you'd have to have them tested.

The amount of dissolved solids in bottled waters differs so it is impossible to make general statements about them.

In Europe bottled waters list their ingredients. Look for ones that contain at least 15 ppm calcium



NUTRIENTS AND FERTILIZERS

Photo: Rachael Szmajda

Prepared fertilizer mixes are designed to ensure that plants receive the essential nutrients required to reach their maximum potential. Once the plant is in the ground, or a container, the two easiest and most reliable ways to meet the plant's needs are to use a prepared hydroponic fertilizer, a liquid organic fertilizer, or compost teas. Hydroponic fertilizers are blended as balanced and complete nutrient formulas. Non-hydroponic fertilizers often contain only **macronutrients**—nitrogen (N), phosphorus (P), and potassium (K). Organic fertilizers, such as fish emulsion, guanos and manures, and many blends of organics, contain additional trace elements found in the organic matter from which they are derived. Fertilizers may contain an incomplete menu of nutrients; always check the labels.

Most indoor plant fertilizers are water-soluble minerals. A few of them are time-release formulas mixed into the planting medium as it is being prepared. Plants grown in high quality soil mixes can typically get along using basic fertilizers, while plants grown in unenriched soilless mixes definitely require micronutrient enrichment plus calcium (Ca) and Magnesium (Mg).

Dolomite is composed of calcium magnesium carbonate $CaMg(C0_3)_2$ and is a good natural supplement. To ensure a well-balanced diet of nutrients, many cultivators mix several products into a solution, or switch fertilizer formulas between feedings.

Mixing products from different companies can be risky since the formulas are may have minerals that interact adversely and create a nutrient imbalance. Choose proven products from reliable and established companies and follow their recommendations.

Plants grown in a nutrient-rich medium with compost, manure, or time-release fertilizers may need no additional fertilizing when planted in a large enough container or outdoor garden. Additional nutrients can be administered in supplemental amounts if the plants begin to show deficiencies.

Demand for critical nutrients, such as nitrogen (N), phosphorus (P), and potassium (K) varies with the growing conditions and changes during the plant's life cycle. Marijuana uses more N during the vegetative cycle (before flowering) than in later stages. The plant's use of P increases when it begins to flower, while the need for K increases after fertilization to aid flower formation and seed production.

Your plants' N requirements also vary with light intensity and temperature. Plants growing under hot conditions should be given 10-20% less N, to prevent the thinning and weakening of stalks. Plants transpire, or sweat, on warm days and use extra water, concentrating nutrients. By diluting the nutrients a bit, they won't overdose when they use water for transpiration.

Give plants in cool or cold regimens 10-20% more N because they will not be absorbing as much water. Under intense light conditions use more N and, conversely, less N in low-light conditions.

Teas, made by soaking organic matter or compost in water, enhance the plant's ability to absorb nutrients and fight off diseases and insects. Worm castings, compost, and commercially prepared tea formulas are the most popular. Some hydroponic stores brew teas on site. Live compost tea must be brewed with a lot of oxygen or airflow. Without proper aeration compost tea will become infected by anaerobic bacteria which is a source of disease. Other ingredients used for teas are composted manures, blood meal, coffee, plant meals, minerals, ground rock, and oyster shells. The nutrient value of organic teas varies by ingredients and processor and are rarely well described well on their labels.

In hydroponic mediums, the plant is dependant on the gardener for all of its food. Some nutrient mixes are specialized to be multi-functional: they provide food and other services to the plant. BioBizz BioHeaven enhances the plants ability to absorb nutrients and boosts the antioxidant system of the plant, ridding it of toxins built up during periods of stress.

There are many organic fertilizer mixes on the market. Some are added directly to the soil or planting mix, while others are readily available formulas added to the water. The ingredients of all fertilizers are listed on the label as well as the elemental content by percentage.

Organic ingredients usually contain **micronutrients** as well as macronutrients. Make sure to look at the figures on the bag container when you purchase supplements. In addition to N-P-K, look to see if the product contains calcium (Ca), sulfur (S) and magnesium (Mg), which are crucial for bud formation. Most single ingredient organic fertilizers are not complete; they are more often used as a supplement or with other ingredients. Mixed ingredient balanced, complete, organic formulas are available both as soil additives used before planting, blended into the soil during the growing cycle, as well as water-soluble formulas that are used as plants are irrigated.

Organic fertilizers are usually not used in hydroponic systems because they ferment in reservoirs and are not completely soluble, so they clog up some systems.

DEFICIENCIES OF NUTRIENT ELEMENTS IN MARIJUANA

Suspected Element—

Symptoms	N	P	K	Mg	Fe	Cu	Zn	B	Mo	Mn	Over-fertilization
Yellowing of:											
Younger leaves					x					x	
Middle leaves									x		
Older leaves	x		x	x			x				
Between veins				x						x	
Old leaves drop	x										
Leaf curl over				x							
Leaf curl under			x			x					x
Leaf tips burn:											
Younger leaves								x			
Older leaves	x						x				
Young leaves wrinkle & curl			x				x	x	x		
Necrosis			x	x	x		x			x	
Leaf growth stunted	x	x									
Dark green/purplish leaves and stems		x									
Pale green leaf color	x								x		
Mottling							x				
Spindly	x										
Soft stems	x		x								
Hard/brittle stems		x	x								
Growing tips die			x					x			
Stunted root growth		x									
Wilting						x					

Most hydroponic formulas and other water-soluble fertilizers are formulated from minerals blended to create soluble salts. These dissolved salts are composed of molecules small enough to be absorbed through the root openings and are instantly available to the plants. These fertilizers can be used to provide nutrients either on a regular basis or a quick fix to resolve deficiency problems.

Fertilizers should be applied on the low side of recommended rates. To determine a plant's nutritional needs, don't only measure nutrients carefully, but use EC, PPM and pH testing devices. Even more important, look at the plants carefully to accurately diagnose the problem plaguing it. Throughout the plant's life stages, it is critical to keep a close eye on the plants for minor symptoms of deficiencies.

In a hydroponic system, nutrients can get locked up and become unavailable to the plant if they aren't delivered in pure, fresh, pH balanced water. Home and Garden Aqua Flakes Nutrients supply the plants with essential nutrients and cleans the water.

If added nutrients cure a deficiency, the plant usually responds in apparent ways within three to five days, depending on what element is deficient. Typically, the spread of the symptom stops and plant parts that were only slightly damaged begin to repair themselves, with the exception of calcium which is a non-mobile nutrient. Leaves and other parts that were slightly discolored may return to normal, although plant parts that were severely damaged, or suffered necrosis, will not recover. The most dramatic changes can be monitored through new growth—you will be able to differentiate plant parts that grew before and after the deficiencies were corrected. Maintain balanced nutrient solutions and keep an eye on new growth, this way, problems will become apparent quickly before they become serious.

OVER-FERTILIZATION

Over-fertilization occurs when a plant absorbs more fertilizer than it needs either as a result of excess fertilizing by the gardener, or when soil or soil less mixes become saturated with nutrients accumulated over time. The minerals fill extra-cellular space as well as change the chemistry in individual cells. An osmotic imbalance occurs when water is sucked from the plant by salt accumulation in the root zone.

Be wary of the numerous expensive supplements that are popping up at garden supply stores. These products are often designed more to improve the company's profits rather than the quality of your crop. Growers have been growing great buds for decades using pure water, hydroponics and basic nutrients from reputable manufacturers. Some of the supplements are good, but often not necessary. Try the supplement with a few plants, but leave some of the same variety untested (controlled) because that is the only way to decide the effectiveness of the supplement. Many of the products are nothing more than very dilute phosphorous and potassium solutions.

COMPOST TEA

by Bonnie & Clyde

Compost tea is used for two reasons: 1) to inoculate microbial life into the soil or onto the foliage of plants, and 2) to add soluble nutrients to the foliage or to the soil to feed the organisms and the plants present.

Compost tea can be used any time that the organisms in the soil or on the plants are not at optimum level. Chemical based pesticides, fumigants, herbicides, and some synthetic fertilizers kill a range of the beneficial microorganisms that encourage plant growth, while compost teas will

improve the life in the soil and on plant surfaces. High quality compost tea will inoculate the leaf surface and soil with beneficial microorganisms instead of destroying them. Compost tea is a liquid produced by leaching soluble nutrients and extracting bacteria, fungi, protozoa and nematodes from compost.

Tea production is a brewing process. This process must stay aerobic. Non-beneficial organisms can grow more rapidly in reduced oxygen conditions. Anaerobic teas can result in the growth of some harmful bacteria and might be toxic to your plants. The brewing process is performed at a constant temperature. As the organisms grow and reproduce, it may elevate temperature. Using only high quality compost that contains bacteria and fungi, protozoa, and possibly nematodes will be the best to make Actively Aerated Compost Tea.

BENEFITS OF USING COMPOST TEA

- **Improve plant growth as a result of protecting plant surfaces with beneficial organisms which occupy infection sites and prevent disease-causing organisms.**
- **Improve plant growth as a result of improving nutrient retention in the soil, and therefore reduce fertilizer use, and loss of nutrients into ground and surface waters.**
- **Improve plant nutrition by increasing nutrient availability root system.**
- **Improve uptake of nutrients by increasing foliar uptake as beneficial microorganisms increase the times stomas stay open, while at the same time reducing evaporative loss from leaf surface.**
- **Reduce water loss, improve water-holding in the soil, and thus reduce water use in your system.**
- **Improves soil structure. Only the biology builds soil structure, and ALL the groups in the food web are required to be successful.**

AEROBIC COMPOST TEA SHELF LIFE

Because this tea is a concentrated solution teeming with life, it is very perishable and should be used within 6-8 hours of brewing, although in the soil these organisms can keep on working for months. There will be microorganisms alive for 12 to 48 hours, but in reduced quantities.

Compost tea is fast becoming a popular way to provide organic nutrients to plants growing in a soil medium. Organic Bountea comes enriched with the macronutrients N, P and K as well as providing beneficial microorganisms and natural stimulants to enhance plant growth and quality.

There are three common indications of over-fertilization; wilting, a darker than normal shade of green in the leaves, and “crepeing,” or thickening of the leaf tissue (like crepe paper). This does not necessarily harm the plant nor cause death. It is a yellow light of caution: the plant is in a very rich environment and needs no additional nutrient supplementation. The soil or planting medium should be flushed with water and be given much lower doses of fertilizer. Be very wary of nutrient solutions stronger than 1200 ppm (EC 2.4 mS).

FERTILIZER OVERDOSES

Plants use a phenomenon described in the second law of thermodynamics that states that in a solution the concentration of salts becomes equal throughout. Liquid flows from the weaker to the more concentrated solution to achieve equilibrium. By maintaining a more concentrated solution in the tissue, the plant easily draws water and nutrients in.

MANURE NOTICE

It is critical to dry out animal manure and then compost it for at least six months before usage. Dry to prevent bacterial activity that may attack beneficial microorganisms, while also allowing free air passage. If your compost reaches high enough temperatures, it should kill most pathogenic organisms, as well as weed out seeds passed on by grazing animals. Cat and dog manure should never be used on edible plants because they carry many of the same pathogens as humans. Poorly composted manure can be a source of disease including salmonella.

Normally, plants maintain a higher salt concentration than the surrounding environment so they easily absorb water. When the solution outside the plant becomes more concentrated than the solution inside, the plant cannot draw water and wilts.

Fertilizer overdoses happen quickly (within hours or less) resulting in wilting followed by tissue damage. The symptoms of fertilizer overdose are sudden wilting with drying out and crinkling. It occurs when the nutrient content of the rooting medium develops such a high concentration of salts that the liquid is sucked from the plants, which have a lower concentration of dissolved solids. This back and forth flow is also called "osmotic pressure". The plant maintains osmotic pressure according to the salt content of the water in the root zone.

To save plants suffering from toxic overdoses of nutrients, run plain water through the system to flush out the medium so the nutrient concentration becomes diluted. When this happens, the process reverses and the plant is able to pull water inside, once again becoming turgid.

Products that flush or clean the rooting medium can strip away accumulated salts. It is a good idea to use one of these products monthly to drench the roots, or run overnight in a hydroponic reservoir. For hydroponics, drain the reservoir of the old tired nutrient solution, refill with fresh water, add the cleaning product as recommended, run overnight, drain, and refill with fresh water and fertilizer. This method prevents nutrient imbalances that cause plant stress.

Many nutrient deficiencies are the result of minerals being locked up (precipitated) because of a pH or nutrient imbalance. Rather than just adding more nutrients, check the pH first. If the pH needs to be adjusted, it can be changed by irrigating with pH-adjusted water.

To get nutrients to the plant parts immediately, spray the leaves with nutrients. If plants do not respond to the foliar spray by producing normal new growth, they are being treated with the wrong nutrient. Calcium deficiency is not easily corrected with a foliar spray. For foliar application it is essential to use a very mild strength nutrient, 250-500 ppm is typical (EC 0.5-1.0 mS), pH should be 6.0-6.2. Purified water enters foliage much more effectively than hard water. Do not foliar feed during the flowering phase. It results in bad flavor and can provide mold and mildew an advantage. Do not foliar feed during darkness or within three hours of the night cycle, morning is best.

Good mineral nutrients have a high pH buffering ability that allow the plants access to the nutrients. They also prevent mineral build-up in hydroponic systems. Green Dream from Flairform provides nutrients to the plant and has little effect on the pH of the water.

MEASURING NUTRIENT SOLUTIONS

To find out how much fertilizer to provide the plants you need to know how much is already present in the water or planting medium. The concentration of nutrients in the reservoir and growing medium changes over time as the plants absorb nutrients and water evaporates. An accurate measurement is the only way to be sure your plants are getting the optimal ingredients for maximal growth. Fortunately, chemical test kits and meters are readily available and inexpensive. Some meters combine several measurements, such as temperature, pH, and total nutrient level.

www.amalgoldnutrients.com

Bigger, sustainable yields are achieved when plants spend their time absorbing their nutrition more efficiently. Amino acids, which are organic compounds, increase growth rate and yields by providing bigger building blocks for tissue building. These are used by both the mychorrhizae and the roots. Amal Gold Organic Plant Superfood uses fresh fish proteins to provide a source of amino acids that promote rapid growth and development.

Most chemical molecules are charged either positively or negatively.

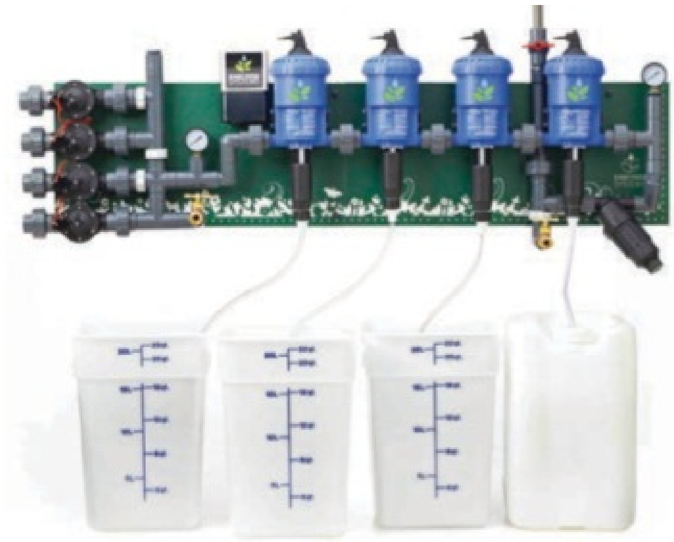
However, some are neutral. EC meters test the charge in the water so they only have the ability to read the charged molecules, not necessarily the amount of molecules of a particular chemical. To more accurately obtain a reading of the amount of a particular nutrient, use a soil test kit that breaks down the individual reading of each nutrient and measures it.

Chemical test kits are actually more accurate because they can provide a measurement of each nutrient. Meters measure nutrient levels indirectly, based on the amount of electricity the nutrient solution conducts. The meters measure how efficiently electrons travel across probes through the solution. Pure, distilled water conducts virtually no electricity. The more nutrients and minerals in the solution, the more electricity is conducted.

Electrical conductivity (EC) is the opposite of electrical resistance (measured in ohms), so the unit is the mho or, in metric units, the siemen. Since the current in even highly concentrated solutions is tiny, meters typically read in either 1/1,000th of an mho (a milli-mho or mMho), or 1/1,000th of a siemen (a milli-siemen or mS).

Some meters provide readout in EC and others read out as Total Dissolved Solids (TDS) or Parts Per Million (ppm) of nutrients. Even those that read directly in TDS or ppm are measuring electrical conductivity (EC) and then estimating the concentration of solids. A measurement of 1,000 ppm means that 1,000 units of nutrients are present for every million units of water. It's important to realize that TDS or ppm readings only tell you the total nutrients in a solution—not how much of each nutrient is in the mix.

Likewise, ppm and TDS vary depending on the type of nutrients present and the conversion factor being used. The conversion calculation is based on what manufacturers consider a typical hydroponic solution. The most common are based on measurements of two types of solutions—either 4-4-2 (40% sodium sulfate, 40% sodium bicarbonate, 20% sodium chloride) or sodium chloride (NaCl)—but they produce different results. The conversion factor for a 4-4-2 solution is approximately 700 x EC in mili-siemens (mS). The NaCl conversion is roughly 500 x EC. This means that the same solution, producing the same EC, converts to either 2100 ppm or 1500 ppm, depending on the scale the manufacturer has chosen. These conversion differences reflect the disparity in conductivity between different nutrients.



When managing a hydroponic system, it is important to balance the correct amount of nutrients in clean, pH adjusted water. The Dosa Easy-Feed System allows the grower to arrange water and nutrient components to meet their individual needs. It allows up to eight different nutrients, additives, and pH adjusters in series at 60 psi.

The unique inline mixer (top) oxygenates the water as it mixes nutrients. Controls (below) allow the grower to read and manage the system.

Proper maintenance of your meter includes periodic recalibration as well as careful cleaning and storage. If the probe is contaminated or dirty, it affects the accuracy of the meter's reading. Similarly, many meters need to have their probes kept moist to protect the electrodes. Check the manufacturer's instructions for how to properly store your probe (most recommend an acidic solution).

SOME COMMON ORGANIC FERTILIZERS

FERTILIZER	% N	% P	% K	REMARKS
Bloodmeal	15.0	1.30	.70	N readily available.
Bone meal	4.0	21.0	.20	Releases nutrients slowly.
Cow manure	.29	.17	.35	Fresh, 80 percent water. Excellent soil conditioner; apply in winter or composts for use in spring. Medium availability.
Coffee grounds	2.0	.36	.67	Highly acidic; best for use in alkaline soils.
Corn stalks	.75	.40	.90	Break down Slowly; chopped stalks make excellent conditioner for compact or dense soils.
Cottonseed meal	7.0	2.5	1.5	Highly acidic; nutrients become available over the course of the growing season.
Dried blood	13.0	3.0	-	More soluble than blood meal.
Fish scrap	7.75	13.0	3.80	Use in compost or turn under soil several months before planting; usually slightly alkaline.
Greensand	-	1.5	5.0	Mined from old ocean deposits; used as soil conditioner; it holds water and is high in iron, magnesium, and silica.
Chicken manure	1.65	1.5	.85	Dried; fast-acting fertilizer. Breaks down fastest of all manures.
Horse manure	1.65	1.5	.85	Fresh, 60 percent water; medium breakdown time.

These are average percentages; the amount of nutrients in a particular sample may vary. The percentage of nutrients in manures depends on water content. Commercial manures are usually rated higher.

Nutrient types and calibration are not the only things that can affect an EC or TDS meter's readings. The EC of your solution also varies based on its temperature since the speed of electron travel is measured, and that increases as the solution gets warmer. Make sure you are measuring the solution at close to the same temperature each time. This won't be an issue if you are using a system with an aquarium heater or other method of maintaining consistent solution temperature. But if the gardening space (and nutrient solution) gets warmer after the lights have been running, take nutrient readings at the same time of day or point in the light cycle.

Soil test kits provide individual readings of nutrients. Meters provide only an overall reading.

It's important to realize that even a properly calibrated and maintained meter used under perfect conditions will not give you a precise reading of your nutrient concentration. Even quality meters are only accurate in the range of approximately +/-5%.

What meters are exceptionally useful for is detecting change in your nutrient solution over time and potentially damaging concentrations of nutrient salts in your solution or growing medium.

If the plants transpire 50% of the water out of the reservoir, the solution's concentration can become dangerously high. Similarly, because your plants take the nutrients they need from the solution and leave the rest, unused salts can build up in the solution. If you just add make-up nutrients without knowing which have been left behind, toxic concentrations can result. If the medium is allowed to dry out, it can accumulate up to 2 or 3 times the nutrient concentration as the starting solution.

As with pH, when the concentration gets too high, your plants effectively lock out water/nutrient uptake. At a ppm of 2000, the osmotic pressure is strong, and plants' roots use more energy to extract water from the salty solution. As the level of nutrient salts increases, the chemicals start to fight each other for water, causing the roots to work harder. The more energy the plants use to extract water, the less they have for growth.

Keeping the solution in the root zone at a moderate concentration of roughly 800-1200 ppm will produce reliable results. Use your nutrient meter to compare the concentration in both the growing medium and the reservoir. When readings in the medium substantially exceed those in the reservoir, it's time to flush the system with pure water.

NUTRIENT DEFICIENCIES

BORON (B)

Boron (B) deficiency is not common. It occurs very occasionally in some western soils. Boron is not mobile.

Symptoms

The first sign of a boron deficiency is the browning or graying of the growing tips followed by their death. Soon after, the lateral shoots start to grow, but then die. Shoots appear sunburned, twisted and a bright green color. The leaves develop small brown **necrotic** dead spots that look like strawberry seeds, and are surrounded by an area of dying tissue between leaf veins. Boron deficiency resembles a calcium deficiency, but can be differentiated by the small size of the necrotic areas.

Stems and petioles (leaf stems) are brittle and show signs of hollowness. Boron deficiency only affects newer growth.

Roots become stunted and the smaller secondary roots become short and swollen as the root tips die. The roots are vulnerable to fungal and bacterial attacks that rot the root hairs and cause discoloration.

Excess boron, which is rare and is caused primarily by over-fertilization, causes the yellowing of the leaf tips which progresses inward. The leaves drop and the plant dies.

Role in plant nutrition

Boron is important in the processes of maturation, pollen germination, and seed production. It also aids in cell division, protein formation, healthy leaf color, and plant structure formation. Proper amounts keep stems, stalks, and branches strong and help plant cells maintain rigidity. It helps calcium maintain solubility.

Boron deficiency. Photo: Turkish

Problem Solving

Treat a Boron deficiency foliarly or through the irrigation water, using one teaspoon (4.9cc) of boric acid (available in drug stores) per gallon of water (1.3cc per liter). Fast-acting solutions also include borax, compost and compost teas.

CALCIUM (CA)

Calcium (Ca) deficiency is rare outdoors except in very acidic soils. The deficiency is occasionally found in planting mixes and is more common in hydroponics. Ca deficiency sometimes occurs in soilless growing mediums that have not been supplemented with lime, which is composed mostly of Ca.

Distilled and reverse osmosis water, as well as some tap water, lack significant amounts of dissolved Ca. This can lead to Ca deficiency unless the water is supplemented with Ca.

Symptoms

Ca deficiency stunts plant growth and makes the leaves turn dark green. Large necrotic (dead) blotches of tan, dried tissue appear mostly on new growth but also on other plant parts along leaf edges. Young shoots crinkle and get a yellow or purple color. In severe cases they twist before they die. Necrosis appears along the lateral leaf margins. Problems migrate to the older growth, which browns and dies. Stems and branches are weak, lack flexibility and crack easily.

The root system does not develop properly, leading to bacterial problems that cause root disease and die-off. The roots discolor to a sickly brown. Ca is semi-mobile.

Role in plant nutrition

Ca strengthens plant cell walls and therefore stems, stalks, and branches, and it aids in root growth—mostly the newer root hairs. It travels slowly and tends to concentrate in roots and older growth. Ca also enhances the uptake of K.

Problem Solving

Outdoors, add Ca to acidic soils to bring them into the pH range of 5.9-6.5. Use dolomitic lime, or garden lime.

Early-stage calcium deficiency. Photo: Senseless

Calcium deficiency. Photo: Senseless

Dolomitic lime, or garden lime, can be added to planting mixes before potting. It provides Ca and also helps stabilize pH over a period of time.

Both planting mediums and hydro systems can be fertilized as directed using a commercial Calcium-Mg (Ca-Mg) formula; this provides instant availability to the plant. It can also be used in planting mixes. Growers often use Ca acetate or

Ca-Mg acetate.

Ca nitrate $Ca(NO_3)_2$ is a water-soluble fertilizer that supplies both Ca and nitrogen. It provides a very soluble form of Ca to the roots and can also be used as a foliar spray. This formula gets Ca to the plant very quickly. Be careful not to add Ca nitrate during the flowering stage because it provides unwanted excess nitrogen.

There are a number of brands of liquid Ca or liquid lime that are absorbed by the roots.

One teaspoon of hydrated lime per gallon of water provides relatively fast absorption. Dolomitic limestone, which contains Mg and Ca, takes longer to absorb. It is a good ingredient to place in planting mixes to prevent deficiency.

Ground eggshells, fish bones and seashells also break down over the season and add Ca to the soil. You can soften them by soaking them in vinegar or lemon juice.

Gypsum, Ca sulfate ($CaSO_4$), can be added to outdoor soils to increase Ca content without affecting the pH too much. It should not be added to soils with a pH below 5.5 because it interacts with aluminum (Al), making it soluble and poisonous to the plants.

General Discussion

Most planting mediums have adequate amounts of Ca. However, Ca should be added to the planting mix if the pH is too low.

Planting mix and hydroponically grown plants are most likely to suffer Ca deficiency. Some hydro fertilizers contain only small amounts of Ca, as the amount of Ca dissolved in the supply water varies. If the water contains more than 150 parts per million (ppm) dissolved solids, it is probably providing the plants with enough Ca. If the water contains less than 150 ppm of dissolved solids, Ca-Mg has to be added to the water to bring it up to 150 ppm. To find out how hard or soft your water is, you will need to have a TDS/ppm meter or refer to the local water district quality report.

COPPER (CU)

Copper (Cu) deficiencies are rare.

Symptoms

Copper (Cu) deficiency first appears in young leaves which exhibit necrosis and coppery, bluish or gray with metallic sheen coloring at the tips and margins. The young leaves turn yellow between the veins.

Other symptoms include limp leaves that turn under at the edges and eventually die, and wilting of the whole plant. New growth has difficulty opening. Flowers do not mature or open in males and in females the stigmas don't grow properly.

Cu toxicity is rare but fatal. As the plant approaches death, its leaves yellow from its inability to use Iron (Fe). The roots are abnormally sized, then start to decay.

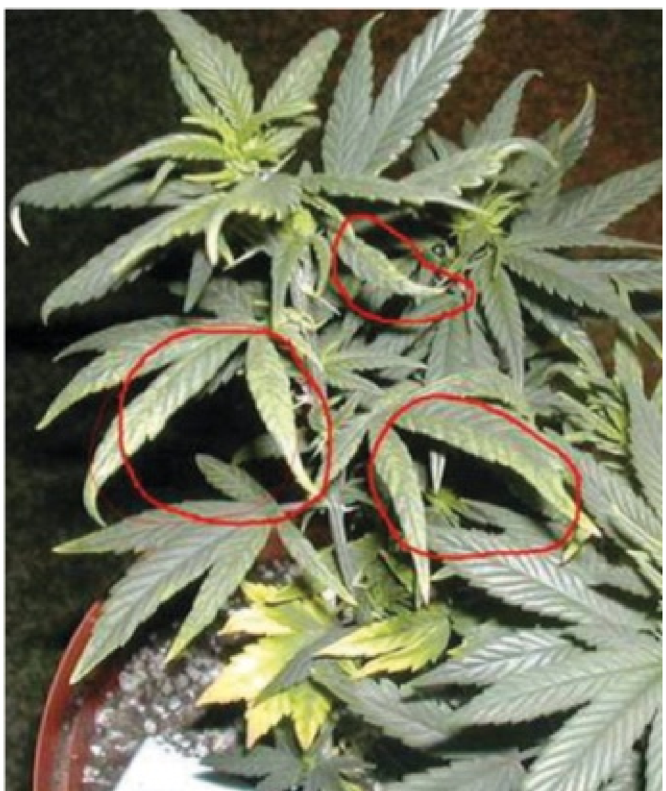
Cu has a low mobility.

Role in plant nutrition

Cu is essential to healthy plant production, reproduction and maturity, and assists in carbohydrate metabolism and oxygen reduction.

Problem Solving

Foliar feeding with copper fungicides such as copper sulfate ($CuSO4$) and chelated copper adjusts a deficiency. Any hydroponic micronutrient formula containing copper helps as well. Compost, greensand, and kelp concentrates are good natural sources.



Though it vaguely resembles nitrogen toxicity, the yellow-white leaf bottoms and brown and dying fan leaf tips confirm the copper deficiency.

Soaking dimes or quarters in water and then using the water to irrigate the plants also supplies copper, since these coins are 92% copper and 8% zinc. (Pennies contain mostly zinc, not copper.) An acid solution such as lemon juice or vinegar dissolves the copper faster.

General Discussion

Copper (Cu) deficiencies are often confused with over-fertilization.

IRON (FE)

Iron (Fe) deficiency occasionally occurs outdoors, in planting mediums, and in hydro.

Symptoms

Fe deficiency starts in the new leaves, which lack chlorophyll but have no necrotic spots. This causes them to turn bright yellow except for the veins, which remain green. New leaves start to experience chlorotic molting, first near the base of the leaflets so the middle of the leaf appears to have a brown mark. The veins remain dark green. Note that a Fe deficiency looks similar to a Mg deficiency except for its location. Fe deficiency affects the new growth but not the lower leaves while Mg deficiency affects the middle and lower leaves first. Fe moves slowly in the plant.

Role in plant nutrition

Fe is necessary for enzymes to function and acts as a catalyst for the synthesis of chlorophyll. Young actively growing tissues need Fe to thrive.

Problem Solving

An Fe deficiency may indicate a pH imbalance. Adjust pH if out of range.

Iron deficiency. Photo: Anonymous

Foliar feed with Fe chelated fertilizer containing Fe, Zn, and Mn, since these deficiencies are often found in combination. Other Fe-bearing supplements include compost, Fe chelates (often found in hydroponic micronutrient supplements), iron oxides (Fe_2O_3, FeO), and iron sulfate ($FeSO_4$) for fast absorption. Supplements should be added both foliarly and to the planting medium. Adding rusty water also works.

General Discussion

An Fe deficiency is often found in combination with Zn and Mn deficiencies.

MAGNESIUM (MG)

Magnesium (Mg) deficiency is common in all mediums and hydro. It is not common outdoors.

Symptoms

Mg deficiency starts in the lower leaves. The veins remain green while the rest of the leaf turns yellow, exhibiting **chlorosis**. The leaves eventually curl up, and then die. The edges of affected leaves feel dry and crispy. As the deficiency continues it moves from lower leaves to the middle to upper half. Eventually the growing shoots change from a pale green to white color. The deficiency is quite apparent in the upper leaves. At the same time, the stems and petioles turn purple. Mg is mobile.

Magnesium deficiency apparent in right plant, contrasted with the green healthy plant on left.

Role in plant nutrition

Mg helps support healthy veins and maintains leaf production and structure. It's required for chlorophyll production and enzyme breakdowns.

Problem Solving

Water-soluble nutrients containing Mg fix the deficiency. Such nutrients are Mg sulfate ($MgSO_4$, Epsom salts) and Ca-Mg for fast absorption; and dolomite lime/garden lime and worm castings for moderate absorption.

In hydro and planting mixes Mg deficiencies are easily fixed using 1 teaspoon (4.9cc) of Epsom salts per gallon (1.3cc per liter) of water in reservoirs. In planting mixes use 1 teaspoon per quart (5cc per liter) of water in planting mixes. After the first treatment, use one-quarter dose with each watering or change of reservoir. Ca-Mg can also be used.

For fastest action Epsom salts can be used foliarly at the rate of 1 teaspoon per gallon (1.3cc per liter). Ca-Mg can be used foliarly as directed.

Dolomitic limestone contains large amounts of Mg. It can be used to raise the pH of soils and planting mixes and supply Mg at the same time.

General Discussion

Mg deficiency is one of the easiest nutrient deficiencies to diagnose and cure. It occurs more frequently if using distilled, reverse osmosis water and tap water that has low ppm count.

MANGANESE (MN)

Manganese (Mn) deficiency is rare and almost always associated with Fe-Zinc deficiencies.

Symptoms

Mn deficiency is generally found in the young leaves. The leaf tissues turn yellow and small areas of tan/brown dead tissue (necrotic areas) appear in the middle of the leaf. The leaf veins usually stay green. The leaf becomes outlined in a ring of dark green along its margins. Too much Mn in the soil causes an Iron (Fe) deficiency. In addition the plant shows a lack of vigor. Mn is not mobile.

Role in plant nutrition

Mn helps enzymes break down for chlorophyll and photosynthesis production, and it aids in making nitrates available for protein production.

Manganese deficiency. Photo: Anonymous

Problem Solving

For fast relief foliar feed with a water-soluble fertilizer high in Mn such as Fe-Zn-Mn fertilizer, hydro micros, or Mn chelate. Then add the fertilizers to the water/nutrient mix. Compost and greensand also contain Mn but they are absorbed more slowly than the water-solubles.

MOLYBDENUM (MO)

Molybdenum (Mo) deficiency is very rare, but is more likely to occur in color-changing strains in cold temperature conditions.

Symptoms

The middle leaves turn yellow. As the deficiency progresses towards the shoots the new leaves become distorted or twisted. A Mo deficiency causes leaves to have a pale, fringed, and scorched look, along with retarded or strange-looking leaf growth. Older chlorotic leaves experience rolled margins, stunted growth and red tips that move inward toward the middle of the leaves.

Sometimes Mo deficiency is misdiagnosed as a N deficiency. However, N affects the bottom leaves first. Mo affects leaves in the middle of the plant first and then moves up to the newer growth.

Excessive Mo in cannabis looks like Fe or Cu deficiency. Mo is mobile.

Role in plant nutrition

Mo is contained in enzymes that help plants convert nitrates to ammonia, which is required for protein production.

Problem Solving

Foliar spraying with water-soluble fertilizers aids in overcoming the deficiency. Because plants need Mo in such small amounts a hydroponic micronutrient mix is often the most efficient way of supplying it. These fertilizers can be used as foliar sprays or applied to the soil, as well as their customary use in hydroponic nutrient solutions.

General Discussion

Molybdenum deficiency late flowering. Photo: Anonymous

Generally a Mo deficiency occurs when S and P are deficient. Mo toxicity does not tend to wreak havoc on plants, but excess intake causes severe problems in humans so extra precautions should be taken when using it.

NITROGEN (N)

Nitrogen (N) deficiency is the most commonly occurring nutrient deficiency in cannabis.

Symptoms

Lower leaves first appear pale green. The leaves then yellow and die as the N travels to support new growth. Eventually the deficiency travels up the plant until only the new growth is green, leaving the lowest leaves to yellow and wither. Lower leaves die from the leaf tips inward.

Other symptoms include smaller leaves, slow growth and a sparse profile. The stems and petioles turn a red/purple tinge.

Too much N causes a lush dark green growth that is more susceptible to insects and disease. The stalks become brittle and break from lack of flexibility.

N can travel anywhere on the plant. Usually deficiency starts on the lower of the plant; because N travels to new growth.

Role in plant nutrition

N is directly responsible for the production of chlorophyll and amino acids, and it is essential to photosynthesis. It is an essential element of tissue; without it growth quickly stops.

Any water-soluble N (especially nitrates, NO3) is quickly available to the roots. Insoluble N (such as urea) needs to be broken down by microbes in the soil before the roots can absorb it. After fertilization, N-deficient plants absorb N as soon as it is available and start to change from pale to a healthy-looking Kelly green. Deficient plants usually recover in about a week, but the most-affected leaves do not recover.

Nitrogen deficiency. Photo: TheNewGuy

N is the first number of the three number set found on all fertilizer packages, which list N-P-K, always in that order. Any water-soluble fertilizer much higher in N than P and K can be used to solve N deficiencies very quickly. Most hydro “Vegetative Formulas” fall into this category.

$Ca(NO_3)$ is water-soluble and fast acting. It can be used as a foliar fertilizer and in the water/nutrient solution.

Urine, fish emulsion (5-1-1) high-nitrogen bat or seabird guano also act quickly. In soils high-N fertilizers such as alfalfa and cottonseed meals, manure, feather meal and fishmeal all supply N fairly quickly.

General Discussion

Without high amounts of N, especially during the vegetative growth stage, the plant’s yield is greatly reduced. Water uptake slows from vascular breakdown in the plants. N issues happen throughout the entire growth cycle. Plants should never experience an N deficiency during vegetative growth. However, over-fertilizing with N causes problems too.

Tapering off the use of N towards flowering promotes flowering rather than vegetative growth. However, a small amount of N is always necessary in order for the plant to manufacture amino acids, which use N as an ingredient. This supports flower growth and utilization of P and K. Some “Bloom Boosters” have N-P-K ratios of “0-50-30.” While high numbers sound impressive, using this fertilizer too early causes the flowers to be smaller than they could have been. If there is not enough residual N available, the plants are not getting the most out of the fertilizer.

In the middle to the end of the flowering stage, plants frequently show a N deficiency. They’re using the nutrients that were stored in the leaves and dropping the their oldest, bottom fan leaves. To prevent the deficiency from getting extreme, switch over to bloom nutrients gradually unless the bloom fertilizer contains some N.

PHOSPHORUS (P)

Phosphorus (P) deficiency is uncommon.

Symptoms

P is the second number found on fertilizer packages. They are always listed in the order N-P-K. Plants deficient in phosphorus grow slowly and are stunted with small leaves. The older leaves are affected first. First the leaves turn dark green and become weak. The leaves develop dull blue or purple hues. The edges of the leaves turn tan/brown and curl downward as the deficiency works its way inward. Fan leaves turn dark green with a purple or dull blue hue. The lower leaves turn yellow and die.

Phosphorous deficiency. Photo: Senseless

The stems and petioles turn purple or red. Some strains, however, normally possess red or purple stems and petioles, so these traits are not a surefire sign of P deficiency.

Plants use high amounts of P during flowering. If they don’t get adequate or even abundant supplies, it results in lower yields. P is mobile.

Potassium deficiency: day 21. Photo: Senseless

P aids in root and stem growth, influences the vigor of the plant, and helps seedlings germinate. P is extremely important in the reproductive stages and flowering.

Problem Solving

P is the second number of the three number ratio listed on fertilizer packages. Water-soluble fertilizers containing high P fix the deficiency. Bloom fertilizers are high P formulas. High-P guano also provides readily available P. Rock phosphate and greensand are also high in P and gradually release it. The affected leaves do not show recovery, but no additional growth is affected and new growth appears healthy.

General Discussion

Deficiency during flowering results in lower yields, but over fertilizing can result in “chemical buds” or burn the plant. Cold weather (below 50° F/10° C) can make P absorption very troublesome. For this reason soluble P such as found in water-soluble bloom formulas can add flower yield in cool weather.

POTASSIUM (K)

Potassium (K) is the third number found on fertilizer packages, always listed in the order N-P-K. Potassium (K) deficiency occurs occasionally in both planting mediums and outdoors in soil, but rarely in hydroponics. Plants often suffer from mild K deficiencies, even in rich, well-fertilized soil, usually caused by improper fertilization. Many organic fertilizers such as guano, fish emulsion, alfalfa, cottonseed and blood meals, and many animal manures contain minor amounts of K relative to N and P.

Symptoms

Plants suffering from minor deficiencies look vigorous, even taller than the rest of the population, but the tips and edges of their bottom leaves die or turn tan/brown and develop necrotic spots.

As the deficiency gets more severe the leaves develop chlorotic spots. Mottled patches of red and yellow appear between the veins, which remain green, accompanied by red stems and petioles. More severe deficiencies result in slower growth, especially when plants are in the vegetative stage. Severe K shortages cause leaves to grow smaller than usual.

Larger fan leaves have some dead patches, or necrosis, on their margins. These leaves eventually turn brown and die off. Plants with K deficiencies tend to be the tallest.

Excess K causes fan leaves to show a light to dark yellow or white color between the veins. K is mobile.

Silicon and potassium work together to build stronger plant cell walls. This creates a barrier against insects and fungi. Dyna-Gro Pro-TeKt provides silicon which increases the plants ability to tolerate drought and heat as well as strengthen the overall plant.

Role in plant nutrition

K is found in the whole plant. It is necessary for all activities having to do with water transportation, as well as all stages of growth; it's especially important in the development of buds. K aids in creating sturdy and thick stems, disease resistance, water respiration, and photosynthesis.

Problem Solving

Although symptoms of minor K deficiency affect the cosmetic look of the plant, it does not seem to affect plant growth or yields.

Water-soluble fertilizers containing high K fix the deficiency. Bloom fertilizer usually contains high K levels. It is used in the formulas to balance the pH. Highly alkaline K is used to balance acidic P. Wood ashes deliver K quickly.

Liquefied kelp, bloom fertilizers and wood ash are commonly used and work quickly to correct K deficiencies, as does potassium bicarbonate (KHCO3), potassium sulfate (K2SO4) and potassium dihydrogen phosphate (KH2PO4). Potassium silicate (K2SiO3) can be used to supply silicon and has 3% K in it. Granite dust and greensand take more time to get to the plant and are not usually used to correct deficiencies, but to prevent them.

Damaged leaves never recover, but the plant shows recovery in four to five days with applications of fast-acting products.

General Discussion

Cold weather slows K absorption, as does too much Ca or NH4+. High levels of Na displace K.

SILICON (SI)

Siicon (Si) deficiency is very rare.

Si has not been proven to be necessary for plant growth. However, the presence of Si promotes the development of strong leaves, stems and roots. It also increases resistance to fungal and bacterial diseases and insect infestation. The plant also exhibits an increase in photosynthetic activity and overall yield increases. Si is not mobile.

Si helps the plant overcome different stresses that occur and helps to protect the plant from pests and diseases. It aids in growth, development, yield and disease resistance. It is used to strengthen stem and branch structure.

Problem Solving

Diatomaceous earth can be added to the planting mix. The Si is dissolved by acids into a form the roots can absorb.

Liquid Si is found in Si supplements. It is immediately available to the plants.

General Discussion

Si is abundant in nature, but it is not included in hydroponic fertilizers, so it should be used as a supplement.

SULFUR (S)

Sulphur (S) deficiency is rare.

Symptoms

The first signs of S deficiency are yellowing, young leaves. Leaf growth is slow; leaves become brittle and narrower than usual, and are small and mutated. Buds die off at the tops of flowering plants. Overall growth is stunted. Some S deficiencies may show orange and red tints rather than yellowing. In severe cases the veins of the growing shoots turn yellow with dead areas at the base of the leaf where the blades join. The stems become hard, thin and may be woody. They increase in length but not in diameter.

Too much S stunts the plant and leaf size, and the leaves look brown and dead at the tips. An excess of S looks like salt damage: restricted growth and dark color damage. This is also rare.

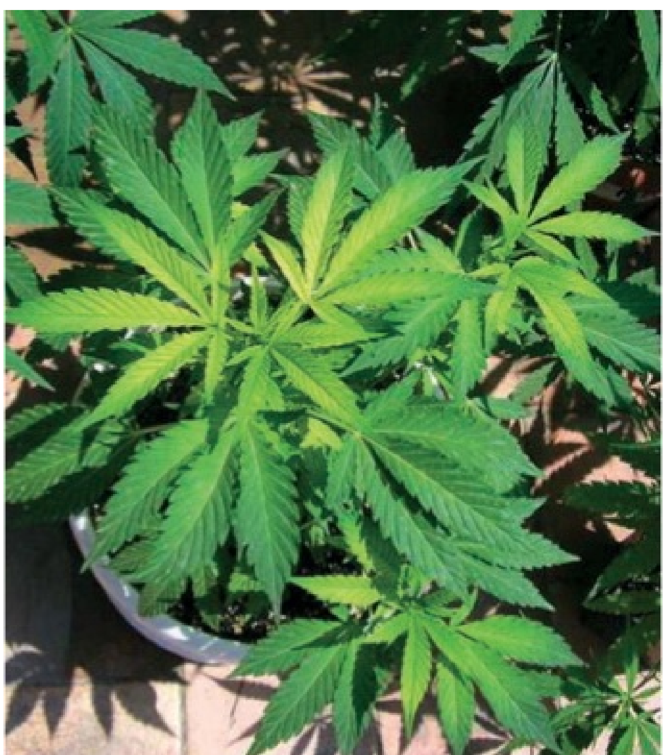
Like iron (Fe), S moves slowly in the plant. Warmer temperatures make S harder for the plant to absorb. But unlike Fe, S is distributed evenly throughout the plant, mainly in the big fan leaves. S deficiency starts at the back of the leaves and creeps towards the middle.

Role in plant nutrition

Sulpher is essential during vegetative growth and plays an important role in root growth, chlorophyll supply, and plant proteins.

Problem Solving

Both organic soils and inorganic fertilizers contain high levels of available S so plants are not likely to suffer from a lack of the element. However, a deficiency is easily solved using Epsom salts ($MgSO_4$). Water the plant with Epsom salts until the condition improves. Mix one to two teaspoons of the salt per gallon (1.3-2.6cc per liter) and apply both foliarly and to the irrigation water. Adding nutrients containing S fixes the deficiency. Mix at recommended strength to avoid nutrient burn. Any water-soluble fertilizer that uses S in the trace minerals also works. Other sources are elemental garden S, potassium sulfate (K_2SO_4), and gypsum. Do not use gypsum on acidic soil (pH less than 5.5); it affects the absorption of soil aluminum, which is poisonous to plant roots.



Sulfur deficiency. Photo: Anonymous

ZINC (ZN)

Zinc (Zn) deficiency occurs occasionally.

Symptoms

New growth has radically twisted leaf blades. Zn deficiencies are identifiable by spotting, chlorosis, and yellowing between the veins of older leaves. Inter-veinal yellowing is often accompanied by overall paleness. During the flowering stage, buds may contort, twist and turn hard. When the deficiency first appears, the spotting can resemble that of an Fe or Mn deficiency but it affects the new growth. Zn excess is very rare, but produces wilting and even death in extreme cases.

Zn is not mobile in plants, so symptoms occur mainly in the newer growth.

Role it plays in plant nutrition: Zn aids in plant size and maturity, as well as in the production of leaves, stalks, stems, and branches. Zn is an essential component in many enzymes and in the growth hormone, auxin. Low auxin levels cause stunted leaves and shoots. Zn is also important in the formation and activity of chlorophyll. Plants with high levels of Zn can tolerate longer droughts.

Problem Solving

Use an iron-zinc-manganese (Fe-Zn-Mn) micro mix to solve the deficiency. Zn sulfate ($ZnSO4$), chelated Zn or zinc oxide (ZnO) also adjust the deficiency.

General Discussion

With low levels of Zn in the plants, the yields are dramatically reduced.

TEMPERATURE, HUMIDITY, AND AIR QUALITY

Marijuana grows well in moderate temperatures – between 70° and 85° F (21°-29° C). Both high and low temperatures slow marijuana's rate of metabolism and growth. Plants grow fastest when the temperature during the lighted period is kept between 72° and 77° F (22°-26° C). When CO_2 is being used, the plant prefers to be a few degrees warmer, between 79° and 85° F (26°-29° C). Individual marijuana varieties differ in their temperature preferences by a few degrees, so some experimentation is required to find the ideal temperatures for the strain you are growing.

Ideal temperature is tied to light conditions. As more light is available, the ideal temperature for normal plant growth increases. Strong light and low temperatures slow growth and decrease stem elongation. Conversely, when plants are given high temperatures and only moderate light, the stems elongate.

Plants growing under moderate intensity lamps (40-50 watts per sq ft, 430-540 watt per sq m) should be kept on the low side of the recommended temperature range. Plants growing under higher intensity lamps (60 watts per sq ft, 650 watts per sq m and higher) should be kept on the warmer end of the scale.

During dark periods, the temperature can be kept as much as 10˚ F (5˚ C) cooler than the lit period without any negative effects. Wider temperature differences cause slower growth, stem elongation and delayed flower ripening.

Plants that are kept at a constant temperature are likely to grow stouter, sturdier stems and have denser bud growth. Plants that experience a large differential between day and night temperatures suffer from stretching and slowed growth rates.

At temperatures below 60° F (15° C), photosynthesis and plant metabolism slow, stopping growth as it waits for better conditions. As soon as the temperature rises, the plant resumes full functioning. When the temperature falls below 40° F (4° C), marijuana plants experience tissue damage and require about 24 hours of warmer conditions to resume growth. Young marijuana plants are somewhat tolerant of low temperatures; when outdoors, seedlings have been known to pierce snow cover without ill effect. But low temperatures during ripening, even just overnight, delay or prevent bud maturation. Some equatorial varieties stop growth after a few nights with temperatures below 40° F (4° C).

TEMPERATURES PLANTS LIKE

Germination: 70-78° F (21-25° C)

Vegetative: 68-82° F (20-27° C)

Flowering: 68-80° F (20-26° C)

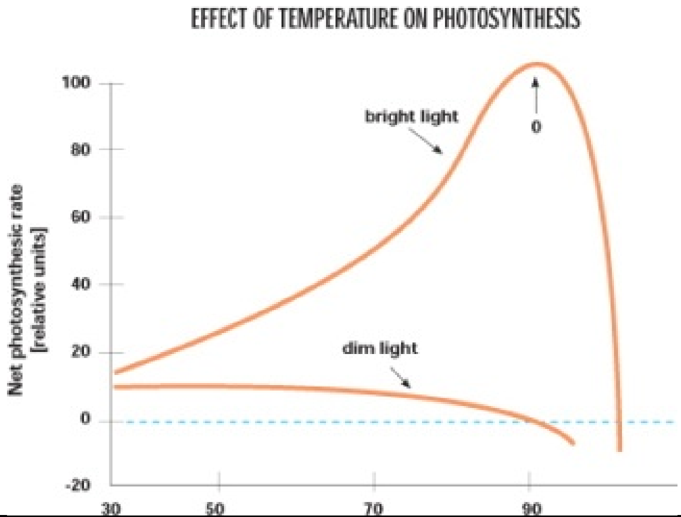
Cloning: 75-85° F (24-20° C)

EXCESSIVE HEAT

Marijuana plants are very hardy and survive outdoors over a wide range of temperatures. They can withstand extremely hot weather, up to 120˚ (49˚ C) for short periods, as long as they have adequate supplies of water and a large root system.

As the temperature rises from the high 70’s into the 80’s F (20-25˚ C), plants spend more energy staying cool and maintaining faster cell metabolism. However, under high light conditions, photosynthesis increases as the temperature rises, resulting in a net gain in plant growth. Photosynthesis reaches it apex at about 85° F (30° C) and between 6000-7500 fc (81,000 lux) of light. However, as heat rises further to 90° F (32° C), photosynthesis slows until it stops at about 95° F (35° C). At this point, plants go into preservation mode; photosynthesis stops as the plants spend energy acquiring water and transpiring it through the stomata in order to keep cool.

Outdoor plants facing long, hot spells should be well watered so the roots can draw upon adequate supplies with little effort. As the soil dries out, water tension increases, and the soil holds on tighter to the remaining water. Keeping the soil moist makes it easier for the plant to draw water from the medium. Plants can also be protected from the heat using a spray-on **anti-transpirant**, which keeps the plant from shedding water. Make sure to use a non-toxic spray that is listed as safe for use on edibles. Still, it is questionable whether sprayed leaves should be used.



Plants photosynthesize more rapidly in high light-high CO_2 conditions when the temperature is around 85° F (30° C)

Excessive heat can be a problem indoors too, though it is easier to control. Gardens using high wattage lamps generate a lot of heat; an unprotected 1000w metal halide and ballast emits about 3500 BTUs, while air-cooled lights generate about 500-1500 BTUs. During the winter, the heat produced may keep the garden space comfortable, but during the summer, the space may get too hot, particularly if there are several lights heating up a room.

The temperature of the uppermost foliage is the specific area of interest. The space in the aisles or the floor may be cool, but that doesn’t matter to the plants. What is important is the temperature of the canopy under the lights where the plants are producing new growth. Even when the overall temperature of the room is in the optimal range, the areas directly under the bulbs can be very hot.

EXCEL AIR SYSTEMS DIY AIR CONDITIONING UNIT—Photosynthesis quickly slows to a stop as the temperature climbs past 90° F (32° C). The Excel Air AC Unit allows you to preset and regulate the temperature and also has the ability to incorporate other essential grow room elements such as CO_2, odor eliminators and air purifiers.

A surface thermometer measures the temperature on the leaf surface. It is the best indicator of the temperature that the plant is experiencing. To use point the infrared thermometer at the leaf or other surface measure, and it will give a digital readout. When using conventional thermometers, make sure to place them at the top of the plant canopy; this provides an accurate reading of conditions in the growing area.

All ventilation systems should have an intake filter to prevent insects and mold spores from entering the space. This Dust Shroom filter cleans incoming air. Notice the pests and dust on the filter surface.

COOLING INDOORS

There are several ways to manage heat in an indoor garden space:

- Don’t create a hot environment. Use air or water-cooled lights to prevent heat from being trapped in the garden space. Keep heat-producing ballasts outside the growing area.
- Run lights at night. If the room is lit exclusively by lamps, the day/night cycle can be reversed so heat is generated at night, when it is cooler outside.
- Vent the garden area with filtered air. During the winter and in the evening, outdoor air may be cool enough to lower the temperature of the garden.
- Install an air conditioner. Air conditioners can be set up to exchange the heat in the room without venting telltale odors. Portable air conditioners work well, and window models can be installed in a window or an internal wall to vent the heat into a central area.

Properly positioned fans in the grow room cool the air heated by the lights, strengthen the stems, and help prevent pests from landing and clinging to your plants. The Max-Fan from Can Filters is small, energy efficient, and quiet.

- Use a cooler. Warm dry spaces can be cooled using portable air coolers. These appliances cool the air using evaporation. Air is drawn through a wet filter; as the water evaporates, it cools the air.

Even without lights, an enclosed space can get hot rapidly when outdoor temperatures rise. Greenhouses get very hot during the summer as bright sunlight heats up the interior and the roof traps the heat, so the temperature increases throughout the day. Some greenhouses have roofs that open to let hot air escape and draw cooler air in.

This portable evaporative cooler contains its own reservoir. It’s easy to move to spaces where it is needed.

For closed greenhouses, swamp coolers are very effective. Water runs through fibrous plastic mats as fans blow air, lowering the greenhouse temperature. Because swamp coolers work by evaporation, they are most effective in hot, dry areas.

Another evaporation technique uses five-micron spray nozzles, or cooling fans, to pulverize water into small particles. The water pieces are so small that they immediately evaporate as they are sprayed into the hot air, lowering the ambient temperature. Spray coolers are available through nursery supply houses.

Plants stop photosynthesizing and buds grow lanky when the temperature gets much above 80-85˚ F (27-30˚ C). A misting fan (circled) blows 5-micron droplets of water into the air that quickly evaporate, bringing the temperature down by 20˚ F (11˚ C) and getting the plants back to work. Strings of 5-micron misters (not pictured) work the same way.

COOLING OUTDOORS

Photosynthesis crawls to a halt when the temperature gets close to 90° F (32° C). In hot weather outdoor plants may be photosynthesizing efficiently during only part of the day. For instance, if the temperature climbs to 90° F (32° C) at 11 a.m. and does not drop below that level until 4 p.m., the plant will utilize only the morning and late afternoon light. High temperatures outdoors during flowering interferes with bud development, making maturing buds airy and lanky. Temperature is a factor when plants are forced to flower in hot areas during the summer.

Fortunately, there are several ways to keep plants cool outdoors:

- A fine spray of water on the plants keeps them cooler during the hot period. The evaporating water absorbs heat from both the leaf and the air in the micro-space at the leaf surface. Use a water spray only during vegetative growth and the earliest stages of flowering. Spray early enough in the day so that all the water has evaporated before dusk.

- Misters that use 5-micron sprayers evaporate water in the air, cooling the space without getting the plants wet. Some systems use rows of emitters, high-speed fans, or a combination of both to create a super-fine mist or fog that evaporates instantly, lowering the temperature as much as 30˚ F (16˚ C). They work best in dry areas.
- Outdoor fans and misters.

ROOT TEMPERATURE

The temperature of the plant canopy is critical, but it is not the only area to consider. Root temperature is also important. Cold floors lower the temperature of containers and the planting medium, slowing germination and growth. Cold temperatures also encourage more of the plants to develop as males when you are growing from seed. When a plant's roots are kept warm, the rest of the plant can be kept cooler with no damage. Ideally, the medium temperature should be 70° F (20° C). There are several ways to warm the medium, or protect it from cold surroundings:

- The best way to insulate a container from a cold floor is to raise it so there is air space between them. A thin sheet of Styrofoam, foam rubber, wood, or even newspaper between the container and the floor serves to insulate.
- The medium can be warmed using overhead fans to push the warm air down from the top of the room, warming containers that are placed on pallets.
- Heat cables, or heat mats, apply heat directly to the root area.
- Heat the water in recirculating systems with an aquarium heater controlled by a thermostat. If the air is cool, from 45°-60° F (27°-15° C), the water can be heated to 80° F (27° C). At these high temperatures, hydroponic system water should be supplemented with oxygen using hydrogen peroxide. Water holds little oxygen above 80° F (27° C).

Humidifiers keep the humidity of clone rooms at the desired 75-80%.

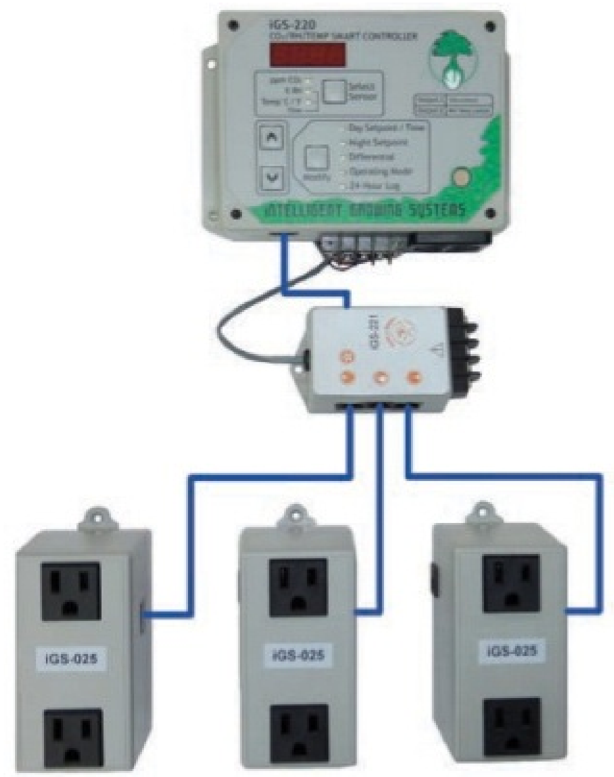
In general, water temperature should be adjusted to balance out the air temperature. If the air is warm, over 75° F (22° C), the water should be no more than 70° F (20° C). Should air temperature rise above 90° F (30° C), lower the water temperature from 70°-65° F (20°-18° C) to help decrease canopy stress.

HUMIDITY

Cannabis grows best in an environment that is mildly humid: 40-55 % relative humidity. Plants growing in drier areas may experience a slight chronic wilt and necrosis of the leaf tips. Plants growing in a more humid environment usually experience fewer problems, but the buds become susceptible to molds that can attack a garden overnight and ruin a crop.

Indoor gardeners are rarely faced with conditions that are too dry. In enclosed spaces, water which is evaporated or transpired by the plants contributes to the humidity. With no ventilation or other humidity control, the space, whether large or small, gets excessively humid within hours.

The solution may be as easy as opening a window or adding a small ventilation fan. A dehumidifier can also resolve the problem in closed environments.



If the air in the room becomes humid, marijuana crops run the risk of becoming moldy. Products that maintain pre-set climate levels are helpful in areas with extreme temperatures and high or low humidity. The Novabiomatique Plug ‘n’ Grow controls the temperature, humidity, and CO_2 concentration of the room as well as allowing the gardener to prioritize the actions in a logical sequence, and efficiently adapt to local climate conditions.

Dehumidifiers work the same way as a refrigerator but instead of cooling a space, moisture in the air condenses and collects on the cold tubes. A dehumidifier may be needed only a few hours a day. If the plant regimen includes a dark cycle, then the dehumidifier can be run when the lights are off, easing the electrical load. The smallest dehumidifiers (which can dry out a large space) use about 15 amps.

AIR CIRCULATION

Good air flow within the growing space is important to the plants' health. Plants depend on the air movement to grow strong and vigorously.

Without air currents, the leaves' rough surface and tiny hairs trap the air in a micro-environment that differs significantly from the surrounding atmosphere. The plant uses CO_2, and produces oxygen and water which depletes CO_2 in the air surrounding the leaf, but contains more humidity and oxygen than the rest of the space. Until this air is replaced with new CO_2 laden air, photosynthesis slows.

Marijuana depends on air currents to move air and renew the micro-environment. When it is not moved vigorously, the growth rate slows and the micro-environment remains CO_2 depleted.

Vigorous air movement mimics the natural environmental stresses that encourage plants to develop firm, sturdy stems. As plants sway with the wind in an outdoor environment, they develop tiny breaks in the stem. The plants repair the damage quickly by reinforcing the breaks and tears, leaving them stronger and stouter than they were originally.

Indoors, plant stems grow weak unless the plants have air flow to resist, or are shaken by the stems daily.

ASK ED: Marijuana Questions

ICE WATER FOR PLANTS

The garden's water source is drying up and won't last through July. The plants are in a field in the sun and it gets really hot here, over 100 ° F (38˚ C) every day during July and August. Can I place ice at the base of my plants or will the cold water have some effect on the roots or growth of the plant? It's easier to carry bags of ice then buckets of water.

The cool water produced by the ice is beneficial to the roots. The soil is hotter than the ideal temperature in the low 70s F (20-23˚ C). The gradual melt will cool the soil enough for the roots to enjoy a reprieve from the ultra-hot and to drink up over a period of time. This method also gives the soil time to absorb the liquid as the ice melts rather than have it pool and flow away.

Remember—one gallon (3.71 = 3.6 kg) of ice weighs eight pounds (3.6 kg).

COMMUTER PLANTS

My plants just started budding and I live in a place where it freezes at night in September. I have been bringing them in at night so frost won't damage them. Is this necessary? The buds are about a half-inch long this morning.

It's good that your plants are in containers and you have the luxury of moving the plants into sunlight each day and into the comfort of a dark garage each evening. You are doing the right thing. Freezes inhibit bud production and ripening. Removing the plants to warmer quarters keeps them on course even as the weather changes.

Make sure to bring them outside and back inside at the same time each day, or at least to give them as much sunshine as possible as the days shorten.

Good ventilation to the outside may be enough to keep the air moving. Place fans at or below the canopy level to push cool air through the canopy. Another solution is to run overhead fans in reverse so that air is pulled up, rather than pushed down.

Be sure to screen any air intake fans, to prevent intrusion of pests from outside.

AIR QUALITY

Besides temperature and CO_2 content, other things to consider about the air in your garden, include dust content, electrical charge, and humidity.

DUST

The dust content of the air affects the efficiency of the plant's ability to photosynthesize. Although floating dust blocks only a small amount of light, dust accumulated on leaves blocks large amounts.

"Dust" is actually composed of many different-sized solid and liquid particles that float in the gaseous soup of the atmosphere. The particles include organic fibers, hair, other animal and vegetable particles, bacteria, viruses, smoke, and such odoriferous liquid particles as essential oils and water-soluble condensates. Virtually all dust particles have a positive electrical charge because they are missing an electron, which causes them to float in gasses.

Dust particles precipitated from the air change the charge using negative ion or ozone generators.

Wash off dust from leaves using a fine mist spray. Be careful when using water sprays around hot lights. If even a little water hits the hot glass of the lights, the bulbs can shatter. Before spraying shut the lights off and let them cool down.

NEGATIVE IONS

Negative ions can precipitate dust, spores, and odors. (*See Security.*) The air's electrical charge affects plant growth and animal behavior, as well as the strength of odors. The clean, fresh-smelling air that follows a rain is due to the extra negative ions left in the air by falling water. Air in verdant, unindustrialized areas and near large bodies of water, is also negatively charged; electrons float in the air loosely attached to oxygen molecules. In industrialized areas or very dry regions, the air is positively charged because molecules are missing electrons. Negative ions jump from oxygen carriers to the electron deficient molecules, neutralizing them and causing them to precipitate.

Negative ion enrichment creates a few readily observable effects:

- Plants in negative-ion environments grow faster than those in positively charged ones.
- Negative ions precipitate dust particles, hair, and dander from the air, so there are fewer bacteria and fungus spores floating around.
- Negative ions eliminate unwanted odors, which are positively charged particles in the air. Increasing negative ions causes the odor-carrying particles to precipitate. With enough negative ions, even a room filled with pungent, flowering sinsemilla becomes odorless.

Many firms manufacture negative ion generators, ionizers, or ion fountains. These units are inexpensive, safe, use minuscule amounts of electricity, and are recommended for vegetatively growing gardens during the first weeks of flowering. However, when they are used in the garden itself during the last weeks of flowering they eliminate odors in the garden and the plants.

Most modern ion generators capture the particles they precipitate in a cleanable, reusable filter. A few cheaper models have no provision for capturing the greasy precipitate. Since the thick film of grime usually lands within a two-foot (0.6 m) radius of the ion fountain, placing newspaper around the unit is a convenient way to collect the residue. You can make a precipitator by grounding a sheet of aluminum foil to a metal plumbing line or grounding box. Attach an alligator clip and a piece of wire to the foil and grounding source. When the foil gets soiled, replace it.

To preserve the classic, bag-busting aroma of your crop, don’t use negative ions in the flowering room during the last three weeks of flowering. Negative ions interact with the odor molecules not only in the air but also those present on the plant that are not fully protected by the trichome membrane. The negative ions neutralize them so they are odor-free. The terpenes inside the membrane are unaffected, so a pinched bud still releases a powerful aroma. But for best results, use ion generators during the last three weeks of flowering only in the rooms surrounding the garden room, not inside.

PART 11 QUICK POINTS: WHAT ARE PLANTS AND WHAT DO THEY WANT

MARIJUANA PLANT LIFE CYCLE

Seeds contain the embryos of plants and when they come in contact with water they begin to germinate. A pair of embryonic leaves, cotyledons, emerge and the plant begins to photosynthesize. At the same time, roots grow into the planting medium to gather water and nutrients.

Photosynthesis is the process in which plants capture the energy from light and use it to power a series of biochemical reactions. Carbon dioxide from air and water are combined to produce sugar and release oxygen into the atmosphere. Sugars created in the process fuel the plant's metabolism; it's energy for life processes.

Cannabis is considered a short-day plant that flowers in the fall. The processes of germination, seedling growth, vegetative, flowering and ripening happen over a 100 to 130-day time period.

Marijuana plants are dependent on their environment for the materials and energy it supplies. There are five factors that affect marijuana growth: light, CO_2, nutrients, water, oxygen, and temperature.

The plant's ability to fully utilize any of the five factors is dependent on the other four. For this reason these five factors are called the limiting factors.

The limiting factor, or the factor that is not supplied adequately, determines the rate of growth. Growth slows or stops when that factor is not adequately supplied.

Things to Know

- Red light from 660 to 680 nm prevents flowering. A short burst of far-red light at 730 nm after lights out or dusk accelerates flowering.
- Chlorophyll is the pigment where photosynthesis takes place. It converts CO_2 and water using the energy from light into sugar.
- Marijuana potency is determined, for the most part, by genetics. It can be increased or decreased by environmental factors.

LIGHT

Plants use the energy they get from light to make sugar from water and carbon dioxide through the process of photosynthesis.

Red and blue are the wavelengths plants use most efficiently because chlorophyll, where light energy is used to make sugar, absorbs light primarily in the red and blue spectrums.

In addition to using light for energy, plants use it to regulate growth. Light determines the direction of growth (heliotropism) as well as whether the plant will elongate or grow stout stems. (Infrared light promotes elongation; red and blue light promote stout stems.)

The amount of THC a plant produces increases with the amount of UVB light a plant receives. This light can be provided to indoor plants with proper lighting. Outdoors, the amount of UVB light is highest during the summer.

Indoor gardeners use fluorescent, metal halide, high-pressure sodium and LED lamps. The indoor gardener can ensure their plants are using the lights provided to their full potential by using a light meter. A light meter lets you double check your calculations and ensure that you have set up a garden with light distributed evenly throughout.

Mixing light sources such as fluorescents or LEDs with high intensity discharge lamps helps the garden because together they provide more light and can fill in the partially shaded areas.

Each lamp has an electrical system that requires conversion to a higher voltage than is delivered through the electric grid. The ballast converts the building current to the appropriate voltage.

Things to Know

- Sativas, and to a lesser extent sativaindica hybrids, require the most light because they evolved below the 30th parallel, near the equator. Because indicas evolved in northern latitudes they are best for low-light gardens.
- The better measure of light in relationship to usefulness to plants is Photosynthetically Active Radiation or PAR light. PAR light, however, does not measure far red and UV light, both wavelengths that marijuana uses for growth.

NUTRIENTS AND FERTILIZERS

Once the plant is in the ground or container, the two easiest and most reliable ways to meet the plant's needs are to use a prepared hydroponic fertilizer or an organic water-soluble fertilizer. Hydroponic fertilizers are blended as balanced and complete nutrient formulas. Most non-hydroponic fertilizers contain only macronutrients—nitrogen (N), phosphorus (P), and potassium (K). Organic fertilizers, such as fish emulsion, guanos and manures, and many blends of organics, contain additional trace elements found in the organic matter from which they are derived.

Demand for critical nutrients (N, P, K) varies with the plant conditions and life cycle of each plant.

Plants grown in soil mixes can typically get along using basic fertilizers such as compost and manure, while plants grown in soilless mixes require micronutrient enrichment in the form of mineral nutrients in the water. Plants grown in a nutrient-rich medium with—compost, manure, or time-release fertilizers—may need no additional fertilizing when planted in a large enough container or outdoor garden. Additional nutrients can be administered in supplemental amounts if the plants begin to show deficiencies.

Many nutrient deficiencies are the result of minerals being locked up because of a pH imbalance. Rather than just adding more nutrients, check the pH first and adjust accordingly.

If added nutrients cure a deficiency, the plant usually responds in apparent ways within one or two days. However, if the gardener over-fertilizes, the plant will overdose, which becomes apparent quickly (within hours or less), resulting in wilting followed by death. Leaves and other parts that were slightly discolored may return to normal, although plant parts that were severely damaged or suffered necrosis will not recover. The most dramatic changes should be monitored in the new growth.

Things to Know

- A plant's ability to absorb nutrients is affected by the temperature, among other factors. Under high light, hot conditions, to prevent thinning of stalks, plants should be given 10 – 20% less nitrogen. Under a cool or cold regimen increase the nitrogen by 10 – 20%.
- Demand for nutrients varies by growth stage. Marijuana uses more nitrogen during the vegetative cycle, more phosphorous during flowering, and the most potassium after fertilization, to aid seed production.

- Over-fertilization occurs when a plant absorbs more fertilizer than it needs. Three common indicators are that the leaves turn a darker green than usual, the leaf tips brown, or the leaves curl down.
- Fertilizer overdoses happen within hours, sometimes sooner. They occur when the nutrient content of the rooting medium has a higher concentration of dissolved solids than the plant itself, rendering the plant unable to draw water, which causes wilting.

WATER

The mineral, carbon dioxide, and oxygen content of water varies substantially, and affects your plants. Mineral content is often referred to as dissolved solids, which are expressed as parts per million (ppm) and can be tested approximately by measuring the electrical conductivity (EC) of the water.

A reading of 125-150 ppm for your water is a good starting point.

The pH is a measure of acid-alkalinity balance and is measured on a scale of 0-14, with 0 the most acid, 7 neutral, and 14 pure alkali. Every point increase or decrease on the pH scale reflects a 10-fold change in acidity or alkalinity.

Most nutrients that plants use are soluble only in a limited range of acidity. Solubility also depends to some extent on the type of soil, planting mix, or hydroponic medium.

Should the water solution in the soil become too acid or alkaline, the nutrients dissolved in the water precipitate and become unavailable to the plants. When the nutrients are locked up, plant growth is slowed.

For absolute control of the planting medium, test the pH weekly. Water should always be pH adjusted after nutrients are added, since they affect its balance.

Things to Know

- The three key measures of water composition are alkalinity (the ability of water to buffer acids), its pH (a measure of the acid-alkalinity balance) and its content of dissolved minerals.
- Most nutrients plants use are soluble only in a limited range of acidity, from about 5.5 to about 6.5 in mineral soil and 5.6-6.3 in hydro medium.

CO_2

CO_2 is one of the two raw materials required for plants to photosynthesize. (Water is the other.) Cannabis uses CO_2 only in the presence of light. Photosynthesis occurs immediately after the plant receives light.

The amount of CO_2 in the air has a profound effect on the rate of photosynthesis and plant growth. Photosynthesis speeds up when CO_2 in the air increases, as long as there is enough light to power it. Conversely, when CO_2 content of the air falls, photosynthesis slows to a crawl and virtually stops at a CO_2 concentration of around 200 ppm, no matter what the other conditions. Lacking CO_2, plants continue respiration for a short time, until their sugars are used up; then their metabolism slows down to conserve energy. Only when more CO_2 is available can the plant continue the process.

Increasing CO_2 concentration without increasing light intensity does not result in a higher rate of photosynthesis. By increasing the light intensity you can encourage your plants to absorb even more CO_2 increasing growth and yield.

The most convenient way to supplement your grow space with CO_2 is by using a meter, regulator and tank kit. Other ways to bring CO_2 into the grow space include water heaters and other gas appliances, dry ice, chemical reactions, and biological processes such as composting, fermentation, and animal respiration.

In most systems, CO_2 should be released just above the plants. The gas is heavier and cooler than the air so it sinks. As it flows downward, it reaches the top of the canopy first. This is where most of the light touches the leaves and where most of the CO_2-consuming photosynthesis takes place.

Outdoor plants growing in the bright light of summer grow heavier and faster when supplemented with CO_2, and produce a higher yield.

Roots do not need CO_2 because they do not photosynthesize and have no use for it. Plants obtain CO_2 through the leaf stomata. CO_2 in the soil or water can pose a problem because it can drive out much needed oxygen.

CO_2 is not dangerous. It is a nonflammable gas. It is non-toxic at the low levels growers employ.

Things to Know

- Plants obtain oxygen in three ways: oxygen released during photosynthesis, oxygen in the atmosphere, and oxygen dissolved in water, which is absorbed by the plant's stomata and roots.
- It is impossible for your plants to "overdose" on CO_2. In fact, your plant can thrive from supplemental CO_2 as long as adequate light and temperature conditions are met.

TEMPERATURE, HUMIDITY, & AIR QUALITY

Marijuana grows well in moderate temperatures, between 70° and 85° F (21°-29° C). Both high and low temperatures slow marijuana's rate of metabolism and growth. The ideal temperature for your plant is tied to light conditions. As more light is available, the ideal temperature for normal plant growth increases. At temperatures below 60° F (15° C), photosynthesis and plant metabolism slow, stopping growth as it waits for better conditions.

Plants kept at a constant temperature are likely to grow stouter, sturdier stems and have denser bud growth. At temperatures below 60° F (15° C), growth slows as plants wait for better conditions.

Marijuana plants are very hardy and survive outdoors over a wide range of temperatures, even including extremely hot weather, up to 120° F (29° C). However as the temperature rises from the high 70s into the low 80s (20-25° C), plants spend more energy staying cool and maintaining faster cell metabolism.

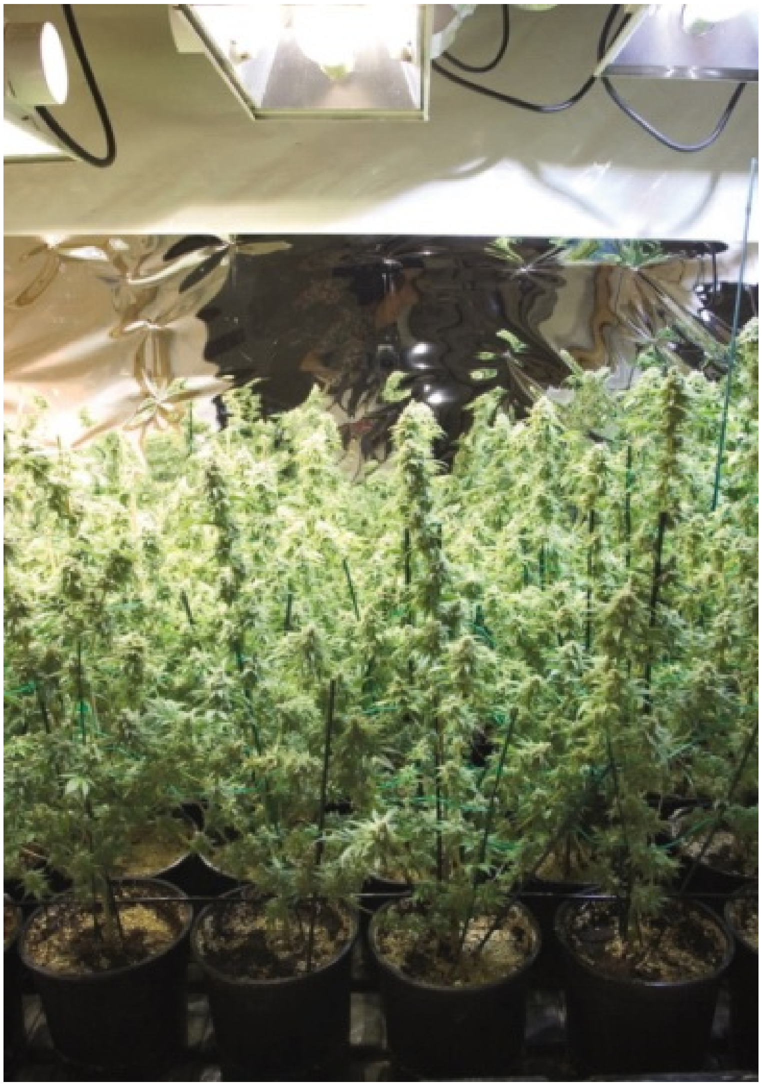
When taking the temperature of a garden, the specific area of interest is in the uppermost foliage of the plant canopy. The space between the plants may be cool, but most important is the temperature of the canopy under the lights where the plants are producing new growth.

Root temperature is just as important as canopy temperature. When a plant's roots are kept warm, the rest of the plant can be kept cooler with no damage. Cold floors or earth slow germination and growth. Cold temperatures also encourage more of the plants to develop as males. Additionally, water temperature should be adjusted to balance out the air temperature.

Besides temperature and CO_2 content, the air quality in your garden is affected by dust content, electrical charge, and humidity. Cannabis grows best in an environment that is mildly humid 40-55%.

Things to Know

- Water temperature should be adjusted to balance out the air temperature. If the air is warm (over 75°F, 22°C) the water should be no more than 70°F (20°C). If the air is over 90°F (30°C) the water can be lowered from 70°F to 65° (from 20°C to 18°C).
- It is important to keep the canopy cool to maintain photosynthetic growth. In high temperatures outdoors, use a fine spray of water from a patio mister, or something similar. Indoors, there are many ways to keep the canopy cool—using air or water-cooled lights, running the lights at night, venting the garden with filtered air, and air conditioning or air cooler units.
- Dust that has accumulated on leaves can affect the efficiency of the plants ability to photosynthesize and should be removed. It may block light and clog the stomata through which plants exchange gasses.



Part III

SETTING UP THE GARDEN

Photo: SUBCOOL

YOUR GOALS

Marijuana is one of the most useful plants on the planet. I speculate that it fascinates and intrigues us mainly due to its enjoyable effect on our consciousness and its gentle nature as a medicine. Many view it through anthropomorphic filters as an ally because of its unique characteristics.

A flowering marijuana plant's life span is about 70 days; the life span of humans is about 70 years. You might say that each day of a plant's life is the equivalent of a year in a human life. Cannabis, like humans, grows better, healthier, bigger and stronger with careful nurturing, proper nourishment and a rich quality of life. Its health is a product of its environment as well as its genetics.

Cannabis is the only annual plant that is dioecious. A plant has only one sex, and like humans you can usually tell the difference. In both species the female form is considered the more beautiful. Other annuals are monoecious—sometimes growing separate flowers for each sex on the same plant or else having both sexes contained in the same flower.

Finally like humans, cannabis easily adapts. First it traveled around the world from its origins in the Himalayas. Then it moved indoors and became higher yielding and easier to grow.

That's why gardeners often name individual plants, refer to them by gender, and think of their plants as good friends, although risky ones to hang with (the kind you don't take home to mother). Don't you just love this plant?

We choose to grow marijuana for many reasons. The majority of us grow marijuana because we want the satisfaction of smoking the fruits of our own labor.

Some gardeners are interested in experiencing new varieties and new ranges of aromas, tastes and highs.

Medical patients want to maintain a fresh supply of bud with specific qualities to treat specific illnesses. In areas where there are no legal dispensaries, patients are simply stuck with what they can get. Growing your own allows you to be strain-specific.

Patients often grow their medicine because they require a large supply. If they have financial constraints, a personal garden is less expensive than buying.

Some patients require medicine with specific qualities to treat a condition. For example, patients often treat chronic pain or inflammation with indica varieties that offer pain relieving, sedating highs. Anxiety and depression is often treated using a sativa.

Many people have never grown plants that they then consumed, nor have they seen up close a vital, productive garden that is used to feed people.

Creating your own produce, whether indoors or out, is a fascinating, awe-inspiring experience. Think of plants as a totally alien life form that help form a portion of gaia—the living planet. After incorporating portions of photosynthesizing bacteria into their cells, plants transformed most of the atmosphere's carbon dioxide to oxygen. They developed co-habitational relationships with animals, which are almost totally dependent on them for food. Without plants, no animals.

The most fascinating part for me is how plants adapt to their environment. Animals have a nervous system to sense the environment and mobility to deal with danger. Plants are dependent on a different set of biochemical and electrical cues to sense the environment and react to it. One might find it hard to relate to them as living beings, but their reaction to environmental cues can be as instantaneous as our reaction to pain. As you tend the garden, step back once in a while to watch the plants and feel the vibrancy of their life and existence.

Caregivers cultivate for their patients. Their gardens should be designed to accommodate multiple strains to meet each of their patient's needs.

Another good reason to begin a garden is just for the joy of gardening. People who buy most of their produce at a grocery store may also have a kitchen garden. You may choose to add marijuana to the plant selection. It might be small, on a windowsill or balcony or larger in a backyard or indoor garden. This garden may not meet all your needs and is not grown out of necessity, but as a hobby. Like gardeners who grow their own produce, you may discover that homegrown is the best.

Once you are growing you may wish to experiment. Marijuana is fun to use because it responds quickly to environmental changes and has separate sexes. By regulating the light cycle to force flowering earlier you can also regulate the plant's growth so it fits better in your garden.

You may live in places where it is extremely risky to grow a cannabis garden. In some states, it is legal to use marijuana as medicine but it is still illegal to grow or dispense it.

In other states, it is illegal to cultivate, possess or use marijuana. You should consider whether you wish to risk the possibility of being arrested. Is the reward worth the risk? If your goal is to provide others with quality medical marijuana, you must consider the risk of this new set of parameters. Are you prepared to cope with a worst case scenario?

You may wish to garden in order to breed your own strains. Developing something new and different is always a thrill.

Whether you are growing a few small plants or contemplating a large garden, think about the repercussions of what you are doing and make sure you really want to proceed.

Before you design your garden decide your goal: How much marijuana do you want to or are you planning to grow? The answer to this question determines the size of the garden and the time, effort and labor required.

Separate your fantasies from a realistic assessment of your situation:

- Do you have the time/interest/finances to set up?
- Is the location secure?
- Is your life together enough to care for new dependents, the plants?
- How about the risk/reward ratio? Is it in your favor or in the red zone?
- Test your goals in your mind and investigate the situation around you to make sure they are realistic. Then, continue with caution. Keep your eyes open and tune your antennae to its sensitive mode.

In the preceding chapters, the factors affecting plant growth were described and methods of meeting plant and garden needs were discussed. It's time to put it all together and to give the garden life.

"If Mary wanna play around, She likes to spread her love and turn your head around."

Lyrics: Rick James, "Mary Jane"

LIGHT, SPACE AND YIELD

Once you have decided on your goals you can begin to design your garden. Yield is based on the convergence of the genetic potential of the plant and the environmental conditions the plant experiences.

Indoors, all the limiting factors—light, nutrients, water, temperature and carbon dioxide—are under your control and each plays a part in determining yield. In indoor gardens light, CO_2 and temperature are the main variables in determining yield.

Using modern varieties that ripen in 7-9 weeks, gardeners can expect yields in the described range. The wide range is the result of the large variation in yield of different varieties, differences in the productivity of growing methods, and the plants' environment.

Each watt of HPS light input produces a yield of between ⅜ and one gram of bud.

- A 150w lamp produces a yield of 50-135 grams. This lamp is not as efficient as larger watt lamps, resulting in lower yield.
- A 250w lamp produces a yield of 85-225 grams. This lamp is not as efficient as larger watt lamps, resulting in lower yield.
- A 400w lamp produces a yield of between 130-350 grams, that is, a little less per gram than a 1000w lamp because they do not produce as much light per watt as the larger lamps.
- A 600w lamp produces a yield of about 250-660 grams. *The 600w is the most efficient of the HPS lamps.*
- A 1000w lamp produces a yield of about 375-1000 grams.

Metal halide lamps are not as efficient as HPS lamps and yield about 10% less bud than HPS lamps of equivalent wattage. However, metal halides emit some UVB light, which increases potency.

CFL lamps emit about 35-25% less light per watt than HPS lamps.

T-5 fluorescents emit about 25% less light per watt than HPS lamps. They may have better spectrums and definitely have more even light distribution but can only be placed four per linear foot (12 per meter) using commercial fixtures.

T-8 fluorescents emit about 30% less light per watt than HPS lamps. Their width prohibits their use at more than two tubes per foot (0.3 m) of width.

OUTDOORS

Outdoors in full sun you can expect between ⅓ and one ounce per sq ft of canopy. The area of the space that is covered with vegetation is the main determinant of yield. The height of the plants doesn't matter: light does not penetrate the canopy. Whether the light is hitting a level surface or meeting the surface at differing heights, it covers the same amount of surface area.

GARDEN SIZE: LIGHTING & YIELD

Size	Area	Watts	Lamp Choices	Yield (grams)
1 sq. ft. (0.09 sq. m)	1' x 1' (0.3 x 0.3m)	40-80w	CFL's with bowl reflectors/ circular or u-tube fluorescent bulbs	10-80g
4 sq. ft. (0.36 sq. m)	2' x 2' (0.6 x 0.6m)	200-240w	Metal Halide or High Pressure Sodium (HID)/T5 fluorescents	50-250g
8 sq. ft. (0.75 sq. m)	4' x 2' (1.25 x 0.6m)	350-480w	T5 Fluorescents or smaller HIDS or large on a track light shuttle	90-480g
9 sq. ft. (0.81 sq. m)	3' x 3' (0.9 x 0.9m)	400-600w	High Pressure Sodium or Metal Halide	100-600g
16 sq. ft. (1.56 sq. m)	4' x 4' (1.25 x 1.25m)	600-1000w	High Pressure Sodium or Metal Halide	300-1000g
25 sq. ft. (2.3 sq. m)	5' x 5'	2 x 750w (1500w)	HID	400-750g
32 sq. ft. (3 sq. m)	4' x 8' (1.25 x 2.45m)	3 x 600w 2 x 750w 2 x 1000w (1500-2000w)	High Pressure Sodium or Metal Halide	700-2000g

With an indoor garden it is unlikely that nutrients or water will be a limiting factor. That leaves CO_2, light and temperature. Since it is easy to control temperature, and with many small gardens it is easy to provide at least ambient CO_2 levels by simply opening a door, that leaves light as a variable factor. The calculations in the last column are based on the amount of light that the plants receive and the variability of the varieties and growing methods. (The low figure is calculated as one-quarter gram per watt of the lowest wattage advised. The high figure is based on one gram per watt of the highest wattage). With some setups you may use a combination of HPS lamps and fluorescents or LEDs, see LEDs.

There are a number of reasons for the variability of yield:

- VARIETIES: Varieties differ in their yields. Some produce a moderate yield, some are high yielders.
- LIGHT: The amount of light that your plants receive can also affect yield, and this varies by region.
- WEATHER: Local conditions affect light as well. Sunny areas receive more light than areas with cloud cover.
- SHADE: Plants that are partially shaded get less light. Gardens in autumn are more likely to be shaded.
- TEMPERATURE: Cold (less than 70˚ F (20˚ C)) and hot (greater than 85-90˚ F (32˚ C)) weather inhibit growth by slowing photosynthesis and stressing the plant.
- WATER STRESS: Too little water slows growth. Even though a plant might have enough water to never wilt, a slight deficiency slows growth by costing the plant more energy to draw it up as the soil clings tighter to the water molecules.
- OTHER FACTORS: Soil, nutrients and gardening techniques.

LIGHTING THE 25 SQ FT (2.3 SQ M) GARDEN

In California individuals are allowed to grow an indoor garden of 25 sq ft (2.3 sq m). There are several ways that this can be configured. Each of these configurations has its advantages and disadvantages, but all of them can be used to grow productive marijuana gardens.

Sativa plants require about 66 watts per sq ft (700 watts per sq m).

Sativa-indica hybrids do best at 60 watts per sq ft (640 watts per sq m) but grow well at about 50 watts per sq ft (535 watts per sq m).

Indicas grow well on 40-45 watts per sq ft (425-480 watts per sq m). They grow bigger, tighter buds at a higher wattage.

GARDEN SHAPES AND LIGHTING

A SQUARE: 5’ x 5’ (152 x 152 cm)

A RECTANGLE: 6’ x 4’ (183 x 122 cm) Same lighting as the square. Any combination of HPS lamps using light movers that travel back and forth about one foot (30 cm), use three or four 400 watt lamps.

A RECTANGLE: 12’ x 2’ (366 x 61 cm), Use three or four 400 watt stationary lamps stationary, or two 600w or 750w lamps that each traverse a 6' (182 cm) distance back and forth using light movers.

A CIRCLE: Diameter 5.5' (168 cm) (The size of many inexpensive hard plastic kiddie pools). Any combination of HPS lamps.

Quantity	Size Lamp	Watts/Sq. Ft.	Watt/Sq. M.	Plant Types
2	1000	80	860	Good for Sativas
4	400	64	685	OK for Sativas, Good for Sativa/Indica, Indica/Sativas
2	750	60	645	OK for Sativas, Good for Sativa/Indica, Indica/Sativas, Indicas
2	600	48	515	OK for Sativa/Indica, Good for Indica/Sativa, Indicas
3	400	48	515	Good for Indica/Sativas, Indicas
1	1000	40	430	OK for Indicas

PLANT SIZE & NUMBER: GROWING IN THE LIMITS

In the discussion of yield in the previous chapter the main determinants of yield were neither the amount of space nor the number of plants. The reason for this is that whether plants are grown in a smaller or larger space given the same amount of light, they will produce approximately the same yield. A single plant that covers the canopy or a group of plants covering the same area produce approximately the same yield.

Nevertheless, plant count and area are the two measurements that are used to regulate legal medical and civilly regulated cannabis cultivation. The federal government uses plant count in determining the severity of the crime and punishment.

These laws and regulations have no scientific basis. They were concocted by cops and law enforcement types rather than by horticulturists, botanists, medical doctors or anyone else who might have expertise or technical information to lend.

The inherent unscientific nature of these two measurement systems is obvious to the experienced marijuana gardener. A plant can be forced to flower at any time by regulating the lighting regime. Therefore, a very small plant that has just germinated and a plant that has grown vegetatively for six months are each counted as single plants. Yet one plant might yield a quarter ounce and the other more than a pound (7g-0.5 k).

The same objections can be made regarding area measurements. No matter whether a space is lit by a few fluorescents or several 1000w HPS lamps, only the area is measured. Yet one garden has the potential to yield considerably more than the other.

The only regulations that would pass scientific scrutiny would consider the wattage of the indoor garden and plant variety. Outdoors, the average amount of light and the size of the garden canopy would have to be taken into account. Unfortunately, we must deal with the regulations as they are written.

Various state laws allow patients to grow six, eight, or ten plants. Other laws permit a garden of only 32 or 100 sq ft (10 or 30 sq m).

Laws and regulations sometimes also include provisions regarding how much ready-to-use medicine you are allowed to possess. Usually these limits are low. This limits the strategies available to the gardener.

The federal government has a 99-plant cut-off. Mandatory 5-year sentences are imposed for growing 100 or more plants.

PLANT LIMIT GROWING STRATEGIES

Most restrictions determined by plant count allow between six and ten plants. Sometimes the regulations also limit the amount of marijuana that the patient or gardener is allowed to possess.

The solution to plant limits is to grow very large plants that produce heavy yields. If there are also limits on the amount that can be possessed at a time, then the plants should be harvested consecutively, one at a time. Ripe plants are removed and new plants placed into the flowering room.

Since marijuana flowering is regulated by the light regimen, plants can be forced to flower at any size. To harvest large plants they must grow vegetatively until they get to a suitable size. With the appropriate variety you can grow very large plants.

A garden that is being grown under a six plant regulatory process with nominal possession limits requires some strategizing. Since the number of plants allowed is limited, yield is dependent on the size and ultimately the productivity of each plant.

This is accomplished by keeping the plant growing in the vegetative stage for several months. It shares a 1000w HPS with three other plants growing vegetatively until it grows a canopy with a three foot (0.9 m) diameter, which takes about three months. At this point the plant is large enough to be placed under its own 600w HPS and to be forced to flower by changing the light regimen to 12 hours of light/12 of darkness. The plant continues to grow during the first few weeks of flowering and fills out a space with a diameter of 4 feet (1.21 m) or more. If feasible, during the last month of flowering it is placed under a 1000w lamp.

The yield from a garden like this, between one and one and a half pounds (0.45-0.68 k) a month may be more medicine than you require. The easiest way of cutting back the size of the plants is to eliminate some of the time plants stay in the vegetative stage. Because yield is directly related to the size of the plant at initiation of flowering, larger plants yield more bud.

When there are legal constraints on space but not plant counts, consider growing many small plants. They spend less time in the vegetative cycle so they yield faster, with less effort.

This system requires three lights. A 1000 watt for vegetative a 600 watt for the first month of flowering and another 600 watt or a 1000 watt for the last month of flowering.

A system growing smaller plants and resulting in a smaller yield can be powered by either a 400 or 600 watt lamp for vegetative growth and a 600 watt or preferably a 1000 watt lamp for flowering. Plants are kept in vegetative growth until they cover a canopy of about 4 sq ft (0.4 sq m), an area of 2' x 2' (0.6 x 0.6 m). Then they are moved to the flowering section. The flowering room holds two plants that were placed in the section a month apart. One plant ripens each month. Expect a yield of one half to one pound (0.25-0.5 k).

A yield of one half to one pound (0.25-0.5 k) a month may exceed your needs. You can downsize the garden once more. Use a 250w HPS lamp or a bank of four T-5 fluorescent lights to grow the plants vegetatively. Keep four plants in the vegetative section. Keep two plants in the flowering section under a 400 watt lamp. The yield for this garden is 4-6 ounces (113-170 g) a month.

(For smaller gardens, see Designing the Space.)

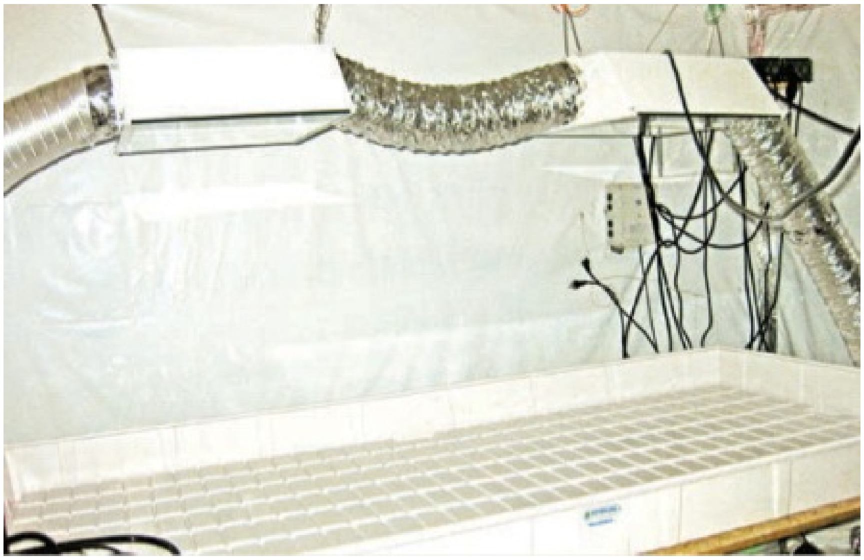
With this ten-plant garden one or two plants are harvested each month. If you use the same lights and the same amount of power, you will find that the two plant harvests are 10-20% higher than the single plant yields. To increase the yield further increase the number of lights in the finishing stages so the plants can spread out for increased yield.

When there are legal limits to the number allowed, it is best to grow fewer, but larger plants.

Some laws and regulations don't have a restriction on the amount of medicine that a patient can possess but limit the number of plants that can be grown. In this situation, you can grow the plants as single groups that are harvested at the same time.

It is far easier to grow a garden that is harvested all at once than one in which the plants are harvested at different times. The reason is that all the plants are about the same size and are at the same stage of growth and can be cared for in a uniform way.

DESIGNING THE SPACE



No matter how large or small the garden, all of the plant's needs must be met. The gardener's duty is to provide his/her dependents with light, water, carbon dioxide (CO_2), nutrients, temperature and humidity.

TINY GARDENS

You may want to grow but you don't think that you have enough space. However, even a tiny space such as a small closet, shelf, armoire or portable container can be converted into a garden.

As an example we will describe the conversion of a closet space to a garden. The closet space has an area of 40" x 22"(100 x 55 cm). It is 80" (2 m) high, divided into an upper and lower space. Each level is 880 sq in, divided by 144 sq in, it equals about six sq ft (0.55 sq m). We will be using only the bottom shelf.

If the space were to be kept at a high temperature (80°+ F) (27°+ C) and was enriched with CO_2 it would be able to use the brightest light, 60 watts per sq ft (650 watts per sq m) This garden space is kept at a lower temperature. CO_2 is supplied by exchange with the air in the room. Under these circumstances the plants are not able to use all the light emitted because both temperature and CO_2 would be limiting factors.

The garden temperature will stay in the mid-to high-70s (25° C) and the CO_2 will be kept close to atmospheric levels of about 380 ppm. Height is also a limitation to be taken into account.

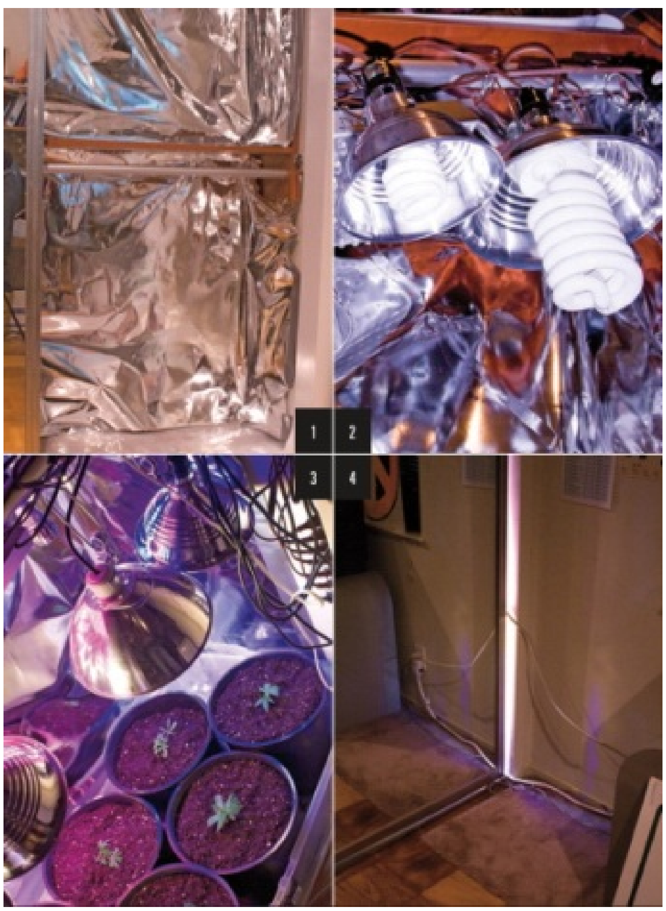
Instead, the top level of the garden will be lit using a 200w LED.

Other good choices for lighting the garden are 250w MH and HPS lamps. They emit about 20,000 and 26,000 lm, respectively. However, without proper ventilation they might create heat problems.

STEPS TO CLOSET CONVERSION

For the bottom shelf, the gardener decides to use LEDs as well as CFLs. The total watts used is 199 watts and the light output is estimated to be about 13,500 lumens.

1. Line the floor with water impervious plastic liner.
2. Line the sides of the garden including the inside of the door with reflective material.
3. Install the lights. The lights for the bottom consist of one 14w LED panel of red and blue emitters, two red and one blue 15w LED spotlights and three 85w warm white CFL lamps.
4. Attach the lights to the metal hanger rod using light fixtures mounted on a clamp.
5. Plug the lights into a light timer that is plugged into a surge protector.
6. Install a negative ion generator to eliminate plant odors.



1. Closet is lined with plasticized reflective material. 2-3. Lights were installed by attaching bowl clamp reflectors to the hanger bar. Six 3-gallon (13 l) containers were placed in a plastic under bed storage tray that fit into the closet and conveniently had wheels. 4. When the door is closed only a sliver of light is visible.

A few weeks later the plants filled the space and were ready to get sexual, so the lights were turned down.

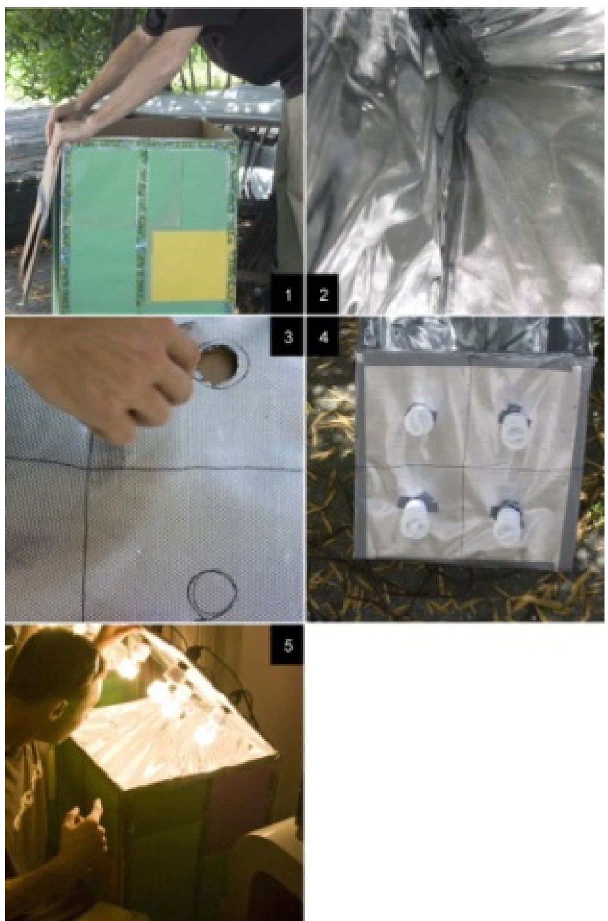
GARDEN IN A BOX

Suppose you have no shelf, closet or armoire to develop as a garden. What can you do? Grow in a box. Not just any box. It should be at least three feet (0.9 m) high, although a taller box would be easier to grow in. This garden was made out of a utility vacuum box. The dimensions are 18” x 18”, 324 sq in, 2.25 sq ft (0.45 x 0.45 m, 0.2 sq m), and it is only 26 in (.6 m) high.

STEPS TO THE BOX GARDEN

1. Empty the box.

2. Create a door. First decide where the door will open. In this set-up, the top will flip open. To make the door three of the four top flaps are cut from the box and the four flaps are taped together using duct tape. One flap is still attached, and serves as a hinge.
3. Cover the inside of the box using reflective material. It could have been painted using flat white.
4. Cut four small holes in the top, one in the center of each quadrant, to hold the light fixtures.
5. Cut two ventilation holes, each 3” x 5” (7.5 x 13 cm), on opposite sides of the box a few inches from the bottom. A 4” (10 cm) round hole is cut into the center of the top of the box to evacuate hot air. The cool air entering and the warm air exiting create an air flow. If additional cooling is needed, place a small inline fan in the top.



CONSTRUCTING A BOX GARDEN
1. All the sides are sealed with tape. The top is cut on three sides, leaving one side that opens like a hinge.
2. Paint the box white or line it with reflective material. The dull side of

aluminum foil works well.
3. Cut holes in the top for the lights and in the side bottom and top middle for air circulation. The hot air will move up and out pulling in cool air from the bottom
4. The lights are installed. With the addition of a tray at the bottom and plants, the unit is ready to go.
5. Lights are turned on.

Rectangular closets with a width of one or two feet and a length of 6-10 feet (1.8-3 m) are easily lit using an HID lamp mounted on a fast moving light shuttle A 400w lamp serves an 8 sq ft (0.75 sq m) garden with dimensions of 1’ x 8’ (0.3 x 2.5 m) or 2’ x 4’ (0.6 x 1.2 m). A 600w lamp can handle a 12-15 sq ft (1-1.4 sq m) garden such as 2’ x 6’ (0.6 x 1.8 m) or 3’ x 5’ (0.9 x 1.5 m). A 1000w or two 600w lamps support a 16-20 sq ft (1.5-1.9 sq m) garden such as 2’ x 8’ (0.6 x 2.4 m) or 3’ x 6’ (0.9 x 1.8 m).

Fluorescent lights can also be used to light rectangular gardens. T-5 HO or CFL lamps are the easiest to use because they emit more intense light than standard fluorescents. This makes it easier to provide plants with enough light to produce an abundance of Grade A bud. The plants should receive an input of 50-70 watts per sq ft (535-750 watts per sq m). Light a 1’ x 4’ (0.3 x 1.2 m) garden using four T-5 HO tubes, each of which uses 56 watts. Another possibility is to use four 55w CFL fluorescents. Both set-ups work well.

6. A tray is placed in the box bottom.
7. Install the light fixtures and hold them in place by fitting them tightly into the holes.
8. Four 25w CFL’s are installed, three warm white and one cool white are screwed into the fixtures. Each of these lamps emits about 1700 lm for a total of about 6800 lm. Other possible lighting choices are a 100w MH, which emits about 8,500 lm, or a 100w HPS, which emits about 9,300 lm.
9. Attach light fixture cords to a surge protector and plug it into the timer.
10. The box is ready for planting.

THE LARGER CLOSET GARDEN

One typical closet size is 4’ x 4’ (122 x 122 cm). It is also a convenient building size since building materials such as plywood and plasterboard come as 4’ x 8’ (122 x 244 cm) sheets. This space is 16 sq ft, (1.5 sq m), which makes an excellent size for a productive personal use garden.

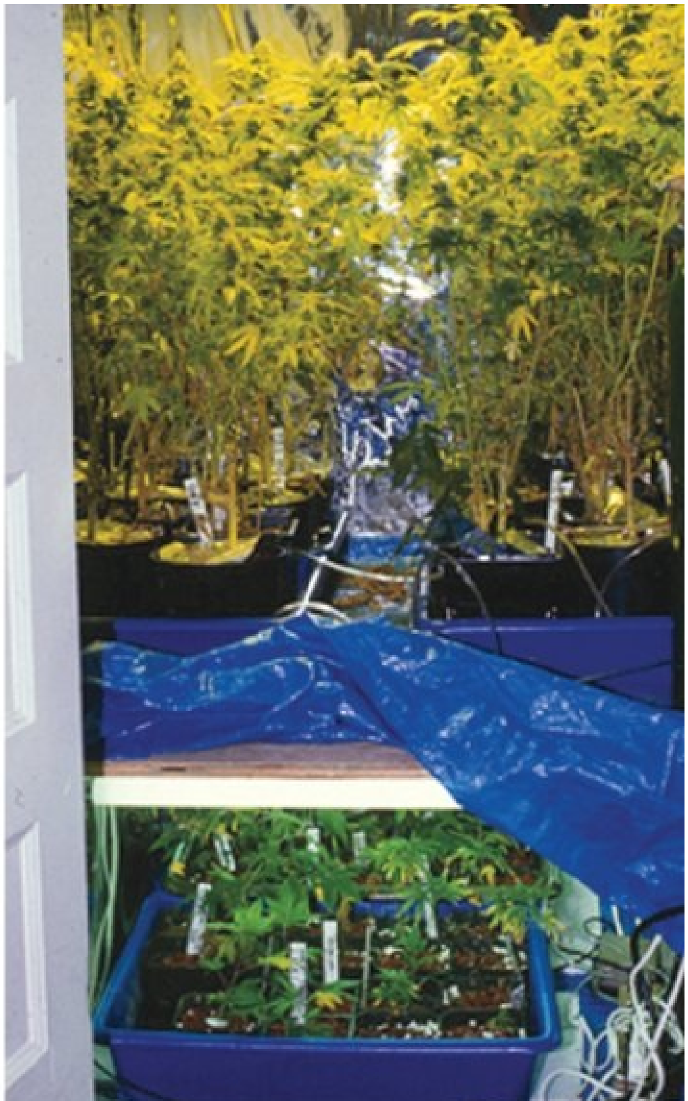
The garden can be set up as it is, or a shelf can be constructed on the bottom for use as a cloning space.

GETTING INTO THE CLOSET

Go through the layers of your life as you empty out the closet. This may be a good time to contemplate how lucky you are to be able to start on this glorious project.

LIGHT

The garden is perfectly lit using a single 1000w HID bulb. It has an electrical input of about 62 watts per sq ft (PSF). (667 watts per sq m). If a 1000 watt lamp draws too much electricity, light the garden using a 600w or 750w HPS lamp. Either is more efficient than the larger lamp, producing about 90,000 and 105,000 lm respectively, which makes for a very bright garden capable of producing a crop of grade A quality buds. A 400 watt lamp emits about 50,000 lm. Gardens growing under its light produce quality buds but they are not as large or as potent as the buds grown under the brighter lamps. The garden’s yield diminishes in a fairly direct ratio to the level of light it receives.



This garden was built in a closet area a little larger than 4' x 4' (1 sq m). The bottom shelf, lit by fluorescents housed clones and young plants. The top shelf was lit using a single 1000w HPS lamp. The plants were housed in a reservoir system with 6" (15 cm) square containers.

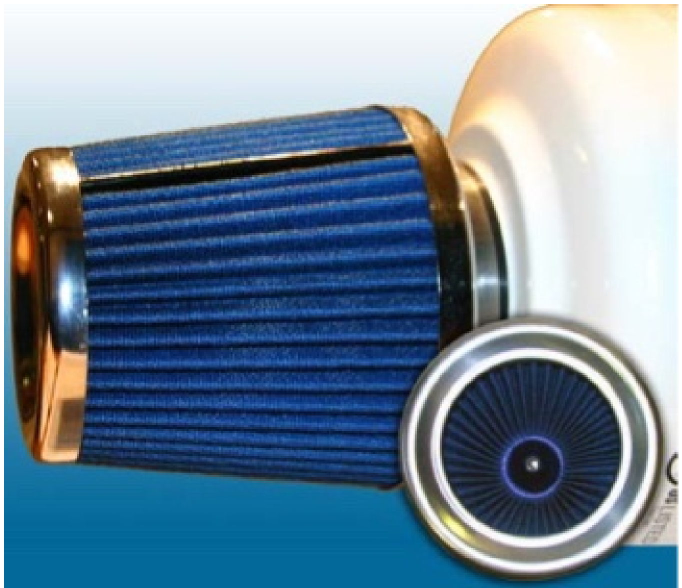
This tray of young plants gives new meaning to the term “guest bathroom.”

The best reflector for this garden is one that focuses the light directly on the plants. Reflect straying light back to the garden using white walls or reflective material placed around the perimeter. Hang the light reflector from the ceiling or structure using a secure fastener. The height of the light should be adjustable. Use link chain, a pulley, or a plant yo-yo. These devices make adjustments very easy. Once the adjustment is made, the plant yo-yo locks at that height.

Set the timer to provide a dark period during vegetative growth if it is desired. Marijuana doesn’t require a dark period during the vegetative cycle but it may be convenient to turn the lights off when guests are around or when you are sleeping. Later, during flowering the timer regulates the light/dark cycle. You can leave the lights off for up to four hours at a time without triggering flowering. If the light must be left off for a longer amount of time, periodically interrupt the dark cycle.

TEMPERATURE AND HUMIDITY

A 1000w HID lamp produces about 3400 BTU’s. Without a bottom glass on the reflector all the lamp’s heat enters the garden. Air cooled reflectors with a glass bottom trap between 66 and 80% of the heat. It is removed from the space using flexible 6” or 8” (15 or 20 cm) tubing attached to both sides of the air-cooled light. An inline fan pushes air through the tubing. One side is connected to a source of fresh air, either from a space adjoining the garden or from outdoors. The heated air has no odor since it was sealed off from the room, so it can be vented indoors or out.



Prevention of pests and diseases should begin from the time the garden is set up. A hepa filter helps keep the space contaminant free. The Organic Air Hepa Filter traps and filters 90% of molds, insect and bacteria.

Humidistat/thermostats can be used to regulate fans, A/Cs and dehumidifiers.

Water-cooled lights remove virtually all the heat produced by the lamp and transfer it to a stream of water in a closed loop system. The water's heat is dissipated using a radiator or reservoir. Without the excess heat the temperature probably stays in the preferred range, below 80° F (27°C).

Air-cooled lights remove most of the heat but any excess must be eliminated. When the closet door is open there is a free exchange of air so heat is exchanged with the surrounding air. This is usually an adequate method of cooling. When the closet door is closed light heats up the garden. It may be convenient to turn the light off during this time. If the light remains on, either the heat must be vented out or the air must be cooled in order to maintain excellent garden conditions.

If the space has a vent at the top the air is removed using an inline fan regulated by a humidistat-thermostat. Another vent, at the bottom of the space, allows cool air to be drawn in as the hot air is pushed out. Whenever the garden gets too warm or humid, the sensor, a thermostat-humidistat, turns the fan on. Air is drawn through a carbon filter to destroy odors, before it is removed. Figure that the fan should be able to draw the volume of air in the space in 5 minutes or less. For instance a space 4’ x 4’ x 8’ (122 x 122 x 244 cm) contains 128 cubic ft (3.6 cubic m). The fan should be able to draw at least 25 cubic ft (0.7 cubic m) of air per minute.

A small air conditioner can also be used to keep the garden cool. Some small models can be placed above the garden. A 5,000 BTU portable model is sufficient to keep the garden cool.

AIR CIRCULATION

Place one or two small oscillating fans in the space to constantly create a breeze from below blowing up through the plants. This pushes out heat from the plant canopy and refreshes the CO_2 depleted air with fresh CO_2 laden air.

Set the thermostat/humidistat for maximum humidity of 55%. Keeping humidity under control prevents most fungus infections.

CO_2

If the closet door is kept open during the lit period and the garden is ventilated, the air exchange replenishes the CO_2 as fresh air is blown through the canopy.

If the closet is kept closed then the air needs to be enriched using a CO_2 tank regulated by a CO_2 meter. The meter measures the ppm of CO_2 in the space and opens or closes the valve accordingly. CO_2 is needed during the lit period only, so the valve should remain closed during the dark period.

Install a 20 lb. (9.07 kg) tank with reservoir. Place it in the closet, or to save space place the tank outside. The CO_2 enters the room via tubing.

Place a waterproof tarp on the floor of the closet.

Place a carbon filter, negative ion generator or ionizer in the room adjoining the garden. Each has the capability to eliminate the odor. Place a carbon filter along the vent line to clean exiting air.

THE BOTTOM SHELF

The bottom shelf is used for cloning and for the development of the plants for a few weeks after they have rooted. During the first three or four days the cuttings should receive about 10 watts of light per sq ft (100 watts per sq m). Then they should receive about 20 watts of light per sq ft (200 watts per sq m) until they are rooted. Once they have rooted, increase the light intensity. The entire shelf is not needed to supply the system with fresh clones, so light should be concentrated in one area large enough to light a 20” x 20” space (122 x 122 x 244 cm). That is large enough to hold two 10” x 20” (25 x 50 cm) trays, which are standard in the nursery industry.

Construct a shelf about 15” (40 cm) above the floor. It will be holding the weight of the garden above, so it must be sturdy. One-inch plywood (2.5 cm) or sturdy steel gratings both work well. The composition of the wall will help determine its positioning and whether it is free-standing or attached.

Use two 2' (61 cm) HO T-5 tubes, spaced closely together, rather than spread out.

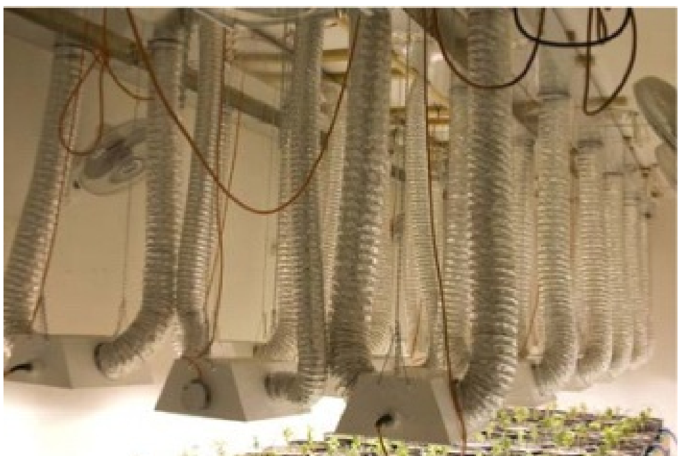
T-8 tubes use 50% less electricity and are less efficient than HO’s—twice as many tubes should be used. Use four tubes to start.

You can use two 15w CFL lamps, raise the shelf a couple inches (5 cm) to accommodate the length of the tube, which hangs down vertically. Attach the light fixtures to the plywood using metal barriers, and place a plastic barrier between the two.

THE TWO LIGHT 1000 W OR THE THREE LIGHT 600 W SYSTEM

Two 1000w or three 600w lamps hang over an area of 4’ x 8’ (122 x 244 cm), 32 sq ft (3 sq m) and conveniently, the same size as many construction materials. There are many ways this unit can be constructed. Remember that you must make the space convenient for you to supply the five essentials: light, CO_2, temperature and humidity, water and nutrients.

Air is drawn from the room, it passes through a carbon filter that deodorizes it, through the lights, and then passes out of the room. Since it is odor-free it can be used indoors or released.



Air is drawn from outside the space through the tubing to cool the lights and then is released outside the room. The air never comes in contact with the air in the room, so it has no odor. It can be removed from the premises or used to heat another space.

Starting the garden may be as simple as hanging lights from the ceiling in an alcove and closing off the area using curtains. More ambitiously, you can build a frame using wood or steel and enclose the space in polyethylene plastic, other reflective material, or build the mini-room using plasterboard or other construction material.

An indoor greenhouse may be the best option for you. These units are easy to assemble, and are designed to install lights and other accessories. Rather than preparing a space you may find it more convenient to use one of these units.

Two 1000w or three 600w lamps illuminating a 32 sq ft (3 sq. m) space is an ideal intensity to stimulate fast, vigorous growth.

THE TWO-LIGHT GARDEN

Construct the structure or prepare the space so the garden is enclosed. It should have inside dimensions a little larger than 4’ x 8’ (122 x 244 cm) so trays and other tools fit inside easily. Make sure that it has doors or other easy access to the plants. It should be about 8’ tall (2.43 m). This is high enough to be able to hang the lights about two feet (0.6 m) from the plant tops, which can be as high as five feet(1.5 m) from the floor at maturity. The unit should be strong and stable enough to support the light.

Install the CO_2 ppm meter. The tank will be kept just outside the garden space so the sensor’s wiring should be long enough to reach the regulator on the tank. A small tube leading from the tank to the garden supplies the gas to the enclosure.

1. Four 2” x 4” (60 x 120 cm) boards are placed over two sawhorses; 2: A 4’ x 8’ (122 x 244 cm) tray is placed over the boards; 3: Two air-cooled lights are installed by hanging them from the ceiling—the air intake tubing is placed in the adjoining room and it exits on the other side; 4: Containers on the tray are ready to be planted.

Several weeks later the plants are basking under the light in their new home.

Three 600w lamps produce the same amount of light as two 1000w lamps but they use 10% less energy.

Install the air system. If the garden is to be cooled solely by venting air from a cool place or outdoors, it should have a filtered air intake near the bottom of the unit.

Tubing should be installed at the top to vent air out.

Fan: the air should be forced out using an inline fan that moves 100 cubic feet (2.8 cu m) per minute evacuates the air from the a 5’ x 10’ x 10’ (1.5 x 3 x 3 m) space every 5 minutes.

Carbon Filter: an inline carbon filter is used to eliminate the odor from exiting air.

Air Duct Muffler: if necessary an inline air duct muffler is used to silence the sound of the fan and rushing air.

In this unit, notice the water-cooled light. It is cooled using a water chiller and a bucket, which serves as a reservoir. Commercial units like the No Holes Bar from Best Coast Growers (Fresa Sol lights also pictured) are moveable and easily adjustable.

Tubing: use 6” (15 cm) tubing for small spaces of two lights. Its area is 28 sq in (28 sq cm). Use an 8” or 10” (20 cm or 25 cm) tube for larger gardens. Their areas are 50 sq in and 78 sq in, respectively.

Thermostat/Humisdistat: Connect the fan to a thermostat/humidistat. If you are using ventilation as the primary means of regulating temperature and humidity the system should also include a regulator that shuts off CO_2 emission when the fan goes on. If the garden is to be cooled using an air conditioner, the need for ventilation is drastically reduced. The thermostat/humidistat controls the air conditioner rather than a ventilation system. Use either a window, or portable air conditioner. It should be mounted securely. The air conditioner can be set to exchange heat but not air so the CO_2 level is not affected. Some portable air conditioners exchange air. This air must be odor filtered before it exits the space. Even with an AC system, it is important to have adequate ventilation available as a redundancy. It doesn’t have to be elaborate. It could be as simple as a carbon filter and fan that are manually controlled.

Hang the lights from the structure. If you are using two 1000w lamps, place each in the center of a 4’ x 4’ (122 x122 cm) area. Since all the light comes from two points some plant parts will always be in shadow. A “light rail” type of light mover adjusted to move back and forth 1 or 1.5' (30-45cm) will keep more of the plants illuminated resulting in larger yields.

Using three 600w HPS lamps is more efficient and cheaper than using two 1000w lamps because the 600w watt lamps use 10% less electricity, but produces the same amount of light. The light is distributed more evenly because it is emitted from three point sources rather than two. No light movers are required.

Lay a waterproof tarp on the floor.

A LARGER GARDEN

HOW I SET UP MY LARGE GARDEN BY JAKE X

Jake X is a garden consultant with 25 years experience in gardening and setting up large scale grow operations.

Originally we were going to grow in two large rooms with 24 1000w lamps in each. Instead we decided to use 600w lamps because they provided more points of light and therefore fewer shadows. In addition they are 7-8% more efficient, creating more light while using less electricity.

The rooms were each 18’ x 18,’ roughly 324 sq ft (5.5 x 5.5 m, 30.25 square meters). In order to maximize the potential of the space, eight 8’ x 4’ (2.45 x 1.25 m) tables were placed on metal wheels so that two people could easily move them. We lined up the eight tables to make a 16’ x 16’ (4.9 x 4.9 m) grow space. Only one working aisle was needed, and the tables could be moved to provide that space.

The lights for one room used about 16 kilowatts, or 142 amps, of power. The best electrical current for this is a 220 three phase with 600 amp capacity, which provides cleaner power. Many factories already have this capability. If you do not, it should be installed before setting up the lights.

We placed three lights over each 4’ x 8’ (122 x 244 cm) table, which provided the canopy with about 5,000 fc or 535,000 lux.

The lamps were placed 3' (0.9 m) above the plants so the light spread out evenly over the canopy. To make sure none of the light reflected off the lamps was wasted, we hung heavy-duty aluminum foil on the outer edge of the reflectors at the perimeters of the room to direct the light away from the wall and back to the canopy.

In addition to the light movers and reflectors, we painted the walls with flat white paint, to reflect any light that hit them.

We chose the wall closest to the intake as the electrical wall. Why? All circuits for the room were controlled from this series of boards. We attached each light by plug to the ballast and made sure to keep all the ballasts on the same “light panel,” which was controlled by a digital timer and allowed all the lights to go on at once.

The lights were air-cooled with 8” (20 cm) diameter flanges on either side so that the tubing for the lights could be at tached easily. Each duct line was attached to six lights and powered by an inline fan. We drew the air in from a duct in the roof and expelled it through a roof vent. There were no other vents in the room, so the garden was sealed.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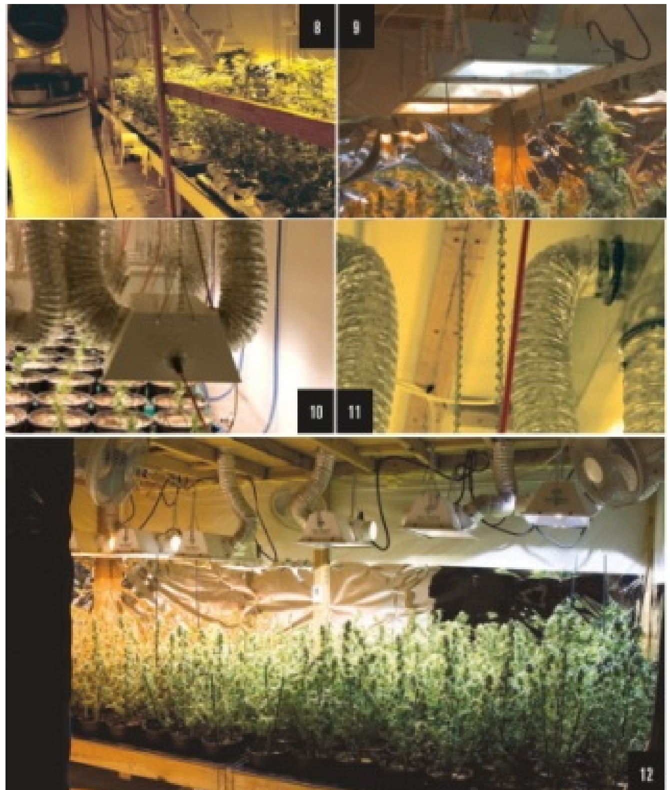


1. The garden room was constructed using wooden framing and white/black plastic as walls. It was a sealed room. The air conditioners exchanged heat and moisture but not air from the room into the central space. Ventilation fans evacuated it through the roof. CO_2 was addded using tanks. 2. Warehouse preconstruction. 3. Several rooms have been framed. 4. Inside partially constructed space. 5. Completed room. 6. The water system had three tanks and is designed to purify water and mix nutrients for five grow rooms. 7. Automated controls for the water system and temperature; switches controlled the pump and aerator; the on/off valve controlled water recirculation and draining. 8. The flowering room; each room had three filters to purify the air amd eliminate odors. 9. Three 600w lights were placed over each table. 10-11. The lights were ducted so that one 12" fan vented all 21 lights. 12. Three 600w lights were placed over each table. In this garden the air cooled lights drew air in from the space. It was cleaned using a carbon filter and then exhausted. Notice the tables are all on wheels and can be moved easily to create a work space.

The air was controlled by a regulated thermostat which automatically turned on heaters if the temperature fell below 65-70° F (18-21° C) during the dark period, which we set to begin at noon and end at midnight.

The heat was exhausted using two 15,000 BTU window-mounted air conditioners which turned on automatically when the temperature exceeded 83° F (28° C).

We supplied the room with carbon dioxide using tanks and a regulator controlled by a ppm meter that maintained the CO_2 level at 1200 ppm throughout the entire cycle. We released the gas from the bottom of the trays near the pots so it would rise through the canopy.

We mounted circulation fans above our head level to prevent lost earlobes and unwanted haircuts.

For a medium, we chose a coir-based soilless mix to fill the 32 nongraduated plastic 5-gallon (22 l) buckets on each 16’ x 16’ (4.9 x 4.9 m) table.

Each 16-table system was fed from a 180 gallon (800 liter) tank that irrigated the containers using 360° sprayers.

During the early growth and vegetative stage, the containers were watered once a week. During peak growth and flowering they received a water/nutrient solution every three days. The pH of the water was kept between 6.3–6.5.

When the plants first started we kept the fertilizer ppm at 900 and over a period of five weeks gradually raised it to 1500. During the last four weeks we gradually decreased the level to 1000. During the last ten days the plants were irrigated simply with pH adjusted water.

Plants were kept growing vegetatively for 10-20 days depending on variety. Several clones were taken from each plant’s center top and lower branches before we placed them in flowering. At flowering each plant had 8-10 branches that were all at about the same height. The varieties we chose were ripe in 7-9 weeks and yielded about two ounces (56 g) per plant.

We used these nutrients:

- Flora Nova Floralicious and Kool-bloom (made the bud more sugary)
- Humic/folic acid (improved vigor)

PREMADE UNITS

The best way to get growing might be to purchase a pre-made indoor greenhouse. These units make it easy to create a discrete area in which to garden. They are available in various sizes. From 2’ x 5’ (60 cm x 150 cm) to about 10’ x 10’ (300 cm x 300 cm). There are even duplex models.

These tents are easy to assemble and create a portable, movable, separate environment. They have a place to hang the lights and spaces cut out for all accessories such as carbon filters, fans, CO_2 units, cooling and light cooling.

These units have a lot of uses. First, they make set-up easy. They are great when you want to isolate plants as quarantine or for breeding.

The tents make it easy to set up a small enclosed garden in a large space without constructing walls or going through the hassle. Just clear the debris enough to make room for the indoor garden, set it up, attach the light and accessories, set up the planting system, and you are a gardener.

Premade units and grow tents allow gardeners with small grows to easily set up a sealed operation in a variety of spaces. The Indoor Grow Tent by Hydrohut features thick Velcro to seal out light leaks, ports, flaps and openings to hook up lights, air conditioning, and the ventilation necessary to maintain the climate of the space.

Left to right: This garden was set up in a couple of hours. Everything is regulated, controlled or automated, so the gardener just has to monitor the systems. A fan and carbon filter remove hot air from the system; an alternative is cooling the air usng an air conditioner to maintain high CO_2 levels.

The SuperCloset is a well-designed complete unit. Just assemble, plug in and start growing. Everything is contained in the steel cabinet. The unit comes with dimmable air-cooled light, circulation fan, and separate chambers for cloning, vegetative growth and flowering. Hydroponic systems promote fast growth and large harvests.

NOVEL GARDENS

SHELF GARDENING

Shelves can be used to house gardens indoors and out. Outdoor shelves work best with small plants that grow no higher than two or three feet (0.6-0.9 m), so the lower and upper plants form a continuous vertical wall of green. In the fall, when the sun's angle is lower, the plants' sides get direct light, helping the buds grow and ripen. Outdoors, a south-facing area can be exploited by using stepped shelves to hold potted plants in a stadium array. Shelves take a bit of horizontal space but they more than make up for it with additional vertical space. Many other innovative configurations of shelves can be devised to customize their use for particular situations. Shelves with wheels can be moved around easily to stay in the sun as its position changes throughout the day and seasonally.

PREMADE UNITS

Premade units are an easy way to provide a complete grow environment. The Stanley 336 Ultimate Hydroponic Grow Box from ACtech makes growing practically automatic. It features CO2, fully automated pH adjustment, a Hydroponic Water Cooler, and 100 percent odor control. The cabinet comes with a choice of HPS or LED lights and optional high-power fluorescent sidelights for fuller plants with more bud sites. An upper shelf on this model provides space for clones to grow as the larger plants develop.

Pictured:
Stanley 336 Ultimate
Hydroponic Grow Box.

For more information:
www.actechwi.com

Indoors, placing plants on shelves provides additional space that is not ordinarily used. Rather than just the floor surface, the garden space includes the walls as well. Hang the bulbs either vertically or horizontally, as long as the light reaches the walls as well as the floor. Use a reflector that keeps light off the ceiling and within the garden. To determine how much light input to provide, first determine the total area of the floor plus the walls or shelves. As an example, a space with a floor measuring 8’ x 8’ (64 sq ft, 6 sq m) might have walls with effective dimensions (subtracting for area lost to corners and shelves) of about 7’ x 7’, or 49 sq ft (4.5 sq m) each. The total area of the shelves and walls is about 200 sq ft (18.5 sq m), or a bit more than three times the floor space.

If this total area were a flat surface, it would require 12 1000w lamps. However, because the light is distributed to the plants in all directions, with almost no loss to reflectors, only four to six 1000w lamps are required to light the space. Place all the lights in the center of the growing area. Place a reflector over the top light, paint the ceiling white or cover it with reflective material such as aluminum foil or white plastic so any stray rays headed up and out of the garden are redirected to the plants.

A two-shelf garden lit with fluorescents.

This shelf is 18” (46 cm) wide, 8’ (2.4 m) long and 24” (60 cm) tall. It was powered by four T-8 HO Fluorescents that emitted a total of 32,000 lumens and use 86 watts each. They were fed guanos, kelp and humic acid. Several indica seeds were planted in each 32 oz Styrofoam container. They germinated quickly. They were allowed to grow for several weeks, until they were about

6” (15 cm) tall. Then they were placed into flowering by lowering the light regimen to 12 hours daily. As soon as they indicated, males were removed. Plants were transplanted as needed so that each container held one female. Here plants are into third week of flowering. The buds lushed out at week six. The plants are ready to harvest. The buds weren’t big, but they were potent and tasty.

Using this technique, a space that normally accommodates a canopy of no more than 64 sq ft (6 sq m) now has an effective space of 250 sq ft (23 sq m). The result is more than a three-fold increase in space that only requires about one third the energy as normal. Gardeners can expect good returns because yield per watt of light is significantly more than in standard systems.

ROTARY GARDENS

Rotary gardens work like ferris wheels with the light in the center and plants orbiting around it. They save time, space and energy while producing yields of up to 1.5 grams per watt of light in short cycles.

The rotary unit is fitted with slots that hold 4" (10 cm) rockwool cubes. The lights are positioned in the middle of the unit, where an axle would be if it were supported with a hub. The wheel turns vertically so the plants do a 360—upright at the bottom, then horizontal, then upside down, then horizontal to the other side and back. This rotation causes stress on the main stem so the plants grow stout. The plant tops are always facing the light, so the plants grow into short, single-stemmed skewers completely covered with buds.

The cubes are watered automatically as they rotate. Once the plants are set inside, they need little care. Staking is eliminated and, later on, manicuring will be abbreviated because of the high calyx to leaf ratio. They are unlikely to get infections because insects have a difficult time landing on moving plants, and the environment is very bright, which deters some pests and infections.

These systems are complex pieces of machinery, and their initial cost is substantial. However, the savings in labor and the increase in yield pay back the investment many times. There are a number of models currently available.

The one drawback to these systems is the number of plants they require. More than 200 rooted clones fit in the system, which pushes plant counts and plant limits. However, if there are no restrictions on the number of plants, these units might help you deal with space limits. The finished plants are all one stemmed, so they take little room. The units can be stacked, so a number of these gardens can fit in a small footprint.

COLISEUM GARDEN

All growers seek to maximize the yield of their gardens. Usually light is the limiting factor.

Indoor grow lighting by HID lamps is limited by the reflectors used to direct it down. Even the best reflectors lose 40% of their intensity in directing the light down onto the canopy. The solution is to build a garden around the lamp, without the use of a reflector. To make this garden, cut holes in plywood sheets slighty bigger than the size of the pots to be placed in them. Stand the sheets on their ends and assemble into hexagons or octagons around the lamps. Fill the pots with a planting mix.

Rotary gardens are very efficient in part because all the light gets to the plants directly from the lamps. 4" (10 cm) rockwool cubes are held in place along the bars. The plants stay short because of their changing position in relation to gravity. Each bar gets irrigated when it reaches the bottom. Looking at the inside you can see the canopy is a sea of buds.

Vertical gardens allow environmentally conscious growers to produce a high yield in a small space. Because the plants create a 360° circle around the light fixture, a higher yield can be produced with less power. The Ecosystem is a complete climate system that allows the grower to plant 20-140 bonsai style plants in a circular area with a 4’ (1.21 m) diameter that is 5’ (1.5 m) high. The water/nutrient solution is pumped to the top of unit and the plants are watered by gravity.

Vertical gardens allow indoor growers to maximize the potential of their indoor growing lights by placing plants in a 360° circle around them. The Octagon works for both soil and hydroponics mediums.

The common feature of vertical gardens is that plants are placed around lamps without reflectors and can be efficiently watered and maintained. They can be built tower style, stadium style, or in walls, rows, and geometric patterns. The objective of a vertical garden is to maximize use of space and increase yield per watt.

Coliseum is made of large half-arcs with a hollow space inside for a growing medium or aeroponic spraying. Up to 150 plants grow from the inside and create a circle around the lights. Often two stacks are lit with 3000 watts and the 300 plants inside can yield 8 or 9 pounds (3.6-4 kg), or nearly 3 pounds (1.36 kg) per watt.

The EcoSystem is a vertical round garden with the added convenience of using ordinary rockwool slabs drip irrigated from one end to water the plants. The original EcoSystem uses 24 slabs and is lighted with two 600w to 750w lights in the included glass tube. The EcoSystem II is larger, composed of two pieces, and lit with two 1000w lights.

FLAT GARDENS

You can grow a "flat garden" that uses wall space but not much depth. This space can be converted to a growing area very easily. Paint the space flat white or cover it with reflective material. If the space is exposed and if that is inappropriate, use a curtain or other visual barrier to hide the garden and separate it from the surrounding environment. This will also keep the light in the garden. These cultivation strategies use space differently than most gardens. Rather than using just the flat floor or ground surface, these gardens use the vertical dimensions of the space, too. This allows denser planting and more efficient use of light.

Fluorescents should be placed facing the wall so as to create a "wall" of lights. The plants are sandwiched between the wall and the bank of lights.

These plants were grown under a reflector that directed light to the walls as well as the floor. To utilize the light energy while keeping the plants from obstructing it, they were placed along the wall, behind netting.

The plants naturally spread out in three dimensions, but their depth or width can be controlled by training using stakes or plastic netting or even chicken wire placed on a frame. You can also just remove the branches that give the plant depth.

The netting is attached to the walls so there is a minimum 4" (10 cm) space between the netting and the wall. Twist ties are used to hold the branches to the frame.

EXAMPLE OF POOR GARDEN DESIGN

- The electrical system is haphazard and dangerous. The wiring is a series of extension cords, some of which are trailing to the floor. The wire jungle could be used as a net trap.
- The light is unprotected and can burst if it comes in contact with a drop of water.
- Without a reflector to direct the light much of it never gets to the garden, so it is wasted. The lamp is illuminating too large an area, about 60 sq ft (5.5 sq m).
- The fan is pointed directly on the light and blowing the hot air over the plant canopy.
- An old fashioned magnetic ballast powers the light; however, electronic ballasts use less power and would have saved about 8% in electrical costs.
- The ballast and tools are on a high shelf that makes them hard to get to.
- There is no indication of ventilation, heat exchange or CO_2 enrichment.

SOIL

THE PURPOSE OF ROOTS

In earlier chapters most of the discussion was about the plant's activities above the soil level. The plant's roots, though hidden, are just as complex as the canopy.

It's obvious that roots anchor a plant in place. The network of branches forms a tight relationship with the soil that firmly anchors the plant in the ground and holds it. Although the canopy may endure winds that tug and pull it, the roots provide stability to the stem, keeping it upright while allowing it to bend.

Roots supply the plant with water and nutrients. Using a complex series of biochemical processes, the roots gather nutrients and release sugars and enzymes into the environment.

Marijuana plants grow roots both vertically and horizontally. The horizontal roots can stretch out to a width equal to the plant's canopy. This means that a plant that is 10' (3 m) wide has roots to match. The horizontal roots also grow down to a depth of between 9-18" (22-45 cm), depending on the soil's moisture. The vertical roots can stretch down to 4' (1.2 m) or more in search of water; in moist soil, the vertical roots may be quite short.

ROOTS IN THE NATURAL SOIL ENVIRONMENT

Plants growing in a natural outdoor environment obtain their nutrients from the breakdown of complex organic chemicals into simpler water-soluble forms. The roots catch the chemicals using a combination of electrical charges and chemical manipulation. They are assisted by a thriving community of microorganisms that live in the rhizosphere, the area surrounding the root. These organisms are involved in a symbiotic relationship in which they help protect the root and supply it with minerals. In return the roots release sugars and other plant manufactures. This ecosystem is generally self-supporting.

NATURAL SOILS

Soils in the northern tier of North America and most of Europe form layers of decomposed plant material in two distinct patterns. Forest soils develop from the tree's leaf drop. They form a layer by continually adding to the top layer. A typical soil of this kind has an undecomposed top layer. The contents are progressively more decomposed with the lower portions forming a fine compost. The depth of this layer varies by locale and natural environmental conditions as well as the forest's history.

SOIL TIPS

Growing in soil has many advantages over any other method. It takes less labor and time to prepare the planting area. Adjusting the soil's fertility with nutrients and amending it with additives such as compost, mulch, or fertilizer takes relatively little time and energy as compared with replacing a container's soil.

Another advantage of soil is that it is easier to meet the plants' needs as compared to using containers or hydroponic systems. Roots can stretch out and obtain water and nutrients from a larger area, and, as a result, they can support the needs of a larger plant.

There is no "perfect" soil for growing cannabis; different varieties each grow within a range of soil condition parameters. The soil must be well-drained, nutrient rich, and have a pH between 5.8-6.5.

Always test the soil to find out its requirements before preparing the soil for planting. The pH and fertility of soils vary so there are few generalizations that can be made about preparing them. Only after soil qualities and nutrient values are determined can the correct

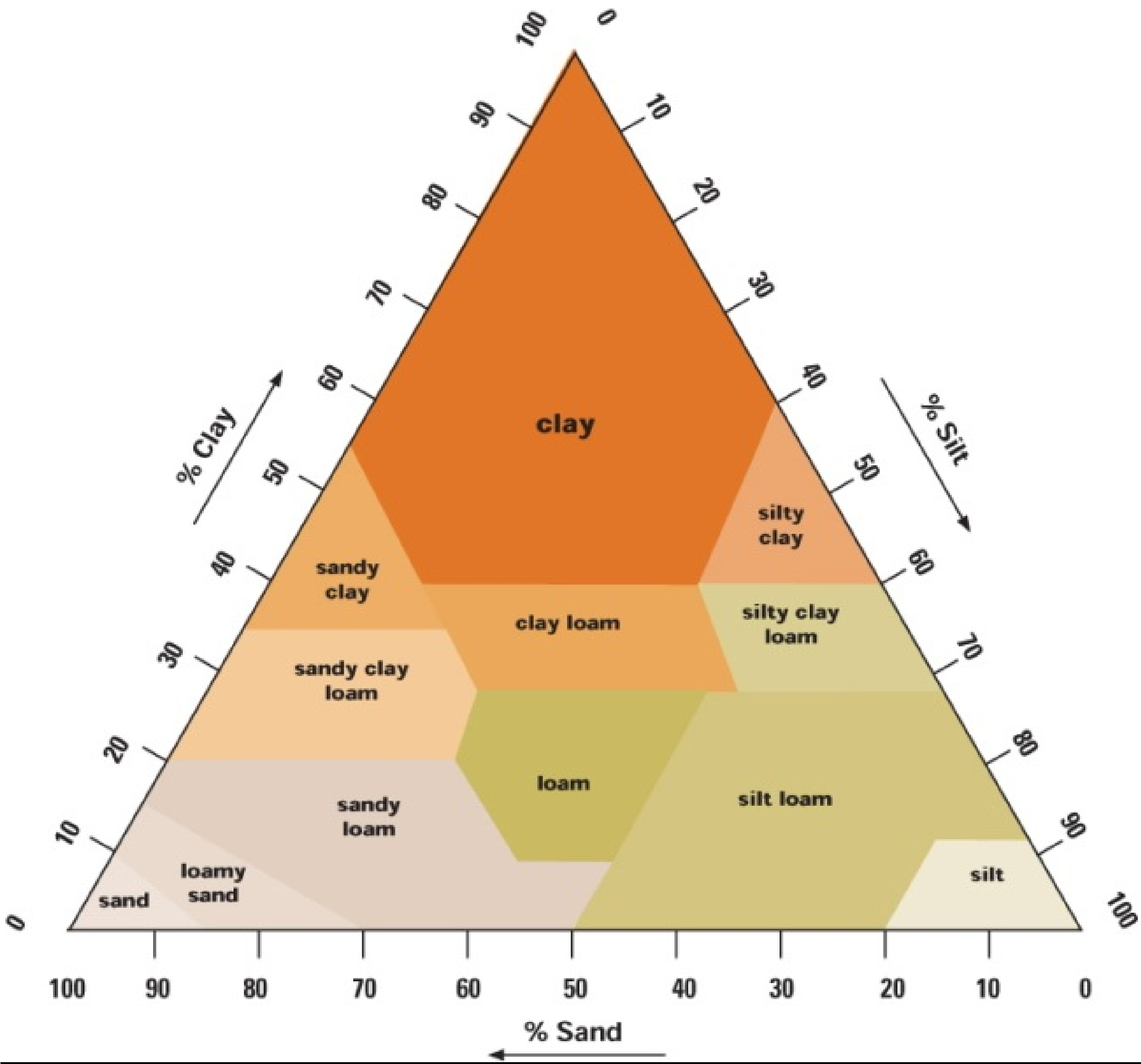
adjustments be made to optimize the soil's fertility.

For marijuana plants, the soil should test high in the three macronutrients: nitrogen (N), phosphorous (P), and potassium (K) (see Nutrients). The most important quality of any soil is its texture, which is determined by the size of the soil particles. Marijuana prefers soil that drains well but also holds moderate to large quantities of water. Depending on the type of soil composition, add materials to improve the texture and nutrients.

When North America was colonized in the 16th century, earthworms were introduced that changed the soils in the eastern half of the continent. Earthworms pull semi-decomposed material down into their burrows, which have a depth of several feet. The large accumulation of duff that typified pre-colonial forests has largely disappeared. In its place, there is a smaller layer of decomposing compost soil. The mineral soil, which formed a distinct layer below the compost soil, is now laden with organic material and burrows that so it is more **friable**.

Grassland and prairie soils have a different history. The annual dieback of canopy growth deposits a small top layer that decomposes in the same way as in forest soils. However, most of the added organic material develops below the surface. It is fed by the dieback of annual plant roots. They compost in place, so the organic matter integrates with the mineral content of the soil, creating deep levels of nutrient-rich, composted material.

Warm soils such as those found in the warmer parts of North America and Europe contain much less organic matter and have fewer nutrients than northern soils because microorganisms, whose metabolic rates increase with the temperature, are more active, so they digest new organic matter almost as fast as it is deposited.



Gardeners can assess their soil using a soil-texture triangle that classifies the soil based on its percentages of sand, silt, and clay. Most gardens and fields that have been cultivated and have grown good crops fall within the acceptable categories of the soil triangle.

Moist warm tropical soils hold few nutrients. Nutrients in these areas are mainly held by living plants. As soon as vegetation dies, bacteria and other microlife feast and render the nutrients water-soluble. They are absorbed into the soil and almost immediately taken up by the roots of higher living plants.

Underneath the layer of organic material in forest soils and the mixture of organic matter and minerals in grasslands lies the mineral soil, which contains little organic matter. The mineral portion of soils is usually composed of three main elements: sand, silt and clay. Each of them lends properties to the mix and each is needed in the mix in order to create a soil that promotes healthy growth.

The negatively charged molecules in clay cling together forming a barrier to water percolation. Clay has a negative electrical charge that binds minerals including Ca, magnesium, potassium and sodium. It releases them in exchange for weak hydrogen ions released by plant roots and microorganisms. Soils that are more than 30-40% clay are considered clay soils because the other ingredients are absorbed into the clay dough.

SOIL TYPE PARTICLE

Particle	Diameter	Description	Source	Effect
GRAVEL	2 mm +	Coarse	Broken Rock	These larger pieces provide channels for water to percolate in compact soils.
SAND	.05–2 mm	Gritty	Ground Rock	Water percolates freely through sand, leaving large spacees for air. Does not stick to other particles so keeps soil from compacting too tightly.
SILT	.002–.05 mm	Floury	Powdered Rock	Particles are spaced very tightly making it dif cult for water to percolate through. Water puddles before it drains. Then the small particles trap water molecules, re-leasing it as needed. Too much silt creates a wet soil.
CLAY	less than .002 mm	Sticky	Alumino-Silicate	The negatively charged molecules in clay cling together to form a barrier to water percolation.

Loams are composed of sand, silt, and clay mixed with organic matter. As a result, the soil particles vary in size. This creates multiple paths for water to flow and also allows air pockets to remain, even when the soil is saturated.

Clay loams can be silty or sandy but are a little heavy and, in wet weather, can become saturated. Adding organic matter and sand increases porosity, although this may be an arduous undertaking.

Sandy soils leach water and nutrients. They need to be irrigated more often because they hold no water reserve. Sufficient amounts of compost, coir, peat moss, leaf clippings and planting mix add texture and increase its water-and nutrient-holding abilities.

Silty soils are composed of very small particles with a high surface-to-volume ratio that makes them chemically active. They hold nutrients in a buffer of charged particles, releasing them as roots draw them out using dilute acids. These soils hold water so well that heavy rains can result in anaerobic conditions, meaning the roots will be unable to get the oxygen they need. Sand and compost help increase soil porosity.

After assessing the soil's pH, nutrients, and texture, the next step is usually tilling. There are two primary methods of preparing soil outdoors: either turning the whole area using a garden fork, rototiller, or tractor and plow or preparing discrete planting areas such as holes, or raised mounds or beds that hold a single plant or group of plants.

Tilling, or turning the soil over, breaks up compacted soil, and mixes in amendments such as compost and fertilizers, and making it easier for roots to penetrate.

Most of the time, soils need loosening to a depth of 10-15" (25-38 cm). However, soil with loose texture, sandy soils, and soils high in organic matter may have adequate aeration, porosity, and space for roots and may not have to be tilled at all.

Soil amendments and fertilizers to improve the nutrients are easily mixed into the soil when it is being prepared.

TEXTURE

Regardless of the particular composition of your soil, its texture is critically important to healthy plants. Texture refers to a soil's density, particle size, and stickiness—all of which affect the soil's ability to hold or drain water. Root health, and ultimately plant health, relies mainly on the soil's drainage ability. If a pool of water develops after rain, the soil is saturated. There are no air pockets and the roots receive no oxygen; plants fail because root and stem rot attack roots weakened by the anaerobic conditions. Well-drained soil allows roots to be in contact with both water and air, the ideal condition for healthy growth.

Medium-textured soils—soils that drain well but can also hold an adequate amount of water—are best for cannabis. Loams, silts, and sands drain well and are usually loose enough to encourage healthy root development. Many clays and mucks are too compacted for lateral roots to penetrate, and when dry clay soils form hard crusts or clods, marijuana plants simply cannot thrive.

There are a few simple tests you should always perform before planting that will help you to check both the moisture-holding and drainage characteristics of your soil. For best results, test the soil when it is moist but not wet.

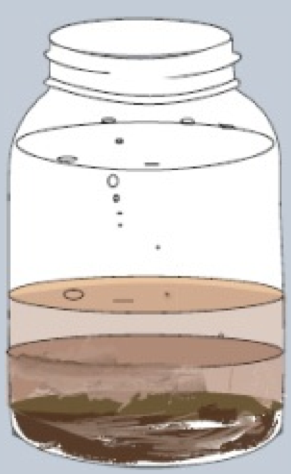
First, dig a hole 3' (0.9 m) deep so you can examine the soil's profile; that is, the composition of its layers. You can use the method described in the box "Determining Soil Texture" to get a more accurate sense of the soil's relative percentages of clay, sand, silt, and humus, but even a visual inspection should tell you what kind of soil you have. Soils that develop under trees or other overhanging plant cover have decaying plant matter at the top that decomposes into a layer of topsoil. The nutrients the plant needs to grow are found at the topsoil layer, though nutrients also leach to the next lower level.

Topsoil, which can be as shallow as an inch (2.5 cm) or several feet (a meter) deep, is usually the darkest of the layers. It is home to an abundance of life, including a variety of worms, bugs, and microorganisms such as yeasts, fungi, anachria and protozoa. If you can dig through the topsoil layer easily with your hands, its texture is right for healthy root growth.

By contrast, soil that has been covered primarily by grasses and annual plants has accumulated organic matter in a different way. Known as "prairie soils," they may have a thin layer of topsoil near the surface, but the nutrient-rich area is deeper than the topsoil. The root layer of annual plants die off and decompose each year, leaving an organic component that provides nutrients, holds moisture, improves texture, and hosts beneficial organisms. This layer, while sometimes shallow, can reach a depth of 10' (3 m).

Whether you've got forest or prairie soil, you'll find a layer of subsoil beneath the nutrient-rich upper layer. The subsoil can be composed of clay, sand, fine mineral particles, and small rocks. Sandy, rocky, and loamy subsoils provide excellent drainage without amending.

DETERMINING SOIL TEXTURE



Fill a quart jar two-thirds with water and add soil until the water nears the top. Screw on lid and shake thoroughly. Allow the soil to settle. The heaviest sand particles sink to the bottom and quickly become visible. It will take hours for the silt and clay particles to settle. The fine clay particles are so small that the molecular action of water will keep them in suspension indefinitely.

Below the subsoil, you may find clay or bedrock; both can create drainage problems, particularly if the area is in a spot with a high water table or where the soil tends to remain wet. If you are hitting clay or bedrock within three feet (0.9 m) of the soil surface, consider alternatives such as building raised beds or mounds to ensure proper drainage and adequate root penetration.

After you've done your visual inspection of the soil, you should use the squeeze test. Take a handful of soil from each layer and squeeze it tightly. Release it, and then poke the soil ball you've created with a finger. If it falls apart easily, the soil is either sandy or loamy. If the soil remains hard and stuck together, or if it feels sticky, you have quite a bit of clay or muck present and you need to amend it.

Testing soil for drainage is very simple. Fill the hole you've dug with water, wait one half-hour to allow the water to penetrate the surrounding soil, and then fill the hole again with water. If the moisture drains easily, the soil you are working with is sandy soil. If the water has still not drained through after 24 hours, the soil has very poor drainage.

TYPES OF SOIL

Each type of soil has its own unique characteristics that determine how it interacts with plants. Soils can be mainly classified as sands, clays, silts, loams, or mucks. Most soil is a combination of two or more of these. Sand granules, bits of clay, organic matter, and fine silty material can all be found in a random handful of soil.

SANDY SOILS

Sand is formed from ground or weathered rocks, including limestone, quartz, granite and shale. Sand doesn't form bonds easily so little water is trapped. Sandy soils drain quickly and they don't hold moisture and nutrients very well.

Some sandy soils are particularly fertile, however, because they contain significant amounts (up to 2%) of organic matter. This matter also helps the soil hold water.

Sandy soils are rich in potassium (K), magnesium (Mg), and trace elements, but are often too low in phosphorous (P) and nitrogen (N). Nitrogen, the most soluble of the elements, is quickly leached from sandy soil. Yellow, pale, stunted or very thin plants growing in sandy soil usually indicate low nitrogen.

Sandy soils are easily prepared for cannabis cultivation. First, clear the ground cover from the soil. Next, treat it with humus, manure, chopped plant debris, chopped newspaper, real charcoal or other organic, nitrogen-containing fertilizer. Adding mineral soil (subsoil) or used planting mix increases its water-holding capacity and fertility.

Sandy soil with some organic matter or loam that are supporting healthy plants doesn't usually need to be turned or tilled because plant roots can penetrate easily. Hoe the planting row immediately before planting. Add nutrients using water-soluble fertilizers.

Water-holding pellets, made with polymers that swell to hold water and release it gradually as the soil dries, lengthen the time between waterings.

Sandy soils are improved by spreading layers of uncomposted vegetative matter over the garden area. Nutrients gradually leach into the soil and the protective layer acts as a mulch to slow evaporation.

SILTS

Silts are composed of fine particles of organic matter combined with minerals such as quartz or other fine sands. Silty soils resemble a sort of mucky clay when wet, and look like dark sand or brittle clods when dry. Silts are the result of alluvial flooding, created by the deposits that remain after rivers and lakes flood. Alluvial silty soils are most commonly found in the Midwest, in valleys and along river plains. The Mississippi Delta, for example, is a very fertile alluvial plain.

If you have clay-loam or compacted soil you can use it for making raised beds. First, turn the soil in the whole area. Construct aisles by digging out pathways and adding soil from the aisles to the beds. As you fill the beds amend the clay-loam by mixing in organic soil amendments and sand. Build the bed 2' to 3' tall (60-90 cm).

Silts drain well, but they also hold moisture well. They are rich in most nutrients unless they were leached out by bad gardening techniques. They are simple to work with when damp and are regarded as some of the most fertile soils for planting cannabis. Gardens using silty soils must be irrigated frequently. Usually, they support very healthy and hearty plants because they contain an excellent supply of nitrogen.

MUCKS

Mucks are composed primarily of humus from drained swampland or bogs and are found in areas that get plenty of rain. Though they are often very fertile and normally support dense vegetation, mucks are fairly acidic. They contain little potassium, so this nutrient needs to be added.

Mucks range from very dense to a lighter, sandy soil. Denser mucks need tilling so that healthy roots can develop. Lighter mucks are easily cleared for planting. The dense vegetation that mucks support may be helpful in that, when turned into the soil, the plant material becomes "green" manure.

SOIL TESTS

The best way to learn about your soil or planting mix is to have a professional laboratory perform a soil test. This is the only way to know exactly how much of each nutrient the soil contains. Using the results, you can target the best ways to amend the planting medium to meet the plant's needs.

These soil tests were performed on various planting mixes that are widely available in hydroponic and gardening supply stores.

The test performed by Perry Labs has 19 parameters. They are listed along with general guidelines for the preferred range:

pH **Proper pH is important because outside of the range some essential nutrients become unavailable.**

EC **(Electrical Conductivity) A low EC means that there are not a lot of available nutrients. When EC is too high, water although present, becomes unavailable to the roots.**

NITRATE (NO_3) **is the form of N that plants absorb most easily. Notice that the manure has a low rating. Most of its N is held in organic compounds and is released over time.**

AMMONIUM (NH_4) **is absorbed, to a limited extent, directly by the plants. However, it is used by soil organisms and converted to the more soluble and plant friendly NO_3. It is not desirable because it is toxic to plants in high amounts.**

PHOSPHOROUS (P) **is one of the macronutrients plants need. Soluble P is very acidic so it brings down the pH of soil in too large an amount.**

POTASSIUM (K) **is one of the macronutrients plants need.**

CALCIUM (CA) **is often considered a macronutrient because plants use so much of it. It is usually adequate in garden soils, but some planting mixes don't contain enough. Coir and pure peat moss have very little.**

There are also results for other plant nutrients including magnesium, sulfur, boron, zinc, copper, manganese, iron, sodium, and chlorine.

The next two categories, Moisture Holding Capacity and Air Filled Porosity, are indications of how well the medium holds each. Mediums with high water holding capacity need irrigation infrequently as compared with those that hold less. The roots need oxygen, which is found in air. Mediums with high air holding capacity meet roots needs. Low air capacity leads to anaerobic conditions.

Cation Exchange Capacity (CEC) is the ability of the soil to hold nutrients. Too low a level indicates a soil or planting medium that has the capacity to hold few nutrients.

Sample Identification	pH	Electrical Conductivity (EC)	Nitrate Nitrogen (N)	Ammonium Nitrogen (N)	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Sulfate (SO4)	Boron (B)	Zinc (Zn)	Copper (Cu)	Manganese (Mn)	Iron (Fe)	Sodium (Na)	Chloride (Cl)	Moisture Holding Capacity	Air Filled Porosity	Cation Exchange Capacity
			RESULTS REPORTED IN PARTS PER MILLION OF DRY SOIL												meq/l		% by volume		Meq/100gm
General Guidelines–Potted Plants in Organic Mixes	5.2-6.5	1.0-3.0	25-50	10-30	25-75	100-300	2000-4000	100-500	25-50	0.5-1.0	2.5-5.0	1.0-2.0	10-20	20-50	<3.0	<3.0	>40	>15	
Coco Tek Organic Grow Medium	7.1	1.2	1	3	5	485	1800	295	222	0.1	1.6	0.8	0.5	1.2	4.7	5.2	55.7	35.4	61.3
Coco Gro Boss 6" cubic Grow Bag Botanicare	6.3	1.1	30	4	5	180	2000	210	110	0.1	2.8	0.8	2.0	1.9	4.1	5.0	54.9	41.7	63.8
Coco Gro Coir org. Soilless Grow Media Botanicare	6.8	0.8	1	2	5	145	1800	190	110	0.1	1.8	0.8	1.8	2.4	3.6	4.0	63.1	31.7	70.6
Dairy Manure Processed & Cleaned	8.0	1.6	1	3	232	535	4100	620	10	0.5	13.2	6.6	15	8.2	7.7	5.2	59.2	25.0	57.5
Fox Farms Ocean Forest	7.2	4.4	25	210	77	325	4000	390	2476	0.1	3.9	2.0	7.5	98	1.8	1.6	53.9	25.0	31.3
New Age Garden Lite Coir	6.0	2.1	0	14	25	1655	700	250	207	0.1	1.8	0.4	1.8	6.9	4.6	14.2	57.8	27.1	48.5
Roots Nat + Org	4.5	4.5	376	21	51	530	2000	240	506	0.1	6.2	1.0	29	124	7.0	5.0	63.0	12.1	44.4
Super Ed's Mix #781 w/less fertilizer	5.2	4.5	11	76	77	885	1600	380	1403	0.7	3.6	1.2	10	145	11.4	18.6	50.5	21.7	34.4
Competitor X	6.5	1.1	45	6	82	300	2400	245	278	0.1	5.3	0.8	17	14	4.0	4.0			

DRAINAGE

No matter how well the soil is prepared, the groundwater level and the permeability of the lower layers are of utmost importance. Soils in areas with high water tables or underlying clay or hardpan do not drain well. In either case, the garden can be grown in raised beds filled with soil from the site that has been amended with additives and nutrients. If the local soil is too poor, use landscape soil or planting mix.

CLAY SOILS

Clays are made of fine crystalline particles formed by chemical reactions between minerals. These particles are so small that they have no structure when wet, but react more like a very viscous liquid. Sticky and easily molded or shaped when wet, when dry clay forms hard clods, normally observed as a grid of square cracks along the ground surface. Clays are rather difficult to work with, mainly because they drain so poorly.

Despite their disadvantages, clay soils are often very fertile. The success of a plant in clay soil depends on how well the soil drains. A reddish-colored clay soil (sometimes referred to as “red dirt”) indicates proper aeration and good drainage. Blue or gray clays mostly have insufficient aeration for growing marijuana; they must be tilled and amended in order to support healthy growth.

Since marijuana roots (particularly the vertical ones) must penetrate the soil, it is necessary to till clay soils thoroughly to loosen them. The addition of perlite, sand, used planting mix, compost, gypsum, manure, and fresh clippings helps loosen and aerate clay soils.

In lowlying areas, stream banks for example, the soil often retains too much water. This can lead to rot in both roots and stems. Planting mounds help the soil drain so the stem and taproot stay dry.

Prepare clay soil in late autumn before frost by tilling it and adding conditioners such as bark, charcoal, compost, grass clippings, gypsum, leaves, manure, paper and cardboard planting mix and wood chips.

Spread ground cover seed such as clover, vetch, or rye over the top of the soil after tilling. This creates green manure that provides soil texture as well as air and water pathways.

If the soil is still sticky, break up large clods and add compost and sand in early spring. At planting, use a hoe to till the specific areas where the seeds will be planted.

As the composts and green manure raise the organic level in the soil, it becomes less dense. With each passing year you’ll find that the soil becomes easier to work with. The roots will have an easier time penetrating the soil. After several years, you’ll likely discover the only thing you have to do is turn the cover crop over. No further tilling should be needed.

LOAMS

Loams are a combination of the soils discussed above. They are usually made up mostly of sand and silt with about 20% clay. They are described as sandy silt, silty clay, sandy clay or organic silty clay. Organic loams are made up of at least 20% organic matter. Loams range from easily worked fertile soils all the way to densely packed sod. Loams with a lot of organic matter produce an excellent marijuana crop with little soil modification.

Loams usually have good drainage, but hold water well. They are packed with nutrients and are excellent garden soils.

HUMUS AND COMPOSTS

Decayed organic matter, including plant life, animal droppings and microbes, are referred to as humus or compost. Nutrient contents depend upon the original ingredients, but most humus or compost contain bacteria, fungi, insects, worms and microorganisms that are necessary for a complete conversion of important nutrients. During their life processes, many of these organisms convert insoluble chemicals to a soluble form that plant roots can absorb.

Humus and composts hold water well and are frequently added to condition soils, as mentioned earlier.

Good compost has a rich, earthy smell and a dark brown to black color. They usually contain partially decayed matter, such as twigs or leaves.

Humus and compost can be produced naturally as part of the soil's life process, or they can be "manufactured" at your grow site simply by gathering the native vegetation and piling it up. It takes between one and three months to cure, depending on what type of matter you are using. Decomposition of the humus or compost can be achieved more quickly by chopping up the ingredients, turning the pile, and adding substances high in nitrogen, including chemical fertilizers Most compost is neutral to slightly alkaline, but acidic compost piles can be "sweetened" using lime. Adding lime to highly acidic compost shortens the curing time since microbes prefer an only slightly acidic environment.

pH

The pH level is a measure of how alkaline (sweet) or acidic (sour) it is. The pH scale runs from 0 to 14, with 7 considered neutral: a pH level below 7 is acid, above 7 is alkaline. The pH determines the solubility of nutrients and affects the plant's regulation of its metabolism and nutrient uptake. Slightly acidic soils with a pH range from 5.8 to 6.5 are regarded as marijuana friendly.

The pH of the soil interacts with the soil's composition to affect nutrient solubility. Soils with a high percentage of organic matter contain nutrients that are soluble between pH levels of 5.0 and 6.5. Phosphorous, manganese, and boron (which are discussed in more detail in the following chapter) are less soluble at pH values above 6.5.

Dry western states have soil that usually ranges from slightly acidic to highly alkaline. Nutrients tend to be quite soluble in these types of soils, providing that the pH range is adjusted to between 6.0 and 6.5. Use a simple pH meter or a test kit, available at most gardening stores, to accurately test the soil ph. If it is alkaline or near neutral, adjust the soil accordingly before planting.

Overwatering combined with a dense, non-porous medium makes roots vulnerable to mold and diseases. House and Garden Roots Excelurator removes mold and disease from the root system removes as well as inoculates the soil with beneficial bacteria that facilitate root growth.

ADJUSTING THE pH

Always test the pH of any soil you are using. The pH of your garden soil may be different from other soils in the area, so don't trust what your neighbor is doing. Developers and homeowners often truck in new soil if the native soil is poor in texture, nutrients, or both.

Keep in mind that soils vary in the amount of material needed to adjust the pH. Sandy soils require less material to change pH as compared to loam. Clays require the most because of their density and the electrical charge of the soil particles. Whether your soil is excessively alkaline or acid, there are a number of materials you can add to adjust the pH.

ADJUSTING ACID SOILS

Limestone, also known as Ca carbonate ($CaCO_3$), is the best way to treat acidic soils. Quarried and powdered limestone contains large amounts of trace elements. It comes in three forms: ground limestone, quicklime, hydrated, and liquid lime (which is the fastest acting).

Dolomitic limestone is a limestone variety high in magnesium as well as Ca. It is a good choice for adjusting the acidic, magnesium-deficient soils often found in the Northeast.

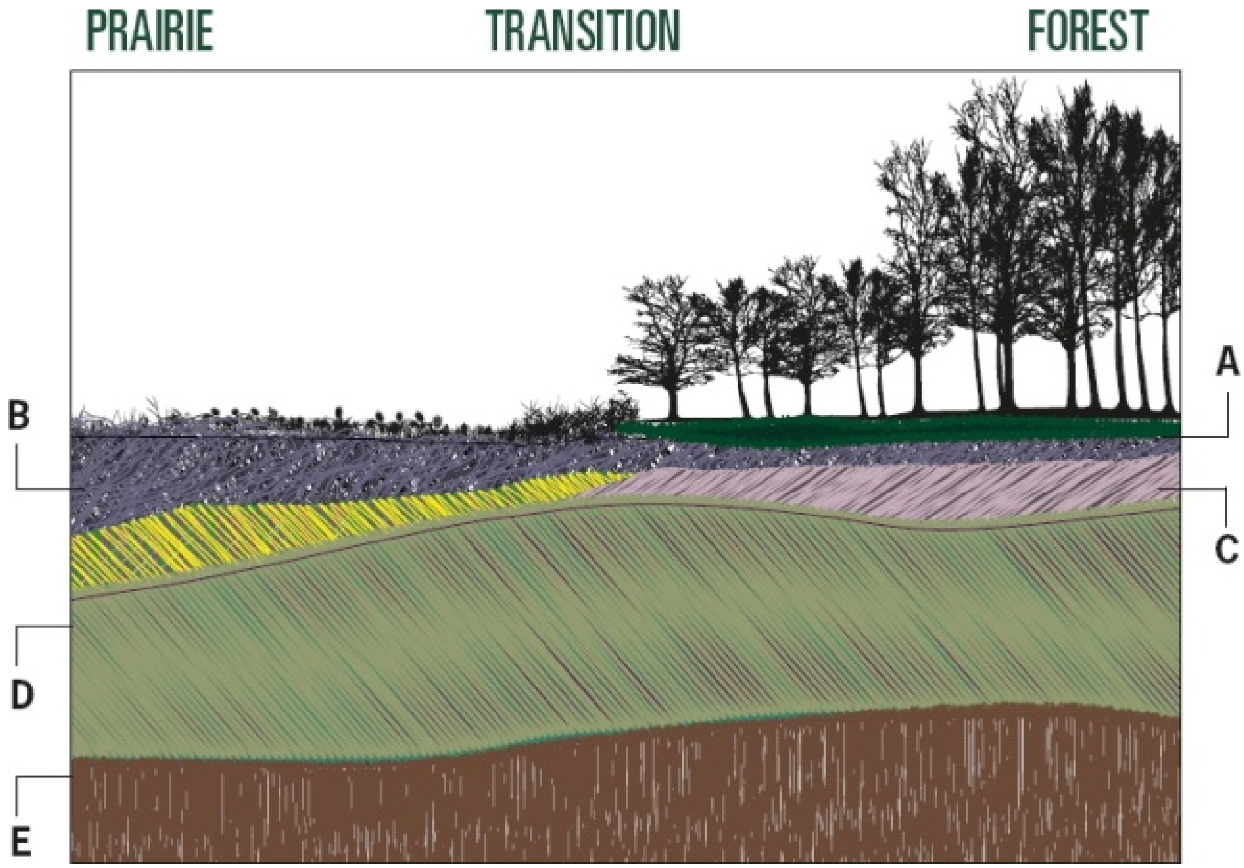
Seashells and egg shells, are composed mostly of Ca and both raise soil pH. Grind them into a fine powder using a blender. They affect soil pH gradually. By contrast, most wood ashes are alkaline and extremely soluble, so they affect soil pH very quickly.

All commercial limes list their Ca carbonate equivalent, which is a measure of their neutralizing power, on the bag.

To determine how much lime to use, divide the total amount of limestone required by the pH test by the Ca carbonate equivalent. For example, a field may require 50 pounds (22 kg) of limestone, and the Ca carbonate limestone we are discussing for our purposes may have an equivalent of 1.78. If you divide the 50 pounds (22 kg) by 1.78, the resulting figure, about 29 pounds (13 kg), is the amount you will require.

Grade, or particle size, of the powder is also listed on the package. The categories used define the fineness of the powder: superfine, pulverized, agricultural grade and fine meal. Finer grades result in faster soil-adjusting action, but are more prone to washing away.

THE TW0 KINDS OF SOIL HORIZONS THAT FORM UNDER PRAIRIE AND FOREST VEGETATION, AND INTERGRADES BETWEEN THE TWO



A: The surface horizon consists of organic debris including dead vegetation and animal droppings. It is in various degrees of decay, the top layer, the most recent has the least decay. This horizon is deeper in forests, where leaves are constantly falling seasonally, adding to the pile. Before earthworms were introduced to the Americas, Eastern forests had larger layers. Now earthworms carry the material to their tunnels below the surface.

B: Uppermost Horizon is more prominent in prairie soils. It consists of minerals and organic matter. Grass roots carry nutrients and organic mateer to the root zone which may extend several feet. The organic matter mixes with the mineral soil already present. In forest soils this layer is much shallower. However, earthworm activity has increased organic content.

C: Subsurface horizon consists of clay or other semi-porous layer. This layer is missing from some soils.

D: Subsurface—a mixture of mineral soil, rocks, pebbles, and clay.

E: Geologic—bedrock, or other non organically produced materials.\

Add lime to a depth of one inch (2.5 cm) four to five months ahead of planting so it has time to adjust the soil. You can water it into the soil. Water well afterwards or spread it before a rain, providing that the soil is moist enough to absorb the water and lime, and it does not simply run off.

Adjust the medium in planting holes and raised beds. Soil can be adjusted with lime during or after planting, as long as the lime doesn't come into direct contact with the plants. You can add hydrated or liquid lime to soil with a hose-end sprayer. Lime can also be mixed in irrigation water; however, it can clog up drip lines, hoses, and pumps. You can also use a liquid hydroponic adjuster such as pH Up (usually a potassium salt) to raise irrigation water pH; it has an immediate effect because it's water-soluble.

ADJUSTING ALKALINE SOILS

Alkaline soils have a pH higher than 7, outside the range for optimum marijuana growth. Adjust alkaline soils using iron sulfate or magnesium sulfate. Both sulfates can be introduced into the soil in the same way as lime. Don't use aluminum sulfate because marijuana has a low tolerance for aluminum.

Some growers adjust alkaline soils using organic mulch or by working acidic material into the soil. Cottonseed meal, for instance, is acidic and high in nitrogen, so it works well. Coffee grounds, pine needles, and citrus rinds are all very acidic.

ADJUSTING ALKALI SOILS

Alkali (as opposed to alkaline) soils have a high sodium content and frequently a pH above 8.5. They are usually hard-packed and crusty, sometimes with white powdery salts on the surface. They don't absorb water easily.

Alkali soils such as those found in western Colorado, parts of the U.S. Southwest, Spain and the Caspian Sea area of Central Europe can be frustrating, energy draining, and time consuming to work with. Farmers usually prepare alkali soils for cultivation by leaching them of the toxic accumulation of salts. This is achieved by tilling the soil to a depth of 30” (75 cm) and then flood-irrigating using 6-12" (15-30 cm) of water at least once or twice to flush the salt deep into the soil, out of contact with the roots. Next, the soil is tested to determine the amount of amendment needed. Phosphorous fertilizers are acidic and quickly bring the pH of these soils down to a more suitable pH.

Another method of adjusting alkali soils is to add a thick mulch layer, which interacts with the soil during the winter. The mulch layer should be a minimum of 9" (23 cm) thick, or about 130 lbs. (60 kg) per 100 sq ft (10 sq m). Thicker mulch layers neutralize more salts faster.

OFFSITE OUTDOOR CULTIVATION

No matter where you are growing, marijuana has the same requirements, so the same gardening rules apply. The difficulty of maintaining an offsite garden depends on the environment. Offsite gardens are usually located in secluded areas that are difficult to access, so growers must adapt their methods accordingly.

Unfortunately, soils in areas suitable for clandestine gardening are often inadequate, and amending the soil can pose challenges. If it is impractical to bring a sufficient amount of bulk amendments to the garden, organic materials can be gathered at the site in the fall and used as compost over the winter. Adding fertilizers high in nitrogen and phosphorous hastens the decomposition.

Transporting supplies and tools to the site can be facilitated by small off-road cycles or pack animals. Horses or mules can also be used to plow, with the advantage that they generate much less noise than motorized machinery and eliminate the need to carry fuel.

Growing offsite can be an arduous adventure.

The gardening methods appropriate for offsite cultivation are determined by local variables. A naturally fertile area near a stream may require little more than clearing vegetation and cultivating in the available soil. By contrast, the soil present on a steep slope may need to be augmented to compensate for the natural erosion of topsoil.

OUTDOOR WATER SAVING TECHNIQUES

This section is devoted to customizing raised beds, planting holes, troughs and hydroponic systems.

Plant size and yield are determined to a great extent by the development of the root system. Even plants that are receiving copious quantities of water and nutrients require enough room for their roots to grow and spread out in order to reach their full potential.

When limited by law to growing just 6 or 10 plants, it is best to potentiate the size of each plant. Creating a large area of prime soil helps the roots penetrate easily and absorb nutrients. Figure that the diameter of the plant is usually the same size to about one-third larger than the diameter of the root ball. A plant with a 10' (3 m) diameter canopy will have a root spread of at least a 7' (2.25 m) diameter.

In dry areas that require irrigation, providing water to plants this size can be an arduous task that requires a lot of water, so water conservation becomes a significant factor. Water that reaches the garden is used in one of these four ways.

1. It is used by the plant. Plants use water for metabolic purposes in much the same way as animals, as a raw ingredient in photosynthesis or they transpire water vapor from the leaves in order to regulate temperature.
2. It evaporates from the earth surface. Heat and sunlight speed the evaporation of water from the top surface levels.
3. It drains from the root level deeper into the earth and becomes unavailable to the roots.
4. It is delivered to the garden, but to areas where there are no roots. It eventually evaporates or sinks, unused.

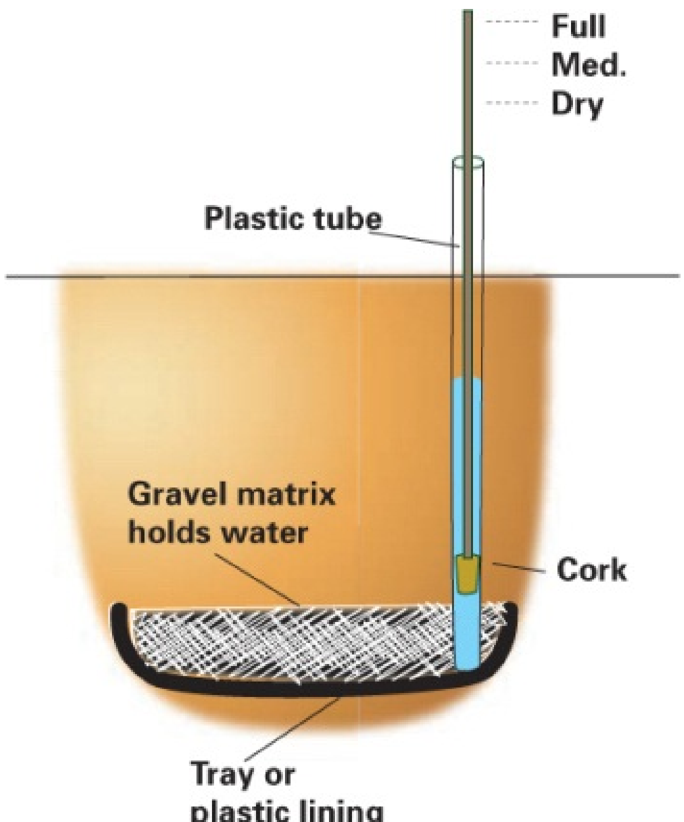
WATER SAVING STRATEGIES

- Organic matter holds more water than the mineral portion of the soil. Adding compost, peat moss, coir, charcoal or other organic matter increases the soil’s capacity to retain water. This is especially helpful in fast draining sandy soils.
- Water holding crystals can be mixed into the soil. These crystals expand to many times their dry size as they soak up water when soil is irrigated. They

release the water as the soil dries. This increases the soil's total water-holding capacity.
- Organic mulch placed on top of the soil layer lowers the evaporation rate: the barrier between the moist soil and heat and light eliminates most evaporation. The soil stays moist longer and the top layer of soil stays moist longer.
- Inorganic soil covering like old rugs placed reverse side up keep soil cool, stop erosion burrowing by pesky mammals and most importantly, keep the soil moist. They work extraordinarily well.

UNDERGROUND WATER RESERVOIRS AND "TILING"

You have dug the planting hole or trough or are about to construct a raised bed, but ordinarily a good portion of the water sinks below the root zone and is wasted. There are several ways of keeping the water available to the roots.



A tray or plastic lining holds water. Place rockwool or gravel at the bottom to prevent it filling with soil. The tube is used as a water level indicator; it rises when the water is high and sinks when water level drops. The roots grow into the reservoir and have a large source of water.

Not only do these methods conserve water, they also keep the soil fertile since the water doesn't drain away after dissolving nutrient salts. The fertilizers in enriched water stay longer in the root zone.

For thousands of years farmers have preserved water at the root level by placing tiles several feet under the soil surface so that the water is trapped and must move laterally rather than vertically to drain. The modern version of this is to place a layer of impermeable plastic at the bottom of the hole or raised bed.

Planting in holes or beds is a labor-saving alternative to tilling the soil of the entire area. For planting in holes, the area to be dug can range from 1' to 10' wide and 1' to 4' deep. Digging can be facilitated using a power auger, a post-hole digger, or a backhoe. Once the hole has been dug, adjust the native soil or replace it with topsoil or a landscape mix.

An agricultural tray or a kiddie pool can be placed at the bottom of the hole or raised bed and filled with gravel; it will collect and hold a large amount of water. An impermeable plastic tarp can also be used. Make sure that the plastic reaches 6-8" (15-20 cm) up the sides of the hole to create a "tray."

Capillary action draws the water up as it used. Using this method, virtually all the water usually lost to draining can be preserved.

To make sure this is taking place and to guide the roots to the pool of water, place wicks made of ⅝" (1.5 cm) nylon braided rope stretching from the reservoir to the top of the soil. The roots grow down into the pool or tray.

Underground, plastic deteriorates much more slowly than at the surface, where it is attacked by light and other harsh environmental conditions. Once the system is in place it can be used for years and the planting mix will just need supplements to retain and improve its fertility.

GROWING IN CONTAINERS

Old rugs, placed upside down so they have a more “organic” look than pink or burgundy, keep weeds from growing and keep the ground moist by absorbing light’s energy and preventing evaporation. They are heavy enough to stay in place.

Until the last third of the 20th century most planting mixes were composed of loam mixed with sand, compost or humus and perhaps some peat moss. These mixes usually worked well but they brought several problems with them. They were heavy, which made them and the plants they held costly to ship and inconvenient to handle. Secondly, loam is mined topsoil that may include hidden pests and diseases unless it is pasteurized. The use of loam also presents ecological problems.

Marijuana grows very well in containers, both indoors and out. They require more care and attention than plants growing in soil. Rather than working with the natural environment, or at least a semblance of it, when plants are growing in containers you control the space the roots have, as well as the water conditions and nutrients. Container size plays a roll in determining the growth, final size and yield of the plant.

INDOORS

Indoors, plants growing in containers should have a root space of 3-5 gallons (11-19 l) per sq. foot (.09 sq. m) of the canopy space the mature plant is to occupy. Sixteen of these containers fit in a 4’ x 4’ (1.21 x 1.21 m) space.

These 3-5 gallon (11-19 l) pots provide the roots with enough space to spread out and down throughout the container without becoming “rootbound,” although the roots provide for a canopy of the same width as the roots. Sometimes the plant canopy spreads up to a third larger than the diameter of the roots. The plants stay in the container for only a few months because they are forced to flower as soon as they grow into the canopy, a matter of weeks. The plant will retire in 10 to 12 weeks. Given an enriched medium or nutrient/water mix the roots will be able to meet all the plant’s requirements.

If plant limits are not a problem, then you can grow plants close together so each plant grows a single stem and is then forced to flower. This system, called “sea of green (SOG),” requires very little time spent in vegetative growth. The plants spend most of their lives flowering. Using this system you can place 64 6” (15 cm) containers in the space. Each container should hold 3-4 quarts (3-4 l) of planting mix.

Containers with handles make it easy to move plants around with the sun. Smart Pots are reuseable and lightweight. Because the container is fabric, ample supply of air reaches the roots and they do not become rootbound.

Woven plastic planting bags: handles make it much easier to move the bags. The rectangular bottom helps them stay upright.

If you are planning to grow plants with a larger canopy, place them in larger containers. Usually as the width of a container grows, the plant's width does too. With seed planted, taproots penetrate vertically and provide extra support and a healthy supply of nutrients through its network of lateral roots. Container height is more important for seed plants than for clones. Clones don't need the height. Rather than using planting containers, you might find 10-12" (25-30 cm) tall trays more convenient because they are shorter and save space and planting mix.

A garden the same size with four plants each set in a container that measures 2' (60 cm) square provides a large enough area of planting mix to support the plants, their numerous buds, and the extensive root systems that provide all the water and nutrients the plant needs.

A single plant in a 16 sq ft (1.5 sq m) garden can be placed in a 3' (90 cm) square container with planting mix 12 in (30 cm) deep.

These containers might seem large and you may feel you can grow plants in smaller containers, but treating the roots generously and letting them stretch out helps the plant reach its full potential so it grows the biggest buds and produces the biggest yields.

Instead of using containers you can use a planting bed. It's just like a raised bed, but indoors. The plants grow directly in the planting mix without the restrictions of containers. Each root system has more total space to explore and grow allowing it to gather more water and nutrients. Once it's set up you don't have to pot or un-pot planting mix. Just freshen it up between crops and you are ready to go again.

Soil bags can be laid flat for use as a planting container.

This Trainwreck was placed in a 30 gallon plastic bag filled with used planting mix. The bottom was cut open for drainage. The roots followed the water into the soil.

CONTAINER FACTS

- Rectangular containers hold more than circular containers of the same size.
- Containers must be able to drain well. Avoid containers with holes on the bottom in favor of holes on the side if the containers are to be placed on a solid surface. Bottom holes are easily blocked. Instead use containers with holes on the sides.
- Unconventional containers are fine to use. Adapt square and rectangular shaped plastic trays and containers by creating drainage holes.
- Plastic grow bags come in all sizes. They work well indoors and out, and are lightweight and inexpensive. Gusseted bags are the best ones to use. They are like paper shopping bags, with a rectangular bottom. Make sure they have drainage holes that are appropriately placed.
- Bags and containers are much easier to move and make gardening much less fatiguing when they are equipped with handles.

- Large containers can be moved with a container handler, hand truck or heavy-duty wagon.
- You can use planting mix in the plastic bag it came in as the planting container. Set the bag upright for good drainage.
- For bigger plants place two bags on top of each other horizontally. Remove the plastic separating them. Place holes along the bottom side of the bottom bag to assure drainage. If you want the plant roots to get rain, open the top bag so it can soak in. If not, conserve water by keeping the top covered. Water the plant manually or using a drip emitter.
- Mount large containers on wheels for easy placement and reorganization.

TIPS FOR OUTDOOR CONTAINERS

- Light beating down on a container can raise the temperature of the soil and roots causing tissue damage to the plant. Black containers are the worst because they absorb all the light. Containers wrapped in light colored material such as cloth, paper or plastic, painted white or pastel or placed in a basket won't get hot.
- Covering containers with white plastic helps slow evaporation.
- If the containers are stationary let the roots migrate from the container to the ground. The new roots will supply the plant with more water and nutrients.

PLANTING MIXES

The most important considerations of planting mixes are their texture, air and water holding capacity. The mixture should drain well so that oxygen, required by the roots, can fill the empty spaces.

Mixes with fine particles are good candidates for small size containers, perhaps up to 6-inch diameter. However they may become soggy and waterlogged in larger containers, creating anaerobic conditions, deadly to the roots.

A moist potting mix with a good texture should form a clump if is squeezed into a fist; then with a slight poke the clod should break apart. If it sticks together it should be amended with ingredients that loosen it up.

These include:

- coir
- perlite
- vermiculite

- compost

High quality commercial potting mixes almost always have good texture and to provide plants with high amounts of water and air.

Most gardeners, even old timers who used to swear by their own mixes, have switched to ready-mixed planting mix. Whether they choose a totally non-nutritive or a fortified mix enriched with organic nutrients the producer has adjusted its pH and nutrient values to assure healthful growth. In side to side tests some mixes perform better than others, so it is worthwhile to test different brands in side by side experiments.

Some gardeners would still prefer to grow their own soil from basic ingredients.

There are two main advantages to growing in a planting mix rather than hydroponically. The first is that most of the ingredients of planting mixes, bark, coir and peat moss, are all carbon based and chemically active so they act as a buffer for fertilizers and nutrients. They catch and hold excess nutrients dissolved in the water/nutrient solution and release them when the nutrient water solution becomes less concentrated. For this reason they are more forgiving than hydroponics, where there is little or no interaction between the medium and the water.

The second advantage of planting mixes over hydroponics is that plants in mixes can be fed organic nutrients. This is very difficult to do hydroponically because the nutrients tend to ferment. Aside from the sensitivity that some people have to inorganically produced ingestibles or smokables, there is a general consensus that organically grown buds have better flavor and aroma than hydroponically grown. This hasn’t been tested in a double blind study, but plants fed inorganic fertilizers sometimes have a distinctive “chemical” taste, especially if they have been overfed or the medium as not been flushed.

Commonly used ingredients are:

VERMICULITE

Vermiculite is a very lightweight processed mineral that is often used as an ingredient in planting mediums. It absorbs and holds water, buffers nutrients, and provides space for oxygen to get to the roots.

Vermiculite rock is mined and then exfoliated by heating it to 1650-2010° F (900-1100° C). It expands for the same reason popcorn pops; water trapped inside the mineral turns to steam and explodes, forcing the layers of aluminum silicate to separate. The rock expands to 11-15 times its original size. This process also sterilizes it.

Vermiculite has a composition similar to mica; a thin layer of oxygen, magnesium, and iron atoms holds flat layers of aluminum-silica together. Looking at a piece of it, you can see the layers. This arrangement, with wide gaps between the layers, allows the mineral to absorb and hold water and gives it a large surface area to bond with nutrient minerals, buffering the water-nutrient solution.

Over time, vermiculite breaks down as the layers, which have tenuous bonds, start to break free. The physical structure, with wide spaces between layers, is eliminated, so there is less space for air. For this reason vermiculite is not a good choice as a single medium in large containers.

This raised bed was 6’ (180 cm) square, and 1’ (30 cm) tall. The bed gave the roots, and the plant, a great head start.

Despite myths to the contrary, vermiculite is not inert. Aside from holding nutrients it slowly breaks up as it releases its magnesium and iron atoms. By interacting with the water/nutrient solution, and providing a convenient space for colonization, the medium promotes thriving rhizosphere activity. Although it is active, it does not contain any nutrients. When it is used alone all of the plant's nutrient requirements must be met using a water/nutrient solution.

Because there is natural variation in its makeup, vermiculite pH ranges from about 6-9. Usually it is near neutral. It is sold in several grades, which are based on the size of the particles.

Seeds and cuttings—Vermiculite is sterile and holds lots of water, but still allows air to penetrate, so it promotes growth of seedlings and clones when using a fine grade. Roots grow into a healthy rootball in it.

Small Containers—The coarser grades of vermiculite are excellent for small containers, up to about 6" (15 cm). It promotes root growth because the medium is loose and porous and gives the roots access to both water and air.

Planting Mixes—Vermiculite is used as an ingredient in many planting mixes because of its water/air holding qualities and because it is lightweight. When considering planting mixes for large containers, especially when they are to be moved, weight becomes a consideration. Vermiculite helps lighten the mix.

Should you find a planting mix is too "hot" (it contains too much nutrient), you can mix in vermiculite to dilute the concentration.

Hydroponics—Vermiculite contains virtually no nutrients so it is an excellent planting medium ingredient for hydroponics. It is usually mixed with perlite or wood chips.

PERLITE

Perlite is a mined volcanic glass-like mineral similar to obsidian which melts at 1560-1740° F (850-950° C). Water held in the rock turns to steam and causes the liquid to foam. It expands up to twenty times its original volume and has a structure with many tiny, closed cells or bubbles. The resulting snow-white particles are sterile, inert and have a neutral pH. The hard pieces remain stable for years. They wick water through capillary action.

The particle surface is covered with tiny craters that create an extremely large surface area that can hold the water/nutrient solution. Passages in the structure also hold pockets of air and promote drainage.

Perlite comes in various sizes, or grades, that range from very fine to pea sized gravel. The amount of water adsorbed on the surface of perlite is a function of particle size. Coarser perlite particles adsorb less water than the finer grades. Generally the smaller sizes are used in smaller containers. Larger sizes are used in larger containers and maintain porous spaces for air. However, various sizes are sometimes included in soil mixes to customize water-holding capacity.

Because it retains air pockets when it is irrigated, the granules float.

Perlite's bright white color protects seeds by keeping them cool and moist even when placed under bright sunlight. It reflects light back to plant foliage which further enhances growth.

Propogation and Seed Cultivation—Fine grade perlite makes a good medium for seed starting and cloning because it maintains a uniform moisture level. Excess water drains so there is no waterlogging. Since the perlite doesn't form a chemical bond with the water, water tension doesn't increase as long as there is moisture present. This helps young plants overcome environmental stresses.

Perlite clings to roots and root hairs so they can form a rootball. This reduces transplant shock.

Planting Mixes—Perlite is often used as an ingredient in planting mixes. Different sizes are used to adjust water-holding capacity and provide aeration. It keeps the mix lightweight and provides it structure since it does not deteriorate.

Hydroponics—Perlite's capillary action and fast drainage are ideal qualities for hydroponic mediums. It makes water management self-regulating. It is inert so it doesn't interfere with fertilizer and nutrient programs.

Perlite can be used in a single ingredient planting medium in many hydroponic systems including wick, reservoir, drip and constant flow. However, because its lightweight granules shift position in ebb and flow systems, plants must be supported using staking or another technique.

Its ability to retain water, provide air spaces, its neutral pH, and non-reactive qualities make it an excellent medium.

Perlite is often used as an ingredient in hydroponic and soilless mediums with vermiculite, peat moss or bark. Part of its usefulness is that it retains its structure as contrasted with peat moss, which deteriorates as it reacts with soil degrades into compost, and vermiculite that gradually loses its structural integrity and collapses.

Perlite can be re-used as long as it is rinsed and sterilized and old plant material is removed. It has been used to remediate clay soils, but this is expensive and doesn't work as well as adding organic material.

PEAT MOSS

Peat moss is mined from peat bogs. It consists of layers of sphagnum moss that died and were naturally buried in acidic, anaerobic water.

Peat moss is probably the most popular container planting material used in North America. It is a key ingredient in most mixes because it holds 15-20 times its weight in water, has excellent buffering ability and is inexpensive. It comes in several sizes, or grades, ranging from very fine, which holds more water because the spaces between the particles are smaller, to larger pieces that provide more airspace.

Peat moss is very acidic and must be treated with lime to raise its pH. Most mixes have already adjusted the pH but you should give it a pH test yourself. Although it has high buffering capacity, it has no nutrients of its own, so un-enriched mix must be fertilized from the start.

Peat moss has a chemical relationship with water and as it loses moisture it holds onto the remaining water more tightly, increasing water tension. This makes it more difficult for the roots to absorb water and nutrients. For this reason peat moss based mediums should never be allowed to get dry out. Although they might feel moist, this water may be unavailable to the roots.

Peat moss is composed of dead plant matter so it contains carbon. Carbon is used by microorganisms in the soil to build tissue which degrades the peat moss over time. At the same time, it shrinks as it loses its structure. For example, you might have noticed that the soil in a houseplant container shrank over a few months, this happens as the microorganisms use the carbons in the soil. This only presents a problem if the plant is in the mix long term. The compacted mix doesn't provide enough air to the roots, the roots don't have as much space to spread out and the plant has less support to hold itself upright. Over a period of a few months this shrinkage does not usually have a noticeable adverse effect.

A plant has become "rootbound" when the roots have run out of space in the container and cannot spread out further in search of nutrients and water.

COIR

Coir, or coco peat, is made from the soft fibers and pith that protect the inner kernel of the coconut. Horticultural coir is made from ripe coconuts. As the fruit ripens the fibers, initially composed mostly of cellulose, change to high lignin content. Lignin, which is also found in wood, resists decomposition better than either bark or peat moss, so it can be used and re-used far longer than bark or peat.

Coir holds between five and eight times its own weight in water. It also has a fairly high cation exchange rate; the fibers not only absorb water but also chemically hold nutrients and buffer nutrient swings. The air porosity, the amount of air the material holds, depends on the size of the particles and fibers. The finer the fiber, the more water it holds in relation to air. The larger the particle sizes, the lower the initial water retention.

Another advantage coir holds over peat moss and bark is that it has a higher pH, and is in the acceptable range for growing mediums of 5.8-6.4. It is also a source of potassium as well as iron, manganese, zinc and copper, which it releases gradually. The finer particles, the pith, can be thought of as organic potassium fertilizer with a sponge like molecular structure. It is combined with short fibers that act as an anti-compacting texturizer.

There is anecdotal evidence that coir possesses fungicidal qualities, which may stem from the lignin or from its surface structure.

There are many grades of coir based on the particle size and which type of tissue is used. Long fibers have granular material, called pith, attached before processing. Sometimes the two materials are left together but usually they are separated into fiber and pith.

Each coir processor has its own recipe for a particular combination of pith and fiber. The more pith that it contains, the better its water retention, but the less air it holds.

Coir chips are another form of coir that is available. These are pieces of coir sliced into cubes ranging from 0.25-0.75” (0.6-2 cm). They are used in place of bark in some soil recipes, as a planting medium for orchids and as a hydroponic planting medium.

I found that some brands of both coir and coir chips contain residual salt from the manufacturing process or from storage. This has to be removed before use, which is not hard to do. Just soak it in a basin of warm water for about 15 minutes and then press until just moist. Some brands now advertise that they come pre-washed and don’t need to be rinsed.

BARK

Chopped or ground bark is often used as an ingredient of planting mixes. The bark’s qualities, such as its water holding capacity and pH level differ by tree variety. The grade of bark and the size of the pieces affect water-holding capacity. The smaller the pieces, the more water they hold and the less airspace between them. Bark contains carbon so it is subject to microbial disintegration. However, this occurs at a slower rate than with peat moss. It also buffers the water nutrient mix absorbing some excess nutrients and releasing them when the solution becomes less concentrated.

If you are planning on growing a plant that will be kept for five months or more select a bark or coir based soil rather than one made from peat moss.

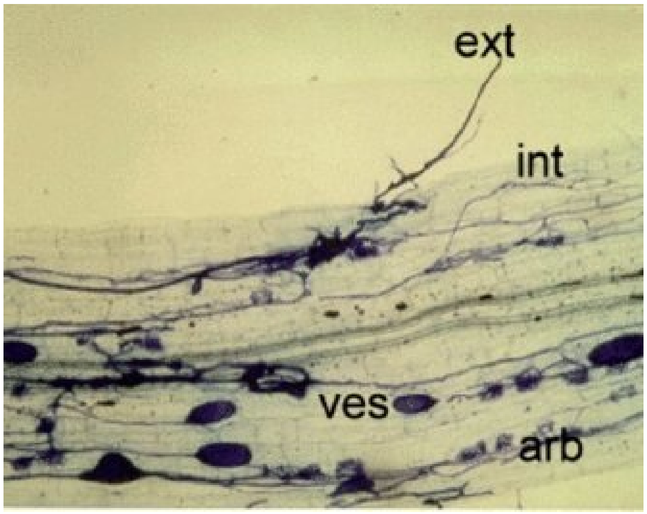
Bark is not usually used in hydroponics except in fertigation systems such as capillary mats.

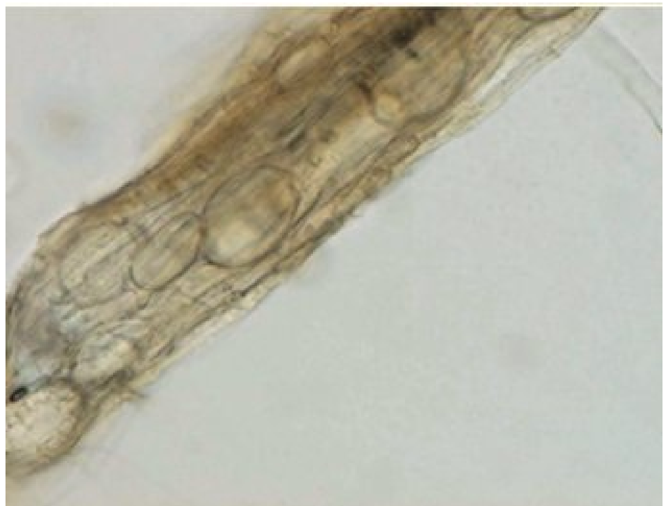
MYCORRHIZAE

Mycorrhizae are fungi that live in soil in various forms and share a symbiotic relationship with plants. They are found mostly in the rhizosphere, the area surrounding the roots where plants absorb water and draw nutrients.

They benefit plants in a number of ways: 1) increased nutrient uptake; 2) exchange of fungal hormones and other manufactures to plants; 3) protection from pathogens and root predators; and 4) better water relations including reduced drought stress.

This results in increased root vigor and growth with more resistance to disease organisms and drought. Bud quality and yield also increase.





Top: fungal structures of the roots are shown here. They have been stained blue to show the external mycelium (ext), the internal mycelium (int), arbuscles (arb), and vesicles (ves). Bottom: the AM fungus glomus intradices frequently forms spores in roots. Photos: Priv. Doz. Dr. habil Ewald Sieverding

TYPES OF MYCORRHIZAE

Mycorrhizae are divided into two groups, endomycorrhizas and ectomycorrhizas. The ecto's are associated with forest trees in temperate climate zones and probably have no effect on marijuana growth.

There are several groups of endomycorrhizae, but we are interested primarily in the arbuscular (named for their "treelike" structure), or AM mycorrhizae. Their hyphae, the center of new growth in AM mycorrhizae, are "root-like or branch-like" structures. Hyphae grow through the plant cell wall and position themselves between the cell wall and the cell membrane. The string-like structures, the arbuscles, colonize new space through growth. As the hyphae mature, vesicles, containing stored lipids saved for leaner times, develop along their length.

Once it has grown into the cell it has parts both in and outside the roots. Outside it grows a fine network of filaments that serve as an extension of the root hairs. They use electrochemical reactions to dissolve nutrients, especially phosphorus (P), but also the micronutrients, and bring them into the cells. Nutrients get delivered to plants inside the roots and absorb sugars and other plant products released by the roots.

The AM mychorrhizae produce and release abundant amounts of the glycoprotein glomalin. A glycoprotein is a molecule that combines protein and sugar, which gives it many unique properties. Glomalin is almost 40% carbon (C), and with that much carbon it can host a lot of microorganisms and supply them with one of their needed sources of food.

Glomalin permeates all the ingredients of soil and organic matter (sand, silt, and clay) and binds them together so they form little clumps of soil granules called aggregates. This adds structure to the soil, and is the first step in nature's erosion control program which keeps stored soil carbon from escaping.

Mycorrhizae increase absorption in two ways: physical and chemical. Mycelia are smaller in diameter than even the smallest root, so they examine the soil more closely, providing a larger surface area for absorption. Fungi use different methods than plant roots to make soil nutrients available. Their work is most beneficial in nutrient poor soils.

Beneficial microorganisms inoculate the soil, enhance root growth, and can promote vigorous growth, abundant flowering and enhance the plant's ability to resist disease and fungal attacks. BioBizz PreMix is a dry fertilizer that is mixed into the soil before planting and contains a mixture of organic fertilizers, rock meals and beneficial microorganisms.

AM Mycorrhizae protect plants from microbial soil-borne pathogens by forming a protective shield around the roots which keeps them healthier. They also produce some warning chemicals that stimulate the plant to prepare for an attack, possibly with protective chemicals, making the roots more resistant to disease organisms and drought because of improved water and mineral uptake.

CONTENTS OF PAUL STAMETS' MYCOGROW™ SOLUBLE

CONTAINS CONCENTRATED SPORE MASS OF THE FOLLOWING:	
Endomycorrhizal fungi	*Glomus intraradices, Glomus mosseae, Glomus aggregatum, Glomus clarum, Glomus deserticola, Glomus etunicatum, Gigaspora margarita, Gigaspora brasilianum, Gigaspora mono-sporum*
Ectomycorrhizal fungi	*Rhizopogon villosullus, Rhizopogon luteolus, Rhizopogon amylopogon, Rhizopogon fulvigleba, Pisolithus tinctorius, Laccaria bicolor, Laccaria laccata, Scleroderma cepa, Scleroderma citrinum, Suillus granulatas, Suillus punctatapies*
Trichoderma	*Trichoderma harzianum, Trichoderma konigii*
Beneficial Bacteria	*Bacillus subtillus, Bacillus licheniformis, Bacillus azotoformans, Bacillus megaterium, Bacillus coagulans, Bacillus pumlis, Bacillus thuringiensis, Bacillus stearothermiphilis, Paenibacillus polymyxa, Paenibacillus durum, Paenibacillus florescence, Paenibacillus gordonae, Azotobacter polymyxa, Azotobacter chroococcum, Sacchromyces cervisiae, Streptomyces griseues, Streptomyces lydicus, Pseudomonas aureofaceans, Deinococcus erythromyxa*

This soil inoculant contains a wide mix of beneficial fungi and bacteria. It is a general mix that works in a wide range of soil environments and planting mixes. It is designed to enhance plant growth and to protect them from pathogens. The ectomycorrhizae probably have little effect on cannabis. The other organisms in the mix work well in marijuana gardens.

Plants grown in sterile soils and growth media don't yield as much as compared with enriched planting mediums and inoculated soils. Add an AM mychorrhizae mix to new soils and planting mediums. AM mychorrhizae take several weeks to colonize a container holding a large plant. However, if you inoculate the plants when they are small, the microlife will grow with the roots and fill the rhizosphere with organisms that ward off pathogens.

AM Mycorrhizae and other beneficial organisms are already present in soil or planting mixes that have been used to grow plants for a crop, especially if the last crop was inoculated and the organisms had time to colonize the roots.

That is why uninfected, inoculated planting mix usually yields a larger harvest on the second and third crops. If you want to change the planting mix, mix some of the old mix into the new medium to inoculate it with the microbes.

In soil and planting mixes most of the phosphate is bound in water-insoluble minerals. The soil water contains very low concentrations of phosphate. Roots often have a hard time obtaining enough phosphate. The root hairs and associated mycorrhizae have an active transport system to supply the canopy with orthophosphate (H_3PO_4). Most plants enhance their nutrient uptake capacity using the fungus to extend the surface area of the roots by proxy. This increases the plant's ability to transport nutrients and to obtain phosphate.

TRICHODERMA

Trichoderma fungi are found in nearly all soils. Some species live freely while others colonize the roots. They are variable because cells often contain more than one nucleus and there is a lot of gene mixing, resulting in many unique combinations.

The fungus grows long filaments, or arms, in their search of food. Trichoderma attack, parasitize and otherwise gain nutrition from other fungi. They use numerous mechanisms to attack other fungi and to enhance plant and root growth. Different strains of Trichoderma control almost every pathogenic fungus for which control has been sought. Each Trichoderma strain has its specialty and controls some pathogens better than others. A particular species may be ineffective against some fungi.

Some species such as harzianum are used in bio-protectants such as RootShield. Mixed species are often included in endo/ectomycorrhizae mixes.

BENEFICIAL BACTERIA

Some bacteria in the rhizosphere also seem to have symbiotic relationships with the roots. Some such as *Bacillus subtillus*, *B.pumlis*, *B thuringiensis* attack pathogens. Serenade® uses *B. subtillus* as its active ingredient.

Some species including *Pseudomonas cepacia, Serratia marcescens*, *Erwinia her-bicola*, and *Phizobium spp*. increase the phosphorus supply in the rhizosphere.

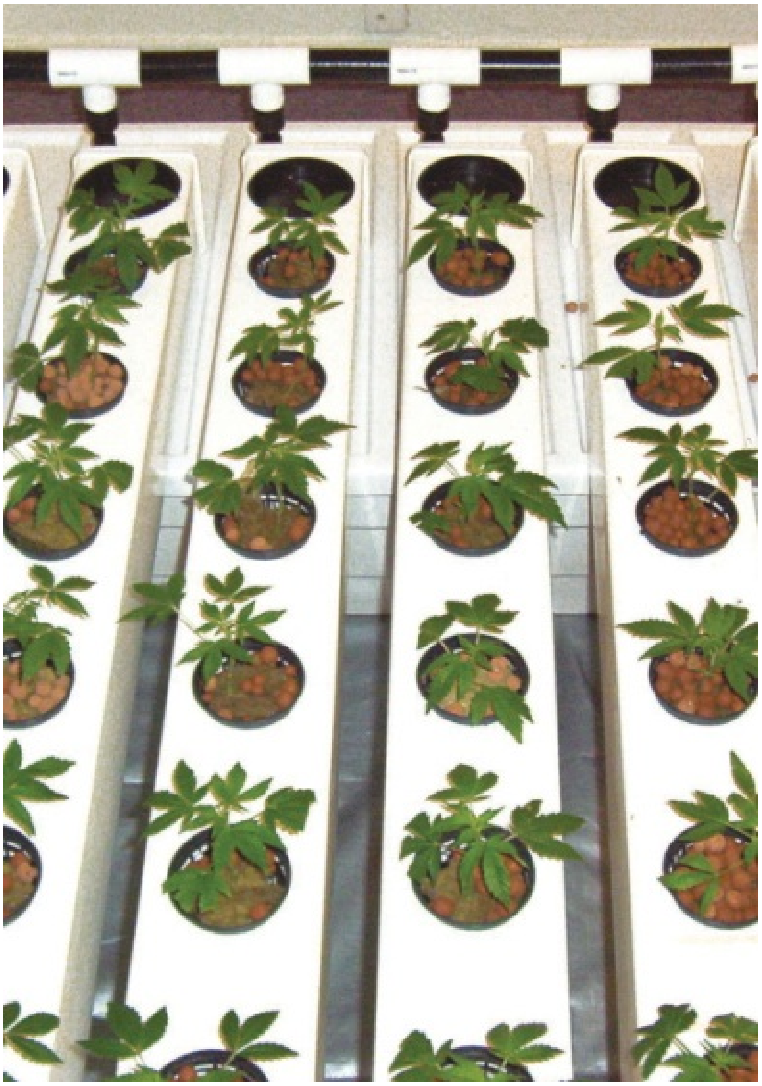


Photo: Sean Mikuriya

HYDROPONICS

PLANTING MIX V. HYDROPONICS

Both planting mixes and hydroponics have advantages and disadvantages. Whether you decide to start a hydro or planting mix garden rest assured that both work, both are capable of producing a high yield, and both provide a satisfying gardening experience. Fertigation is a hybrid between planting mixes and hydroponics and takes advantage of each system.

Hydroponics offers some advantages over planting mixes. They usually take less physical labor to set up and plants can be grown in smaller containers.

Post harvest labor, such as removing the planting mix and replanting are much easier hydroponically.

Plants growing hydroponically usually produce higher yields, faster than those in planting media. However, connoisseurs prefer organically grown to hydroponic weed.

Hydroponic culture is a bit more exacting than growing using planting mix because there is no media. Organic media such as bark, coir, compost, and peat moss buffer nutrient imbalances so the edge is taken off the peaks and troughs. Hydroponic systems don't have this buffer so it is up to the gardener to keep the root conditions perfect.

On the other hand, soil problems that sometimes affect container gardens such as overwatering and soggy conditions do not occur. Nutrient and pH problems can be eliminated since the grower can maintain tight control over the water-nutrient solution. When the solution is kept within the acceptable range there is little chance of lockup.

Modern planting mixes are made using non-nutritive ingredients including peat moss, bark, coir (coconut husk), rice husks, vermiculite and perlite. All of these ingredients can also be used as planting mediums in fertigation and hydroponic systems.

Higher quality mixes often include biologically active ingredients such as compost or worm castings, guanos, seed meals, ground rock and parts from dead animals such as blood, bone or feather meal. These mixes support plant growth for a month to six weeks with no additional fertilizers providing the roots have a sufficient area to grow and gather nutrients.

Some mixes are enriched using inorganic fertilizers. A few brands contain time-release fertilizers designed to support plants for several months. They require little or no additional fertilizer as long as the plants are grown in a large enough container.

Hydroponics is the method of gardening in which plants are supplied with nutrients through the water solution. Gardeners have a choice of systems to accomplish this. Deep Water Culture (DWC). Drip, Ebb and Flow, Nutrient Flow Technique (NFT), Reservoir and Wick are easy to construct and most of them are also available as commercial units. Another kind of system, **Aeroponics**, is also discussed here.

Growstones are a very light substrate made from puffed glass. They hold water within their structure and wick it up through capillary action, and can be used to loosen soil or planting mix or as a hydroponic substrate. They are reusable and easy to sterilize by boiling.

Fertigation is practiced in many commercial nurseries growing potted plants. It is a hybrid between planting mediums and hydroponics. That is covered here, too.

Hydroponic systems vary in their complexity and the amount of care that they require. However, the simplicity of construction or difficulty of maintenance does not infer that the crop will be larger or higher quality. The systems will be discussed in order of complexity.

Systems fall into one of two broad categories: passive or active. Passive systems such as reservoir or wick setups depend on capillary action to make water available to the plant. Active systems, including ebb and flow, nutrient flow technique (NFT) and deep-water culture, use a pump to provide the plants water and nutrients.

HYDROPONIC PLANTING MEDIUMS

Gardeners have a choice of hydroponic mediums. Most are inorganic, meaning that they do not contain carbon molecules, and do not deteriorate quickly.

A few, such as peat moss, wood chips and bark react with nutrients over time and deteriorate into compost. This usually takes several years, so the reaction in plants that only grow over a three to six month period is minimal. However, these materials need to be replaced over time.

Perlite and LECA are the most desirable materials and can be used for long periods of time.

LECA

LECA (Light Expanded Clay Aggregate) can be used as a media in all types of hydroponic systems including Reservoir, Wick, Deep Water Culture, Nutrient Flow, Aeroponic, Ebb and flow, and Drip systems.

You can adjust the moisture level of LECA by adding vermiculite. The vermiculite breaks apart and covers the pebbles. Use about 1 part vermiculite to 10 parts LECA by volume.

It is made by baking pure natural clay at 2200° F (1200° C) for three hours. As a result the pellets expand into a lightweight, semi-porous medium. It is pH neutral so it doesn’t affect the water/nutrient mix.

LECA provides both moisture and air to the roots using capillary action. The water/nutrient solution is wicked up along the pebble surface. Overwatering and root rot are eliminated due to the space between the pebbles which allows oxygen to get to the roots.

ROCKWOOL

Rockwool is sterile and convenient to set up and remove. It holds together well and is easy to handle if you follow basic precautions. It is made by melting basalt and chalk and then spinning the molten rock mixture in a process very similar to making cotton candy. Long strands are formed and then processed into different shapes, textures, and sizes that vary from 1” (2.5 cm) starter cubes up to 3”x 12”x 36” (7.5 x 30.5 x 91.5 cm) slabs.

Rockwool is constructed so that 18% of the space is reserved for air, even after the blocks have been irrigated to saturation. Water tension doesn’t rise as the material becomes drier, so it is easy for the plant to absorb moisture until it is used up. These two characteristics mean that rockwool retains both water and air, so the roots’ needs for oxygen and water are easily met.

Rockwool comes in many sizes and several forms including cubes and slabs, pellets and as rockwool “wool.”

New rockwool is highly alkaline because it contains residual lime as the result of manufacturing. To remove the lime, soak it in an acidic, 5.1 pH, water solution for 24 hours to dissolve the lime. Adjust the water using pH Down. Then flush the cubes or slabs with nutrient-water solution. They are now ready to use. From this point on, the rockwool has only a slight alkaline value. Adjust the pH of the nutrient-water solution so it is no higher than 6.1 to buffer the medium’s alkaline qualities.

Cubes range from 1” to 4”(2.5 -10 cm). The two sizes of “starter cubes” used for marijuana propagation are the 2”x 2”x 1.5” (5 x 5 x 3.75 cm) unwrapped cubes and the 1.5” square (3.75 cm) plastic-wrapped cubes that slow evaporation. The 4” (10 cm) square cubes are large enough to support small plants. For larger plants, place the starter cubes on top of rockwool slabs or into other growing mediums.

Roots quickly grow from the 4” (10 cm) cubes.

To move plants to larger quarters, place the cube over a 8” (20 cm) slab. The roots will quickly grow into it. Photos above: Angelic C.

Slabs are all 3 inches (7.5 cm) deep and 36" (91 cm) long and come in widths of 6, 8, 10 and 12 inches (15, 20, 25 and 30 cm). The 6”(15 cm) and the 8” (20 cm) width slabs are by far the most popular sizes and are large enough to grow just about anything.

The slabs come wrapped in plastic, which can be left on to prevent algae and other infections. Remove or slice the plastic on the bottom to allow easy drainage, but don’t remove the plastic from the top or sides. To transplant a cube to a slab, cut an “X” the size of the cube in the plastic. Fold up the corners of the “X”, and place the cube directly on top of the slab. The roots quickly grow into the slab and lock the cube in place.

Loose rockwool is another option. It is available with either water absorbent or repellant qualities. Using loose rockwool enables you to fill pots or other containers with the growing medium. Another benefit of using loose rockwool is that you can custom tune your medium to retain just the right amount of water for the set-up.

Use care when working with rockwool. Its dust and fibers pose health risks. They can cause skin rash or lodge in your lungs, causing temporary micro-ulcers. First, wet it down so fewer fibers become airborne. At the very least, wear a mask, long-sleeved clothing, and rubber gloves when working with dry rockwool. When working with loose rockwool, a bodysuit with ventilator is the best protection. Wetting the rockwool before handling reduces dust.

Rockwool is not environmentally friendly. It is hard to dispose of responsibly because it does not decompose, even when buried. Fortunately, rockwool is easy to re-use. Although most home gardeners use it only once, commercial greenhouses growing roses and tomatoes often use the material for one to two years, until it starts to fall apart.

Rockwool cubes can be used to grow large plants and support them through flowering.

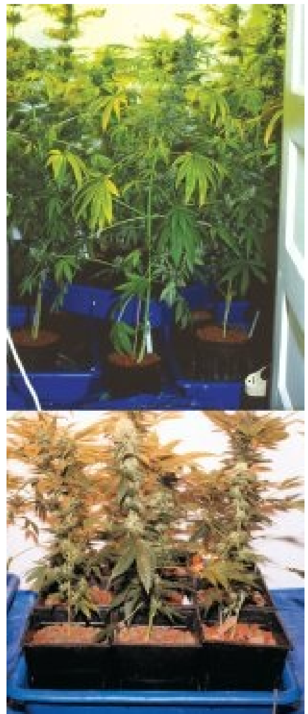
To prepare rockwool for reuse, it’s best to let it dry out a bit, so figure on alternating two sets of blocks between crops. Cubes are easily removed, but it’s easier to work with slabs while they are in place. First, pull out stems and roots or cut them off. Then sterilize the rockwool by soaking it in a 3% hydrogen peroxide solution for 24 hours or by using drippers or ebb and flow to deliver the solution to the material. After treating with the hydrogen peroxide solution for 24 hours, rinse the rockwool thoroughly.

HYDRO METHODS

FERTIGATION

Fertigation is the simplest form of hydroponics. The plants are grown in regular planting containers. They are filled with non-nutritive planting mix and watered by hand, drip system or using a capillary mat. Nutrients are supplied using a nutrient/water solution.

Fertigation systems are frequently used in the nursery industry to grow potted plants. They are simple to construct and maintain and can easily be upscaled. Any non-nutritive medium can be used but peat moss and peat moss blends are favored because they are inexpensive, have good buffering ability and have good capillary action.



A reservoir is the simplest hydro system to set up and maintain.

Peat moss and vermiculite-perlite require less irrigation than other hydroponic mediums because they hold more water. Fertigation is often used in conjunction with capillary mats.

PASSIVE HYDRO SYSTEMS

Passive systems use capillary action to draw water through the planting medium. As water is used it creates “tension” which pulls water molecules up. It supplies plants with as much water as they need.

ACTIVE HYDROPONIC SYSTEMS

Active systems use pumps to move fresh water/nutrient solution to the plants so the environment is refreshed by a solution that hasn’t been mined of nutrients and oxygen. There are many types of active systems but most of them fall into one of five categories: deep water culture, drip, ebb and flow nutrient film and aeroponic systems.

THE RESERVOIR SYSTEM

The reservoir system is by far the easiest system to set up and maintain. Plants are grown in ordinary plant containers of the chosen size. The containers are placed in a tray that has walls 4-6 inches (10-15 cm) high.

The containers are filled with clay beads. Alternatively the bottom third of the container is filled with beads and the top portion is filled with a hydroponic mix such as vermiculite-perlite, peat moss (Sunshine Mix #4) or even a non-hydro planting mix. The container is placed in the tray, and sits directly in a hydroponic nutrient-water solution with about 20-25% of the container immersed in the water. Immerse a container with planting mix 4 inches (10cm) high in water 0.75-1 inch (2-2.5 cm) deep. A 12 inch (30 cm) tall container should sit in 2.5-3 inches (6.5-7.5 cm) of water.

The water in the system is circulated using a small pump or aerated using an air pump or bubbler. Its temperature is maintained at about 72˚ F (22˚ C) using an aquarium heater.

This may be the most inexpensive system and the fastest one to set up, and is an excellent technique for use outdoors since the container has its own limited reservoir and can be attached to a larger water source using a float valve.

Make sure to use a light colored plastic cover over the tray to prevent rain from entering and to keep the roots cool.

This technique can be adapted so that containers have their own internal reservoirs, rather than external trays. Fill the bottom 20% of the container with water. A gauge can be placed in the container to measure the water level.

To make a gauge use a plastic tube with some holes drilled in to allow water to enter and exit freely. Place it vertically in the container and affix it with silicon glue or place the pebbles around so it is held vertically. Take a thin wooden or plastic rod and affix a cork on the bottom using silicon glue. A bamboo stake works well for this. Place the stake in the tube. The cork will float on top of the water, pushing the rod up to indicate water level. Mark the rod so it shows maximum desirable levels. To drain water from the pot remove the rod and insert a small tube attached to a pump or siphon.

It’s important to be as “green” as possible when growing green. The Tray Hugger line of reservoirs available from Humboldt Wholesale is made from 90% recycled plastic and features rounded corners and reinforced sidewalls.

Almost any tray can be used as a reservoir.

Another gauge can be made using a piece of transparent flexible plastic tubing. The tubing is inserted into a hole at the bottom of the container and silicon glue is used to prevent leaks. The tube is attached vertically to the side of the container so it indicates its water level. To drain water, change the tube’s position. Using tubing, several containers can be connected to a single reservoir regulated by float valves.

STEPS TO SETTING UP A RESERVOIR SYSTEM

1. Obtain enough clay beads to fill the containers.
2. Rinse the stones in water until the pH tests close to 7, neutral.
3. Pour the neutralized LECA into appropriate sized containers.
4. Place the containers in the tray.
5. Water the containers from the top to get started. Make sure the planting medium is thoroughly moistened
6. Mix nutrient/water solution and adjust it using meters to test the EC or ppm and pH of the solution.
7. Add a small submersible pump in the tray to circulate the water.
8. If the room temperature gets cool, it may cool the water too much. Add an aquarium heater to the tray.
9. Use a sheet of white/black polyethylene or other opaque cover to place over the tray. The cover keeps light from getting into the nutrient/water solution, where it would promote algae growth.
10. Optional Accessories: water reservoir regulated by a float valve. The water level of this system should be maintained at a fairly stable level. As the plants grow they will use larger quantities of water so it will have to be replaced more frequently as the garden proceeds towards flowering. With an external reservoir the system is automated and does not have to be serviced as long. Water should be added to containers with drains sitting in trays from the top so that any buildup of nutrient salts caused by evaporation gets washed back out of the container into the tray.


This system used a kiddie pool as the reservoir, and a pallet as a platform.


The roots often trail the wick down into the water. Roots that grow in water are thicker and have fewer root hairs, but supply the plant with enormous amounts of water. To keep them healthy, give them plenty of oxygen using a pump or air bubbler to circulate the water.

SUPPLIES AND TOOLS REQUIRED

- LECA (Lightweight Expanded Clay Aggregate)

- pH test meter or pH test paper
- Planting containers
- Tray with walls of the appropriate height.
- Hydroponic nutrient solution.
- EC or ppm meter
- Submersible pump
- Aquarium heater
- Tray cover
- Reservoir (optional)
- Float valve (optional)

THE WICK SYSTEM

The wick system is inexpensive to construct and easy to set up and maintain. The planting container is held above a reservoir. Both ends of braided nylon rope hang from holes in the bottom of the container into a reservoir filled with water/nutrient solution.

The principle that drives this system is capillary action, the same chemistry that draws water up a napkin. As the water is removed from the wick the water molecules above draw neighboring molecules towards them to maintain the electrical charge and ultimately equalize water tension. As a result, with no work on your part, the wick maintains moisture by drawing up water as needed.

The wick is made from braided nylon rope. The diameter of the rope increases with the size of the container.

An ordinary nursery container, a bucket or even a soil bag can be used. Before the container is filled with planting mix, install the wicks in the container. They should be long enough to stretch from the bottom of the reservoir through the bottom or side hole of the container, then exit the hole on the other side and run down to the bottom of the reservoir. Each container should receive two wicks at 90˚ angles.

Keeping the holes in the container small makes it difficult for roots to penetrate to the reservoir. Keeping the roots from growing down the wick into the reservoir may be a matter of convenience. However, once the roots hit the water, both their growth and the growth of the plant spurts because the roots now have access to cheap water and nutrients.

The wick system is self-regulating; the amount of water delivered depends on the amount lost through evaporation or transpiration. More than monitoring the containers to check to see that they are moist, with the wick system the main thing is to keep your eye on the reservoir. As long as the reservoir has water, the plants are being watered.

A number of different mediums can be used as planting mixes for wick systems, but virtually any planting mix can be used since soils generally draw water. Using a planting mix has the advantage of providing the plants with a nutrient-rich base that can be supplemented using a water/nutrient solution. If the medium does not seem to be drawing water and is too dry, adding 20% vermiculite to the mix will add drawing capacity.

A mix consisting half each vermiculite and perlite provides a non-nutritive medium that is easy to work with and has a nice consistency and draws water well. Using vermiculite-perlite allows you to have complete control over the nutrients being supplied to the plants. Adding 10% worm castings or compost increases the microbial life and provides a substrate for them to thrive. Their symbiotic relationship with the roots increases plant vigor and growth.

Each medium has a maximum saturation level. Beyond that point, an increase in the number of wicks does not increase the moisture level.

Wick systems are easy to construct. The wick should extend from the container to the bottom of the reservoir. Supports keep the containers above the level of the water in the tray. Cement or wooden blocks and pallets make good supports. Place the containers on the blocks. Make sure the wicks are touching the bottom of the tray. Fill the tray with nutrient/water solution. Replace the water in the tray as it evaporates or is absorbed by the medium through the wick.

You can construct variations of wick and reservoir systems using two planting containers such as five gallon (19 l) buckets. One container should fit inside the other. The bottom container, which has no drainage holes, will be the reservoir. It is fitted with a support on the inside bottom that keeps the upper container from fitting tightly into it. This keeps the containers from locking tightly, ensuring that they come apart easily. A block of wood or Styrofoam or even a rock can be used for this purpose.

Nylon starts to unravel when cut. Bind the ends together by heating the end with a jet flame, or use silicon glue.

CONTAINER DIAMETER	ROPE DIAMETER
Up to 6” (15 cm)	**.25” (0.6 cm)**
8-9” (20–22 cm)	**3/8” (1 cm)**
12–15” (30–38 cm)	**5/8” (1.5 cm)**
15”+ (38 cm +)	**3/4–1” (2–2.5 cm)**

If the unit is to be used outdoors drill holes in the outer container just below the level where the inner container will rest. These overflow holes prevent waterlogging of the upper container should it rain. Placing a cover over the container prevents water from entering.

Fit the inner container with wicks, place it in the reservoir container and fill it with planting mix. Using these closed systems rather than containers with drain holes that let water escape conserves water and requires less frequent irrigation.

The unit can be fitted with a water level gauge as described above.

It is easy to automate individual buckets so they are self-watering. Tubes connect several bottom containers to a reservoir regulated by a float value. The valve is adjusted to close when the water reaches a height about 0.5 inch (1.25 cm) below the bottom of the growing containers.

The automated wick system requires no power. Water siphons into the growing buckets as it is needed. To get the siphon started, the valve container is primed and raised above the level of the individual trays. Water flows from the valve to the plant trays as a result of gravity. Once the containers have filled and displaced air from the tubes, the water siphons automatically.

A simple system can be devised using a plastic kiddie pool and a shipping pallet. Place the pallet in the pool. Install wicks in the containers and place them so they sit firmly on the pallet. Fill the pool with water/nutrient solution up to the bottom of the pots. The wicks move the water to the pots automatically as needed.

Reservoir and wick systems are available from several manufacturers. They require no moving parts and are reliable, although much more expensive than homemade ones, which are simple to make. Although these systems are denigrated to an extent by industry because they are so simple to construct and maintain, they supply all the plant needs and are high producers. In addition they are much easier to care for than systems that move water from one container to another.

STEPS TO SETTING UP A WICK SYSTEM

1. Install the tray in the grow space.
2. Find a support to raise the containers 4”-6” (10-15 cm) from the bottom of the tray. Wood blocks, pallets, and cement blocks all work well.
3. Measure distance from bottom of the tray through the container and back to the tray bottom. Cut the nylon rope. Seal ends.
4. Place rope in containers. Tape or glue in place. Once the medium is added it won't move.
5. Fill containers with planting medium.
6. Place containers on supports. Make sure the wicks hang down to the bottom of the water tray.
7. Fill the tray with nutrient-water mix.
8. Water the containers from the top to get started. Make sure the planting medium and wicks are thoroughly moistened.
9. Mix nutrient/water solution and adjust it using meters to test the EC or ppm and pH of the solution.
10. Add a small submersible pump in the tray to circulate the water in the tray.
11. If the room temperature gets cool, it may cool the water too much. Add an aquarium heater to the tray.
12. Use a sheet of white/black polyethylene or other opaque cover to place over the tray. The cover keeps light from getting into the nutrient/water solution, where it would promote algae growth.

13. Optional Accessories—Water Reservoir regulated by a Float Valve. The water level of this system should be maintained at a fairly stable level. As the plants grow they will use larger quantities of water so it will have to be replaced more frequently as the garden proceeds towards flowering.

EQUIPMENT

- One tray
- Support for containers—pallet, cement blocks, wood block wire trays
- Appropriate diameter nylon rope
- Planting containers
- Tape or glue
- Planting mix
- pH test meter or pH test paper
- Hydroponic Nutrient Solution
- EC or ppm meter
- Submersible pump
- Aquarium heater
- Tray cover
- Reservoir (optional)
- Float valve (optional)

CAPILLARY MATS

Capillary mats are about a quarter inch (0.6 cm) thick. They are made from soft polyester covered with opaque polyethylene perforated with small holes. They have great wicking ability and are used in sub-irrigation systems. When containers are placed on the mat it compresses. This indent is below the level water travels.

The media draws water only as needed; the water requirements of different size plants on the same mat are met without under or overwatering individual containers.

A table is covered with polyethylene plastic to create a water barrier. It has a slight slope, about 2.5%, 1" per 40" (2.5 cm per 100 cm). Place the capillary mat over it. Make sure the containers have drainage holes on the bottom. The water in the mat puddles around the depression made by the container and is drawn through the media by capillary action, in the same way a tissue draws up water.

Capillary mats: water gathers in the indent made by the container in the fabric. The containers wick up water as needed.

This system is used in large greenhouses because it is easy to set up and is very reliable.

There are several ways to keep the mats water filled. The easiest is to have it draw water from a reservoir that it drapes into. Another method is to use a small pump to deliver water from a reservoir. The water flows through the mat and drips back into the reservoir.

Capillary mats are effective in irrigating containers up to about ten inches (25 cm) high. They are simple to maintain and a very efficient method of using both nutrient and fertilizers.

DEEP WATER CULTURE (DWC)

DWC systems keep the roots bathed in an oxygenated water/nutrient solution. The system consists of a submerged container that holds the plant stem in place above the water level. The roots hang down into the oxygenated water. The roots have total access to water, nutrients and oxygen, which is dissolved in the water. This promotes extremely fast growth and high yields.

Plants thrive in this type of unit because it allows them easy access to nutrients. Active hydroponics systems oxygenate the roots through constant air circulation. The Under Current by Current Culture mixes nutrients with oxygenated water and circulates the solution under the roots throughout all the buckets.

DWC systems require sensitivity to the plants on the part of the grower. Unlike planting mixes that buffer nutrient imbalances, the DWC environment is instantly affected by changes to the water. The result of these changes, helpful or harmful, become apparent very quickly. Experienced gardeners can “read the plant” to determine its health and needs.

The common denominator of all DWCs is a container that holds water that the roots hang down into. A container holds a hydroponic planting medium such as clay pellets or rockwool cubes over the water. The reservoir water/nutrient solution is aerated using airstone bubblers, circulaing water or a waterfall.

DWC systems are manufactured as stand alone containers, as well as sets attached to a central reservoir. Other models circulate the water using tubes that connect the containers to each other. The plants are held in held in small containers above the water.

BUILDING A DWC BUCKET

Use a three– to five–gallon bucket. Measure its diameter. Most standard buckets are 11½" (29.2 cm) wide.

1. Use a hard plastic flowerpot drain tray that fits over the bucket.
2. Use a 6-8" (15-20 cm) ribbed container to hold the planting medium.
3. Using a pair of clippers or a saber saw cut a hole in the tray large enough to let the ribbed pot fit firmly inside. Drill a hole in the tray large enough to allow ¼-inch (0.6 cm) air tube to slide through.
4. Slide the tubing through the hole in the tray. Attach an air stone to the tubing that is going into the container. Attach a small air pump to the other end of the tubing.
5. Place a small fish tank heater set at 70° F (21° C) inside the container.
6. Fit the tray onto the container. Place the ribbed pot into the tray. Fill with LECA.
7. Add water leaving about four inches (10 cm) for air. Plug in bubbler and heater

EQUIPMENT

- 3-5 gallon (11-19 L) bucket
- Hard plastic plowerpot tray
- 6-8” (15-20 cm) ribbed container
- Air pump

- ¼” (.63 cm) tubing
- Airstone
- Fish tank heater
- LECA

EBB AND FLOW SYSTEMS (FLOOD SYSTEMS)

Ebb and flow are the systems that most people think of when hydroponics is mentioned. The containers or rockwool cubes are held in a tray. Its depth varies depending on the containers’ height. Water is periodically pumped to the tray. The planting medium holds enough moisture between irrigations to meet the needs of the plant.

Ebb and flow systems are easy to construct, promote vigorous growth, and their maintenance is fairly carefree. They can be used to irrigate rockwool cubes or any of the hydroponic planting mediums.

BUILDING AN EBB AND FLOW SYSTEM

1. To construct simple manual ebb and flow system use a tray about 6” (15 cm) deep. Attach a flexible ½-1" (1.25-2.5 cm) tube to the one of the sides at the bottom. This tube will be the drain.
2. Fill 8” (20 cm) tall planting containers with one of the recommended hydroponic mediums and place them in the tray.
3. Rockwool can also be used. If you are growing small plants just use 4” (10 cm) cubes. If the plants are to be larger place a rockwool slab down first and set the cube on top.

DWC systems promote lush root growth.

4. To water, hold the tube above the tray so it doesn’t drip. Pour the water from the container into the tray. Then place the tube below the tray so the water drains into the container.
5. If you use LECA, the first time fill the tray 4” deep with water and let it stand. If you are using LECA leave 1-1½" (2.5-3.75 cm) of water in the tray. LECA doesn’t hold much water but it readily wicks it up as it is needed. If you use coir, peat moss, a peat blend or vermiculite-perlite, fill it 3” (7.5 cm) deep and with 4” (10 cm) rockwool flood only to 2” (5 cm). Add more to maintain the level until the medium is saturated. Drain it into the container using the flexible tube. This is the more than the maximum amount of water/nutrient solution that will be needed each time the plants are watered. Not as much drains back in as was poured out; some water is retained by the medium. Garden irrigation needs differ because of planting medium, garden temperature and the size of the plants. If the medium feels moist the plants

do not require irrigation. A more scientific way of determining whether the plants need irrigation is to use a moisture meter. These meters can measure water availability at different levels in the container, giving you a better idea of what is going on.

ASK ED: Marijuana Questions

WASHING LAVA

I have just started to try out lava rocks in 8" baskets using ebb and flow tables. I was told to wash the lava rocks before using. I gave them a good rinsing, but it wasn't good enough. The dye has been washing off, giving everything a red tint (except the plants). I drained and cleaned everything, but still some has remained. Is this dye harmful to the plants, and what is a good way to rinse the lava?

The red stuff that is rinsing off the lava is not dye; it is lava dust. Red is lava's natural color due to its iron oxide content. Once most of the dust has been rinsed off, its time to use the lava. Don't worry about small amounts of it in the water. After the lava is used for a short time, the water will drain clear.

6. Automating this unit is not difficult. Place the garden above the reservoir. A tube attached to a submersible pump in the reservoir lifts water into the tray above. The pump is controlled be a short cycle timer and possibly a float valve switch. The tray's drain is designed to flush slowly into the reservoir. When the pump turns on, water flows into the tray faster than it drains. The recirculating water dissolves dried salts and freshens the water in the medium. When the pump turns off the water drains back into the container from the tray.
7. An overflow drain installed at the maximum water level prevents flooding and other accidents if a timer controls the pump's off switch rather than a

float valve. This is a necessity.

EQUIPMENT REQUIRED FOR AN AUTOMATED EBB AND FLOW SYSTEM

- Tray to hold rockwool or containers
- Rockwool or Planting Containers
- Planting Medium (if using containers) LECA or VermiculitePerlite, or Peat Moss Mix
- Short Term Timer
- Float Valve Switch (Optional)
- Submersible Pump
- Tubing
- Several ebb and flow gardens can be plumbed to a central reservoir using a pump for each garden. The lost water can automatically be replaced from a reserve reservoir.

Ebb and Flow system kits and components are readily available commercially. The ready-made systems are convenient, reliable and have ironed out all the kinks that a home-builder is likely to encounter. Components to make your own system are available at hardware stores and indoor garden centers.

DRIP SYSTEMS

Drip irrigation works by delivering water slowly to the planting medium or soil using an emitter installed at the end of the irrigation tubing. Emitters are manufactured to deliver water at a set rate such as 1 gallon (4 l) per hour. The system consists of a submersible pump that delivers water from a reservoir to a flexible tube that stretches the length of the garden. Spaghetti tubing is connected to the central tubing using connectors that are punched into the main line and fit into the smaller tubing. An emitter on a spike that attaches it to the container or cube is connected to the other end. Each container or rockwool block is serviced by its own emitter. Different sized plants can each get the appropriate amount of water by using drippers with different flow rates or several emitters.

Fertilizer residues can accumulate over time in both hydroponic and soil mediums. General Hydroponics FloraKleen makes a good final flush before harvest. It removes accumulated fertilizer salts as well as relieves plant stress. It can also be used monthly to flush and upkeep fertilizer and soil systems.

First a frame was constructed to hold the tray in place. A table could also have been used. The reservoir was placed in the center of the frame so that water drained directly back into it. The tray was placed in the frame. Notice that the drain has been raised about 1.5” (4 cm). After the water drained, the remaining pool of water was used to keep the LECA moist between irrigations. With a moister medium such as vermiculite-perlite this additional water becomes unnecessary and the drain should be left at tray level.

Plants growing vigorously in the tray.

Drip rings deliver water in a circle pattern around the container rather than in one spot. They are a more efficient way of irrigating and are especially useful with LECA. Almost all hydroponic drip systems recirculate the water and include a reservoir that catches the drain water.

Drip emitters are used in rockwool, coir, vermiculite-perlite, peat moss and LECA.

Both the reservoir and wick system units can be converted into active systems with the addition of a pump, tubing, drip emitters and optional features such as an additional reservoir.

One example is a reservoir system in a 4’ x 4’ (122 x 122 cm) horticultural tray that holds 8" (20 cm) tall containers filled with LECA. The plants do well, but providing a constant stream of water-nutrient solution increases the growth rate.

Small submersible pumps with tubing attached are placed in the reservoir, one for each container. Each tube sends a small steady stream of water to the top of the container and it trickles through the rocks. The roots receive plenty of oxygenated water and the spaces between the rocks provide ample amounts of oxygen.

CONSTRUCTING A DRIP SYSTEM

1. A drip emitter system is easy to make using a sturdy table or by building a wooden frame such as two saw horses. Frames can also be made using steel shelving or PVC pipe. If you are using a frame place a piece of ½” (1.25 cm) thick plywood for use as the top. Arrange a slight slope of 2½% (i.e., 1” in 40”—2.5 cm in 1 m) so the water drains easily. Place a piece of corrugated plastic over the tabletop so the water runs along the troughs to drain. Install a drainage trough along the side of the table or frame. The trough is made using plastic rain gutter. Place a holding tank at the end of the trough to catch the draining water.
2. Place the containers or rockwool on the corrugated plastic.
3. Set up the drip system using a temporary reservoir such as a plastic bucket.
4. First, attach tubing to the submersible pump.
5. Place the pump into the temporary reservoir and install the tubing across the center of the garden.
6. Install the spaghetti tubing. First measure the length of spaghetti line required and cut the piece off the roll. Push the connector into the spaghetti tubing. Push the emitter into the other end of the line. Punch a hole in the main tubing using the tool sold with the drip equipment. Push the connector into the main tube and place the emitter into the rockwool or container. Repeat with each cube or container. More sophisticated systems use pressure regulators and filters. These options are highly recommended. Automated systems continually measure water pH and nutrients and make adjustments as needed. These systems are designed for greenhouses and commercial gardens rather than the small garden. Hobbyists who are computer savvy might wish to check out some articles on designing your own computer controlled pH and nutrient delivery.

Drip: the corrugated plastic grooves guide drain water to the gutters.

7. To determine how large a reservoir is required, run the system with the emitters draining directly onto the plastic. Measure how much water is emitted in one minute. If possible use 100 times that amount. If that is too large a reservoir for one reason or another, use the biggest reservoir you can. The smaller the reservoir, the more maintenance that is required.
8. Place a catchment bucket at the end of the table to hold water that pours from the drainage gutter. Place a sump pump in the catchment bucket. Alternatively, devise a drain system that returns the water directly to the reservoir. The water is transferred back to the reservoir.
9. Place the pump into the reservoir. The system is ready to go.

EQUIPMENT NEEDED FOR DRIP SYSTEM #1

- Table or frame with sturdy top such as 0.5” (1.25 cm) plywood

- Corrugated plastic (available in home improvement/building supply stores)
- Trough to catch drain water from corrugated plastic made from a rain gutter
- Rockwool or planting containers
- Bucket for use as a temporary reservoir
- Submersible pump used to supply water to the drip emitters
- Spaghetti tubing from pump to garden area
- Drip emitter
- Connectors from main line
- Punch tool
- Reservoir
- Catchment bucket
- Sump pump
- Pressure regulator (optional)
- Filter (optional)

DRIP EMITTER SYSTEM 2 (FOR ROCKWOOL)

1. This is a design for a system that is on a 4’ x 8’ (122 cm x 244 cm) table.
2. Use a table or frame with a sturdy top.
3. Raise one end of the table about three inches using blocks or supports to facilitate drainage.
4. Outline each foot of the table’s four foot width. Position an 8’ (2.4 m) gutter in the middle of each marked foot. Alternatively, use eight 4’(1.2 m) gutters that cut across the table’s width.
5. Fasten the gutters to the table using silicon glue. If that isn’t sturdy enough use metal fasteners and then seal the fastening with silicon glue. Close the upper end of the gutters using caps.
6. Attach a gutter to the table or frame to catch drainage.
7. Place the submersible pump with tube attached into the reservoir and bring the tube up to the garden.
8. Place eight rockwool cubes in each gutter.
9. Measure drip line length and cut the lines.
10. Attach connectors and emitters to each of the 33 spaghetti drip lines, then connect them to the main line.
11. Attach an emitter to each of the cubes.
12. The spare emitter is placed in the system to check what’s going on. Place it in a large measuring cup to get an exact reading of how much water is being emitted.

EQUIPMENT

- Sturdy table or frame with top
- Five plastic gutters, four cut to 8' (2.43 m), one cut to 4' (1.2 m).
- Silicon glue and/or fasteners
- Four caps
- Catchment bucket
- Sump pump
- Reservoir
- Submersible pump
- Tubing
- Spaghetti tubing
- 33 connectors
- 33 drip emitters
- 32 rockwool cubes measuring 4” x 4” x 4” (10 x 10 x 10 cm)
- Large measuring cup

NUTRIENT FILM TECHNIQUE

The nutrient film technique (NFT) uses a film of water that is constantly moving around the roots. This technique is used in many commercial greenhouses to cultivate fast growing vegetables such as lettuce without any medium.

Most NFT systems use net pots sitting in covers over flat-bottomed, ribbed, heavy plastic trays that are 4”-6” (10-15 cm) wide and also 4-6” (10-15 cm) tall. A film of water passes slowly over the flat bottom. The roots dangle from the containers and thrive in the moist air created by the closed environment. Within a short time the roots reach the water in the bottom of the gutter and thrive in the flowing oxygenated water/nutrient solution.

The plant roots grow in a covered tray irrigated by a shallow, slow-flowing nutrient solution, so good aeration of the nutrient/water solution is essential for fast healthy growth. Aerating the water in the reservoir using water circulation, air bubblers and water sprays that come in contact with air assure oxygenation.

NFT systems can be enhanced using misters that spray water in all directions. The highly oxygenated spray keeps the humidity high in the air space above the flow of nutrients. Some growers will place air stones in the NFT trays to be sure that roots can have adequate supplies of oxygen for gas exchange. Remember that good air in the root zone helps plants take up nutrients faster and easier!

Reservoirs that hold large volumes of water keep the pH and nutrient levels more stable than small reservoirs. Figure that the system for each 600 watt lamp requires a reservoir that holds about 25 gallons (94 l) of water.

NFT systems are best for growing small plants rather than large ones for two reasons. Large plants have prodigious root growth that tends to eventually block the water channel. Secondly, they don't supply a lot of support for the stem. With small plants this isn't a problem but it causes large plants to tip and fall over if they are not supported.

These recirculating drip containers each contain their own reservoir. The tubes outside indicate water level.

Drip irrigation containers were held in place with drainage tubing.

Another type of NFT system doesn’t use channels, but ordinary planting containers that are filled with LECA overcomes these limitations. The containers are placed either in a planting tray or channels wider than the containers. The recirculating system uses a drip hose with no emitters attached to deliver a continuous stream of water from a reservoir to the tops of the containers. The water flows over the pebbles in a thin film so the roots have access to both water and oxygen. Should the roots grow out of the containers they are embraced by a stream of water flowing in the channel or a drain placed at a 1" or 2" level (2.5 - 6 cm) level that keeps a thin pool of water in the tray.

This homemade aeroponics system was made using square PVC fence-posts, a clone sprayer, and Rubbermaid storage bins. The water/nutrient solution was aerated in the storage bin and pumped through the fence-posts to be misted on the roots, which thrived in this system. Roots in an aeroponic system do not anchor into a medium, so they require support. This system can be supported by PVC bars (pictured) as well as with a "Screen of Green (SCROG)." Photo: Stinkbud

AEROPONICS

Aeroponic systems spray an atomized mist of water/nutrient solution directly on the roots. The tiny droplets of fast-moving water are well aerated so they constantly replenish the roots with oxygen. The nutrient/water spray also delivers nutrients in an absorbable form which encourages extremely fast growth.

Aeroponics systems are used mostly for cloning and many cloning machines that use this technique are available. Appropriate aeroponic systems can maintain plants through flowering and ripening.

In both clone and plant systems the plants are held in small baskets, usually 2.5-5” (6.5-12.5 cm) in diameter, and filled with rockwool or LECA. Pumps produce a high-pressure 10-20 micron mist spray that flows over the roots that grow out of the baskets with a constant shower or waterfall. The container is set into a tube or tray that sits 6-15” (15-40 cm) over the bottom.

A plastic storage container with cutouts in the cover can be modified to use as an aeroponic unit.

Use a pump that puts out 60 pounds per square inch (psi) (27.2 kg per 6.45 sq cm), which is strong enough to produce a fine spray. Less powerful pumps result in a coarser spray. Use a recycling timer to set the pump to spray for a minute and then rest for three.

To prevent bacterial infection, add 1:12 parts 3% hydrogen peroxide or a 1:40 parts 10% hydrogen peroxide solution every three days.

The roots grow down to the bottom of the container and then continue growing. In order for the water to drain, place the tube or container at a 2.5° angle, 1”or 1 cm for each 40” or 40 cm of length. If the root growth is too prolific and clogs the water so it has trouble draining, increase the angle.

Another way to prevent disease in an aeroponic system is to use a UVC water sterilizing light. It damages microorganism DNA that passes through in the water stream.

Aeroponic cloners shoot a fine mist at the cuttings which provides them with plenty of air and water.

Aeroponic gardens can produce large yields and speed up growth and maturation time. The problem is that there is little room for error. Should the spray stop or the misters malfunction, the plants go down in a matter of hours. For this reason gardeners use small reliable aeroponic clone units but few venture to grow plants to maturity using this technique.

OUTDOOR HYDROPONICS

Plants grow very well in hydroponic systems outdoors. Unlike soil systems, where the roots are in a dynamic environment that sometimes limits their access to water and nutrients, the hydroponic environment ensures access to adequate quantities.

Hydroponic systems are water savers because water does not seep below the root level and none drains away, taking it beyond useful bounds. Also, virtually no water is lost to evaporation since the growing units are enclosed on top. The plant utilizes almost all the water going into the reservoir.

Rockwool slabs can be used outdoors or in a greenhouse.

Hydroponic units can also be used to control root temperature. A water heater keeps the roots warm during cool weather. Water chillers are used to cool the water during hot weather.

To grow a large plant hydroponically, a large container is required. The largest commercial container is 16 gallons (60.5 l). It supports a plant with a diameter of about 8' (2.5 m). You can make larger units using plastic storage containers.

Most hydroponic systems can be used, including wick and reservoir systems which need no power.

The pumps for recirculating drip, deep water culture and ebb and flow systems can be powered using a small portable solar panel. The panel supplies the pump power during the sunny part of the day, when the plants require more water.

Smaller hydro units can also be used outdoors. Even a five-gallon (19 l) unit can support a large plant. The problem with smaller units becomes apparent when the plants grow larger. On warm sunny days they quickly use all the water in the reservoir. This water must be replaced as needed or the roots and plant will suffer irreparable damage.

One solution to this problem is an auxiliary or central reservoir that feeds the hydroponic unit(s) on demand. Many commercial units have integrated reservoirs into the system.

Plant support often becomes a problem with smaller hydroponic units. The root system is held in a small amount of planting medium, leaving the unit top heavy.

Planting holes are easily converted into hydro units using pool liner to hold the water. You will have to brace the walls so they don't collapse.

Pea-sized lava chips or another inexpensive gravel that is available locally are often good choices as planting mediums for outdoor hydroponic systems. They are inexpensive and heavier than clay pellets so they provide more mass to support a heavy plant. The lava chips often have irregular surfaces, cracks and crevices that hold the roots tightly, are reuseable, and have capillary action. To increase the capillary action of the planting medium add peat moss or vermiculite at the rate of about 1 part to 10 by volume. This coats the rock with absorbent material that wicks water.

OUTDOOR IRRIGATION & HYDROPONICS

Water is one of the five limiting factors. Plants react to the environment by adjusting their growth. The difference in growth between a plant receiving adequate water and one that has limited access may not be immediately apparent, especially if they are in different gardens. The adequately irrigated plant grows larger faster and yields more, but matures slightly later than the plant on water rations.

The water needs of plants vary incredibly because of plant size, climactic conditions and the temperature, rainfall, and the water holding capacity of the soil.

In areas where rain falls during the summer or where there is a high water table, which among other areas, includes most of northern Europe, eastern Canada, and the eastern U.S., and other areas, there may be no need to irrigate plants at all or to use it as just a supplement to natural sources.

Automatic drip makes watering easy. The water was distributed to feeder lines pierced with spaghetti tubing.

GeoPot containers air prune roots forcing them to branch out and form more feeder roots. The porous fabric provides for better drainage. A velcro side seam makes removal for transplanting easy. Some smaller bags have handles. Larger sizes can be used to grow plants to maturity.

In areas where there is a summer drought such as parts of southern Europe and the North American west, irrigation is required or the plants will die.

Outdoor plants and gardens can be irrigated using a hose that fills a trough reservoir, using a gravity powered canal that delivers water to a group of plants or most efficiently using a drip system.

Overhead watering is very inefficient because of loss to evaporation and the shotgun approach of delivering water in areas where there are no crop roots. Once the plants are flowering, overhead water is dangerous to the buds which are susceptible to attack by mold when moisture is present.

DRIP SYSTEMS OUTDOORS

Drip irrigation is a 90% more efficient method of delivering water to plants outdoors than other methods. That is much higher than flooding an area using a hose, or overhead spraying. The result is more water delivered to the root zone than any other watering system. Drip irrigation has other benefits that make it useful. It is easy to install, easy to design and is inexpensive.

Drip systems use pressure from the public water system, gravity or a pump to deliver water where it is wanted. Spaghetti lines tap off a main delivery line that is connected to the water source. An emitter on the other end of the spaghetti line controls the rate at which water flows.

As with other plumbing systems there are all kinds of accessories to deal with problems that may be encountered by plants or gardens. Some of these are gardens located on different levels, remote gardens and different size plants with varying water needs. The plants can be fertilized using a fertilizer siphon placed in the water line.

Irrigation systems vary tremendously in their complexity resulting from the tasks they are designed to accomplish. Store bought kits are suitable for most backyard gardens. Even simpler is the pinhole pail or bag irrigation. A container is filled with water. The water slowly drips to the desired area through small holes drilled or pierced into the reservoir. It delivers water slowly to the plant so that little is lost.


For even distribution, use a water soaker hose, which “leaks” water through its porous material.

SECURITY

A few guidelines can help keep your secret garden a secret:

- Keep your mouth shut
- Don’t act suspicious
- Respect Mother Nature
- Keep your indoor grow space clean, safe, and up to code
- Control the odor
- Be a good citizen, neighbor, and friend
- Be wary of your internet presence

…and most importantly,

- KNOW YOUR RIGHTS!

GET FAMILIAR WITH THE LAW

In the United States, there is considerable ambiguity in the laws about cultivation, possession, and use of cannabis—medical or recreational. According to federal law, marijuana is still a prohibited Schedule I drug subject to hefty mandatory minimum sentences. But more than a dozen states have said medical use is legal, and many have decriminalized possession of modest amounts for recreational use. In states where medical marijuana is legal, the laws are often convoluted and localized, and none provide protection from standing federal laws. Now more than ever, it is important to keep your garden secure and ensure that you will not get busted or, in the event that you are, that the charges won't stick.

The first thing to do is make sure you understand the law and your rights where you live. Although a state may have passed a medical marijuana law, in some states, individual cities and counties pass and enforce their own measures and restrictions.

The language of medical marijuana laws can be confusing, and the legal status of specific provisions are susceptible to rapidly evolving interpretations as courts, legislators, public agencies, and law enforcement seek to obstruct, modify or implement the laws' intent.

HOW YOU GET BUSTED

SNITCHES

Most busts happen when word of your garden makes it to the cops. There are two types of informants: the involved informant, and the uninvolved informant. The involved informant, or snitch, is the worst kind of person but also the easiest to guard against by being discreet.

Every time you tell someone about your garden, you should assume you have just told ten people. You may consider the person to be trustworthy, and the friend most likely doesn't mean to expose your secret maliciously, but that friend may end up "accidentally" telling another friend who ends up being less than trustworthy.

Often the snitch is a jilted ex-lover, a disgruntled former business partner, or someone you just irritated, such as a neighbor you argued with over parking or party noise. Sometimes the bust is a direct result of your loose talk or other indiscretion. *Don't mess with your friends' lovers.*

Seriously evaluate the character of the people you recruit to help you with your grow, and use common sense in how you act. In small towns, everyone knows the local gossip: what people do for a living, their hobbies and habits, and their daily schedules. You can't control this, but you don't have to make it worse, either.

You should have some "legitimate" work or source of income. Having inherited money is not uncommon, but getting welfare assistance in the off-season and passing as wealthy when the crop comes in will make people talk.

If you party excessively at harvest time or flash cash, you'll be identified as a grower. The garden's location will become a matter of speculation. If it is at or near your house, it will be found. People who act outrageously in public are often busted and cause official inquiries into their lives. This causes problems, especially if they’re not prepared to answer questions about money sources.

If you attract the attention of the wrong sort of people, you and your family could be in serious danger. Snitches and undercover cops are bad enough, but there are also armed thieves out there who will kill.

“Don't you brag and don't you boast Grief comes to those who brag the most”

Lyrics: Clancy Eccles, "Bag-A-Boo"

Successful growers resist the temptation to talk to strangers who seem to have an interest in marijuana. Even if the stranger doesn’t seem to know who you are, he or she can create problems. Undercover cops often say they’re growers, seem to know a lot, and don’t hesitate to talk about their projects. If you are smart, you won’t take this as a sign that these are “real” or friendly people.

Learn to read the warning signs. Does a friend suddenly want to reminisce over the phone about “old times”—including specific dates, names, and amounts? Have they started referring to “nicknamed” friends by their given names? Have they been in trouble with the law recently? Did your friend suddenly transform from an “it’s 4:20 all day long” smoker to a social-smoking, one-hitter quitter? Did they actually “reform,” or did the cops make them agree not to partake while they bust others? Do they now score and split instead of hanging out to smoke a joint?

Just because someone still smokes with you does not mean they aren‘t a potential snitch. Cops and snitches still use drugs while undercover (and probably on their own time as well), even though they will probably deny it in front of a judge. In court, you might implicate yourself further if you mention that the informant was your smoke buddy.

Don’t associate with suspected or proven snitches. Tell them you don’t want them coming around you, your house, your children or friends. If they approach you or your group of friends in public, politely ask them to leave. If they refuse, the group should reassemble elsewhere.

Do not engage in a conversation with any person you suspect. If the snitch persists, do not become violent, but you may have to be impolite. You may even have to call the police and file stalking charges or get a restraining order

THE UNINVOLVED INFORMANT

The uninvolved informant, or anonymous citizen, is considered the most reliable. The police need little to no corroboration for reports of crime from them.

Usually the citizen informant is a person who is a victim or witness to a crime. If someone sees a bank robbery and says, "That's the man," the police will detain and probably arrest the suspect. The same holds if a hunter, fisherman, or backpacker stumbles across your backcountry project, or if the meter reader sees the Jesus Light beaming from under the garage door. Their information is enough for the police to get a warrant and make a visit.

Similarly, if somebody at the electric company notices that a house is showing the consumption of a lot of juice, they may suspect you've got a grow room and call the cops. Utility workers are sometimes rewarded for the tip, so assume they're looking diligently. This information may not be enough for a warrant but it is likely to bring the cops to the house to look for more evidence. They can go through your trashcan (perfectly legal), ask a compliant UPS employee for delivery records, and gather information from cooperating grow-supply stores. All this goes into an affidavit to support the search warrant; it's usually issued, and the garden is usually busted.

Even burglars and robbers sometimes become citizen informants. You might think that people who come with larceny in their heart and a weapon on their hip are more deserving of prosecution than the person who is growing weed. But police and district attorneys are rarely sympathetic to a marijuana grower.

There was a time, now all but forgotten, when marijuana growers were given reasonable disposition of the case (and occasionally a dismissal) in return for their testimony against the people who were there to rob them. This is no longer the case. The escalation of the War on Drugs has made punishment more fierce and unforgiving than at any other time in U.S. history. Even if you are a qualified patient in a medical marijuana state, it's a toss-up whether the police will have any sympathy for you, in any circumstances.

UNDERCOVER COPS

Police and their agents don't have to admit they're cops if they're asked directly. Entrapment laws don't apply here. Being undercover means you never have to say you're sorry.

"Nobody knows, nobody sees, nobody knows but me"

Lyrics: Marijohn Wilkin and Danny Dill "Long Black Veil"

A legal garden needs no camouflage.

The whole modus operandi of undercover cops is to lie to you well enough to make you believe they're not what they are. Their lives depend on their ability to fool people. They seldom have much trouble with amateurs like you. An average judge or jury member doesn't stand a chance of being able to tell when an undercover cop is lying. These guys are professional liars, and they love doing it!

USA PATRIOT ACT

In October 2001, in the wake of the 9/11 attacks on the World Trade Center, Congress rushed to pass the USA Patriot Act. It granted the federal government the power to secretly intercept personal telephone conversations and email communications and investigate medical, financial, and library records—without a warrant.

Under the USA Patriot Act, if the federal government considers you a potential “terrorist,” they have the legal power to investigate your personal communications and records. Since there are no set guidelines for identifying someone as a “suspected terrorist,” there is no way to know for sure if the federal government considers you one. It is safest to assume that they do. Of 763 warrantless wiretaps conducted under the Patriot Act in 2008, only 3 were related to terrorism, while 65% were drug cases.

Avoid speaking on the phone about your garden. If you have patients you supply or friends or partners who help you with your grow, call only to arrange an in-person meet up. Avoid using full names, exact dates and locations, or explicit information about your operation over the phone. You literally have no idea who is listening on the other end. It’s bad enough to get busted, but it’s even worse when you’re the one who leaked the information.

Plants camouflaged by fall colors.

As important as it is to be brief, discreet, and self-conscious on the phone, it's just as important to not implicate yourself digitally. Every computer has an unique IP address, and content posted online can be traced back to your specific computer. In the event that you are busted and your home or business is raided, the police often take any computers as evidence. A quick scan of your hard drive will turn up any photographs of your garden, any records and notes you kept digitally, your friends contact information, and even your finances. A hard drive full of incriminating evidence is your ticket to prison.

The cannabis grew between the sunflowers, which were taller. They were good camouflage early in the season, but they finished earlier and did not hide the mature cannabis plants.

TOP 10 STUPID GROWER TRICKS

10. **Drive to the grow supply store in the car registered at the garden's home address.**
9. **Purchase all growing supplies over the phone or Internet and have them sent to the garden address.**
8. **Tell two friends. They will be sure to tell two friends, who will tell two more…**
7. **Invite everyone to the garden for "an after-hours party."**
6. **Mess with your best friend's lover.**
5. **Mess with anyone, if you have a lover who can find out.**
4. **Plant an outdoor plot two blocks from the municipal airport.**
3. **Make yourself known to local cops by speeding, getting into bar-room disputes, or engaging in other nasty habits.**
2. **Smoke fatties when there's a major drought and no one else has weed.**
1. **Brag about what a great grower you are and the great success of your last garden.**

If you feel you must keep records and photographs of your grow, store them on external hard drives, flash sticks, cloud memory sites, or CDs. None of these storage systems are entirely secure, but if you must keep digital records and photographs, they are much harder to find on a well-hidden external storage drive or in a safe than right on your home computer.

ACCIDENTS

Besides the snitch, another common way to get busted is an accident. Although a person can't always stop accidents from happening, many of them can be prevented or ameliorated. For instance, a passive watering system is less likely to leak than an active one. Smoking a joint in a car while transporting cannabis could create a disaster. Using an unlicensed car, or one that stands out or has mechanical problems, is asking for trouble.

A fire in the grow room, or someone getting hurt in or around your property, may implicate you in a grow. Keep your home and especially the grow space up to code. Keep a charged fire extinguisher on hand and make sure that all electrical plugs, connections, and outlets are safe from dripping water and none of the wires are exposed.

DON'T ACT SUSPICIOUS

You should be paranoid, because they are out to get you. On the other hand, while you should always be alert and aware of your surroundings, looking guilty usually means you are, and neighbors, police, and passersby will pick up on this.

These plants were grown outdoors when search planes were expected. A shed was placed on tracks and could easily slide over the plants and cover them. When the danger passed, it was rolled back to "holding position."

RESPECT MOTHER NATURE

Not only is it morally reprehensible not to be “green” while growing green, disrespect for Mother Nature can invite a bust. A yard that is littered with trash—discarded grow supplies, empty fertilizer boxes, broken pipe fittings, and other junk—irritates your neighbors and shows your lack of respect for the property.

In an outdoor grow, cut branches and uprooted vegetation are a dead giveaway. The aerial over-flight has ended the clean-cut methods of the 1970s. The cut end of a 3-inch (7.5 cm) diameter tree branch may stand out up to a quarter-mile away because its color or shape is not natural looking. It is easily, if accidentally, spotted from any airplane or helicopter that happens by -- cops or not. Smart growers treat their garden as part of the natural landscape.

Any disruption of nature stands out. Non-natural shapes and colors stand out dramatically. From an airplane, the circular shape of the piled brush enclosure, or of the Doughboy pool used for water storage, is eye-catching. Paths are also quite noticeable from the air; if they lead to anything of interest, a bust may follow. Obvious paths should be avoided, though established animal trails may work. Rocks can be used as stepping-stones, tree limbs as bridges; other “trail-less trails” can be devised to break the connection from any well-traveled path to the private one.

Expert growers’ paths are tended like Zen gardens. A person who “sees” the environment can “read” which creatures have been visiting. There are usually areas of clean, bare dirt where one would ordinarily leave a trail. To conceal activity, these are swept clean coming and going, leaving no tracks to be seen.

There is truth to the notion that marijuana has a particular color. Some studies show that a particular wavelength of light is specific to marijuana plants. The Feds have used super-sophisticated, computer-controlled, color-differentiated spectroscopic analysis from satellites and spy planes to determine the extent of coca and cannabis cultivation worldwide. The usual “color bust” is a result of well-fed and watered plants that are unlike the struggling native vegetation. One solution: dinner for all the plants in the neighborhood. Another is a foliar spray of inert color. Some also plant weeds or native vegetation in between cannabis plants to act as an aerial camouflage.

Water lines are responsible for some seizures. If the line is not buried at least 6" (15 cm) deep, it has a very distinctive infrared signature, easily identified by a cop with an infrared camera. If a hiker or deer hunter sees water lines or an instream pickup system, either a bust or a rip-off may soon follow. A garden using a stationary reservoir as a water source is an easy bust. One grower claimed he had never been busted because he uses a water-bag reservoir, mounted in his pickup, to irrigate plants.

KEEP YOUR HOME OR INDOOR GROW SPACE CLEAN, SAFE, AND UP TO CODE

The perceptions of you and your home are vital to the security of your garden. Keep your yard clean and trimmed, keep your grounds and property safe, and most importantly, have a reason to have so many garden supplies! A house with cement in the front and back yards and a trash can full of garden supplies may be more than a little bit suspicious.

Grow vegetables and flowers that thrive in your region. That means low-water plants like succulents and vines in dry areas, vegetables and flowers in moderate climates, and hearty plants such as potatoes and other tubers in colder climates.

TRASH

The U.S. Supreme Court says you can have no expectations of privacy for trash you put out for collection. Cops can root around in your trash to determine what goes on inside your house. They may even arrange with trash collectors to later retrieve what they have picked up. (If you have good trash karma, the trash people may tell you the cops have asked about you, so do everyone a favor and separate your trash and recycling correctly, and compost food scraps, paper towels, and biodegradable containers.)

LIGHT

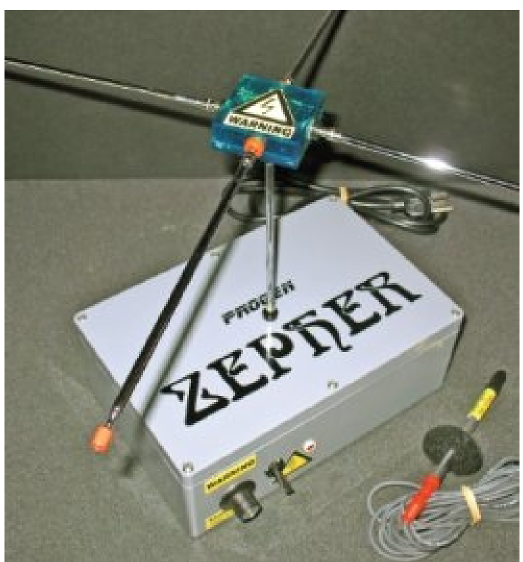
Seal windows in the grow space so light does not escape. Place curtains or blinds in the window and close them. Traditional window coverings reduce suspicion. An obviously boarded-up window not only degrades the appearance of the home but is incredibly suspicious. Seal out light behind the initial window covering with thick dark cloth, black plastic, or wood.

The odor of growing marijuana, especially in plants approaching ripening, is a dead giveaway of an indoor garden. Carbon filters are an efficient way to trap the odor molecules before they reach anyone's nose. The Phat Filter uses tightly packed, low-density virgin carbon to remove the telltale odor emanating from your room.

ODORS

Most gardeners have to find a way to solve the odor problem. The plants don't usually have much of an odor during the vegetative stage and during the first weeks of flowering. However, during the last half of flowering the trichomes start growing on the flowers and the leaves surrounding them. As the buds ripen, the molecules become more concentrated and the odor becomes more intense and pungent. It peaks at maturity.

The trichomes are the glands that grow above the tissue surface. THC is produced and stored in the trichomes. The cap on top of the stalk also contains a number of terpenes, the odor molecules. The terpenes evaporate through the trichome's porous membrane. They are composed of various combinations of the molecule C_5H_8, (carbon and hydrogen) which gives them different odors. Terpenes are categorized as volatile organic compounds (VOCs), which is why the smell of marijuana can easily permeate its surroundings.



Negative ion generators purify air and neutralize odors.

There are several ways to eliminate these odors: carbon filters, negative ionizers, odor absorbing gel, and ozone generators.

CARBON FILTERS

Carbon filters use activated carbon to capture the molecules through adsorption, the adhesion of molecules of gas, liquid, or dissolved solids to a surface. The charcoal is processed to become very porous so it has a large surface area. One gram has a surface area of 5380 sq ft (500 sq. m). This provides a large area where chemical reactions can occur. Atoms at the surface of the activated carbon are ready to bond with suitable partners, including VOCs. Once the surface areas are covered with adsorbed molecules they lose their effectiveness and must be replaced.

Carbon filters clean the air in gardens and keep it clean of odor. Inline fans convert air that is to be evacuated to an innocuous odor-free state.

Carbon filters work by drawing air through the filter using a fan. The VOC's are adsorbed by the activated carbon as they pass over the surface of the carbon particles in the filter. The VOCs are attracted to the solid carbon because they have a positive charge (they are missing an electron) and are pulled into the crevices of its cavernous surface.

Carbon filters can be used both in closed systems and those with ventilation. In ventilated rooms the filters are usually placed close to the air intake. In closed rooms they are used as standalone units that clean and recirculate the air.

Since the effectiveness of a filter is based on the amount of unfilled pores it contains, its efficiency declines with use. By placing a pre-filter over the unit many particles are caught before they get to the filter, preserving the life of the carbon. When the filter loses its effectiveness it must be replaced.

VOLATILE ORGANIC COMPOUNDS can mean any organic compound (containing carbon) that is volatile (evaporating or vaporizing readily under normal conditions). They evaporate at low temperatures and float in the air until they are evacuated or eliminated.

Excel Air Odor Eliminator filters odors through five trays of custom charcoal, ensuring that new scents are removed from the area to outside the grow room. It can be ducted into any space and can clean areas up to 800 sq ft.

Carbon filters are sold both as standalone units and as inline units that attach to the ventilation tubing. They are easy to use, effective and reliable. Their one drawback is that they are on the heavy side.

ODOR ABSORBING GELS

Odor absorbing gels are made from essential oils and other plant derived compounds. Some of the ingredients mask odors and others bond with the odor molecules rendering them odor-free.

They come in several different forms: evaporative discs, gels, sprays, and liquids. There are several brands available using different formulas. All of them received high ratings from gardeners who have used them.

NEGATIVE ION GENERATORS

(For more information, see Temperature, Humidity & Air Quality)

OZONE GENERATORS

Ozone is a highly effective, fast acting, odor eliminator but should be used only in spaces that are not unoccupied by people or animals.

The usual form of oxygen as a gas is O_2. Two oxygen atoms form a molecule. However in the presence of UV lamps or a high voltage electrical arc it forms the unstable ozone molecule O_3, consisting of three oxygen atoms. Ozone breaks apart on its own and reforms into more stable O_2 molecules over a short period of about 90 minutes. It is also a powerful oxidizer and when it encounters VOC's—it oxidizes them, renders them odorless, and neutralizes their charge so they precipitate rather than float in the air. In addition to oxidizing VOC's, ozone also oxidizes particles floating in the air such as mold and fungus spores, other microlife and dust.

The main drawback to ozone is that it is harmful to animals and humans. They should not come in contact with it. It can be avoided by not entering a room where it has been used for about 90 minutes after it is turned off.

Ozone generators are small devices, are lightweight, use little electricity and are convenient to use. To avoid contact with ozone they can be set on timers so they are switched off several hours before you are to be in the space.

When you first come in contact with ozone you can smell its distinctive odor. Remove yourself and other animals from the space until the ozone has dissipated or been evacuated from the room.

TEN COMMON SENSE POLICE RULES

1. **Don't consent to a search of your body, your house, your car, or any other personal property.**
2. **Don't talk to cops about the garden or any other property. Show them proof of your medical status.**
3. **Request a lawyer.**

4. **Don't believe ANYTHING cops say about you, your friends, loved ones, neighbors or partner. They are trained to mislead suspects in order to elicit information.**
5. **Don't sign any statements.**
6. **Don't volunteer information.**
7. **Don't give in to their threats.**
8. **Answer questions with questions. For example, if asked, "Where are you going?"— answer with, "Why do you want to know that?"**
9. **Be polite but ˚rm.**
10. **Do not resist physically.**

BE A GOOD CITIZEN, NEIGHBOR, AND FRIEND

One of the easiest ways to get busted is to make other people hate you. At the slightest suspicion that you are growing, they will likely snitch. Make polite small talk with your neighbors and avoid confrontation.

Stay on your neighbors' good side. Do not host loud parties or receive late-night visitors. Keep your vehicle clean and registered; do not allow it to become an eyesore or nuisance. Be careful where and how you park; more than one grower has been busted over disputes with the neighbors about parking or noise.

Pay your taxes, your bills, and your rent or mortgage on time. Keep debt collectors away from your house, and keep the feds out of your finances.

Keep the interior of your home and car clean and tidy. The cleaner the vehicle or space, the less there is to search in the event that you are busted. Create private, sealed spaces not only for the garden but for your stash and the equipment you use regularly.

GUNS—DON'T HAVE THEM

Regardless on your position on the Second Amendment, your gun can and will be used against you in a court of law. Sentencing enhancements for having a gun if you’re busted growing are serious.

BE WARY OF YOUR INTERNET PRESENCE

The trend with every new generation of online social networking is increased connectivity. More people are publicly sharing photos of themselves using and growing marijuana. Even if the DEA or your local law enforcement had the time, money, and manpower to sift through every online profile or trace incriminating evidence back to you computer’s IP address, they probably still wouldn’t. A more likely situation is that, once you’ve aroused suspicion, what you put online will be used to get a warrant and if you’re busted what is on your hard drive can and will be used against you.

Earlier I mentioned that for every person you tell about your garden assume you just told ten. Similarly, for every person online with whom you share pictures or information from your garden, assume that millions in the world may see it. Social networking is not just a way for people to stay in touch; it is a highly effective way to spread information, including your secrets. Be careful what information you post online or access through a computer. You leave an electronic trail.

SOCIAL NETWORKING PROFILES

Sharing your grow online is risky. On the other hand, the internet has provided gardeners around the world the opportunity to share tips, tricks, and advice, which helps us all become better growers. A good way to minimize your risk online is to set up specialized social networking accounts and email addresses. If you have pictures of yourself and personal communication on one account, create a separate one for your garden. A search of your computer can still find the account, but it makes evidence gathering a lot more difficult.

Start by creating a separate email account that you use ONLY for social networking profiles, forums, and websites associated with marijuana. Treat this email account like a phone you know is tapped. Never share specifics about your grow, your identity, or the names of anyone you know. Keep communication brief and inconspicuous. It is safer to not use the email account to communicate at all; just use it as a dummy account to register with websites, informational forums, and your social networking pages.

MEMORIZE THIS:

1. **DO NOT CONSENT TO ANY SEARCH.**
2. **REPEAT LOUDLY, "I DO NOT WANT TO TALK TO YOU. I WANT TO TALK TO AN ATTORNEY."**
3. **DON'T BELIEVE ANYTHING A COP SAYS, ON OR OFF THE STAND.**
4. **DON'T SIGN ANY STATEMENTS REGARDING THE "CRIME."**

Social networking sites have trended towards “micro-blogging"— brief but highly public diary-style communication. This type of information can definitely arouse suspicion and is virtually impossible to protect. Do not share any grow information through these websites.

KNOW YOUR RIGHTS

If worse comes to worst and you have a law enforcement encounter, be sure to exercise your rights: do not answer questions, and never consent to any search.

You have the right to remain silent, and anything you say can and will be used against you in a court of law. Don't forfeit this right. Simply state, "I don't want to talk with you. I want to talk to an attorney." Let your lawyer decide what is appropriate to say to the police, not your own intuition.

PART III QUICK POINTS: SETTING UP THE GARDEN

SOIL

Plants grown in containers require more care and attention. Rather than working with the natural environment, or at least a semblance of it, when plants are growing in containers you control the space the roots have, as well as the water conditions and nutrients. Container size plays a roll in determining the growth, final size and yield of the plant.

Roots anchor a plant in place and supply the plant with water and nutrients. Using a complex series of biochemical processes, the roots gather nutrients and release sugars and enzymes into the environment.

Always test the soil to find out its requirements before preparing the soil for planting. For marijuana plants, the soil should test high in the three macronutrients: Nitrogen (N), Phosphorous (P), and Potassium (K).

Regardless of the particular composition of your soil, its texture is critically important to healthy pants. Texture refers to a soil's density, particle size, and stickiness, all of which affect the soil's ability to hold or drain water. Root health and ultimately plant health relies mainly on its soil's drainage ability. Well-drained soil allows roots to be in contact with both water and air, the ideal condition for healthy growth.

The pH of the soil determines the solubility of nutrients and affects the plant's regulation of its metabolism and nutrient uptake.

Things to Know

- Roots supply the plant with water and nutrients. Using a complex series of biochemical processes, the roots gather nutrients and release sugars and enzymes into the environment.
- The pH determines the solubility of nutrients and affects the plant's regulation of its metabolism and nutrient uptake. Slightly acidic soils with a pH range from 5.8-6.5 are regarded as marijuana friendly.
- Medium-textured soils—soils that drain well but can also hold an

adequate amount of water—are best for cannabis. Loams, silts, and sands drain well and are usually loose enough to encourage healthy root development. Many clays and mucks are too compacted for lateral roots to penetrate, and when dry clay soils form hard crusts or clods, marijuana plants simply cannot thrive.

HYDROPONICS

Water is one of the five limiting factors. Plants react to the environment by adjusting their growth. The difference in growth between a plant receiving adequate water and one that has limited access may not be immediately apparent, especially if they are in different gardens. The adequately irrigated plant grows larger faster and yields more, but matures slightly later than aplant on water rations.

Hydroponics is the method of gardening in which plants are supplied with nutrients through solution in water. The plants are grown in regular containers filled with non-nutritive planting mix and watered by hand, overhead drip system or using a capillary mat. Nutrients are supplied using a nutrient/water solution.

Plant size and yield are determined to a great extent by the development of the root system. Even plants that are receiving copious quantities of water and nutrients require enough room for their roots to grow and spread out in order to reach their full potential.

Hydroponic systems are water savers because no water seeps below the root level and none is lost to capillary action. Virtually no water is lost to evaporation since the growing units are enclosed on top. The plant uses virtually all the water going into the reservoir.

Things to Know

- Hydroponic systems fall into one of two broad categories: passive or active. Passive systems such as reservoir or wick setups depend on capillary action to make water available to the plant. Active systems, including ebb and flow, nutrient flow technique (NFT) and deep-water culture, use a pump to provide the plants oxygenated water and nutrients.
- The principle that drives passive hydroponic systems is capillary action, the same chemistry that draws water up a napkin. As the water is removed from the medium, in some cases a wick, the water molecules

above draw neighboring molecules towards them to maintain the electrical charge and ultimately equalize water tension. As a result, with no work on your part, the wick maintains moisture by drawing up water as needed.

SECURITY

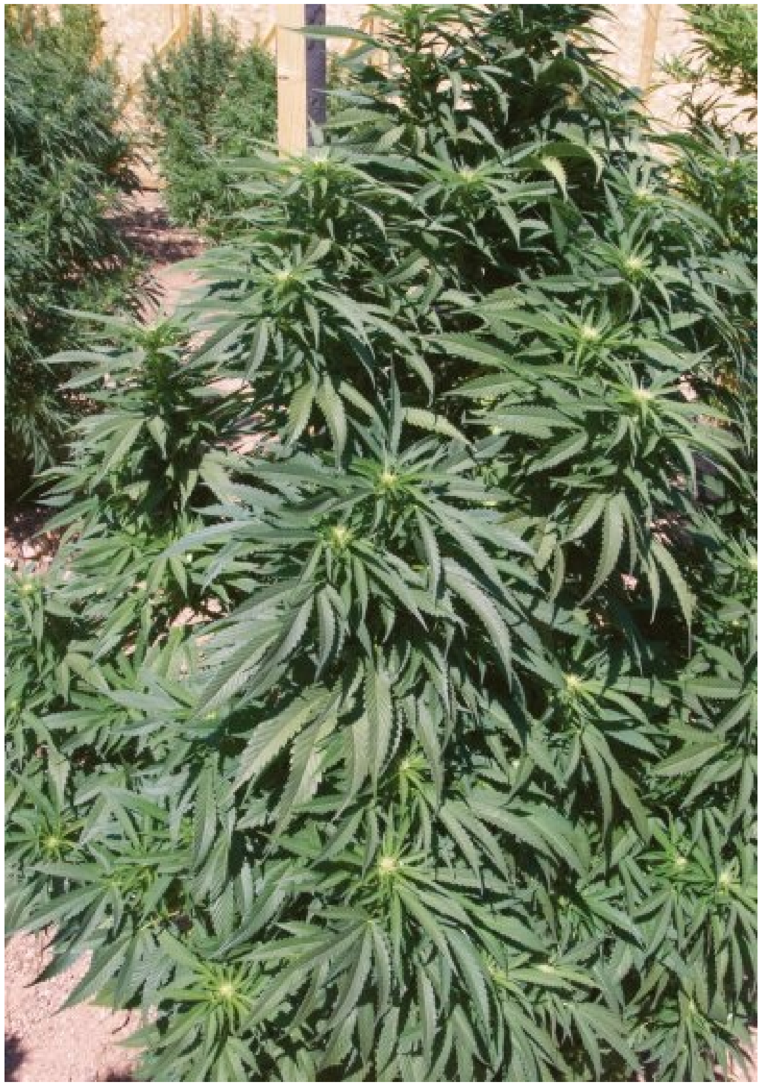
There are a few guidelines to follow to keep your secret garden a secret: Keep your mouth shut, don’t act suspicious, respect Mother Nature, keep your indoor grow space clean, safe, and up to code, control the odor, be a good citizen, neighbor, and friend, be wary of your Internet presence and most importantly, know your rights!

The legality of your garden varies by location, and in most places is a legal gray area.

If worst comes to worst and you have a law enforcement encounter, be sure to exercise your rights. Do not answer questions, and never consent to any search. You have the right to remain silent, and anything you say can and will be used against you in a court of law. Do not forfeit this right. Let your lawyer decide what is appropriate to say to the police, not your own intuition.

Things to Know

- Police and their agents don’t have to admit they’re cops if they’re asked directly.
- The perceptions of you and your home are vital to the security of your garden. Keep your yard clean and trimmed, keep your grounds and property safe, and most importantly, have a reason to have so many garden supplies! A house with cement in the front and back yards and a trash can full of garden supplies may be more than a little bit suspicious.
- There are several ways to eliminate cannabis odor: carbon filters, negative ion generators, odor absorbing gels, and ozone generators.



Part IV

LET'S GET GROWING!

GETTING STARTED

INDOORS

The lights are in position. The growing unit, hydroponic system or planting containers are in place. Fans are installed in the space as appropriate to provide air circulation. A CO_2-enrichment or ventilation system is set up to provide a continuous source of CO_2 during the lit period.

Temperature and humidity are controlled with sensors and automatic systems using air coolers, air conditioners or a ventilation system using filtered outdoor air.

You should also be prepared to monitor the nutrient mix by measuring either the parts per million (ppm) of nutrients, the electrical conductivity (EC) of the solution, or the total dissolved solids (TDS). You have a pH meter or test kit to measure pH. A surface temperature meter and a light meter are also useful.

GREENHOUSES

The greenhouse is in working order. Vents, openings, misters, swamp coolers, or other cooling methods are operable, preferably on an automatic system controlled by a thermostat. Any supplemental lighting is in place to increase the intensity of the light during low-light months. (A 1000w lamp covers an area of 30-100 sq ft (9-30 sq m), while a 600w lamp is good for 30-65 sq ft (2.75-6 sq m).

Lighting may also be used to interrupt the dark with short periods of light to prevent plants from flowering too early. These lamps are used when daylength is short.

If soil is being used, the planting beds or containers have nutrients and soil amendments mixed in so they are ready to plant. If a hydroponics unit is being used, it has been set up and is ready to plant.

Marijuana initiates flowering based on the length of the dark period. Interrupting the dark with short periods of light prevents undesired flowering.

Optionally, blackout curtains are installed. They are used to force flowering out of season. This way, a harvest can be scheduled for midsummer, when UVB light is strongest, producing the best flowers. With planning, greenhouses can yield two or three harvests annually.

OUTDOORS

The ground, planting holes, or raised beds are prepared and ready to be planted. In dry areas where there is little rainfall during the summer, irrigation is required to grow crops, so the water is sourced and ready to flow. If the plants are to be forced early, the frames and blackout curtains have been installed.

Everything is set.

Let's give this garden life!

SEEDS OR CLONES?

There are two ways to start a garden—using either seeds or clones.

SEEDS

Seeds have several advantages:

- Plants from seeds grow a better taproot than clones. The taproot is the equivalent of the main stem. It grows straight down with lateral branches growing along its length. A deep taproot reaches the water table or moist soil at a lower level of topsoil or penetrable subsoil.
- Seeds are free from disease and pests, including viruses. Clones can transfer both pests and disease.

- You know you have the variety you wanted when it comes from the seed company.
- Seeds are the product of sexual reproduction so they inherit genetic characteristics from both parents. Plants from seed exhibit some genetic variation, so you can choose the best plant or the one you like the most. Growing from seed is more adventurous, because you are not sure exactly how the plants will turn out.

This seedling's taproot will continue to descend vertically unless it is obstructed. The lateral roots grow from the side of the taproot.

- Seeds of many varieties are readily available in shops, dispensaries, by mail and over the internet. When they come from a seed company, you can have confidence in getting a variety with the basic characteristics you want.
- They are very portable and easy to store for long periods of time.

Seeds have several disadvantages:

- Marijuana has separate male and female plants. Unless they are used for breeding, males are of no use and are dangerous pollinators that endanger the potency of the female flowers with the risk of pollination.

- Usually about half the plants are males that have to be detected and removed. This can be an arduous task and the consequence of missing one can be seedy buds throughout the garden.

FEMINIZED SEEDS

Feminized seeds have been bred to produce only females plants. They are the solution to the problem of sexing males since all the plants are females.

Germinating seeds is a more delicate operation than transplanting clones.

Seeds take longer to grow and be ready to flower because rooted clones are already biologically mature and have a headstart on root development.

Plants from seeds don’t reproduce exactly their parents’ traits. Seeds from a variety you saw and tasted will not grow to be exactly the same as their mother, though it will be a close approximation.

This stem was taken from a clone that was grown for three months in a container. It shows growth of lateral roots but no dominant taproot.

Because you will discard roughly half of the plants once they can be sexed, growing from seeds can more easily put you over any legal plant count limits, or leave you with fewer plants than allowed or anticipated.

CLONES

There are many benefits to working with clones:

- Clones are taken from female plants so they are female, too. There are no males or hermaphrodites to mess with the buds.
- Clones get you past the germination "hump" that seeds present. Seeds take several weeks to catch up to a rooted to replace plants as they are placed into flowering.

Notice how the roots of the three-month-old plant wound around the side the pot. The plant was "rootbound" which stunts its total growth.

The lateral roots from this clone plant moved outward laterally until they reached the container and then they circled around.

Disadvantages of clones:

- Clones are only available commercially in some states that have medical marijuana laws.
- Clones of the particular variety that you would like are not always available, even where they are legal.
- Clones can carry diseases and pests that can infect your whole garden. Clones from friends are more likely to be infected than professionally grown clones.

Major disadvantages for outdoor growers:

- Clones do not grow as vigorously as seed grown plants, especially outdoors, because clones do not grow a taproot. They only grow secondary roots from the stem and subsequently most of their growth is lateral rather than downward. The main advantage of having a taproot is the ability to dig deep into the ground and reach water not available closer to the surface. The taproot grows lateral branches along its entire length providing the plant with a network of roots that occupies a larger three-dimensional area. The result is that there are more roots in several layers of soil so they can obtain more water and nutrients to support the plant's growth. This doesn't affect plants grown inside as much because the plants don't grow as large and the taproot isn't as important in a container environment.

- The taproot on plants grown from seed is an extension of the stem so it anchors the plant and holds the canopy securely. Clone plants have a single layer of lateral roots. The stem ends close to the soil line, where it was cut. This doesn't provide as much support as a plant with a taproot.

Seed plants have a taproot that is an extension of the main stem and grows downward. Lateral roots grow out laterally from the taproot, which is a direct transport route to the canopy. Clone plants never had a taproot. They develop a set of lateral roots from the side of the stem. The roots grow down a bit but they are adapted to having lateral roots, not the strong root that grows from seed. Outdoors, or indoors with older plants, one or two lateral roots may become dominant and develop into short tap roots that help to anchor the plant and also produce lateral roots. Their connection to the stem is reinforced from layers of growth.

These clones are being repotted into larger containers so their growth isn't stunted.

These plants were grown outdoors from seed early in the season so they could be sexed just a little before the longer days kept them in the vegetative stage. They were shielded from pests and cool overnight temperatures using a clear plastic tarp that was removed each morning.

STARTING SEEDS

Gardeners using standard seeds can expect $^{1}/4$ to $^{1}/3$ of the seeds they plant to reach maturity. Fresh seeds are usually viable, with high germination rates. Seeds more than two or three years old may not germinate as well. Older seeds may have a higher percentage of weak plants, and slower germinating seeds are more prone to attack from molds and bacteria.

Intact, dark brown or grey seeds are most likely to germinate. Whitish, light tan, or cracked seeds are usually not viable. Most guide books suggest that growers select the largest seeds in a batch for planting, but the size of the seed is genetically as well as environmentally determined and does not necessarily relate to its germination potential.

Marijuana seeds germinate best in a warm, room temperature range of 70-80° F (21-26° C), temperature. At lower temperatures, germination proceeds slowly, and seeds are subject to attack by fungi and bacteria.

There are two methods of germinating marijuana seeds.

The first method is to place the seeds between the folds of a wet paper towel or cloth until a shoot breaks the shell, and then place them in the growing medium.

Moisten the paper towel or cloth with water until it is almost saturated. Place the marijuana seeds on the towel and fold it over. Put the folded towel or cloth on a bowl or plate and cover it with plastic wrap. Check the seeds once or twice a day for signs of germination. When it is apparent that the taproot is emerging, place the seed in the prepared growing media at a depth of about .025 inch (0.5 cm). Keep it moist.

To keep the environment disease free, treat the water with a 0.5% solution of hydrogen peroxide. Drugstore hydrogen peroxide is 3%, so mix one part hydrogen peroxide for every five parts water to create a 0.5% solution. Dilute compost tea also protects germinating seeds and seedlings because it contains living organisms that fight pathogens and aid root growth.

PLANTING IN PLACE

Alternatively, seeds can be germinated directly in the ground or planting medium, or in small cups or containers using soil or planting mix, in peat pellets, rockwool cubes or other germination mediums.

Pasteurized or sterile mediums, such as vermiculite or rockwool, and most indoor planting mixes are excellent for seed starting. You can keep the water pathogen free by using a 0.5% solution of hydrogen peroxide or you can protect the roots using compost tea or root-protecting organisms such as mycorrhizae, or both.

Paper or styrofoam cups are convenient germinating containers. Lightweight cups are ideal containers for plants that are germinated at one location and then moved to another location. Containers made from straw, rice or paper can be placed directly in the ground or into a larger container without disturbing the roots.

“"You know all the rules by now And the fire from the ice Will you come with me? Won't you come with me? What I want to know is—Will you come with me?"

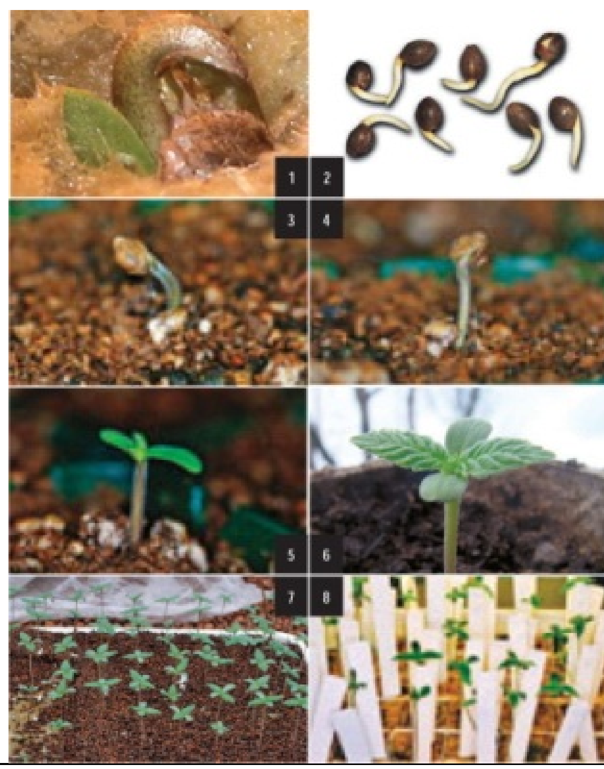
Lyrics: Robert Hunter & Jerry Garcia "Uncle John's Band"

Use mature uncracked seeds that are dark tan and brown.

Germinating in rockwool blocks also avoids having to remove rooted plants from the medium. Rockwool starter sheets fit in standard 10” x 20” (25-50 cm) horticultural trays and are divided into either 50 or 72 cubes. Seedlings should be attached to larger growing blocks or sheets about a week after germination.

Four-inch diameter cubes can hold the plants for two to four weeks without inhibiting growth.

Whether seeds are germinating indoors or outside, the planting medium must be kept moist during the entire period. Seeds dry out quickly during this process, and dry medium results in dead seeds. If you can, place a dome over the trays or cover them outdoors with clear plastic film. The sun can dry the surface of the soil very quickly, so it is often easier to germinate in the shade outdoors and then transplant. This is more of a problem in the late spring when the light becomes more intense, and high temperatures promote evaporation.



1. The stem is emerging. 2. The seeds have germinated. Their taproots have just emerged. They should be placed in the planting medium before the roots get longer. 3. The stem has just pierced the soil and reached the light. 4. The cotyledons are opening, pushing the seed cover aside. 5. The cotyledons have opened and the first true leaves have appeared. 6. The leaves are open and the seedling is ready to begin fast growth. 7. These seedlings were started in a seedbed. I prefer individual containers so the roots aren’t disturbed at transplanting. 8. Each seedling has been labeled and will carry its ID until harvest. These seedlings are a bit stretched but will strengthen their stems if given more light and perhaps cooler temperature.

Seeds usually germinate in three to ten days. Germination time is affected by the seed’s age and health and the media temperature. First the root emerges. Shortly after the stem emerges from the seed and shoots above the soil line. It orients itself perpendicular to gravity. Folded on top of the stem, a pair of embryonic leaves called cotyledons unfold and begin to supply the plant with the sugars it needs for growth and respiration. Cotyledons are rounded single blades and look nothing like mature marijuana leaves.

As soon as plants germinate, they require light. If the light is not intense enough, the stem stretches, reaching for it. You can start seeds under either standard T-8 or T-5 fluorescents or under CFLs. Place them about 6" (15 cm) above the canopy. Space High Output (HO) T-5s and high watt CFLs about a foot (30 cm) above the plants. You can also start the plants under Metal Hallide (MH) or High Pressure Sodium (HPS) high-intensity discharge lamps or place the seedlings under them soon after germination. HPS 600w and 1000w lamps should be placed about 1.5'-3' (45-90 cm) above the canopy if they are air cooled, and about 3'-4' (90-120 cm) if not. You can germinate seedlings under HPS or MH lamps, or place them under the lamps shortly after. They can also be moved outside.

Outdoors, the sooner after germination you plant the seedlings, the faster they adapt to the environment. Place them outdoors at the same time of the season as tomatoes and corn are planted. However, depending on your latitude, the dark period may be too long early in the spring, forcing some varieties to flower prematurely. For more on this, see the sections on varieties and flowering.

These seedlings’ elongated stems are the result of too dim or too little light, or too high a temperature.

SEEDLING VULNERABILITIES

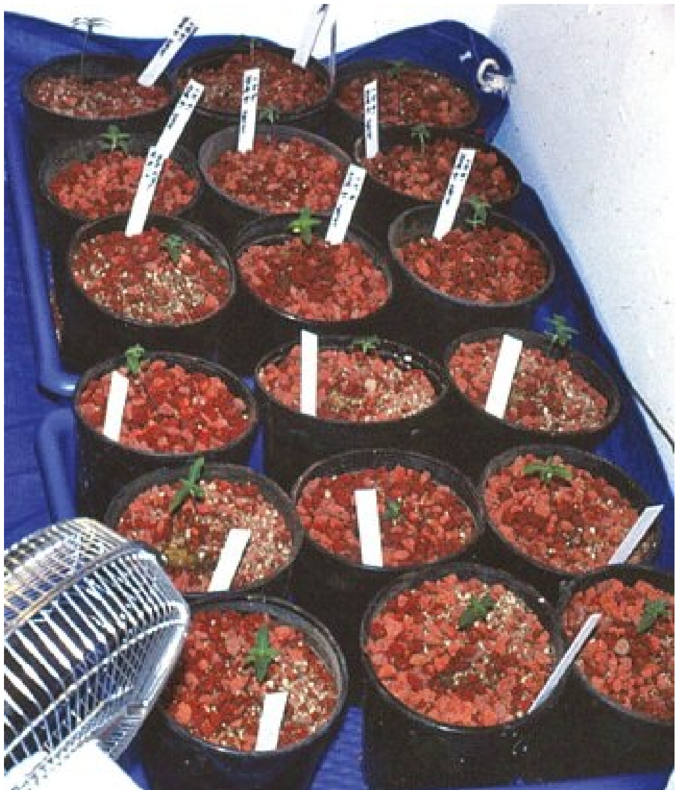
Seedlings are at their most vulnerable stage immediately after they germinate. Stem rot, a fungal infection, attacks when the medium is kept too moist or when roots are deprived of oxygen. This can happen when the soil or planting mix is too fine, so it holds too much water but not enough oxygen. This condition is exacerbated by over watering; fine soils don’t need to be watered as often as media with more porosity. As with germinating, compost tea or a 0.5% hydrogen peroxide solution prevent both fungal and bacterial infections in seedlings.

Dry mediums damage both roots and canopy leaves. The time between first signs of wilt and irreparable damage from dehydration is very short for young plants, which don't have much of an infrastructure reserve. Dry conditions cause the leaves to wilt as they use the available water in the cells and lose turgidity. If the conditions are caught in time, the plants recover as soon as they are irrigated. This situation is time sensitive and should be corrected immediately.

Mice, pet birds, dogs and cats have all been noted to have a fondness for marijuana sprouts and young plants. These animal friends should be protected from temptation by installing a barrier. Another problem with pets, especially those that live both indoors and out, is that they may be carrying insect pests into the garden.

Seedlings given too little light in too warm an environment stretch their stems. The long, slender shoots subsequently have problems staying upright and become top-heavy. The long, thin stem indicates that these plants need more light. To correct stretch that has already occurred, support the seedlings using toothpicks, chopsticks, skewers or thin bamboo stakes.

Too little sun can be a problem for young plants, but so can a withering sun. Seedlings have more problems with this when they are set outside in late spring or during the summer. You can help plants adjust to intense sun by starting to transplant them first in a shaded area or under screens. They can be moved to full sun gradually over five days or so. You can also protect the plants by spraying anti-transpirants on them before they are placed outdoors. These substances place a barrier between the leaf and the sun and slow transpiration so the plants don't wilt. New leaves that grow in the sun will grow longer mesophyte/palisade cells that absorb more light before it reaches the chlorophyll. They position the chlorophyll so it receives less light, protecting it from the more intense environment. New leaves will not have the sensitivity to UV light that destroys indoor-grown leaves placed outdoors. Seedlings started outdoors easily adjust to the bright sun.



Reservoir system: these containers are large enough to support fast growth of one stem plants to full maturity.

To transplant, first put a small amount of soil or planting medium in container. Place the transplant on top of the medium, then pour soil around the roots and stem. When the container is filled, gently compress the mix so that it holds the plant firmly. Stretched stems can be buried a little to keep the plant stable.

Fill the container with enough planting mix so the transplant sits about 0.5" (12 mm) below its original position. Place transplant. Add planting mix to 0.5" (12 mm) above transplant, pat soil down. Add more if necessary.

If it is inconvenient to plant at the moment, seedlings and cuttings can be placed in the refrigerator, not the freezer, to stop their growth. You can store them in the vegetable crisper of the refrigerator for a week or more. Keep them in a moistened plastic bag with the temperature above 40° F (4° C) to prevent cell damage. This treatment does not adversely affect the plant's later growth and, in fact, is an easy way to harden up plants that are placed outdoors later.

PLANTING SEEDLINGS AND CLONES

Seedlings and clones are ready to transplant when they have developed a network of roots and several sets of leaves and are able to cope with and take advantage of the environment.

Plants grow large quickly. This transplant will double in size in about 10 days.

If the plants are being transplanted into soil or planting mix, place the entire rootball in the medium just slightly deeper than the rootball's height so it is covered with soil. The roots will grow from the small ball in all directions, downwards and outwards.

Roots concentrate their growth in permeable areas of the growing medium that contain water, nutrients and oxygen. Whether nutrients are held in the soil or provided using a nutrient-water solution, roots absorb them as simple salts. Microorganisms in the planting media digest complex organic nutrients and then release them in a water-soluble form available to the plants. As the plant draws up the nutrients from the water, the planting medium gradually releases more that dissolve in the water. Enriched planting mediums and soils contain high levels of organic amendments or compost that support seedling growth and will not need supplementation for at least a week.

To save space, plants can be transplanted to progressively larger

containers:

- **8 oz. (0.25 l) containers support root growth for 7-10 days after germination.**
- **16 oz. (0.5 l) containers support root growth for 10-20 days, but a 32 ounce (10.9 kg) container will support faster growth.**
- **1 gallon (3.75 l) containers support plants for 15-30 days.**

By eliminating males from the equation, breeding becomes much easier. However, when females are crossed for breeding over several generations, breeders are inadvertently selecting for hermaphroditism. The reason is that females that produce the most pollen have a tendency towards hermaphroditism. When this is compounded over several generations, the plants are more likely to carry the hermaphrodism trait.

As a practical matter, breeders have found more success in crossing plants than in self-crosses. The self-crosses result in more hermaphrodites. They also say that gardeners should expect about 5% of the plants from feminized seed to be hermaphrodites or males. This is the result of multigenerational crossing. First generation feminized seeds have fewer hermaphrodites. Even so, gardeners still have to inspect and sex the plants.

Some mediums support plants longer. A few are made with time-release formulas that last the entire growing season.

The length of time that a planting mix or soil can support growth depends on several factors. The most important ones are: size of the space that the roots have to grow, nutrient levels of the mix, and growth rate of the plant.

Generally speaking, when growing in soil or planting mix, the canopy of the plant will grow to equal the size of the roots or be at most one third larger. Soils rich with organic fertilizers that break down gradually and soils with time-release fertilizer may need little or no additional fertilizer.

A plant with a 10' (3 m) diameter canopy will have a root system 6-10' (2-3 m) in diameter. The same ratio applies to a plant with a canopy 2 feet in diameter; its root system will range from 1.3 – 2'.

In contrast, hydroponic plants can grow considerably larger than the size of the root zone because easy access to water and nutrients encourages roots to grow much more densely. As long as the roots have access to water and air they will colonize the growing medium very densely.

The canopies of hydroponically grown plants cover an area from the diameter of the container to three times as wide depending on how well you supply the plant with its essentials. If two plants are growing under identical conditions, except for the container size, the one in the larger container will yield more. Contrary to urban myths, there is no harm done in growing a plant in a container larger than is required. However, growing plants in containers that are too small slows growth and stunts the plant.

Starting the seeds in one-gallon containers or transplanting to that size gives the young plant's roots enough space to spread out while it is being sexed. After sexing, the plant can be placed in an appropriate-sized container.

Plants probably grow a bit faster without being transplanted from container to container. However, the light and space saving more than compensates for the lost growth. By graduating plants from smaller to larger containers, light is being used most economically because it is focused on plants rather than the floor.

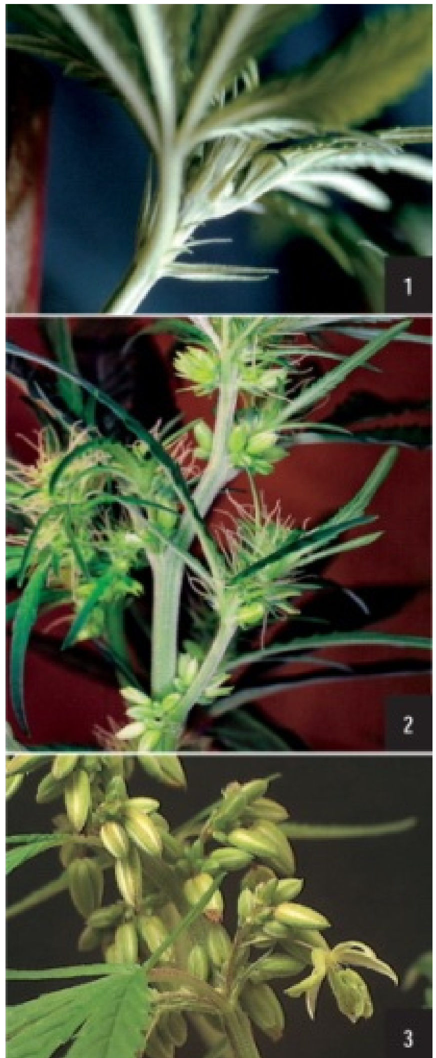
LIGHTING, TEMPERATURE, CO_2 AND NUTRIENTS FOR SEEDLINGS AND CLONES

After cuttings have rooted, the clones begin to grow new stem and leaves, starting at the apical meristem, the very top of the growth tip. After seeds germinate, they develop a taproot and the first true leaves emerge. In both clones and young plants, the new growth indicates that they are now ready to develop under full light indoors. Once placed in the garden, the new growth adjusts to the light intensity.

During marijuana's early growth, the plant needs little special care. The plant adjusts to its environment and grows at the fastest pace limiting factors allow. Most seedlings and clones survive the perils of early growth and, within a matter of weeks, develop into vigorous young plants.

SEXING THE YOUNG PLANTS

Sexing, the process of identifying the gender of your plants, is discussed in more detail in Flowering. But since there are few things more important to careful gardeners than being sure their crop is protected from unwanted pollination. Sexing the plants as early as possible is a good idea, even at the seedling stage.



1. Sometimes a flower grows on young plants at nodes below the top of the canopy. This seedling has a stigma indicating a female flower. 2. This is a hermaphrodite. It has both male and female flowers. These plants should be removed from the garden. 3. These are unripe male flowers. As they open, the heads move from drooping to upright. When the petals open the pollen is released into the wind. These plants should be removed from the garden as soon as they appear.

Be sure to force your plants to flower before they get too tall.

Clones and plants grown using feminized seeds are almost all female, but they still have to be sexed. Plants grown from standard seed are either male or female, in a roughly 50-50 ratio. Unless you are planning to breed plants, males have no use in the garden and are detrimental to the crop if their flowers are allowed to open and pollinate the female flowers. Pollination not only creates seeded bud but lowers the effective potency and usable weight. By eliminating males, no resources or effort are spent caring for plants that won't yield a quality crop of sinsemilla—a term that comes from the Spanish phrase *sin semilla* literally "without seed."

Rather than wait until late in the season to determine sex, there are methods you can use to sort the plants much sooner. Male plants are likely to be taller and more vigorous than females early in life, so gardeners are often disappointed when their favorite plant turns out to be male; however, plant morphology is a very difficult way to figure out the sex.

Two good ways to determine sex are:

- Look at the nodes of the young plant where the leaf petioles and the stem are joined. Sometimes a small, single male or female flower grows at this point. The plant is the same sex as this single flower. Some varieties indicate more than others, so while this method can be helpful, it cannot be used to determine every plant's sex.

- Another way to determine sex is to induce early flowering. However, forcing the whole plant to flower requires 10 days as it switches to flowering cycle and 10 days to switch back to vegetative growth. Use cuttings instead: take a cutting of each young plant that you wish to sex and mark each plant and the cutting that was taken from it. Place cuttings in a planting mix or a cup with water under a flowering light regime of 12 hours on, 12 hours off. Cuttings will begin to flower and indicate sex within 10 days. Giving them more darkness—16 hours of darkness and eight hours of light per day—speeds flowering by a few days. They will indicate faster if you keep the cuttings in darkness for three days before placing them under a reduced light cycle. The cuttings and the plants from which they came have the same sex.

Pollen remains useable for years when packed with a desiccant and stored in a sealed container in a freezer.

Once the cuttings have indicated remove the corresponding male plants from the garden and destroy them. They have no use except in breeding programs. Sentimentality should play no part your decision. The indicator cuttings are not worth saving, either.

(For more on Sinsemilla and Sexing see Flowering.)

EARLY PLANT GROWTH

In a few weeks, the plants grow a foot (30 cm) or more in height and develop branches typical of their variety. By now, plants from standard seeds should be sexed, leaving only females in the garden. If the plants have been transplanted to a small container from their seedling or clone container, the plant should be transplanted to their final container or the ground.

Seedlings and clones that are transplanted into hydroponic units or an un-enriched planting mix need fertilizers to supply them with nutrients. Start both clones and young plants on fertilizer with a nitrogen-phosphorous-potassium (N-P-K) ratio of 1-1-1, 3-5-5, or 3-4-2 with micronutrients on the mild rather than strong side. Limiting the amount of N in relation to P and K increases stem diameter and discourages elongation.

After transplanting, keep the temperature in the low 70's F (low 20's C), if possible. Photosynthesis is limited when the air is kept cool. Since less water and nutrients are required with slower photosynthesis, the roots don't get stressed and there is less chance of wilting. Keep the CO_2 at 500-600 ppm, giving the plants easy access to the gas.

After three days or so, the plants are entering vegetative growth. Increase the CO_2 to 1,200 ppm, raise the strength of the water-nutrient solution to mid-range, and bring the temperature to 80° F (26-27° C). Keep the lights on 24 hours a day if the plants are to be grown indoors. However, if the young plants are destined to be grown outdoors, cut the light regimen to 18 hours of light, 6 hours of darkness. Some varieties, especially indicas, are less likely to be shocked into flowering when moved outdoors if they spend the indoor segment of their lives under a regimen of 16 hours of light, 8 hours of darkness.

PLANT AND CONTAINER SIZE

Indoors and out, the size of the container helps to determine the size of the plant and its yield. As mentioned earlier, if two identical plants are given the same conditions except for container size, the plant in the larger container will produce more. For this reason it's wise to give roots as much room as possible to spread out. Indoors, the container size should be limited only by the space each plant has in the canopy.

Both planting mix and hydroponically grown plants produce more when they are grown in the largest containers possible. Containers should taper slightly so that plants and medium can slide out easily. Plastic containers are usually the most convenient to use because they are lightweight, do not break, and are inert. Plastic grow bags are convenient containers, especially for outdoor gardeners. They take up little room in a backpack and are easy to set up. They have a square bottom so they balance easily and remain upright. Special woven plastic containers have handles that make moving plants around an easy task.

Fiber containers are also popular. They are inexpensive, last several growing seasons and are biodegradable. Metal containers are not recommended because they react with the nutrients in the solution.

CONTAINER SIZES

These recommended container configurations all assume a garden space 12 to 16 sq ft (1-1.5 sq m) powered by a 600w or 1000w HPS.

- **A single plant can be grown in a container as large as 50 gallons (190 liters or 6.7 cubic feet).**
- **Two plants can be grown in two containers as large as 30 gallons each (113 liters or 4 cubic feet).**
- **Four plants can be grown in four containers as large as 20 gallons each (75 liters or 2⅔ cubic feet).**
- **Eight plants can be grown in eight containers as large as 10 gallons each (38 liters or 1⅓ cubic feet).**
- **Sixteen plants can be grown in 16 containers as large as 5 gallons each (19 liters or ⅔ cubic feet).**

VEGETATIVE GROWTH

As soon as the roots have adjusted to the new environment, it is time to increase the light and nutrients. Firm, turgid leaves and new growth are indications that the plant is ready for rapid growth.

Turn the lights to their maximum level for vegetative growth, and change the fertilizer solution to one with nitrogen-phosphorus-potassium (N-P-K) ratio close to 3-1-2, 4-2-3, or 5-3-3. The plants should be kept on a high N fertilizer regimen until they are put into the flowering regimen. “Grow” formulas that include micronutrients support rapid vegetative growth.

INDOORS

You can start vegetative growth indoors any time it’s convenient, since you determine the plant’s environment and simulate seasonal variations by adjusting the periods of light and darkness.

Nonetheless, seasonal conditions can affect your decision about when to plant. In some areas, summer heat or bug infestations make it inconvenient or impractical to grow during the summer. In such areas, indoor gardens may be shut down or downsized to just mothers or clones before being restarted in the fall.

OUTDOORS

Gardeners using natural light either as a primary or secondary source must take the seasons into account. Planting time and strategies vary depending on the environment.

The earliest that seedlings or clones should be planted outdoors is when the soil temperature three inches (7.5 cm) below the surface reaches 65˚ F (18˚ C) in the afternoon and slips no lower than 50˚ F (10˚ C) at night. They can be planted when ground temperatures are lower, but growth will be slow until the ground heats up.

Marijuana seed is best planted when the minimum soil temperature doesn’t slip below 60˚ F (15˚ C). At lower temperatures the seeds absorb moisture but root and sprout initiation are delayed. This leaves the seed vulnerable to attack by fungi and yeasts. In areas where there are four distinct seasons, clones or starts should be planted outdoors at the same time as tomatoes.

Plants started or transplanted outdoors from late April through July will ripen between September and November, depending on the variety. No artificial light is needed as long as there is plenty of sunshine.

As discussed in more detail in the lighting section, supplemental artificial light can be used to help the plants to maturity in the fall. At higher latitudes, the intensity of light plants receive from the sun in September or October is a fraction of the light in June. The amount of UV light also diminishes.

Plants use light for growth. When they are shaded they don’t get very much light and growth is slowed.

The sun’s angle changes over the season, too, so plants that were in direct light in spring and summer may be in shadow by autumn.

If your plants are in containers, you may be able to move them to get more direct sunlight. Plants in the ground that are in shadow require supplemental light to grow and ripen properly.

On overcast days, clouds absorb most of the light, so overcast periods also delay ripening. Even sunny gardens receiving direct but weak sunlight may require more light for the buds to develop well.

Supplying the plants with 10-30 watts per square foot (110-330 watts per sq m) of supplemental light, depending on the type of lamp, from HID lights, CFLs, or HO T-5 fluorescents during the brightest part of the day is all that is needed to help the buds mature in September or October. See the lighting section for how to select the appropriate type and wattage of lamp for your needs.

Gardeners in lower latitudes, such as Mediterranean and subtropical regions, can grow outdoors virtually the entire year. These areas include the southern tier of Europe, the southern tier of the United States, and all of Mexico and Central America. In these lower equatorial latitudes, day length and light intensity does not vary as much between summer and winter as in higher latitudes.

Most indica and indica/sativa hybrids are early ripening, meaning they require the least amount of darkness to flower. Some varieties trigger immediately when placed outdoors; for them, the night length is long enough in both summer and winter to promote flowering.

One strategy for taking advantage of this is to grow plants indoors until they reach the desired size, then set them outside to flower. They will grow another 25-50% larger during their flowering period.

Sativas and sativa/indica hybrids are usually late-season varieties that require a longer dark period to flower. Some equatorial sativa varieties do not start to flower until late September and don’t ripen until December or January. In winter, flowering is induced quickly, but the plants may continue to grow vegetatively for a month or more before they concentrate their energy on flowering. The result is that they can be planted any time of the year. Plants transplanted outdoors in the spring and summer flower in late fall. Sativas set out between August and December ripen within 120 days; indicas ripen in 60 days or less.

Greenhouses and natural light gardens in temperate areas can be used to grow up to three crops a year using supplemental light. The determining factor is root and air temperature. Plant growth is slow when air temperature is below 60˚ F (15˚ C). It quadruples with adequate light as the temperature increases from 60 to 80˚ F (15˚-26˚ C). At the same time, ground temperature below 65˚ F (18˚ C) hinders root function, which affects the supply of water and nutrients to the canopy. With this in mind, you can plan your garden based on average temperature for your area, which can be found in almanacs or on the Internet.

In subtropical areas gardens can be planted all year. In some warm areas, where spring comes early, gardens can be planted in early February, as the sun’s intensity starts to increase. Young plants placed outdoors immediately start to flower, because the night period is still longer than 12 hours.

Indicas and indica-sativas continue to flower as the days get longer. However sativas and sativaindicas revert to vegetative growth unless flower forcing continues using light deprivation techniques such as blackout covers.

The size or age of the plant has no effect on the quality of the bud. Small plants are often more convenient because they can be moved around with the sun.

In some areas, it's just too cold to plant in February or even in April, but greenhouses move the planting period forward by about three weeks. A heated greenhouse can overcome inclement and cold conditions, but cloudy spring skies may not provide quite enough light to the plants. HID lamps or CFLs can provide supplemental light for 5 or 6 hours during the brightest part of the day.

Removable tunnels are another way to get a jump on the season. They keep the outdoor garden warm and sheltered from the cold, wind, and rain. They are easily constructed using rebar or metal pipe covered with (6 or 8 ml) clear polyethylene. The plastic is removable, so it is placed over the plants only when there is cold or inclement weather. In early spring, it might be used nightly. The tunnels should be constructed about 6' (1.75 m) high so they can be used for forcing flowering with blackout covers later in the season. They are often 10' (3 m) wide, but can be designed for any width.

Using a tunnel or a greenhouse, it’s possible to manipulate the light cycle to either prolong vegetative growth or to force the plants to flower. Using these techniques, it takes 90 days or less to produce a crop, depending on the variety.

One example of greenhouse strategy is to plant April 1st. The plants will ripen June 15th or earlier. Immediately after harvesting the June crop, the next crop is planted and will ripen by August 30th. A third crop is then started. It will flower immediately and is ready by November 15th.

Even if you’re not trying to squeeze in multiple crops, there are several advantages to forcing an early harvest.

- The crop is less vulnerable to thieves or law enforcement, who look for gardens primarily during the fall harvest season.

In tropical and subtropical areas where plants can be grown outdoors in winter such as parts of the Southern United States, Hawaii, and portions of the Mediterranean, pure sativas have the time to flower under short days. In more northerly areas plants in greenhouses have the same opportunity; however, the plants may need supplemental lighting to produce grade A buds.

- Second, plants harvested in summer are not vulnerable to mold or the vagaries of weather that plague farmers in the fall.
- Third, the bud quality is higher when plants flower and are harvested under the strong UV rays of summer.

During early spring, plants usually require an interruption of the night cycle so they do not go into the flowering stage prematurely. Lights on a timer can be used to interrupt the dark period briefly during the night. For instance, a 400w

HPS covers an area of about 600 sq ft (55 sq m) with enough light to stop flowering. Or you can use CFLs at a ratio of one 24w bulb per square yard or square meter. Flash the lights on for 10 minutes using a multi-cycle timer at least once during the middle of the dark period. Gardeners with large spaces sometimes stagger the timing of the night lights.

Night and day are each 12 hours long two days a year: the spring and fall equinoxes. After March 22, the Northern hemisphere spring equinox, nights continue to grow shorter until June 22, the first day of summer. The summer solstice has the longest day and shortest night, though the number of hours varies depending on latitude. After that, the night starts to lengthen again until it reaches 12 hours of sunlight and 12 hours of night on the fall Equinox, September 22. The longest night is December 22, the winter solstice.

HPS reflectors are available that oscillate a 1000 watt lamp, which covers 1,500 sq ft (130 sq m).

Incandescent bulbs are not very efficient or as effective as fluorescents because they emit far-red light, which counters red light's inhibitory effect. HPS lamps and warm white fluorescents emit a high percentage of red light, the spectrum used by plants to prevent flowering.

REGENERATION

Regeneration is the technique of using mature plants, whose ripened buds have been harvested, to produce a second harvest. It can be used indoors or out, but is most frequently used outdoors.

Since marijuana grows and flowers based on the number of hours of light and darkness, manipulating its light cycle can convince a flowering plant to return to vegetative growth.

When the buds are harvested, leave undeveloped flowers and many of the leaves on the plant. Increase the light regimen to support vegetative growth; indoors leave the light on continuously; outdoors use night cycle interruption. The plant may start re-growing vegetatively, a process known as regeneration. Leaves start to grow and the plant exhibits renewed vigor.

This can also happen under natural light conditions when flowering was induced early in tunnels or a greenhouse. Spring crop plants often revert back to vegetative growth under the long days of June and early July. Some varieties require an interruption of the dark period using artificial light. As the nights get longer, the plants revert back to flowering, producing buds that will be ready for harvest in the fall.

Gardeners can use this to their advantage in several ways. Plants that were grown indoors under lights and harvested can be placed outdoors to generate a second harvest. Indoor plants that were grown to a large size to satisfy legal restrictions on plant numbers can be harvested, regenerated, and then induced to flower again. Because they already have an infrastructure of roots and stem, they can be forced to flower faster, shortening the time between harvests. Outdoor plants that were forced to flower early for harvest in July or early August can be regenerated and re-flowered to produce a second harvest. In warm areas, plantings can be timed for three harvests, at least two of which are from the same plant. Spring plants that were flowered and harvested indoors can be placed outdoors without treating them to continuous light. The long days of early summer combined with the increased intensity of the sun’s light push them back into vegetative growth.

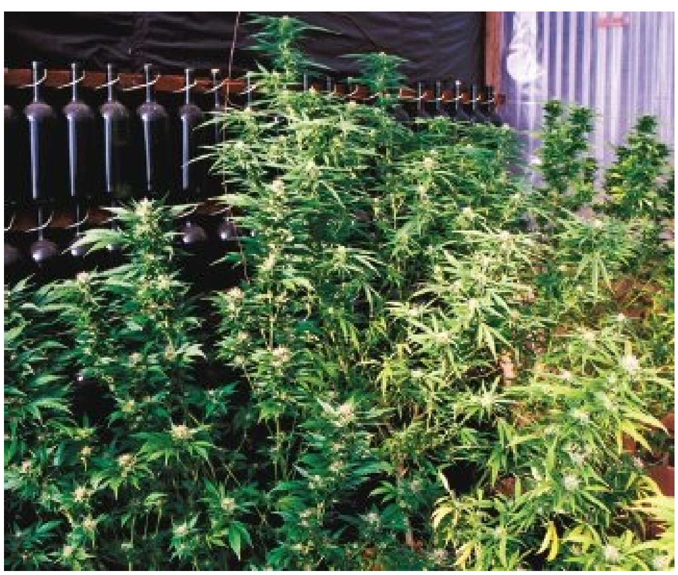
When most varieties receive light for long periods they revert back to vegetative growth. Harvested plants can be placed outdoors to regenerate and produce a fall harvest.

This plant signals its crossover back to vegetative by growing a swirled leaf. This trait was first noticed by the famous breeder Soma.

The regeneration process starts with harvest. Instead of harvesting the whole plant by cutting the stem off, or cutting off all the branches, leave parts of some branches intact, including green leaves and small parts of buds. Then place the plant under continuous light. In 7-10 days the plant will start to grow vegetatively again. At this point, the light can be cut to 18 hours. When the plants have grown enough new vegetation to support heavy flowering on colas, change the light cycle back to flowering: 12 on, 12 off. The plants will start to flower as usual.

Use HPS lamps to supplement natural light when it has a low intensity and to increase the length of the lighted period.

Shading was used to induce these plants to flower during the summer.



This greenhouse is heated passively using dark, water-filled wine bottles placed along the north wall. The bottles absorb and store heat from sunlight and the warm air during the day and release it at night.

Regenerated plants tend to have a lot more branching than first-time flowerers, so you should practice branch control *(see Pruning)*. Selective pruning results in fewer flower sites, but the buds on each one grow larger, resulting in more Grade-A flowers.

INDOOR-GREENHOUSE MANIPULATION

Gardeners can use a combination of indoor and greenhouse or outdoor gardening. Plants are started and initially grown indoors to get a head start, then moved outdoors. By starting early with large plants, you can get a jump on the season. This also helps with light deprivation techniques for harvesting more than one crop a year.

Plants grown indoors that are placed outdoors during late spring and during the summer usually need to adjust to the harsh UV rays by keeping them in the shade at first or using an anti-transpirant.

MAXIMIZIING THE INDOOR-GREENHOUSE GARDEN

Some growers can combine indoor gardens and greenhouses. For best results, start plants indoors in late November and let them grow vegetatively for three months until they are fairly large. In February, transfer them to a heated greenhouse. For 8 hours a day during the sunlit period, use supplemental light of 600 watts over every 30-40 sq ft (9-12 m).

This farm in Switzerland produced three crops of small plants over the season. A recently harvested field was just replanted.

Use removable clear polyethylene tunnels to create a greenhouse effect and to conserve the heat at night. Then use black plastic for shading. This farm in Switzerland produced three crops a year using this strategy.

The plants start flowering immediately, because they are receiving more than 12 hours of darkness daily, and ripen by the end of March.

Return the plants to vegetative growth by using the MH light on a timer to break up the dark cycle until they regenerate.

Around May 15th, after growing vegetatively for 6 weeks, force the plants to flower again by covering the greenhouse with blackout material each evening, so they receive only 12 hours of light daily. This results in a harvest around July 15th.

Clear out the old plants and replace them with a new set of plants that have been growing indoors vegetatively for two or three months. They are not as big as the plants moved to the greenhouse in February but have a bit of branching. These plants have to be hardened up to withstand the intense midsummer sun. Use a 30% shade cloth for the first five days, and spray the leaves with an anti-wilt product or anti-transpirant. Grow the plants under natural light for a month, until about August 15th, then force them to flower using a blackout curtain to establish 12 hours of darkness. They are ready for harvest by October 15th.

NUTRIENTS FOR GROWTH

When marijuana is supplied during the vegetative stage with ample amounts of all its requirements, including nutrients, it grows very quickly. If the soil or planting mix cannot meet the plants' nutrient needs, they require fertilization.

If the plants are suffering from a particular nutrient deficiency, supplying that individual nutrient puts them back on track.

There are many brands of hydroponic and specialized fertilizers available. Most of them have been available for many years and have satisfied customers, otherwise they would go out of business. Try a brand according to the directions provided. If you are satisfied with it, stick with it, if not try another. If friends or garden supply store employees offer you different mixing recommendations or odd combinations of products, test with just one plant first to see if the recommendation is beneficial or perhaps harmful. Generally speaking, use milder not stronger nutrient mixes. Use a conductivity meter to test your water and your nutrient strength. With soluble fertilizers 1,000 ppm or an EC of 2.0 mS is normal strength. If you have hard water, for example 250 ppm, then you should dissolve fertilizer into the water up to 1,000 ppm. Testing pH and adjusting it to between 5.8 and 6.4 is a good idea if you find that your pH is too high or too low.

Plant leaves catch dust. So even if you're not foliar feeding, it is a good idea to mist the plants every 2-4 weeks with a fine spray, letting the water drip off the leaves. Do this at the beginning of the light cycle, so the leaves are sure to dry completely and the lights are not yet hot. Be careful not to direct the spray near the lights. If the reflector does get sprayed, clean the glass plate so light is not

obstructed. Don’t spray when HID lights are on, if there is any chance that the spray will get near the bulbs.

Water quality is important and can cause problems when it is too hard, is contaminated or has strong residual disinfectant like chlorine or chloramine. Collecting rainwater is a good way to obtain soft water.

You may wish to compare two fertilizers and see how their performance in your garden differs. Differences in performance are often due to the quality of water. Fertilizers are a lot like jeans. A brand will fit one person well and the next not so well. Differences in plant response may be caused by the quality of the water. Each fertilizer affects the combination of environmental conditions and plant genetics differently. Some companies offer special fertilizers formulated for hard water.

To improve the flavor of the final product, use unfertilized water for the last seven days. Many of the **fan leaves** yellow and wither as the remaining nitrogen migrates from old to the new growth. As a result, the buds have less of a green, minty (chlorophyll) taste. They also lose the chemical taste of over-fertilized bud. (*For more on nutrients, see Soil)*

WATERING AND IRRIGATION

Marijuana is a water-loving plant. It thrives in moist soil and responds to dry conditions first by slowing then halting photosynthesis. As dry conditions continue, the leaves lose turgidity and wilt. Then they dry up. Even a short period without water can result in a dead plant.

Marijuana that has easy access to water can grow to its full potential. This translates to maintaining a moist, but not waterlogged, medium. The reason is that as the planting medium becomes drier, the water bonds more tightly with its molecules. This is expressed as water tension. It costs the plant more energy to tear the water from the medium as water tension increases. When there is a continual water deficit, the plant is not able to get all the water it needs, so all the plant’s processes slow as it adapts to the limiting factor in its environment.

WATER USE ON HOT DAYS

Plant Diameter	Square Area	Water Requirement
4 feet (1.2 m)	**12 sq. ft. (1 m2)**	**3-3/4 gallons (4 L)**
10 feet (3 m)	**78 sq. ft. (7 m2)**	**25 gallons (95 L)**
On hot summer days, plants may require as much as a half-inch (1.3 cm) of water.		

OUTDOORS

Under natural growing conditions, marijuana planted outdoors uses between 20 and 30 inches (50-75 cm) of water over the season. Most of it is used in June, July, and early August, when the plants are in the vegetative stage and growing rapidly. This is also the period of peak temperature, so the plants use of water increases dramatically because it is used for both photosynthesis and transpiration. Photosynthesis increases in relation to higher light intensity and rising temperature. At its peak, this process uses large amounts of water. Transpiration increases with more light and heat, as it helps cool plants through water evaporation and it draws more water from the roots.

Many factors affect how much water is available to an outdoor garden. In areas where there is regular rainfall or a high water table, plants may need no irrigation. However, areas with a Mediterranean or desert climate, where there is very little rainfall in the summer, cannot support plant growth without irrigation. Water availability also varies by soil type. Clays, mucks, and loams with high content of organic matter hold more water than sandy soil. Water loss to soil evaporation can be eliminated or slowed using mulch, pebbles, or plastic sheeting to protect the soil from the sun, keeping the soil cooler. Container systems that catch and recycle the excess water that would otherwise drain past the roots also conserve water.

Plants growing in soil or soilless mixes should be watered before the medium dries out, but only after the top inch or two (2.5-5 cm) has lost a bit of its moisture. If the soil or mixture drains well, over-watering does not create anaerobic conditions, since the excess water drains. However, soluble nutrients are leached out by over-watering, and unnecessary water use can be costly and environmentally unfriendly.

Plants have problems with some soils not because they are too wet, but because they have too fine a texture and do not hold air between the particles. When roots have no access to oxygenated air, they become stressed and susceptible to attacks by pathogens. *(For more on this, see Soil.)*

HYDROPONIC WATER USE

Hydroponic gardens typically use one half to two thirds the amount of water that plants grown in the ground require, because almost all the water in a hydroponic system is used directly by the plant.

Gardeners using hydroponic systems just add water to the reservoirs, replenishing water that is either lost to evaporation or used for transpiration, photosynthesis, and general metabolism. Before adding water, check the nutrient levels of the water-nutrient solution remaining in the reservoir. Adjust the nutrients in the water to be added so that when it is combined with what remains in the reservoir, the pH and nutrient levels are within acceptable range.

Growers using active hydroponic systems, such as drip emitters or ebb and flow, should adjust the watering cycle so that the medium never loses its moisture. Each type of medium retains a different volume of water, but media for active systems drain well, so the roots are always in contact with air. The plant's size and growth stage, as well as the ambient temperature and humidity, all affect the amount of water used, so adjust the recycling schedule accordingly. Cycles might start once every six hours of light during the early stages and increase as the plants grow.

INDOOR WATERING

As with plants growing in the ground outdoors, plants growing in soil or soilless mixes indoors in containers need water once the top layer is no longer moist but before the soil in the root zone dries out. Over-watering is not a problem so long as the soil or planting mix is porous and drains well.

As long as a medium allows both air and water to penetrate, roots remain healthy. If the roots do not have access to air, they grow weak and are prone to attack by bacteria. Planting mixes vary greatly in their water-holding capacity, so the watering regimen must be developed based on the medium and growth stage.

These manual water timers each control one section of a garden. The valve shuts the system off so it can be adjusted easily. Each water meter is turned on manually after the gardener checks the garden and sets the number of minutes for the water to shut off automatically.

The leaky hose lets water drip from its porous sides. The soil was enriched before planting, so the hose carries only water.

With an automated drip you don't have to physically water the plants in order for them to get adequate water.

When plants are small, they use less water. As they grow, their water needs increase, so the watering schedule should change. In general, plants require more water during vegetative growth than during flowering; however, even during flowering, the plants are most productive when they have easy access to water.

Some growers withhold water for several days before harvesting, but this results in a slightly smaller yield but may result a slight increase of potency. A better practice is to limit fertilizing to improve bud flavor.

FOLIAR FEEDING

Plants can absorb both water and nutrients through their leaves, so the nutrient-water solution supplied to the roots can be misted on the foliage as well. Leaves have stomata that serve the same purpose as pores: They open and close as needed to regulate the absorption of CO_2, water, and nutrients. Foliar-fed plants grow faster. It also saves fertilizer compared to soil; about 95% of the fertilizer is absorbed as compared with between 10 and 20% using conventional methods.

Foliar feeding is especially helpful when plants are suffering from a deficiency, because the needed nutrients are delivered directly to the plant parts that need it, the leaves.

You can start foliar feeding as soon as the seeds germinate. Once they have roots, clones also grow faster when they are misted with a water-nutrient solution. Since the ability of young plants to absorb water is limited, a dilute nutrient solution spurs growth. Continue foliar feeding during vegetative growth and early flowering. Stop spraying once the flowers are 3-4 weeks old and are beginning to develop water-trapping crevices. Buds at this stage are susceptible to mold and infections promoted by excess humidity.

PRUNING AND TRAINING

There are probably as many theories about pruning and training and their effect on crop yield as there are cultivators. Pruning and training theories are complicated by the many varieties of marijuana, which have different branching patterns and growing habits. But the intent of pruning and training plants is almost always to increase yield.

Traditionally, gardeners have been more interested in the total yield of their garden space, rather than each plant. Marijuana gardeners have become concerned with the yield per plant primarily because of regulations regarding the number of plants. Medical growers, for instance, may be limited to only a few plants, so each plant is nurtured to produce the highest possible yield. Only when the regulations limit canopy space rather than plant count does it make sense to be concerned about total yield of the space rather than the yield per plant.

Left: The lower portion of the plants was removed to create more air circulation and reduce humidity. The leaves were a net energy drain because they weren't receiving any light. Right: All the action is in the dense canopy because light can only be used once. Plants were growing in 4" (10 cm) rockwool cubes placed on rockwool slabs. They were fed through drip emitters until they started to drain once every three days.

PRUNING TECHNIQUES

Some pruning techniques increase yield in a given area. In addition pruned plants usually occupy more space than plants left unpruned, so yield per plant may increase substantially with pruning.

Marijuana adjusts well to many kinds of pruning techniques. It can be pruned to become bushy rather than tall, trimmed to only a few branches, cut to fit a space, or stretched out to promote branching. Flowering plants can also be pruned to increase flower production. For more on those techniques, see Flowering.

To make a plant bushy, clip the tip of the growing shoot after the third set of leaves has developed. The branches surrounding the top branch are no longer inhibited from growing and create a rosette of three or four branches. Meanwhile the two top shoots that have been hanging out at the pair of top nodes begin to grow. Other lower branches grow a bit as well. After the plants have grown another three or four sets of leaves, clip the tops again if you would like the plant to grow even bushier. Sometimes the plants are pinched once or twice more during the vegetative stage. Cutting the tips encourages plants to spread out rather than to grow vertically.

The three plants in one container (shown in photo above and on the left in top photo) had the greatest yield. The topped plant, with expanded side branches was the next highest, followed by a single untopped plant.

Indoors, the canopy absorbs virtually all the light, leaving little in the shadows below. For this reason, the understory below the canopy contributes little energy to the plant. Instead, it costs the plant nutrients, increases humidity, and stops airflow.

Pruning the lower limbs creates more airflow under the plants and creates cuttings for cloning. It also forces the plant's growth to the top limbs that get the most light, maximizing yield. These lower leaves and branches should be removed to create an open airspace.

FLAT PLANTS

Selective pruning creates "flat", two-dimensional plants that can be placed against walls, positioned close to each other, or used in unusual configurations.

Marijuana typically grows leaves on opposite sides of the stem, with each set of leaves perpendicular to the next. Each leaf is attached to the stem at approximately a 90˚ angle, parallel to the ground, positioned to catch light. Opposing branches develop at the nodes between the leaf and stem, so the plant basically has four corners.

By removing the branches from every other set of leaves, you can create plants with branches that are opposite each other in two dimensions. This technique can be modified to remove only one branch from every other set of leaves, so one set of branches juts out at a 90˚ angle from the opposing pairs, creating a more triangular shape. This way, the flat side can be placed against a wall, while the others project into the room.

These plants were “lollipopped.” The lower branches were removed because they didn’t contribute to yield.

This plant was topped several times and developed into a bush.

These plants have been dwarfed by constant removal of fan leaves. They would have been twice the size if the leaves had remained. If the plants didn't use the leaves it wouldn't grow them. Another problem is the black containers baking in the sun absorb the sun's heat and bake the root ball, damaging the roots. The solution: Paint the containers a light color, wrap them in light colored paper, plastic or fabric, or place them in baskets.

Left to right: Only the tops remain on this plant. Each branch receives its own bamboo stake for support. Use twist ties to bind the stem to the stake. Two months later the four-4 bud trim pays off.

FLORIBUNDING (FIMMING)

Trim the top 80% of the apical growing tip, leaving about 20% intact. The tip develops multiple tops creating a bushy plant laden with heavy branches. Topped branches usually develop two to four new tops for each one cut. Using this technique, a single branch produces six to eight tops.

These plants were tied to a horizontal pole to keep them from growing taller.

SUNLEAF (FANLEAF) REMOVAL FOR LIGHT

Contrary to myth, most sun or fan leaves should not be removed from the plant during the vegetative stage. These leaves are costly for the plant to produce, and they are sugar factories that turn light into chemical energy. These sugars are used to power metabolism and are also used for tissue building by combining them with N and P to make amino acids and proteins. When a leaf is removed, the plant loses a source of energy, and its rate of growth slows. Gardeners who routinely remove the fan leaves from their plants outdoors slow growth and lower yields.

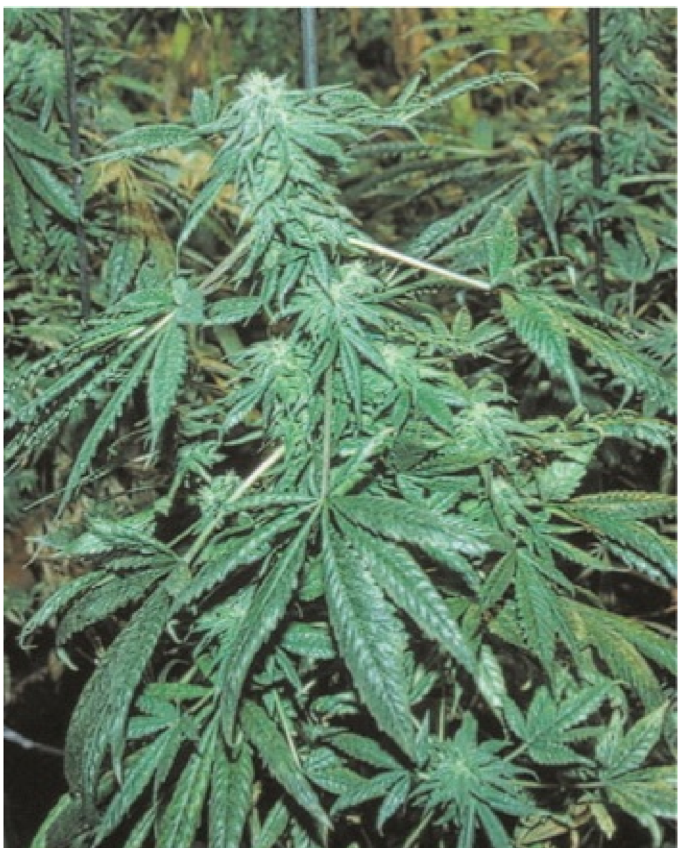
If you don't believe this, try an experiment. Use a plant that has two sun leaves opposite each other with a small branch growing from either side. Remove one of the leaves and see which side branch develops faster.

Left to right: 1. A one-bud plant tied to a stake for support. 2. With two buds each stake holds one bud firmly in place. 3. With three buds the stakes hold the buds upright and spaced from each other. 4. Four-bud trims work really well for plants in containers with a diameter of 10-12” inches (25-30 cm).

Sometimes a few fan leaves block light from a large section of a plant. These leaves can be removed if, on the whole, the plant receives better distribution of light.

Similarly, leaves that are constantly in shadow such as leaves below the canopy indoors are not contributing to plant growth, so they should be removed. Similar to “lollipop” pruning, this eliminates the risk of infection, improves air circulation, lowers humidity, and reduces the demand for nutrients.

Leaves that are directly blocking light from getting to buds or the cola should also be removed. This becomes more apparent as the buds grow and become more prominent. However, leaves near the buds but not blocking light should be left in place.



This plant has only a single bud, which allows it to spend less energy developing its infrastructure and more energy developing its flowers. With only a single bud the plant doesn’t spend much time developing infrastructure.

Remove yellow leaves, as well as any infected or infested material.

SINGLE-BUD PLANTS

Plants can be put into the flowering cycle when they are only a foot or two (30-60 cm) tall, before they have developed branches. They grow into plants with only one bud. The main stem becomes swollen with flowers, but there is little to no branching. These plants are useful for compact gardens because they require only between one quarter to one square foot (7-30 sq cm) of floor space.

BENDING AND CRIMPING

Bending should proceed carefully, to avoid breaking the stem or branches. The plant will repair damaged stems if there is some snapping or pinching, so long as the stem is not severed or split. Young branches that are still green are more flexible than older ones that are woody and have turned tan or brown, which cannot be bent much before they snap.

One method of bending the branch is called **crimping**. The goal of this technique is to stress the branch by twisting top stems so the plant will reinforce the damaged area. The plant repairs the damage quickly. The stem remains bent and the repaired area is stronger than it was before it was treated.

To crimp a stem or branch, use one hand to hold the stem in place. With the other hand, gently twist the stem back and forth by rolling it between your thumb and forefinger until you feel tissue crunching or snapping. On larger branches, an audible break indicates that the twisting has damaged the stem. Smaller branches can be pinched rather than twisted.

Large rings hold each plant firmly in its own space.

TOMATO RINGS

Plants can be "opened up" to allow more light to lower branches in the interior. This usually entails positioning branches so they don't shade the interior or so that they get more light themselves. String, rope, cloth, gardener's tape, twist-ties, stakes, and braces are all useful for bending branches to your will. Also, plants can be controlled by keeping all branches inside the cone. This way they are kept within a designated canopy area.

Tomato trellises (the metal cones) can be used to open up the plants when they are still young. The branches all get more light from the opening and respond by growing bigger buds. Position branches around the outside of the cone, and tie them to it using twist-ties or plastic gardening tape. Indoors, these conical trellises can be used to contain unruly plants. A canopy of sativas and other large plants can be confined so they don't infringe on their neighbors using the four or five foot (1.2-1.5 m) cones.

This ring was placed in the ground inverted. The branches were tied up outside it to open them up to light.

You can also train your plants using a trellising technique commonly used by grape growers. Stretch ropes at one foot (30 cm) spacing between posts. Tie the plant branches to the ropes. Stretch each branch horizontally so the plant has virtually no depth.

Alternatively, use chicken wire attached to a frame as a trellis. As the plants grow, use twist-ties, gardener's tape, or soft string or cloth to attach them to the wire.

INVERTED TOPS, SUPERCROPPING, BENDING

Removing the top bud stops growth-inhibiting auxin production so the lower branches begin to grow. A way to achieve this result without the loss of the top bud is to bend the top bud down. When it is positioned at a height below the side buds, it stops producing auxin. The side branches are no longer inhibited, so they start growing. At this point the main bud can be released and it will start to grow again. This results in more very large buds.

Metal framing around the outside of the plant gives it support and keeps the branches within its perimeter. The wooden frame on top opened the branches so more sunlight could reach the interior.

Framed netting is used to support the buds. The netting is put in place before the plants reach their ultimate height. As the buds get larger, they are supported so they don’t fall over.

Stakes were placed around the plant. Then rope was strung around the posts to keep the plant within their perimeter.

Supercropping is a similar technique of training top branches to grow horizontally so that the primary bud is exposed to more light. With more areas exposed, the bud grows larger than normal. This technique can also be used when one bud is growing taller than the rest of the canopy. Position the branch by bending, tying down or gently snapping it.

There are several ways to tie the top bud. The top of the stem near the growing tip is composed of flexible soft green tissue, so it can be gently bent down or sideways. To secure the stem and branches, use soft string or cloth, gardener’s tape, twist-ties or stakes. Keep any knots loose to minimize damage. The branch may have to be supported by splinting with a skewer or bamboo suppport.

When the top branch is bent so that it is positioned lower than some of the side branches, the side shoots grow as if the top branch was cut. After the side branches have started growing, you can release the top branch so it can grow upward again. Branches produce more growth than they would with the top branch dominating. The plant with a group of branches produces more bud weight than top dominant plants.

FLOWERING

Photo: Rachael Szmajda

Marijuana is a short-day plant. As the days get shorter, marijuana determines when to flower based on the number of hours it receives of uninterrupted darkness. It measures the length of the dark period using the hormone phytochrome, which has two states. The hormone's inactive state, Pfr, occurs when it absorbs red spectrum of light at 666 nanometers. It also has a slight sensitivity to blue light. The hormone changes to its active form, Pr, over a period of two hours when the plant is in darkness. When the Pr flowering hormone levels remain high for a critical period of time over several days, the plant changes from vegetative growth and initiates flowering.

The number hours of darkness plants need to initiate flowering differs by variety. Sativas require a longer period of darkness than indicas because they developed near the equator, where the length of daylight is much more consistent than at northern latitudes, where indicas developed. Some sativas continue to grow vegetatively with 10 or 11 hours of darkness, which usually cues most plants to flower.

Many sativas initiate flowering only when the dark cycle increases to 12 hours or more, which occurs September 22 in the Northern Hemisphere.

By contrast, most indicas flower with 8 to 11 hours of uninterrupted darkness (13 to 15 hours of light). In southern tiers of Europe and the U.S., a few indica varieties flower as early as June 22, the shortest night of the year. For this reason, outdoor gardeners in these regions should consider sativaindica hybrids and sativas. In the central and northern tiers, indica and indica-sativa hybrids usually start flowering in August and are ready to harvest in September through mid-October.

Some sativas and sativa hybrids require a longer dark period at the end of flowering to fully ripen their buds. Outdoors, this happens in due course as the nights lengthen in the fall. Indoors, change the lighting regime to 14 hours of darkness/10 hours of light to promote ripening. This is especially helpful in finishing low latitude varieties that don't reach maturity in their native lands, where there is no winter, until the middle of the short-day season.

INDOOR FLOWERING

Flowering time of female marijuana plants is regulated by the length of the uninterrupted dark period, so gardens under lights can be forced to flower at any time with the flick of a timer switch.

Look a few nodes down from the plant top. A small flower sometimes grows presaging the plant's sex, allowing the gardener to identify its sex.

To determine when to flower the plants, look down at the canopy. When two-thirds of the floor space is hidden by plant canopy, it is time to start the flowering process. The remaining space will fill in during the flowering stage. You may need to consider not only the breadth of the plants but also their height. If the garden has height limitations, the plants should be forced to flower before they get too tall.

Sativas grow the most after forcing—typically an additional two to three feet

(60-90 cm). Sativaindica hybrids increase in height by one to two feet (30-60 cm), indica-sativa hybrids one to one and a half feet (30-45 cm), and indicas grow up to one foot (30 cm).

To force flowering, lights must be turned on and off with consistent regularity, and the darkness must be uninterrupted. For that reason, it is essential to use a timer to regulate the lights. Set the timer so the lights stay on for 12 hours and then remain off for 12. Within a week, you will notice a change in growth. The plants are responding to the new light regime and are beginning to flower.

You do not need to taper the light change. Reduced light from 18 hours daily (or continuous) down to a flowering cycle of 12 hours of light and 12 hours of uninterrupted darkness with no intermediate steps. The change in the light regimen does not shock the plants.

SINSEMILLA & SEXING

Marijuana users prize seedless female flowers, known as sinsemilla because they produce far more useable buds than seeded buds; nothing is wasted on seed production. Sinsemilla is also more attractive and far more convenient to use. Marijuana seeds have an obnoxious oily odor when they burn, so they need to be removed before smoking. Sinsemilla buds are seedless, so there are none to remove.

In order for female flowers to ripen without seeds, they must remain unpollinated (unfertilized). Because cannabis is dioecious, male and female flowers appear on separate plants and must be kept seperate. If you are growing from unfeminized seeds, roughly half of what you germinate will be male and must be removed from the space as soon as they can be identified. This culling should be done early in the male plants' development, before any large flower clusters appear. Even a single open flower can release enough pollen to fertilize dozens of neighboring female buds.

Marijuana can be sexed early. There are two basic methods:

1. Identifying early, premature flowers
2. Forcing plants to flower by altering the light regimen

There are several ways to use the forcing method, each with pros and cons.

Visual identification of the plant gender is easiest, since it requires no intervention. Sometimes, while a plant is growing vegetatively, a single, small flower appears at the space where the leaf joins the stem (node) two to four pairs of leaves from the top. The sex of the plant is the same as that flower. This method is also the easiest to get wrong, since identifying the tiny, premature flowers can be challenging, and not all plants produce them. Use a magnifying glass or photographer's loupe to get a clearer image.

Dusk and dawn differ from sunrise and sunset. They occur preceding and proceeding dawn and dusk, respectively. They represent the time the light gets to Earth before sunrise and after sunset.

Forcing plants to flower is a more certain method. Since flowering is regulated by the number of hours of uninterrupted darkness plants receive each day, it's easy to manipulate them to reveal their sex. Establishing a long-night regimen for a week forces them to indicate. Then remove the males from the garden, (or separate them if you are to breed) and returned the garden to the vegetative growth cycle by changing the light regimen back to the long day/short night.

A good alternative is to take a cutting from each plant and force it to flower. Carefully tag each cutting to identify which plant it came from. Set the clones in a grow medium and provide a light regimen of 16 hours darkness/8 hours of light. Within a few days, the clones will indicate. Since each clone has the same sex as its parent, you have identified the parent's sex without taking it out of the vegetative stage and disrupting growth.

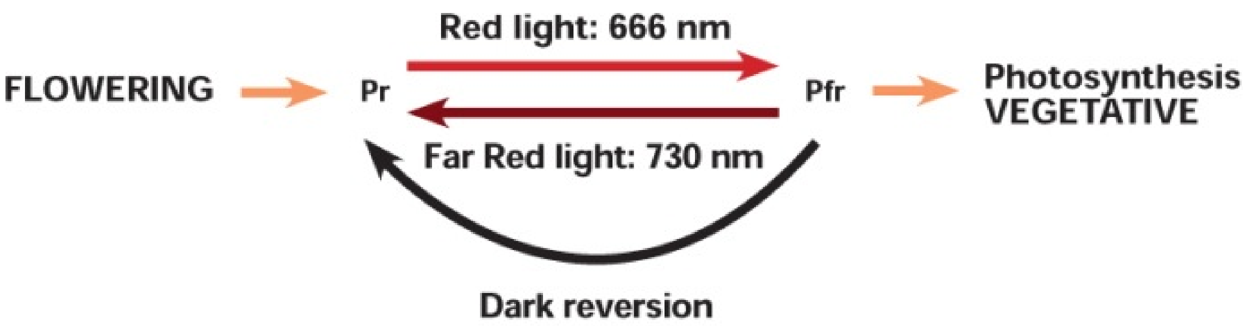
You can keep the female clones under the flowering regimen to get a tiny taste of the parent's future buds. This also allows you the opportunity to eliminate weak plants. Be careful to label cuttings and plants so you can match them up accurately once they've been sexed.

BLUE LIGHT

Blue light is another option for sexing. As mentioned earlier in this chapter, marijuana flowering is very sensitive to red light of specific spectrums. Any interruption of the dark period with light that contains the red, 660 nm spectrum returns the flowering hormone Pr back to its inactive state, Pfr. This prevents flowering.

Blue light at 400-450 nm also has an inhibitory effect on flowering, but its effect is weaker than red light. Plants grow some flowers when blue light is kept on during the dark period; however, they continue to grow vegetatively as well. If you use blue LED or fluorescent lights to provide the plants with nothing but pure blue light, they will get enough stimulation to produce some flowers for sexual identification but not go into full flowering mode.

PHYTOCHROME RESPONSE



Phytochrome response chart shows phytochrome Pr-Pfr sensitivity across the light spectrum.

This is a good sexing technique to use anytime, but especially when a large number of plants are involved. No cuttings need be taken and matched to their mothers, so there is no chance of a mix-up or dead, non-indicative clones. As soon as a plant produces male flowers, eliminate it from the space. Once all the plants indicate, replace the blue light with a full-spectrum light period to keep the plants growing vegetatively.

Plants use blue light to regulate flowering as well as for photosynthesis. Blue light is not as efficient a source of energy for photosynthesis as red light indoors because blue light has a higher energy value than red light and it requires more energy to produce than red light. However, the plant obtains the same amount of energy from both of them. When blue light is turned on during the dark period, plants photosynthesize, but the growth from the blue light is not significant. The stems grow a little more stocky.

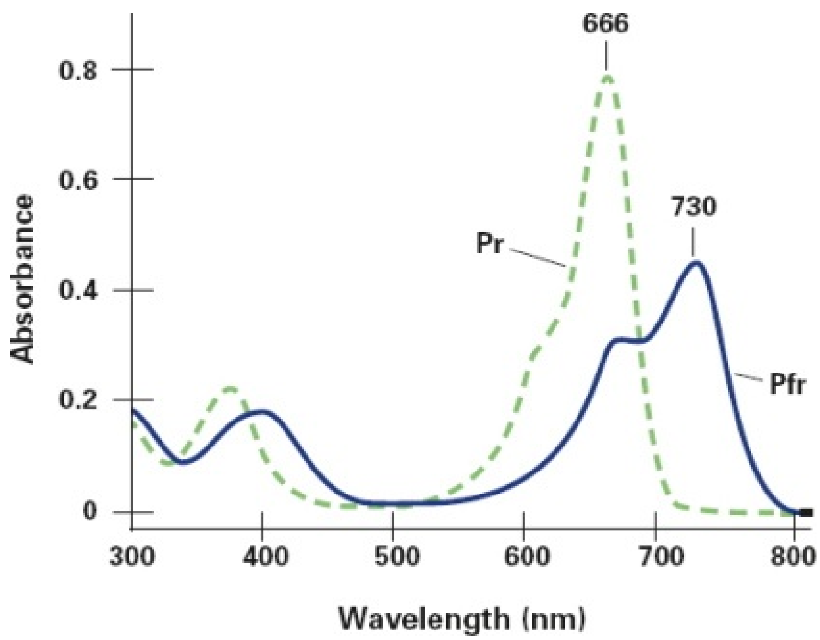
Flowering is a localized response by the plant. When one part of a plant is placed in a flower-inducing dark period, but the rest of the plant is not, only the part under the reduced-light regimen flowers.

This is also a viable technique for sexing plants.

The effect of blue light on flowering is more important to us. See the Phytochrome Response chart, which shows phytochrome Pr-Pfr sensitivity across the light spectrum. The red-far-red portion shows high activity. The blue spectrum shows just a little bump. This indicates a slight activity. The result is sporadic flowering on all the plants.

You can create a pure blue light with LEDs and blue CFLs. Use about 200 watts of mixed blue light per 1,000 watts of regular light. I have done only initial experimentation with this so test this in a limited way first.

ABSORPTION SPECTRA OF PHYTOCHROME



Plants exposed to pure blue light peaking at 400 nm with effects at 400-450 nm during the dark period produce a few flowers but continue growing vegetatively. In this way blue light is used to force plants to indicate sex without interfering too much with vegetative growth.

THE FLOWERS

Identifying the sex of marijuana flowers is easy once you know their characteristics. Male flower buds look like balls dangling from thin stems, with a curved protrusion at the bulb's end that comes to a blunt point. As the male flower ripens, the head's position moves from hanging down to upright. The petals that formed the bulb open, revealing five simple petals that range in color from cream to yellow. Each has a stamen in the middle that releases pollen to a breeze or wind.

Female flowers have no petals, but they are identifiable because of their pistils. The **pistils** have noticeable stigmas, two white or sometimes pastel pink or lavender antennae-like protrusions, attached to an ovary, which is an oblong pod-like structure. The stigmas pull pollen from the air and then transfer it via hollow tubes down to the ovary. In the ovary, the captured pollen from one stigma fertilizes the egg to form an embryo. The pollen from the other stigma is combined with portions of the ovary to form a food source for the embryo within the seed. The stigmas of fertilized flowers then dry up, beginning at the tips. Each fertilized flower produces a seed. Seed development starts as soon as the female flower is fertilized and is apparent by the third day. The ovary at the base of the pistil swells as the new seed grows inside of it.

Full-blown male flowers as they open to reveal five creamy yellow petals.

An hermaphrodite bud. Both male and female flowers are apparent. Sometimes hermaphrodites have just a few hidden male flowers. A single hermaphrodite plant can pollinate an entire garden and should be removed before the flowers have a chance to release their pollen.

A single male flower sometimes grows from nodes lower on the plant before flowering begins. This indicates sex.

This is not going to happen in your garden unless you are careless or planning to produce seed. Since you’ve eliminated the males, the females’ stigmas search in vain for pollen. Eventually they dry up and become part of the ripe, unfertilized bud. The females’ leaves start growing closer together as they form strong stems that will hold clusters of flowers along a branch. These branches of ripening buds are often called colas.

As flowering proceeds, closely watch any plants that have not clearly indicated their sex. Males usually indicate earlier than females, so you are less likely to encounter males starting to indicate later in the season.

Male flowers sometimes appear just as a bud is maturing. They are an indication that the bud is ripe.

HERMAPHRODITISM

Some plants that are primarily female become hermaphrodites and grow male flowers in addition to female ones. This can happen indoors and outdoors, though stress plays a role, and some varieties are more prone to hermaphroditism than others.

A hermaphrodite's male flowers may be interspersed among its female buds; they may appear in clusters; or they may occupy one or more separate branches.

For obvious reasons, hermaphrodites are dangerous in any sinsemilla garden; even a single male flower can ruin many neighboring buds. Any plants with male flowers should be removed from the garden. This is the only safe course of action.

Older male flower: In your sinsemilla garden, these are useful to breeders.

Trying to control a hermaphroditic plant by removing just the male flowers is an extremely difficult task, and one mistake, lapse in monitoring or hidden flower can cause serious damage. Even if the plant seems like a winner, it is not worth risking the rest of the buds in the garden.

There are several reasons why a plant becomes hermaphroditic. It may have a genetic disposition to be a hermaphrodite. For instance, French hemp breeders have developed monoecious varieties; all of the plants have both male and female flowers. Female plants sometimes develop male flowers as a result of stress, including irregular light cycles and heat stress during flowering, or other drastic changes in the environment.

Some plants develop male flowers just as they ripen. This is an indicator of ripeness, and is not a danger to the garden since the plants are to be harvested shortly.

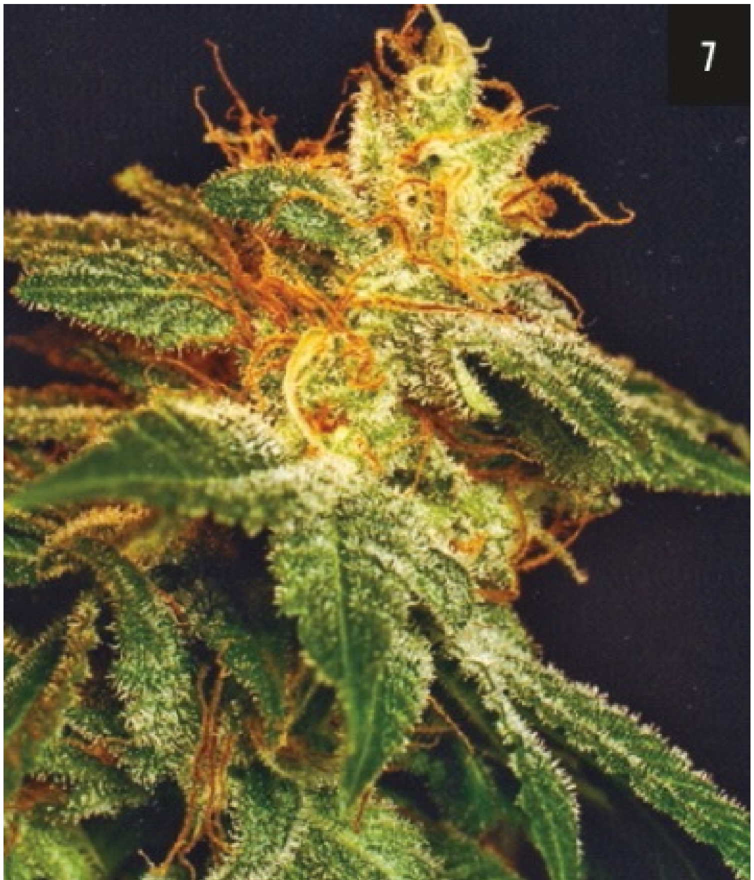
Use blue fluorescents or LEDS to induce indication flowers in vegetative plants. Give the plants 12 hours of regular light and then 12 hours of blue light. The plants will continue to grow vegetatively, but they will also produce some flowers.

FLOWER GROWTH

Within a few days of establishing a long dark period the plant's growth pattern changes. First, its rate of growth, which might be as much as two inches (5 cm) a day during the vegetative growth cycle, slows. Under a flowering light regime, indica varieties usually grow another 20-25% taller and wider. Sativas can double in size before growth stops. Hybrids have growth patterns that vary between these two extremes. If you are intending to produce seeds and have both male and female plants growing, they begin to differentiate and become dimorphic.

The males elongate and grow new shoots that hold the flowers, or they develop flowers along their existing branches. Upon ripening, the male flower sacks, which contain copious amounts of pollen, tower above the females. This difference serves the plant well, since marijuana is normally wind-pollinated, and the pollen from a tall male plant is more likely to catch the wind for a ride and drift down into an obliging female stigma below.

Within the first week, females start to grow stockier stems with shorter nodes between the leaves. The number of fingers on new leaves decreases, and the plants no longer form leaves on opposite sides of the stem but now alternate sides. Most importantly, the first stigmas appear.



JACK HERER VARIANT SATIVA-DOMINANT—Flowering by weeks: (1) Week 1: Vegetative growth has slowed, growth is in transition. (2) Week 2: First stigmas appear. (3) Week 3: Vigorous flower growth begins. (4) Week 5: As vigorous flower growth occurs, layers of stigmas appear. This continues through week 7. (5) Week 8: New flower growth ends; stigmas start to dry and trichomes become more prominent. (6) Week 10: Stigmas have dried and changed color from clear to milky white or amber. Trichomes stand more erect as they fill with resin. The ovaries are beginning to expand. The odor is becoming more pungent. (7) Week 11: This bud is ripe! The trichomes are erect and the caps are stretched thick with resin. They fluoresce in the light and the odor has intensified.

Using specialized formulas and nutrients during the flowering cycle can help increase your crop’s yield. Home and Garden Shooting Powder is a flower booster that starts a new flowering cycle after the regular flowering phase, which creates a new layer of growth over the existing flowers and increases yield by up to 20%.

Home and Garden Bud XL can be used in conjunction with Shooting Powder, and helps direct energy to new growth in the flowers, rather than the leaves.

Flowers develop capitate trichomes all over their outer surfaces. They also develop along the small leaf parts surrounding the flower. These capitate trichomes are unlike the sessile trichomes found on the immature plant, the sun leaves and the stem. The sessile glands are small and are either directly connected to leaves or stems or rest on a one-cell stalk. Capitate trichomes have a much longer, four-celled stem with a large, bulbous cap at the end. When these trichomes first appear, the caps are small, but they swell as the resins are produced and stored. By the time they are ripe, the caps look like balloons so over-inflated that they might burst. Given any stress, such as wind, rain or touch, many of them will.

By the second week, the first stigmas are joined by a cascade of flower growth. The plant is now spending most of its energy on flower development.

The flowering pattern changes as the stigmas begin to wither, dry, and turn red, purple, or even a light brown, similar to the pattern of fertilized flowers. In the third week, a large number of stigmas form along the stem and on the tops of the branches. As long as it remains unfertilized, the plant continues to produce new flowers.

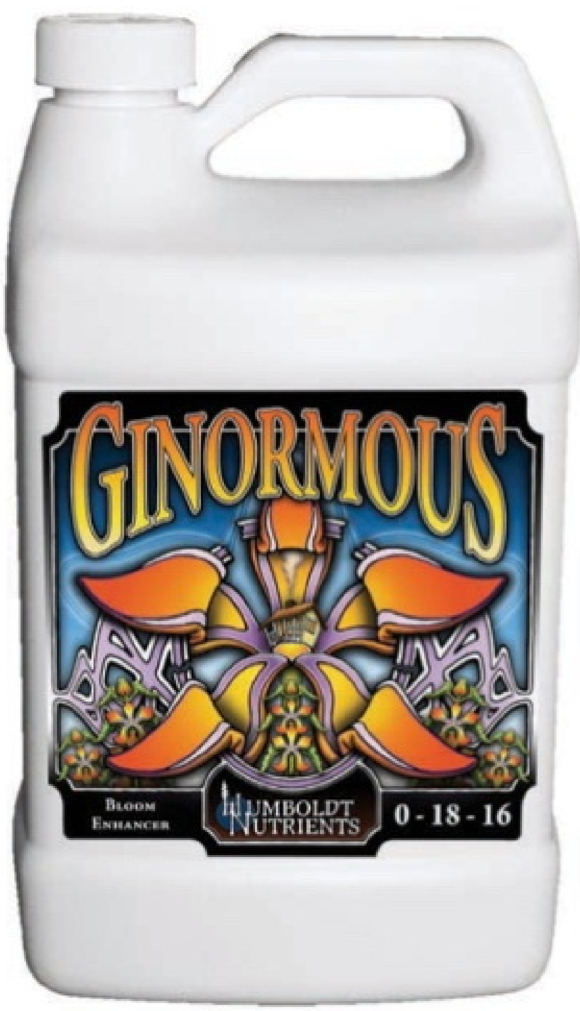
Over a period of several weeks, the clusters grow thick with unfertilized flowers forming at each leaf node along the branches and main stem. The buds fill out with fresh, moist stigmas reaching out for pollen. Just as the cluster looks like it’s finished, a new wave of flower growth appears, usually concentrated in a relatively bare spot. Successive waves of flowers may appear for weeks.

The stigma's color is a factor of genetics and temperature. Many indicas and most sativas develop a red color; however, the color may change to purple or become more pronounced, particularly if the roots are subjected to a cool environment, below 55˚ F (12˚ C).

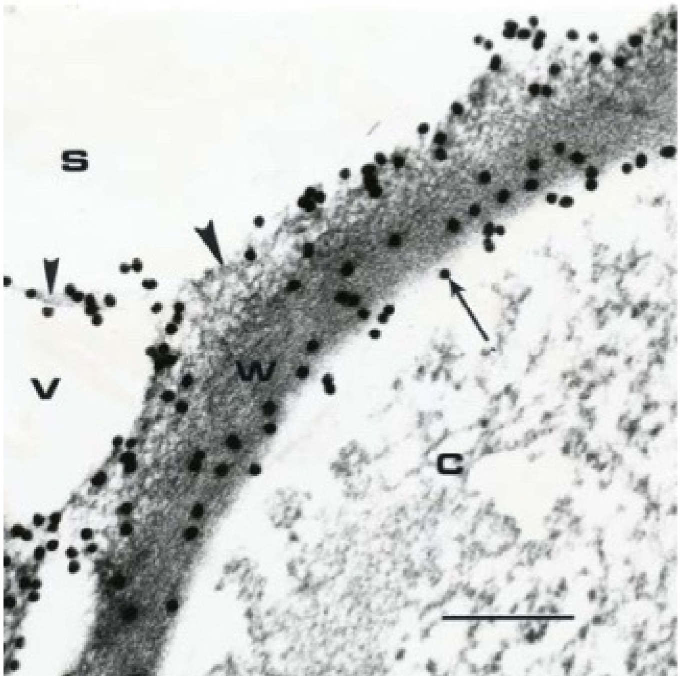
Flower ripening starts between the fifth and eighth week. The calyxes (ovaries) start to swell. These are false seed pods; the flowers have not been fertilized and no seed can develop. The swollen calyx is one indication of ripeness. It begins about two weeks before maturation, so the timing depends on the variety.

Capitate trichomes, the tiny stalk-like resin glands that fill with THC, terpenes, and other cannabinoids, start to grow on the leaves surrounding the flowers. The flower areas will become totally covered with resin glands. The length of this stage of growth can last from two to five weeks, depending on the variety. Varieties that ripen in seven weeks usually spend about three weeks in this period of heavy flower growth. Late-season and long-maturing varieties linger in this stage for five weeks or more.

The trichomes become more prominent and stand more erect. The cap that tops each one swells with resin. The viscous, sticky liquid contains terpenes and cannabinoids such as THC, which are produced on the inside membrane of the trichome cap. As the resin accumulates in the cap, the flowers' odor becomes more intense.



Many growers like to give their crop a "bloom booster," before their final flush. Bloom boosters are nutrient formulas designed to improve the flavor, aroma and size of buds. Ginormous from Humboldt Nutrients is 100% biodegradable and can be applied foliarly during the first week of flowering.



This X-ray micrograph shows THC manufactured at the inner wall of the trichome membrane. The little dots represent THC molecules at the surface of the inner wall. The photo was taken by creating an antibody enhanced with gold that docked to the THC molecule, making it visible through an X-ray image. Photo: Professor Paul Mahlberg.

Many gardeners pick the buds before they are ripe. They miss the intense odors and flavors of ripe cannabis, not to mention the enhanced high and stronger medical properties. It's worth the extra time to harvest ripe buds. Would you want to eat an unripe peach?

The odor reaches a peak at the same time the trichomes begin to fluoresce in the light, twinkling like little crystals. In some varieties, they are so prominent that the whole bud sparkles. Using a magnifying glass, a photographer's loop, or a microscope, you can monitor the buds progression to the peak of ripeness by watching the resin in the gland tops. Under magnification, you can see the individual glands turn from clear to amber or a cloudy white as they mature. These colors indicate that the THC is beginning to degrade into two other cannabinoids, CBL and CBN, which are not nearly as powerful as THC. When they begin to change from clear to amber or cloudy white, the buds should be harvested. This is the peak moment.

No bud should be picked before its time. Plants and varieties differ as to maturation pattern. Some plants mature all at once, so that the whole plant can be picked. Other varieties mature from the top down, or the buds on the outside of the branch mature faster than inner buds hidden from the light. Once the outer buds are harvested, the inner branches are exposed to light and quickly ripen. It can take two weeks of choosing mature buds before the plant is totally picked. Picking the plant a little at a time ensures that every bud is at maximum potency and quality.

VARIATIONS ON LIGHT AND FLOWERING REGIMES

The flowering response to different light cycles is a graduated one. Plants that initiate flowering at a particular light to darkness ratio will flower more heavily when the length of darkness is increased. This response is more pronounced on plants such as indicas that originated at higher latitudes, where the light cycle is more pronounced. All varieties respond to a longer dark period by hastening ripening. Shortening the light regime down to 10 hours of light and 14 of darkness forces all plants, indicas as well as long-flowering sativas, to ripen faster.

Cannabinoids and terpenes are costly for the plant to produce, so they must serve a purpose, or they would never have evolved. THC and the water-soluble compounds which impart the taste and aroma to cannabis flowers protect the plant:

- **By acting as anti-bacterial agents.**
- **Repelling or trapping insects.**
- **The psychoactive effects probably causes mental discomfort to birds and mammals that eat it.**
- **THC levels increase as UV-B exposure increases, so THC**

probably protects the plant from UV light. This is not an uncommon use of chemistry by plants.

- **To assure that the flowers and seeds are not consumed before they mature, plants produce a powerful array of chemicals to thwart predators.**
- **Once the seed matures and drops out of its resin-coated pod, it is far more palatable to animals that were repelled by the resin. Small mammals and birds may eat the seeds, and some of the seeds pass through the animals' digestive systems and remain viable. As animals excrete viable seeds on suitable ground, they spread the plant to new locations.**

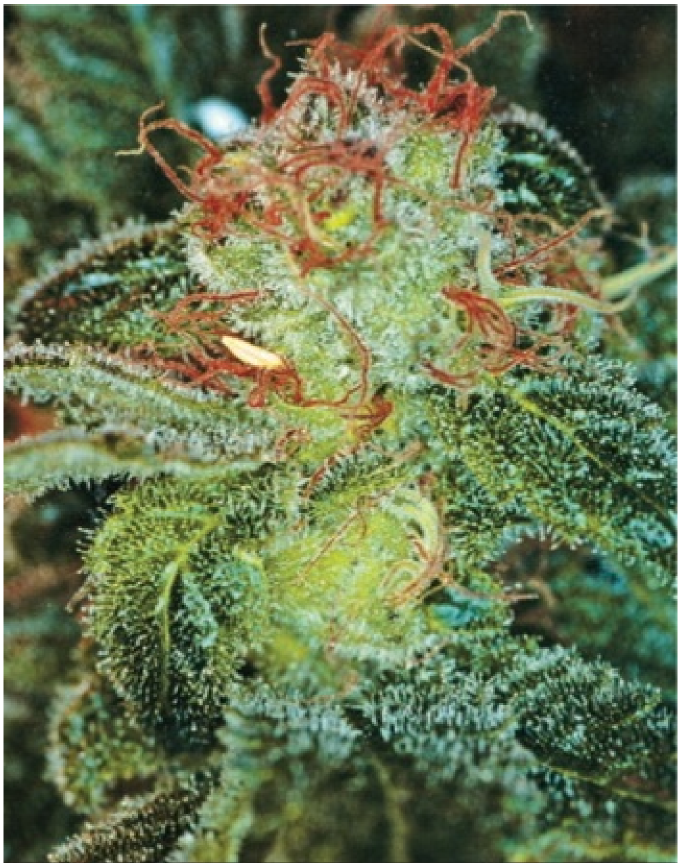
A consistent, uninterrupted dark period is key to good results for marijuana and other long-night flowering plants. Chrysanthemums are an example whose growth patterns and flowering behaviors have been studied extensively by the greenhouse industry. Researchers found that the largest flowers with the highest total weight are grown when the dark-cycle routine is provided each night. When the plants were in darkness only six nights a week, there was a slight diminution of flower size and total weight. With each additional lost night, flower size and weight dropped.

Without consistent dark periods of sufficient length, cannabis buds elongate and grow looser. Every time the dark period of the flowering cycle is interrupted, there is a slight loss of flower-growing time and thus of yield. A spate of light interruptions of the dark cycle may also stress the plant to the point that it becomes hermaphroditic.

Some cannabis varieties have a flowering trigger that they respond to under normal growing conditions, but when they are accustomed to an unusual light regimen, they may respond to the change in the light conditions in unusual ways. For instance, early-flowering indicas normally trigger when they receive a minimum of 10 hours of darkness, but when they are grown under continuous light, a regimen of just eight hours of darkness, they will initiate flowering.

Once indicas are triggered, the light cycle has little effect upon them. The developing flowers are not as sensitive to occasional interruption of the darkness cycle. Indica-sativa hybrids, early-flowering indicas, and South Africans react similarly. These plants don't revert to vegetative growth as easily as some sativaindica varieties, so the plants are harder to regenerate. Some varieties, especially indicas, respond to unnatural light cycles by showing photoperiod response disorders. For instance, some female plants turn hermaphroditic when exposed to long dark periods during early growth.

A bud, ready to pick. It has been held upright using a bamboo pole and a twist-tie.



A stray male flower on an older bud is often an indication of ripeness.

Cold may hasten sexual expression but not flower development of some northern varieties. Cold weather slows growth, lowers yield, and delays ripening. In autumn, gardeners often protect their northern-variety plants from bad weather, waiting for a few days of warm, sunny weather so the buds will ripen.

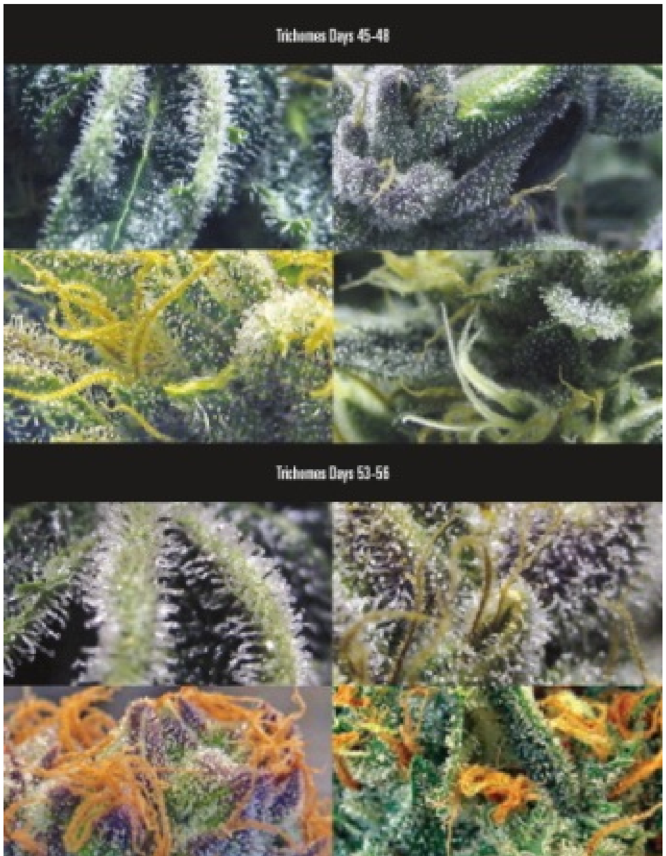
Males and ruderalis strains from the far north are not photosensitive at all. Both age and development play a role in determining when these plants flower. Ruderalis develops flowers under continuous light within a few weeks of germination. Males of most varieties indicate under continuous light within three to nine months. Some equatorial sativa males are exceptions and require a dark period to flower. Under 18 hours of light, males indicate sooner than under continuous light.

AUTO-FLOWERING PLANTS

This trait has been bred into several varieties that are available commercially as “auto-flowering” plants. No matter what light regime they are growing under, they will germinate, grow and flower in a predetermined pattern. Some varieties are 90-100 day plants from germination to harvest. These varieties produce small plants for the most part. They are very difficult if not impossible to treat as clones so feminized seeds are helpful when growing a garden of the auto-flowering plants.

Notice the circled areas. The glands stand completely erect since they are filled with resin (notice the circled areas).

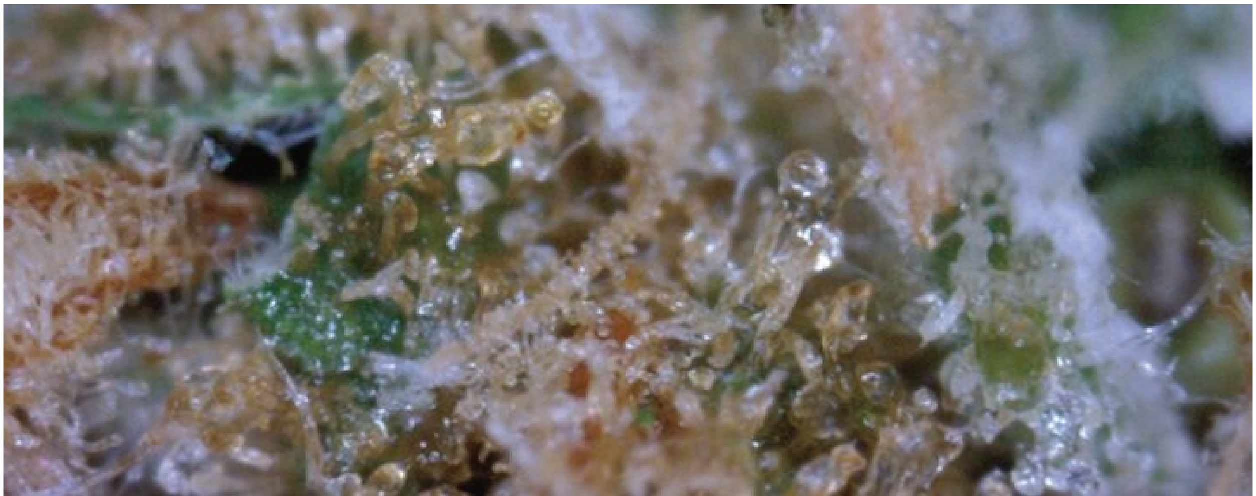
1-2. Close-up of mature buds. The trichomes look like little crystals as they fluoresce in bright light. 3. Two stigmas are attached to each female flower. Both must be pollinated. One becomes the seed and the other the endosperm, food for the embryo. 4. With rough handling the outer gland heads fall off. Be kind and gentle to your buds.



The path to ripening takes many commercial varieties only 55 to 65 days. The last quarter of the flowering period is the most exciting. At day 45 the stigmas are still fertile, searching the air for pollen. The trichomes are present but the caps have not yet filled. At day 48 the stigmas are still fertile but the trichome caps are becoming more visible. By day 53, the stigmas have turned brown and the bud has taken on purple tones, but the trichomes aren’t filled to membrane stretch. The odor intensity is increasing. Finally, at day 56 the trichome cap membrane is stretching and creating glistening crystals under the light. The odor has reached its peak intensity. Photos: Rachael Smzajda, Courtesy of Harborside Health Center

UNRIPE BUD: The caps on the trichomes have not swollen to the point where they look like they will burst. All of the glands are still clear, indicating continuing growth.

RIPE BUD: The caps are swelling and the first ones are turning translucent or milky white, an indication that THC deterioration has begun. The caps are fluorescing.



OVERRIPE BUD: The caps are falling off the trichomes and changing color. Photos: Rachael Smzajda, Courtesy of Harborside Health Center

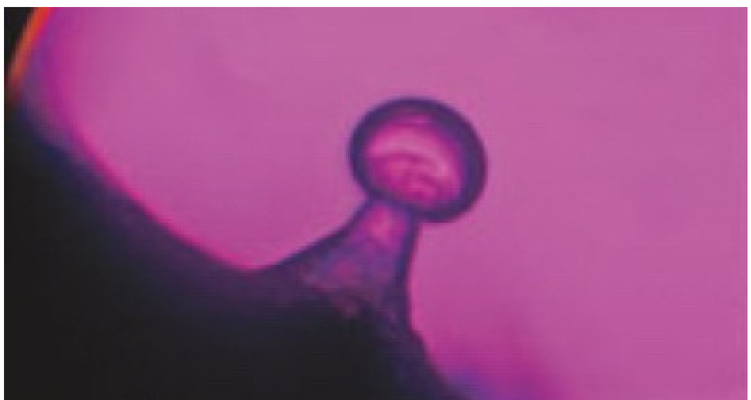
CRITICAL LIGHT PERIOD

The 12/12 light-dark period formula has been accepted without question by growers all over the world. Probably one of the reasons for this was my discussion of the technique in some of my early books. The 12/12 regimen was selected because my co-author and I reasoned that no matter what critical period a variety might have, given 12 hours of darkness it will flower. However, most marijuana varieties need fewer than 12 hours of darkness to flower.

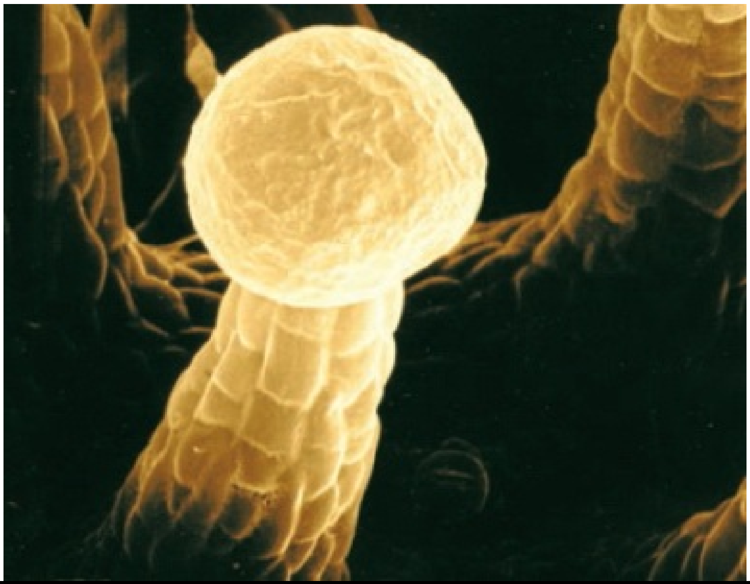
If marijuana plants grown outdoors required a 12-hour dark period to flower, they would not be induced to start flowering until September 21st, the first day of autumn, when day and night are equal length. They would ripen 6-8 weeks later. Most modern varieties ripen between early September and late October. Budding was triggered six to eight weeks earlier.

For instance, an eight-week variety that requires 55 days from forcing to maturity, which would normally ripen on October 1st, would start flowering August 1st. At that date in San Francisco, sunrise occurs at 5:14 am and sunset at 7:18 pm, a total of 14 hours 4 minutes. Dawn and dusk add another 15 minutes of red light. Plants use the absence of this spectrum to measure the dark period. The total lit period came to about 14 hours and 20 minutes, leaving nine hours and 40 minutes of darkness. The critical period for this plant was nine hours 40 minutes. If it were given just 10 hours of dark period daily indoors, rather than 12 hours, it would still flower. To initiate ripening, give plants an extra hour of darkness after the first 3 or 4 weeks of flowering.

A forest of immature capitate trichomes. The caps that hold the THC and terpenes have not filled. Photo: Tom Flowers

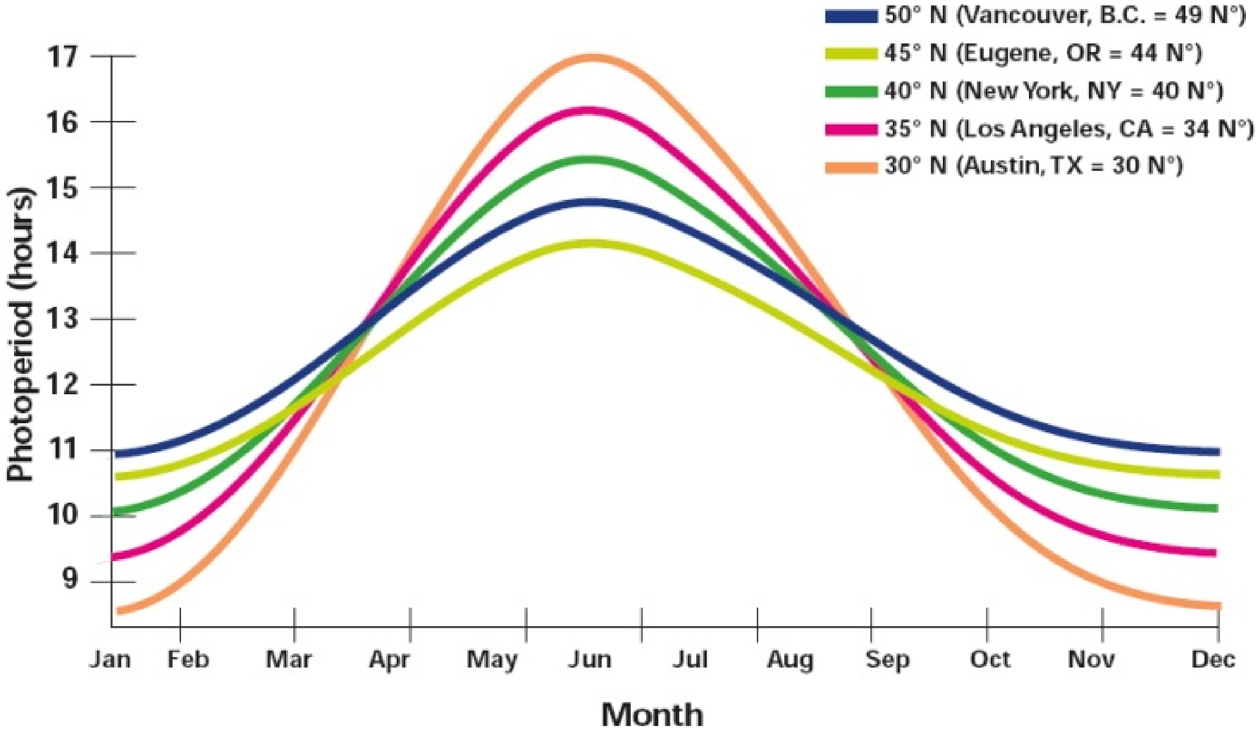


A single mature trichome. Notice the top has blown up like a balloon. Photo: Tom Flowers



Electron micrograph of a single trichome in a forest. This gland is filled and ripe. Photo: Paul Mahlberg

PHOTOPERIOD CHANGES BY MONTH & LATITUDE



The further a region is from the equator, the greater the seasonal variations in light period.

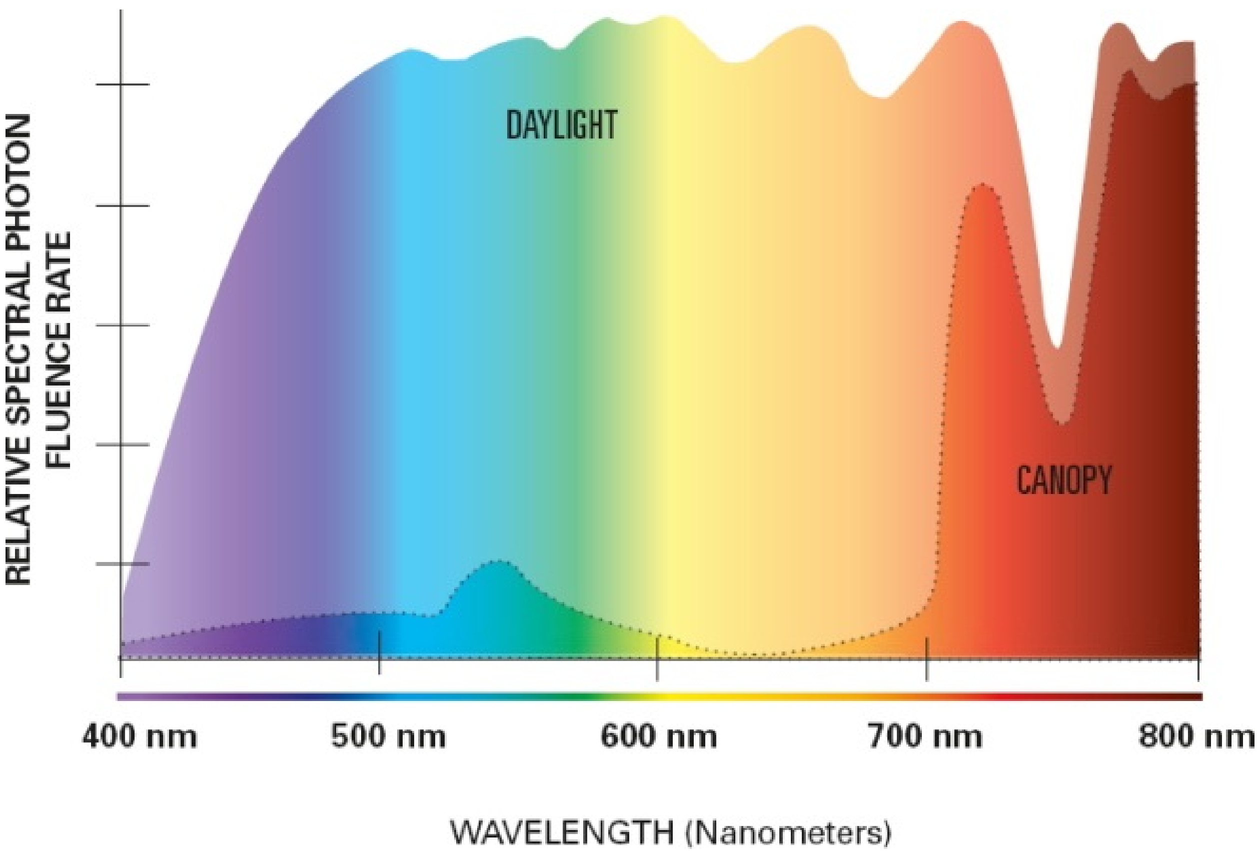
The latitude of your location affects ripening time. Take this into account when developing a growing strategy.

Gardeners growing outdoors who discover the critical time needed to induce flowering can use this information to get more efficient use of their indoor garden. Currently, plants grown under a 12/12 cycle spend half their time in the dark. If the plants have a critical flowering time of, for instance, 10 hours of darkness daily, they can be provided 14 rather than 12 hours of light each day so that they receive almost 17% more energy with which to produce sugars used for more and faster growth.

MANIPULATING LIGHT OUTDOORS

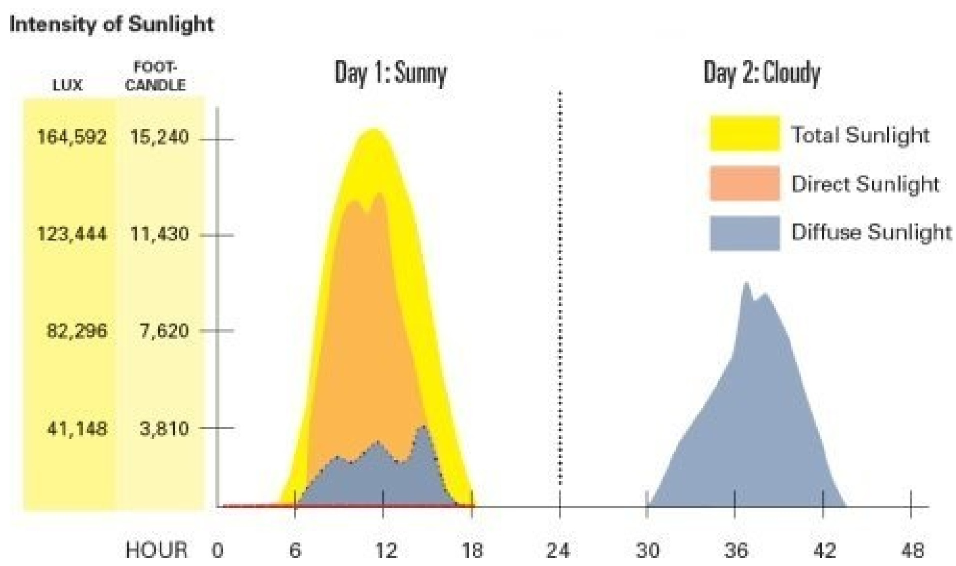
Sometimes I think nature didn’t get it quite right on marijuana ripening, as far as we are concerned. If it were determined by human needs, the buds would be ready in late spring and ready to enjoy in early summer—the party season. If they ripened at the best time for the farmer, it would be in high summer when the weather was warm and the sun strong. Alas, nature has chosen the fall. The harvest can be good if the weather doesn’t attack first.

ACTIVE SPECTRUM OF PHOTOSYNTHESIS



The upper line shows sunlight reaching the top of the canopy. The lower line shows light reaching the understory. Plants absorb or reflect most of the blue, green, yellow and red light. Some of it is used for photosynthesis. Far-red light (730 nm) is mostly transmitted or reflected, so there is a much higher ratio of far-red to red light under the canopy than in full sunlight.

SUNLIGHT INTENSITY ON SUNNY AND CLOUDY DAYS IN EARLY SUMMER



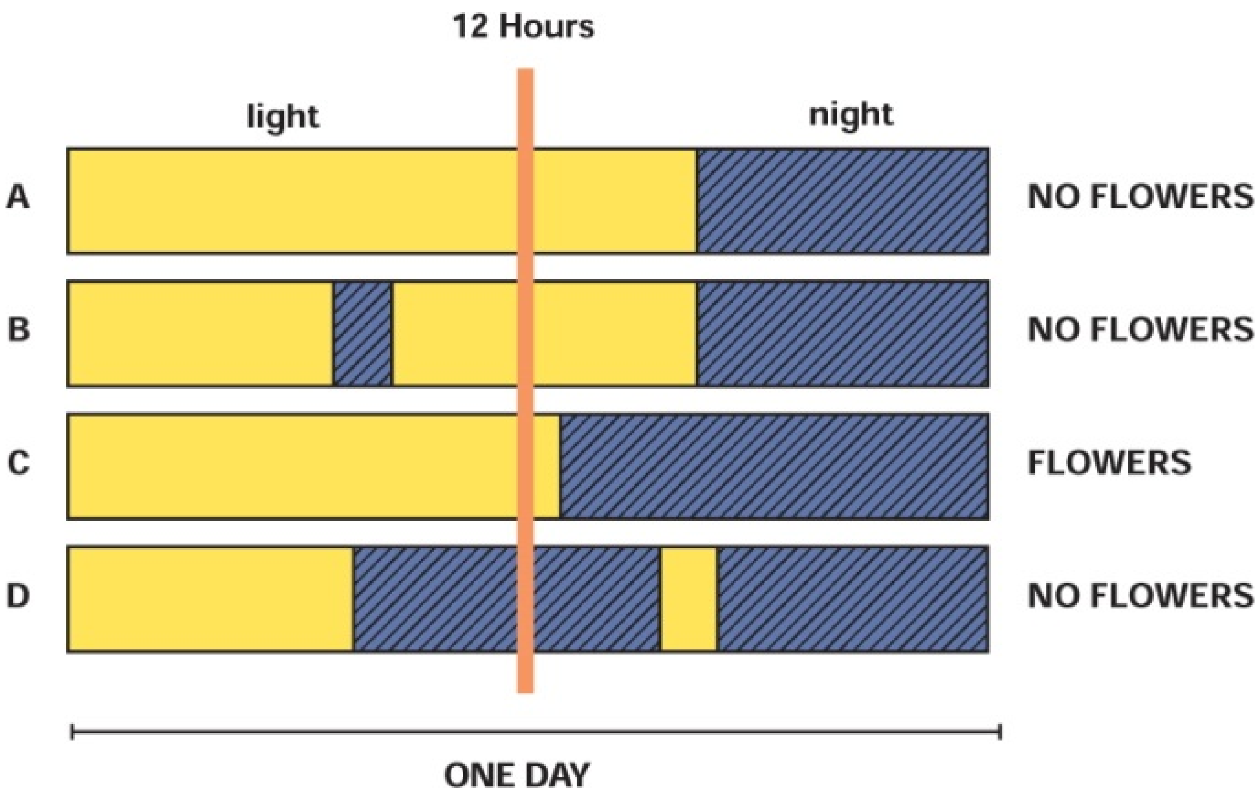
Notice the difference in the amount of light between sunny rather than cloudy days.

With a bit of effort you can manipulate the outdoor light cycle to grow and flower the plants at your convenience. I think that the best and most convenient time to harvest is during the summer rather than the fall. Buds that ripen midsummer experience much more intense light and much more UV spectrum than fall ripened buds. The intense light gives the plant energy to grow a bigger bud. The UV light increases its potency.

During the late summer through winter and mid-spring, the dark period is long enough to trigger plants to flower. Sativa dominant hybrids continue to grow even after they have been triggered to flower. Indicas grow just a little after they are triggered to flower.

Another technique is to interrupt the dark cycle with light. The light doesn’t need to light the plant for long, just a few seconds. Think of it as a water spray. You want to get all the leaves “wet” with light, but once they have been sprayed they need no more light. This short interruption of the dark cycle is enough to reset the time count of uninterrupted darkness. By lighting the plants every few hours during the dark period, the plants continue to grow vegetatively, and not flower.

FLOWERING CHART



A. If the plants receive 18 hours of light, they do not flower. B. If the light cycle is interrupted by a dark period, the plants will not flower. C. When the plants receive 10-12 or more hours of uninterrupted darkness, they flower. D. When the dark period is interrupted, the plants won't flower.

When the light interruption stops, the plants immediately start to flower. Plants can be started in August and planting can continue through the winter. To increase growth natural light can be enhanced using reflective material and electric lights. Spring starts on March 22nd and on that day light and dark share equal time. At the equinox, or shortly thereafter, the dark period may become too short to support flowering, and the plants will grow vegetatively.

To get the best possible harvest, force spring plants to flower in June. If plants are forced June 1st, they will be ready mid-to late-July. If they are forced July 1st, they will ripen mid-August.

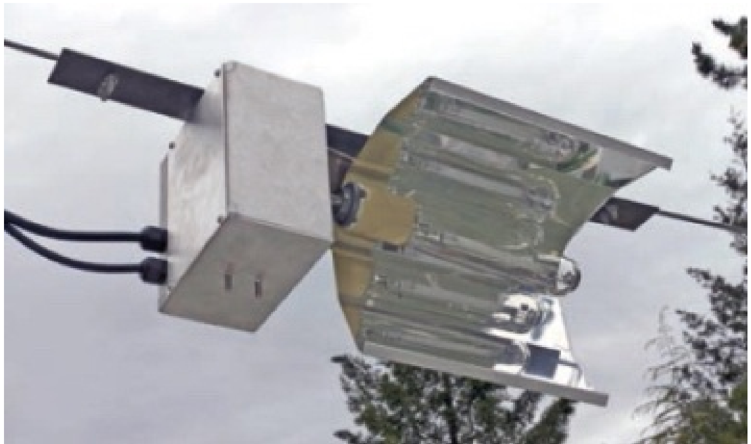
EARLY HARVESTS & PHOTOPERIOD MANIPULATION

In some areas, the light is intense enough and the temperature sufficiently warm to garden early in the year, sometimes beginning as early as February. Greenhouses increase the number of gardeners who can use this method. The only problem facing the gardener is providing the 14-15 hours of light the plant needs to grow strong vegetative growth.

Plants started indoors can be placed outdoors in February and or early March, when they receive more than 12 hours of darkness and they will immediately start to flower. To keep the plants growing vegetatively, interrupt the dark cycle using periodic lighting at night. Since photoperiodism is a localized effect, the whole plant must be bathed in light for a short time to interrupt the flowering response. Both warm white fluorescents and HPS lamps can be used to prevent flowering because they are strong in red light but contain no far-red. The lights can be used a single time during the night cycle or, for best results, switched on every few hours. Once the plants reach the desired size, turn the lights off, and they will start to flower.

If the temperature around the root ball becomes too cold, it can stunt plant growth. Although the light may have extended during the day, in colder areas it is difficult to plant outside due to frost risk. Thermoplanters from Black River Nursery keep the temperature of the root ball between 75-80° F (24-26° C), which eliminates root disease and fungus problems as well as cold root shock. It uses less water than a traditional planter because the heated planter evaporates the water back up to the plant. It comes with a plastic cover that converts it into a miniature heated greenhouse.

The garden was in a warm area so the plants were placed outside early, in March. Since the nights were still long the plants would ordinarily have started to flower. By interrupting the dark period after five hours with bright lights the plants continued growing vegetatively. Several 24w warm white CFL fluorescents were placed in bowl reflectors and attached to a pole with clamps. Usually two people walked the pole over the plant rows. The plants didn't need to be under the lights for long. A leisurely stroll once a night for 45 nights kept the plants growing vegetatively.



This light, called a beam flicker, rotates the light back and forth to provide plants with enough light to interrupt the dark cycle. It covers about 2,000 sq ft (190 sq m). It is much easier than a daily stroll and is automated using a timer.

This technique of interrupting the night cycle may also be necessary for certain varieties in outdoor gardens in lower latitudes. For instance, most indicas and some indica-sativa hybrids flower very early in the season in the southern tier of the Northern Hemisphere because the light cycle never gets long enough to prevent it. Plants closer to a 50-50 indica-sativa mix withstand the long summer nights and continue growing a bit through part of the flowering cycle. These are good candidates for early harvests.

LATE-SUMMER CROPS

You can generate a late-summer crop by moving indoor plants outside late in the season. Most varieties start to flower when they are exposed to 10.5 to 11 hours of darkness daily. This occurs between late July and mid-August in most of the middle U.S.

This home-built greenhouse was situated atop a building in Amsterdam. It helps grow beautiful buds to maturity in the short, cool, cloudy Dutch climate.

Plants placed outdoors in July have a chance to grow a bit during the waning days of summer before longer autumn nights force them to flower. Plants placed outdoors in August, when the dark period has increased to 10.5 to 11 hours, will flower no matter what size they are.

Sativas continue to grow a bit even as they transition to flowering. As flowering progresses, they put all of their energy into reproductive development, producing long colas filled with buds. They often require 90 days or more to ripen, so they can only be grown where the growing season extends into late October or early November.

Sativaindica hybrids continue to grow a bit although they are transitioning to flowering. They are the best varieties to grow in areas where plants can be harvested in mid to late October.

Indica-sativa hybrids don’t grow much larger after they start flowering. They are likely to be shocked into flowering when they are placed outdoors after being grown under continuous light, so use 18 hours daily indoors. They ripen six to eight weeks after being triggered to flower.

During the intense days of early August, indoor plants moved outside require conditioning in shade before being placed in bright light. An anti-transpirant can be used to help the plants withstand sunburn and adjust to UV light, which is mostly absent indoors under HPS lamps.

WINTER CROPS

This technique works best in conjunction with an indoor garden to supply plants. The idea behind this is that from late August through the beginning of February, plants placed outdoors are triggered to flower by the long nights. Plants placed outdoors start flowering and ripen within eight weeks.

This technique can be used in subtropical and low-latitude mild-climate areas such as Florida, the Gulf Coast, Hawaii, Southern California, and the Mediterranean zone, all of which receive sunlight intense enough to support fast growth in winter.

Light deprivation gives the gardener control over the light cycle outdoors and in greenhouses, allowing them to grow more crops, and crops out of season. The Light Deprivation Greenhouse by Forever Flowering uses a breathable fabric that rolls out with the flip of a switch. It allows the gardener to supplement light inside as well as block out light from the outside. They are environmentally friendly as well as convenient for overheard security.

There are many advantages to growing winter crops:

- They require less irrigation than summer crops.
- Non-summer crops grow in a better temperature range. Temperatures lower than 85° F (29° C) support rapid growth and dense bud development. Temperatures above 90° F (32° C) stress the plant and decrease growth and result in looser buds.
- Plants are less likely to be attacked by insects because fewer of them are around, and they are less active in lower temperatures.
- The plants stay much smaller and are more controllable.
- Cops and robbers are not looking for cannabis out of season.

GREENHOUSES

Greenhouses are ideal environments for extending the garden season. Even unheated greenhouses add three weeks of growing time to both the beginning and end of the season. You can gain another two weeks of growing time using passive heating techniques such as blackened water containers which absorb sunlight and radiate heat at night. Mechanically heated greenhouses can be used all winter.

JUMP STARTING FLOWERING

Long periods of uninterrupted darkness are nature's trigger to marijuana to begin flowering. This is measured chemically by phytochrome, which is deactivated by red light. The inactive form is referred to as Pr. In the absence of red light, with a peak at 666 nm and effects from about 500-700 nm, Pr drifts into its active form Pfr, over a period of about two hours. This begins at dusk or when the lights are turned off. This transition period, during which Pfr has limited effectiveness, can be dramatically shortened.

Pr is sensitive to far-red light with a peak at 730 nm and is affected in a range of about 700-750 nm. In its presence it changes almost immediately to the active form, Pfr. This effect is useful for shortening the two-hour time it takes plants to switch from the inactive to active form.

Indoors, after the grow lamps are turned off, expose the plants to

far-red (730 nm light) which turns the Pr to Pfr much faster and induces flowering within a shorter dark period. You can provde far-red lighting using LEDs or some fluorescents. Far-red light can also be used to restore the active form of the hormone if the dark is interrupted by light. This may ameliorate the consequences of darkness interruption.

Outdoors, you have no control over dawn and dusk, but you can force flowering out of season by using far-red lighting to increase the time the plants are under Pfr's flower-inducing influence by two hours. Plants receiving 15 hours of light and 9 hours of darkness react as if they were under a lighting regime of 11 hours of darkness because of the additional two hours of active hormone. Most plants initiate flowering under 11 hours of darkness, which is shortened to 9 after exposure to 730 nm far-red light. The plants should be exposed to far-red light each evening at the end of dusk. They need only a few seconds of the light each night.

Growers in all latitudes can use this technique as well. In northern areas, the plants require supplemental illumination and heat in winter because the intensity of sunlight drops precipitously low beginning mid-November and continuing through mid-February. Even with the additional effort needed to meet the plant's environmental and energy requirements, greenhouse gardening is far easier than growing indoors.

Late ripening sativas can be forced to flower using light deprivation. By forcing them in late spring or early summer they will have enough time to ripen.

These plants were harvested August 12 after seven weeks of flowering using light deprivation. After 12 hours of light the white/black shade curtains were placed over the plants. This took place between 6:00-7:00 PM. The curtains were removed shortly after dusk to prevent humidity build-up from condensation created by the plant transpiring. Make sure the framing is secure.

Unheated greenhouses are often used to grow late-flowering sativas that need some protection from the changing climate. They can also be used to produce a harvest using late planting. By supplementing the weak sunlight of late autumn using metal halide lamps during the lit period, the yield can be increased substantially. The amount of light used during the daytime can be adjusted to take into account the sunlight's intensity. Use 20 to 30 watts per sq ft (0.09 sq m) depending how dim the sunlight is.

White/black plastic polyethylene is an excellent covering because it is opaque. Use the white side out, so the light is reflected and doesn't heat the interior.

Keeping the plants on a 12-hour schedule by lighting the plants at full-strength 60 watts per sq ft (0.09 sq m) at the beginning or end of the night also increases yield. For example, lights might be turned off from 11:00 am to 2:00 pm when the sun's intensity peaks. A timer then turns on lights providing 30 watts per square foot for three hours as sunlight dims towards dusk. The second timer then kicks in when the 60 watt per square foot (650 watts per sq m) lights are run for the few hours necessary to get to 12 total hours of light, then turned off. This can be configured with either two completely separate sets of lights — one that provides 30 per sq ft (25 watts per sq m) and a second set that adds an additional 30 watts (325 watts metric) to the late-afternoon lighting. Don't use air-cooled reflectors if the temperature is below 80° F (26° C) in the greenhouse; the heat from the lamps and ballasts will help keep the greenhouse warm.

High temperature can be a problem when forcing plants during the summer. Buds stretch and are looser and growth actually slows when the plant temperature rises above 85˚ F (29˚ C). There are several solutions:

Water in hydroponic systems can be cooled using an aquarium water cooler or a hydroponic water chiller. Keep the root temperature in the high 60's (19˚ C); the cool roots ameliorate the heat stress in the canopy.

Misting fans and micro misting systems spray tiny water droplets that evaporate before they reach a surface. They use little water but can cool an area by 15˚ F (-9˚ C) or more. They are regulated using a thermostat, and turn on when the temperature nears 80˚ F (26˚ C) a the canopy.

UVB LIGHT AND FLOWER FORCING

Marijuana has evolved a very successful survival strategy. It domesticates easily and escapes domestication just as easily. Throughout almost its entire history of symbiotic relations with humans we accepted its natural life cycle without trying to alter it beyond developing varieties that matured a little sooner or later.

To make a change there has to be an advantage for at least one species. We have always respected marijuana as a fall flowering and ripening crop. However, it turns out that our interests and the plant's natural proclivities have diverged.

John Lydon published his Ph.D thesis in which he reported on experiments he performed on marijuana. They showed that the amount of THC that a high quality marijuana plant produces goes up in a direct ratio to the amount of UVB light that the plant receives.

The relevance of this information to this discussion is that when the angle of the sun to the earth is most perpendicular, on June 22, the first day of summer, is when that hemisphere receives the most UVB light, which is past the far end of the visible spectrum, on the blue-violet side. As the angle of the Earth and sun becomes more oblique, Earth receives a higher proportion of light from the red spectrum and less blue and UV. By September or October, when sinsemilla normally ripens, not only is the light far less intense, but the amount of UVB being delivered is a small fraction of the amount that is received on June 22nd.

UVB LIGHT CHART

The amount of UVB light a plant receives affects THC and terpene production. Plants growing under higher UV levels are more potent.

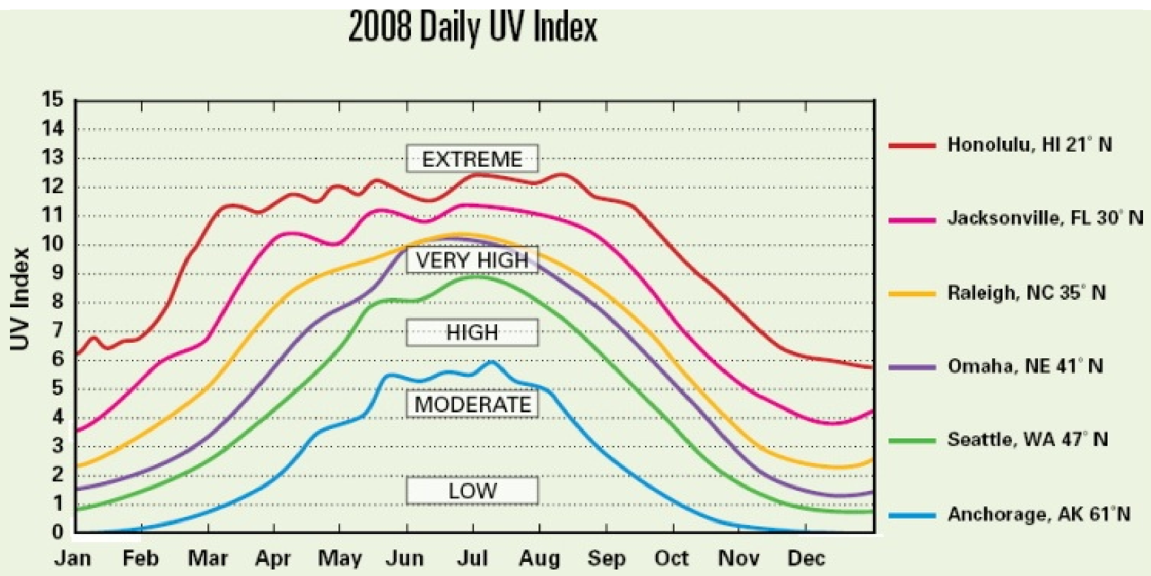
The amount of UV light that an area receives is determined by the latitude, season, climate, and weather. Light reaches the equator most directly, and is the most intense. As the latitude increases light reaches Earth at a more oblique angle so it becomes less intense.

Throughout the Northern Hemisphere, which includes North America and Europe, UV light is at its lowest levels in December and January. After these months, the levels start rising. The further from the equator, the longer it takes to peak, the shorter the peak period and weaker the light.

For instance, in San Francisco (latitude 37.75), UVB reaches it peak with a UVB index between 9-11 around May 15. It stays there until around August 15. By September 1 it drops down to 8 and by October down to 6.

If you can ripen plants during the peak UV period the plants will be at their most potent. As the season wears on and the UVB levels decline the marijuana does not attain the same potency.

Using this information, no matter where you live, even in the far north you can grow potent plants using light deprivation, so that plants ripen at the peak period rather than late in the season. This chart can help you determine planting strategy.



In Alaska (latitude 61.22), UV peaks around May 20 and starts declining at the beginning of September. At its peak, it stays within 5 and 6 on the UV index, and stays below 2 on the index between September 15 and April 1. At the other extreme, Hawaii's UV peaks and stays at between 10 and 12 on the index between March 1 and October 1. At its lowest point in December it is at level 6, a higher level than Alaska at its peak. More UV index information is available online at: http://www.weather.gov/view/national.php?prodtype=ultraviolet

Marijuana buds that are ripening under the intense sun of early summer grow bigger, denser and are more potent than when they ripen under the waning sun and variable weather of the fall.

To induce flowering in plants they should be placed under 12 hours of darkness each day. Darkening curtains are placed over the garden, There are many ways to accomplish this. They range from moving the plants to and from a dark place daily, to covering the garden using an opaque plastic sheet over tunnels, to automated blackout gardens.

UVB light has health consequences to humans. It is a known carcinogen and leads to cataracts. Always shut UVB lights off before

you start working in your garden. Outdoors, protect yourself from the sun's UVB rays by covering your body and applying sunscreen. Protect you head and face by wearing an extra wide brimmed hat.

To force plants to flower you must be punctual and watch the daily changes in dawn-dusk times to make sure that the plants are getting enough darkness. You can also use an automatic system to regulate the curtains.

There are two ways to approach restricting light: darken in the morning or at night. Morning darkening is the preferred method. The shade material is placed over the garden each morning before dawn. The plants need to be shaded counting forward 12 hours from dusk. If dusk is at 9:00 pm and dawn is 6:00 am, curtains should cover the garden before dawn, around 5:30 am They should be removed at 9 a.m. after receiving 12 hours of no light.

The other method is to install the curtains in the evening. Count back 12 hours from dawn, which occurred at 6 am in the above example. The curtains are placed over the garden at 6 am Then at 9 pm, after dusk ends and night begins, the curtains are removed so that any condensed moisture can evaporate into the night air.

To force the plants to flower during the summer they need to receive the critical dark period each day. Covering the plants with a blackout cloth each day so they receive 12 hours of darkness pushes the plants into flowering mode.

In late stages, mold prevention measures should be taken because moisture levels often build up when the plants are covered. Spray the plants with Serenade® biological fungicide, Ed Rosenthal's Zero Tolerance® herbal fungicide, potassium bicarbonate, diluted milk or other organic fungicides to prevent fungal attacks.

The advantage of placing the curtain over the garden early in the morning rather than before or after dusk is that the plants transpire and dew settles after dusk. The plants stay wet under the tarp. When the tarp is spread in the morning there is less moisture to deal with. The further from the plants that the coverings are placed the less of an effect condensation has on the garden.

The very best outdoor marijuana is grown using this technique. The reasons are more intense light, more UVB light and better weather conditions with less chance of cool weather that slows growth and development.

UVB LIGHT FACTS

Ultraviolet B (UVB) light is a spectrum of light that is invisible to us but is visible to insects and some other organisms. On humans it causes suntan and sunburn and is implicated in the formation of eye cataracts. Tanning bulbs emit UVB light.

UVB light also affects marijuana potency. The potency of high quality marijuana increases in direct ratio to the amount of UVB light it receives. This is very significant. In California, where medical dispensaries operate in an unrestricted market, many dispensaries reject fall-harvested outdoor material as inferior. They have found it lacks the potency of indoor crops and is a harsh smoke. However, marijuana grown outdoors that was forced to ripen August 10th was accepted—because it had the high potency and lacked the harshness of indoor crops. Harshness is probably a result of cool nights.

Indoors, under fluorescent and High Pressure Sodium (HPS) lamps, gardens receive little UVB light. Metal Halides (MH) without glass reflectors emit a bit more. However, there are ways of supplying your garden with UVB light. Tanning lamps work, that is, lamps that tan people, because of the UVB light they emit. Using tanning lamps increases the THC content of the crop. Reptiles and lizards require the UVB spectrum to stay healthy, so 10% of the output of "reptile fluorescent" lights is UVB. Tanning lamps are available on the Internet. Use between 5-10% of your total wattage to these lamps. For a 1,000 watt garden use 100 watts of special lighting.

"Everyone smiles as you drift past the flowers, That grow so incredibly high."

Lyrics: John Lennon and Paul McCartney "Lucy in the Sky with Diamonds"

Adding UVB light to your garden enhances your marijuana naturally, without "special formulas" and chemicals.

A green CFL can be used in a flowering garden without upsetting the flowering cycle.

This light has green LEDs installed; clipped to a hat it creates a hands-free green light.

GREEN LIGHT AT NIGHT

Plants evolved for hundreds of millions of years and never encountered a separation of light spectrums or unusual lighting regimes. When they received light it came from the sun in a mixture of spectrums from which they could pick and choose. With the advent of gas and then electric lighting, plants encountered unusual regimens and splintered spectrums.

Plants measure day length using the red and far-red light spectrums. While they use other spectrums, they are not sensitive to most of them as far as flowering is concerned.

They use less green light than other spectrums, and reflect much of it while absorbing most other spectrums. Plants' insensitivity to green light can be used to a gardener's advantage. Turning a light on in the middle of the dark cycle disturbs the plants' flowering paradigm. HPS, fluorescent and MH lamps all emit red light. Green fluorescent and LED lights contain no red light and will not disturb the dark period. You can go in the garden under adequate light to work, as long as it is green.

PART IV QUICK POINTS: LET'S GET GROWING!

VEGETATIVE GROWTH

As soon as the roots have adjusted to the new environment, it is time to increase the light and nutrients. Firm, turgid leaves and new growth are indications that the plant is ready for rapid growth. The plants should be kept on a high nitrogen (N) fertilizer regimen until they are put into flowering.

When marijuana is supplied during the vegetative stage with ample amounts of all its requirements, including nutrients, it grows very quickly. If the soil or planting mix cannot meet the plants' nutrient needs, they require fertilization.

Leaves have stomata that serve the same purpose as human pores: they open and close as needed to regulate the absorption of CO_2, water and nutrients.

Plants that are foliarly fed grow faster. Foliar feeding is especially helpful when plants are suffering from a deficiency; because the needed nutrients get directly to the plant parts that need it, the leaves.

Some pruning techniques increase yield in a given area. In addition pruned plants usually occupy more space than plants left unpruned, so yield per plant may increase substantially with pruning. Pruning, bending, and supercropping can be used to increase yield, control shape and direction of plant growth.

Things to Know

- It is important to prune the lower leaves of the plant to provide airflow under the canopy and to create cuttings for cloning. This also maximizes yield by forcing the plant's growth energy to the top limbs where they receive the most light.
- Contrary to myth, most fan leaves should not be removed during the vegetative stage. They are sugar factories that turn light into chemical energy. They are used to power metabolism and build tissue by

combining them with nitrogen and phosphorous to make amino acids and proteins.

FLOWERING

Marijuana is a short-day plant. As the days get shorter, the plant determines when it is time to flower based on the number of hours of uninterrupted darkness it receives. The natural life cycle of the marijuana plant, a fall-flowering annual, is to germinate in the spring, grow vigorous vegetative growth through midsummer, then flower and produce seed in the fall. You can manipulate the natural cycle and increase production by altering the light regime, even outdoors.

As long as the plant is exposed to red light in the 680 nanometer range, phytochrome, the hormone responsible for flowering, remains inactive. When the plant is in a period of extended darkness, the hormone gradually changes to the active form over a period of two hours. When the flowering hormone levels remain high for a critical period of time over several days, plants change their growth from vegetative and initiate flowering.

The number of hours of darkness plants need in order to initiate flowering differs by variety. To force flowering, lights must be turned on and off with consistent regularity, and the darkness must be uninterrupted. A consistent, uninterrupted dark period is key to good results for marijuana and other long-night flowering plants.

In order for the female flowers to ripen without creating seeds, they must remain unpollinated (unfertilized). Because cannabis is dioecious, male and female flowers appear on separate plants. Male flower buds look like bulbs growing from thin stems, with a curved protrusion at the bulb's end that comes to a blunt point. Female flowers have no petals, but they are identifiable because of their pistils. Some plants that are primarily female can become hermaphrodites and grow male flowers in addition to female ones.

It is clear when the flowers have approached maturity and have begun ripening; capitate trichomes, the tiny stalk-like resin glands that fill with THC, terpenes and other cannabinoids start to grow on the leaves surrounding the flowers. The flower areas will become totally covered with resin glands. The trichomes become more prominent and stand more erect. As the resin accumulates in the cap, the flowers' odor becomes more intense and reaches a peak at the same time the trichomes begin to fluoresce in the light.

Since marijuana grows and flowers based on the number of hours of light and darkness, manipulating its light cycle can convince a flowering plant to return to vegetative growth.

Things to Know

- The active state of the flowering hormone phytochrome is called Pr. The inactive state is Pfr.
- Some plants that are primarily female can become hermaphrodites and grow male flowers in addition to female ones. This may occur for several reasons including genetics, stress or other drastic environmental changes.
- All marijuana varieties respond to a longer dark period by hastening ripening. Shortening the light regimen down to 10 hours of light and 14 of darkness forces plants to ripen faster.
- When the caps of the trichomes, which fill with resin as the plant ripens, turn from clear to either amber or cloudy white, the buds are ready to be harvested.

Part V

HARVEST AND BEYOND

HARVESTING

When the bud is ripe, it's time to harvest. As you would expect, there is more than one way to harvest the plant. The methods fall into two main categories: harvesting the entire plant or harvesting individual buds as they ripen.

The advantage of harvesting individual buds as they ripen is that it gives the lower buds and buds hidden inside the canopy the chance to fully mature. This usually occurs within 10 days. There is a significant difference in potency and quality between unripe and ripe buds, so the extra time and labor that multiple harvesting sessions or daily bud inspections entail are well worth the effort, even for large harvests.

PICK NO BUD BEFORE ITS TIME

Some buds ripen before others since the upper canopy captures most of the light. Indoors, if there are only one or two stationary lights, a high proportion of the plant parts near the tops are in continuous shadow. Buds and leaves beneath the top canopy are also in shadow. Fewer portions of the plant are in shadow when light movers or multiple sources of light are used. However, there are still buds in the understory (the area below the canopy top) that are not ripe and need additional time.

Outdoors, buds may be hidden by fan leaves or other plant parts. Even if the plant was pruned and tied, parts may be in shadow some of the time. The variety is a factor in how the plants mature. Some plants ripen top first, others ripen bottom up, and usually buds closest to the outer edge ripen first.

Waiting the extra time and picking no bud before it is ripe assures you the finest harvest.

Another advantage of partial harvests, particularly for large crops, is that there is more time to process the material. A large harvest cut over two weeks is a lot easier to process than one that is cut all at once.

MANICURING

Manicuring is the process of removing the leaves that are growing around the buds. The best time to manicure is when the plants are freshly picked. Fresh, “wet” vegetation is turgid while it is being clipped so it is easy to handle. Just as important, the trichomes that hold THC and the terpenes are pliable rather than brittle, and are more likely to stay attached to the plant.

When dry, many of the glands snap off when the bud is handled. Growers sometimes manicure a bit while the plants are still standing. The plants are in a convenient position to remove fan leaves and other vegetation so there is less damage to the bud. Use this technique only a few days before harvest.

The plant is cut using large clippers.

Close-up of cutting.

The plants are placed in a pile that will be moved to the processing area within minutes.

Once you’ve harvested, use plenty of light when manicuring so you can see clearly exactly what you are doing. Overhead lights as well as directional desk lamps get the light where it is needed. Work over a smooth surface so the clippings and loose trichomes can be easily collected. Some manicurists work over a screen made from silk, nylon, or steel wire stretched tightly on a frame. A screen with a mesh count of about 100 strands per square inch allows any glands broken off while manicuring to drop through for later collection, while keeping the plant material on the screen. The loose trichomes, called kief, contain cannabinoids but little vegetation, so they are much more concentrated and potent by volume than the buds. Once they are collected, they can be smoked, vaporized, or added to edibles.

There are many ways to manicure, and gardeners use all kinds of scissors. What’s important is that the scissor blades are long and thin enough to get to the petiole, the leaf stem. Spring-loaded trimmers are probably the most popular. They reopen after they have been squeezed shut, so the operator doesn’t expend muscle pulling the blades apart. They also offer better control.

The procedure for manicuring freshly harvested plants begins with clipping the branches from the stem. You can then manicure the leaves while the bud remains on the branch or pick the buds from the branches.

Next, remove the large sun (fan) leaves from around the buds. This material is known as leaf. Some manicurists find it easier and faster to remove some of the vegetation by hand before switching to scissors. Fan leaves often snap off when they are pulled down.

Next, clip away the smaller, multi-fingered leaves surrounding the bud. This is known as trim. It has more glands than the leaf, so it is better quality. It is used for processing.

The bud should now appear almost naked, except for some single-fingered leaves sticking out from between the flowers. You may clip some of these leaves off at the petiole. Alternatively, trim the leaves down to the bud surface.

These four steps: clipping stem from plant, bud from stem, large leaf removal, and bud leaf removal, can be performed as one integrated operation or in steps. The choice depends on the size of the crop, the number of people trimming, and, more importantly, your preference.

Ganja being stripped by hand in Khandwa, India (1981).

This leaf is ready for further processing.

Hand manicuring. Gently hold the bud in one hand while clipping away extraneous material with a spring-loaded clipper.

This manicure screen captures the glands that fall from the buds as they are manicured. After you trim, you can scrape up the kief and smoke it!

There are many other manicuring techniques. Here are a few of them:

1. Hang the plants upside down on a taut rope or thin rod. Clip off the large leaves while they are still on the stem.
2. Cut the stems to a convenient length, such as 9" (25 cm). Then you can hold them while you are trimming the bud.
3. The market prefers naked buds, but home growers may wait on trimming the small leaves surrounding the bud. Remove them only when the bud is about to be used. The leaves form a protective shield around the bud, resulting in less damage and loss of trichomes during storage and handling.

As you become acquainted with different varieties, you will notice that their bud characteristics vary quite a bit: some are bulkier, others are longer. Bud size also varies by its position on the plant.

The amount of vegetation surrounding the bud also varies by strain. Nutrients and light intensity also play a role. For these reasons, as well as differences in the manicurists' skill, it is impossible to provide an average time it takes to manicure a given amount by hand, but the range is anywhere from one to eight hours for a pound (two and a half to 20 hours per kg) of bud.

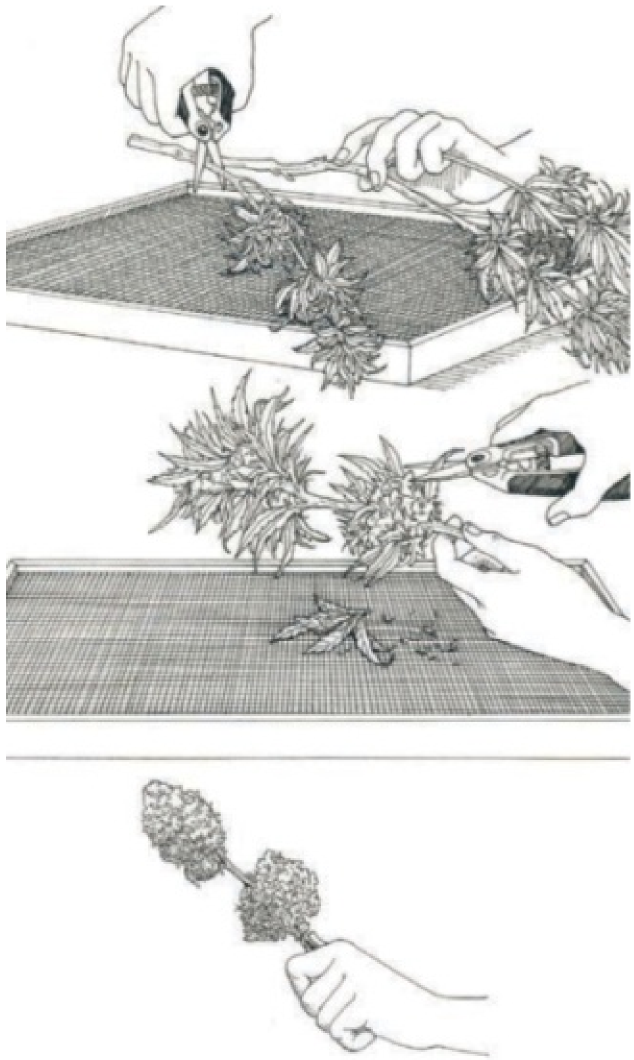
Hand processing is labor intensive and tedious. That's usually not a problem for home growers, who may enjoy its novelty every once in a while. However, with larger crops, it becomes a challenging chore or a tedious task. Larger crops require planning for the avalanche of buds that need to be harvested and processed in a short time.

First, the trimming space must be prepared. It should be clean, free of dust, and animals—especially shedding dogs and cats because their fur and dander stick to the vegetation and can pass through screens, which lowers the quality of both buds and leaf products.

The large harvest was hung to dry in the barn. It will be manicured later.

Hanging plants impatiently waiting to be processed.

Branches of buds cut to about 15” (35 cm) are hung on string lines. They will be manicured when dry.



Glands fall through the large manicuring screen and are collected later.

The space should include three sections: the holding area, the processing area and the curing/drying area.

THE HOLDING AREA

This is where the unprocessed material is stored. Whole plants can be hung. Cutting the plants into more manageable sizes, between nine and two inches (25-60 cm) saves space by eliminating the stem and bare branches, and makes it easier to store them on trays or in boxes. If the buds are to be processed while they are still turgid, keep the temperature of the storage area as low as possible. The plants remain fresh and turgid when they are kept in the low 40s F (4-6° C), the temperature range of a refrigerator. For moderate amounts, you can use the vegetable chiller section of a refrigerator. Storing the fresh harvest in the low 60s

F (15-16° C) reduces moisture loss considerably, but storage at this temperature makes the buds susceptible to mold. Lowering the temperature to the 50s F (10-15° C) keeps the vegetation fresh. Strong air circulation helps keep the buds from being attacked. If they are to be dried before processing, the buds should be cured first, if possible. Buds on plants take a longer time to dry than cut branches because a lot of the vegetation is eliminated when the branches are cut up. This slow cure mellows the taste.

Bad planning and the wrong furniture slow processing. Manicurists should sit at tables with work chairs that bring the workers towards the table. Plastic patio chairs push people back so they must lean over to work. This is an uncomfortable position that impedes workflow. Use proper furniture for the job.

PLAN AHEAD FOR MANICURING

Manicuring is fun for the first hour. Afterwards it's a job that can be physically tiring if the work area is not organized well. Don't wait until harvest to think about this important step. Planning ahead will make this labor-intensive function go more smoothly.

- **The trim area should be well lit.**
- **Promote good posture by using tables and chairs that are compatible in height.**
- **Utilize ergonomically sound equipment and tools.**
- **Respect your scissors–keep them sharp and clean.**

While manicuring, get more from the harvest by using a tray with a fine mesh screen. This captures the glands that fall from the buds as they are being trimmed. The fine powder is called Kief and can be smoked just how it is or pressed to make hash. It can also be processed into tinctures or capsules. Some people like to cook with it because it has a milder flavor than leaf.

The TrimBin from HarvestMore turns any chair into a comfortable workstation that will reduce stress injuries and increase productivity. The tray includes a screen to catch glands.

A manicure party for the annual harvest is a fun, joyous occasion. A comfortable work environment is essential for manicurists. Notice that the room is well-lit and they are working over a table sitting in sturdy chairs.

THE PROCESSING AREA

Plants or branches are brought into this area for manicuring. Appropriate tables and chairs and bright, high-quality lighting improve work conditions and speed its flow. On the other hand, inappropriate furniture such as low tables, plastic patio chairs, and uneven, low-intensity light impede it. It should have separate areas for the unprocessed and processed bud, as well as for the trim and fan leaves, which should not be thrown away.

THE CURING-DRYING AREA

This is where the processed buds are stored, undisturbed until they are ready to be packaged. The manicured bud is either placed in boxes or trays in a shallow layer, so all of the buds have access to air or it is hung to dry. Fans circulate the air. Ventilation fans provide cool, dry air, and dehumidifiers remove the moisture.

MANICURE CREWS

When marijuana is grown commercially manicure crews are sometimes used to process harvests. This works out well for the most part. However, outside labor has inherent shortcomings:

- Secrecy is compromised because more people are involved who will talk with others.
- Workers' ability and speed varies.
- Workers must be fed and perhaps housed.
- Pot-pocketing and thefts are endemic.

One solution to a large harvest that cannot be manicured all at once is to process it just enough so that it doesn't mold or rot. Once the buds are secure from deterioration, manicure them at a later time.

Drying is the key. Plants can be hung to dry whole, cut into branches that are hung to dry or the buds can be cut from the stems and placed on netting or trays to dry. Whole plants take more time to dry than cut branches; branches take more time then unmanicured buds. Removing the buds from the stems and placing them in single layers on trays spaced 8-10 inches (20-25 cm) above each other conserves a tremendous amount of space.

The Bonsai electric scissor has three stationary blades and one that zips back and forth. As the manicurist holds the handle, the blades clip the plant, sort of like a clipper giving a buzz cut. With a few minutes of practice this clipper can buzz through fresh large buds still on the branch.

The Big Red Shredder speeds up hand manicuring. It can be used for buds of all sizes.

Once the buds are dry, manicuring actually speeds up. The leaves are brittle and break away easily from the stem. Scissors do not need to be used as much since the leaves snap free from the stem easily as they are grasped and pulled. Scissors can be used for touch up, clipping buds and petioles from the stem.

Hand processing is an arduous, time-consuming task that can be sped up using automating tools.

Manual trimming may be ideal for the large colas, but for medium sized projects, hand trimming is too time consuming. The Spin Pro allows the grower to trim an ounce of wet marijuana in less than a minute, is easy to clean and easy to collect for kief.

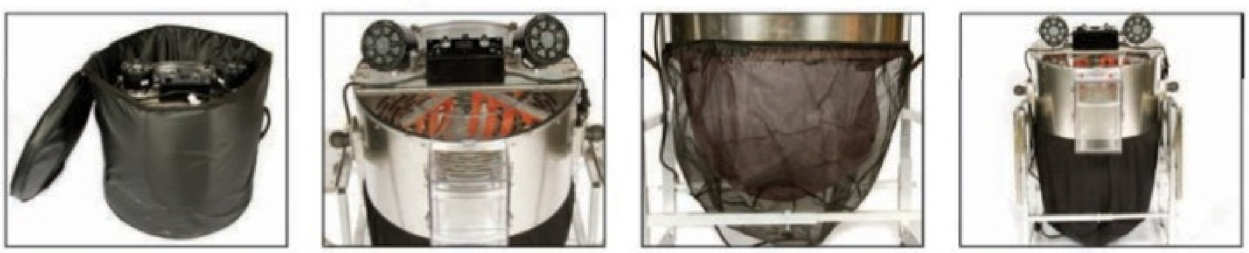
- **Bonsai Hero** is an electric scissor that consists of two fixed blades and a two-sided middle blade that moves back and forth and cuts in either direction. The blade makes six complete trips a second. The operator holds the handle and guides the blades up the bud, leaving it well-trimmed. After a short learning curve, the operator can trim two to three times faster than manually.
- **Big Red Shredder** is a small, fairly portable machine that is used as an adjunct in hand trimming. A tube with a slit at the top extends from a rectangular box. The box is attached to a vacuum cleaner that creates suction at the slit. A blade spins just below the surface of the slit (but out of the reach of stupid hands). When the machine is turned on, the suction starts, and the blade spins. The manicurist brings the bud to the machine and directs leaves and other trim towards the slit. It is drawn in and sliced. The machine cuts hand-trimming time of all sized buds by 50% or more. The machine is noisy, especially if the vacuum is in the same room, so wear a pair of sound-eliminating earphones or ear plugs.

The TrimPro reduces processing time by two-thirds. Top to bottom: Unmanicured buds are glided along the grill. The blades underneath pull leaves down and clip them. The leaves have been removed; the bud is ready for clipping or drying.

The TrimPro Rotor table-top machine speeds manicuring. It is easy to use and requires no learning curve. Leather straps rotate buds along a grate. Buds are trimmed by blades spinning underneath. Trimmed buds look good.

- The **Hand Spinner** consists of a bowl with a grill that buds are placed on. The top is fitted in place, then the operator turns the handle found at the top of the cover. The buds come in contact with the blades, quickly trimming the leaves from them. The Spinner also comes as an electrified model which works faster and doesn't require a strong arm.
- **The TrimPro and the Hedge Hog** are hand-manicuring machines with a grill, a spinning blade, and vacuum-created suction. The advantage of these machines is that rather than having a single slit, there is a grill that looks a bit like a barbeque grill, except the slits are longer to protect fingers from the blades. Even so, for safety sake, this machine should be used with thick, industrial, canvas gloves. The larger number of slits and the larger area that these machines can process reduces manicuring time by as much as two-thirds as compared with hand manicuring.

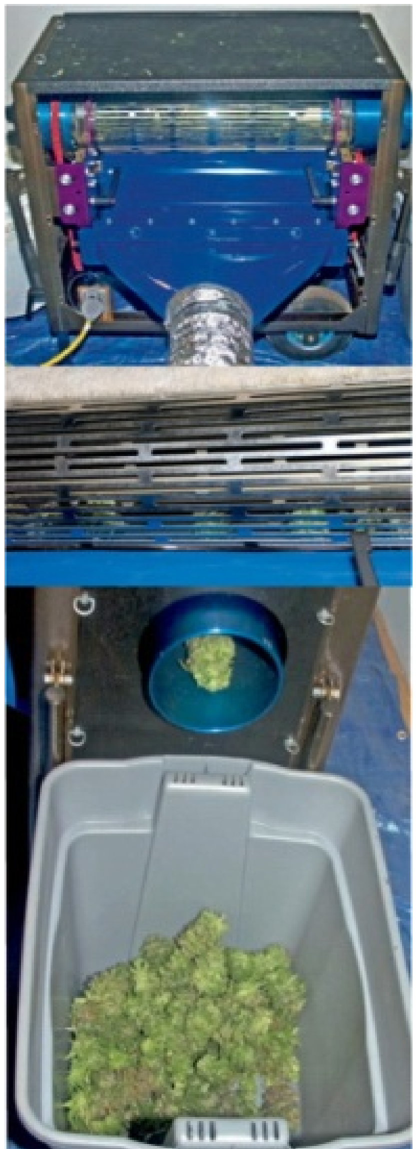
The TrimPro XL Gasoline is powered by a quiet Honda gasoline motor and can easily be adjusted from a “table-top” trimmer to an automatic processor.



EZ-TRIM's Satellite Trimmer combines the use of air flow along with rotor fingers over a covered grate, offering the user full adjustability of the vortex, suction and speed of the trim—mitigating any damage while saving significant time. The three collection bags filter and separate the mulched leaf. From left to right above: transport bag; Ipod/MP3 player (1/8 in Jack); triple filtration bag (wet and dry); fully adjustable.

- **TrimPro Auto** is an auto-processing machine. Buds that have been stripped from the stem are placed in a hopper that is manually released. They drop down into a tub shaped something like an auto tire with a bottom plate where they spin around and come in contact with the cutting blades. When the operator determines the buds look trimmed, she opens an exit tube, and the buds flow out.
- **Tunnel machines** are the fastest, most efficient manicure machines and need the least human attention to run. Buds are placed into a revolving tunnel. As they travel down its slightly inclined path, they are constantly turning. The

tunnel consists of a cylindrical tube with slats. A vacuum cleaner is used to create suction at the bottom of the tube. The bud leaves are drawn into the slats and sliced by a fast-spinning blade. The buds travel through the machine in a couple of minutes. When they drop from the tunnel, they are fully manicured.



The Tunnel Machine makes quick work of buds of all sizes. Buds are placed in one end of the long tube and drop out the other end. Leaves are pulled through the slits in the tube by a vacuum. A spinning blade under the tube snips them off. Buds drop out after processing.

CURING

Curing is the process after harvest but before drying, during which many of the cell's metabolic processes continue for a while. Buds continue to cure when they are kept at about 60-70° F (15-21° C) with humidity of 50%. The cells retain moisture and convert complex carbohydrates back to simple sugars and break down some pigments, including chlorophyll. As chlorophyll is metabolized, the bud turns a lighter shade of green. Other pigments, formerly hidden by the chlorophyll, become apparent, coloring the bud with red, yellow, and purple highlights. Buds can stay alive for up to three days, continuing some life processes. They gradually lose moisture, and after a few days all of the cells have died.

Buds dried too quickly without curing retain more chlorophyll, which gives the smoke a "greener" minty taste and rougher smoke, and often less intense odor. Buds that are cured properly and dried slowly have the smooth draw of fine herb.

Keep the curing space dimly lit and the air constantly circulating. It is important to regulate the humidity so it stays between 45-55%. Excessive humidity promotes mold, and insufficient humidity—40% or lower—promotes drying and stops the curing process.

Buckets of buds, before and after trimming, and a close-up of a trimmed bud.

After the buds are cured, they are dried. At 50% humidity, the buds dry gradually over a week or two, depending on their size. Lowering it to 40-20%

hastens drying. Bud size, and size of the drying space as compared with the amount of bud drying, temperature and humidity all affect drying time. One way to keep the temperature and humidity low is to use an air conditioner with a thermostat set at 65° F (18° C). If the temperature is warmer outside, the air conditioner will remove water from the air.

Large scale grows require a lot of time and work at harvest. All the extra eyes and hands can also become a security breach. Trim machines reduce the time and manpower needed to harvest your crop. The Twister has self-cleaning blades and makes up to 320 cuts per second.

The Rolling Thunder trims 20 pounds (9 kg) or more per hour, using 11 different blades that make over 320 cuts per second. It is one of the fastest, most efficient ways to trim a large crop.

If the temperature outdoors has dropped to around 65° F (18° C), heat the room using a dehumidifier. Then, if needed, at the same time turn on the air conditioner to keep the room cool. The two appliances oppose each other as far as temperature is concerned, but both remove humidity from the room, making it easier for more water to evaporate from the plants. Keep the humidity low or the buds will mold.

Not many growers have used this technique because it takes time, patience, and space, but the finished dried bud is worth the wait. It burns smoothly and retains more odor in contrast to heat-dried bud, which loses the more volatile terpenes during processing.

Most gardeners raise the temperature to dry the bud. While this method hastens the process, many terpenes, the odor molecules that give marijuana varieties their “personalities,” evaporate at between 70-85° F (21-30° C).

Buds dried quickly by raising the temperature into the 90°s F (32-35° C) but lose more of their terpenes, the odor molecules. As a result high-heat dried bud is not as fragrant as cool dried. High temperatures also create an uneven dry. The outside dries crisp while the inside remains moist.

The best way to preserve the integrity of the terpenes and glands is probably to freeze dry the buds after they have cured for a few days. Freeze-dried buds retain all of their flavor and aroma and produce a fine, full-flavored, smooth smoke. The glands and terpenes remain frozen and undisturbed, keeping the bud fresh-picked fresh.

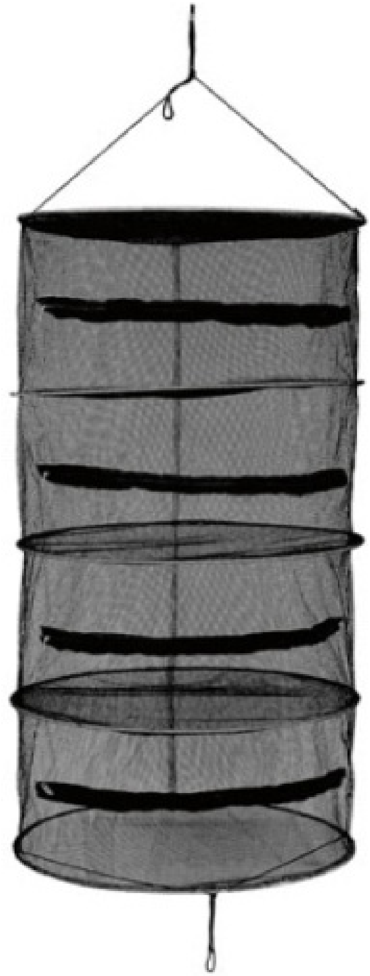
Freeze drying takes advantage of sublimation, the change of a substance from its solid to its gaseous form without going through the intermediary liquid stage. First the bud is frozen, and the water in the cells turns to ice. Then the bud is placed in a vacuum, and the ice is drawn off under the low pressure and evaporates.

Buds drying on a screen.

The drying room has net shelves so buds have plenty of contact with moving air.

You probably have a freeze dryer at home: it is the frost-free freezer attached to your refrigerator. Place the cured, partially dried buds on the freezer racks. Additional racks can be placed in the freezer to process more buds at one time. The buds will freeze within half an hour. The water will sublimate away, turning directly from ice to water vapor, without going through a liquid state. The buds dry in 10 to 20 days. Large quantities of buds can be processed using commercial freeze dryers which dry the buds faster.

Small quantities of marijuana dry quickly in an open room because of the low relative air humidity indoors. Placing the buds in large paper bags slows evaporation, so they have more time to cure. Keep the bags open so the buds can breathe and release excess moisture. Don’t put more than three or four layers of big buds in the bag, because the moisture they release promotes mold growth. High humidity prevents the buds from drying. Moist environments are also conducive to mold, so the humidity must be kept low. When it is humid outside, indoor humidity may be too high for the buds to dry in the open air. Place them in a closed environment such as a closet or room and use an air conditioner or air conditioner/dehumidifier combination.



There are many methods to store trimmed marijuana for drying. Most growers hang plants upside down on strings or place them on a rack. The Rack from Amerinada Distribution is collapsible and easy to hang anywhere. It provides four layers of drying to make the best use of space while providing the buds with air to dry, and is capable of holding over 20 pounds (9 kg) of dried buds.

Drying large amounts of buds requires air circulation and ventilation. Fans create a draft that promotes evaporation, and ventilation exchanges the moist air for dryer air. If mold appears, it is an indication that there is too much moisture in the air. Quickly decrease humidity to 40% or less and increase the temperature to 75° F (24° C). Fungi and molds prefer cool temperatures and stop growing in warm conditions. When the temperature rises, the air holds more water, so the relative humidity goes down.

ARE MY BUDS READY?

The “stick test” is a good indication of bud dryness. Bend the little stem that holds the bud together. If it bends, the bud is still too wet. If it snaps, the bud has dried sufficiently.

The next test is the joint test. Roll a thin joint and spark it up. If the bud stays lit and doesn’t go out between puffs, then it is ready for storing and aging. It is still too wet when it needs constant relighting. Wet bud is not only inconvenient, it won’t get you as high as dry bud because some of the cannabinoids have not become active.

Buds that are packed moist are prone to mold or rot. Mold spores are ubiquitous and germinate under favorable conditions: moist environment, oxygen, temperature between 50° - 70° F (10° - 21° C) and an acidic surface on its host. Mold spores germinate on moist grass, sending strings of hyphae to ingest food from the vegetative tissue.

Don’t put moist buds in plastic bags—they are likely to become moldy.

Make sure the bud is dry and doesn't "sweat" when packaged. If it sweats it has too much moisture and should be allowed to dry further.

Bud infected with powdery mildew or other mold is unfit for smoking. It can be used to make water hash, because the hash-making process washes molds from the glands.

Once the mold depletes the oxygen in the jar, anaerobic bacteria get to work. You can see and smell their effects. The grass turns brown and crumbly, and the herbal fragrances are replaced with the astringent odor of ammonia.

When moist bud is packed in a sealed container in warm conditions, molds may not germinate. Instead, bacteria become active. First aerobic bacteria ingest tissue. When they deplete the oxygen, the anaerobic bacteria start feasting, releasing ammonia.

This bud is getting its final airing, allowing it to lose just a little more moisture before being packaged.

If you have packaged buds, and they start sweating, creating condensation on the box or jar, the buds are too wet and need to dry more. Remove them from the packaging or open it up so they can breathe. Don't repack them until they pass the dryness tests.

Buds should be disturbed as little as possible before they are smoked. Every time they are moved, unpacked, or handled, resin glands fall off. You can see them cascading through the air whenever a bud is handled roughly.

Glass, ceramic, metal and wood containers are the best for storing marijuana. Unlike many plastics, they have no electrical charge that attracts the glands, and they are air-tight. Nonetheless, large plastic containers are often used to store large quantities of dried buds.

Brown-colored "brick weed" started off green, but then turned

brown during the ferment after it was bricked. The moist anaerobic conditions and nutritious vegetation supported the bacteria until the grass dried and the ammonia odor dissipated.

The terpenes which give buds their fragrance are volatile, and some of them evaporate at room temperature. To preserve them and the bud's freshness, the packaged buds should be stored in the refrigerator for medium-long term storage. Kept refrigerated in darkness, there is little deterioration of the cannabinoids or the terpenes.

For even longer-term storage, place the containers of dried buds in a freezer. They can remain there for years with virtually no deterioration.

Sun leaves and trim are unsuitable for smoking but can be used for making kief, bubble hash, and ingestibles, which are described in Post Harvest.

The quality of marijuana improves for several weeks after it has dried because THC acid loses its water molecule and becomes psychoactive.

There are several methods you can use to dry marijuana quickly for testing. None of these methods are recommended for creating high-quality, well-dried, well-cured bud. But fast-dried bud gives you an indication of what to expect once the rest of the harvest is dried. Fast-dried bud retains its minty chlorophyll taste and has a harsh smoke.

- Microwave. Place the bud in the oven for 30 seconds or more so that some of the moisture is removed; then lower the power to two and dry the bud until it is useable. Microwaves kill seeds, so that buds containing desired seed should not be microwaved.
- Food dehydrators dry the buds, but many of the terpenes evaporate in the high temperature environment. They never get very hot, so the THC remains, but the flavors dissipate. This kills seeds.
- Place the bud on top of a warm appliance such as a computer, refrigerator, transformer or ballast. This may kill seeds.
- Don't try drying marijuana in an oven unless it has a "warm" setting and a timer. Even so, the heat may evaporate the terpenes before the bud is dried. Set the temperature at 100° F (38° C). This may kill seeds.

In extreme circumstances, you may possess nothing but mature leaf and trim. These are best used for making concentrates, but they can also be prepared for smoking by soaking them in cold water for several hours and then rinsing them. The water dissolves many of the pigments and resins, including much of the chlorophyll, but the THC remains on the leaves. Dump the water then dry the leaves. They smoke much smoother than they did originally. They can also be used for cooking or brewing.

The smaller leaves that were trimmed from the buds, composed of single-finger leaves and tiny buds, are quite potent but they do not smoke that smoothly. Trim leaves can be vaporized or smoked in a waterpipe or soaked in water first.

The buds are usually saved for smoking.

" Tell me how long

do I have to wait?

Can I get you now, I said,

must I hesitate?"

Lyrics: Smythe, Middleton "Hesitation Blues"

RESTARTING THE GARDEN

CLONING

Almost everyone has taken a piece of a plant and placed it in water or soil until it grew roots. As it developed, the leaves, flowers, fruit and other characteristics of the plant were exactly the same as the donor plant from which it was taken. This is an example of asexual reproduction. Marijuana clones are a result of the same process and they preserve the genetic code of the “mother” plant.

Cuttings root easiest when they are made while the plant is still in its vegetative growth stage. However, they can be taken even as the plant is being harvested.

Cuttings root within two weeks when they are given a clean, humid, moist, warm environment.

Cuttings do not have a root so they have a limited ability to absorb water. Keep the humidity between 75 and 85% so they aren’t placed under stress.

Cuttings root fastest when they are kept at about 80-85° F (27°-29° C). It is important that both the air and the rooting area are kept warm. At lower temperatures the clones root slower.

At first use a moderate amount of light, about 10-15 watts per square foot (110-160 watts per square meter). A 4’ (122 cm) long rack holds four 10” x 20” (25 x 50 cm) trays. Two standard T-8 fluorescents or a single HO T-5 fluorescent provides enough light until the cuttings start to root. After they have rooted, they require twice the light, which is supplied using two T-5 HO fluorescents.

Planting mediums: Cuttings can be rooted in coir, vermiculite, perlite, peat moss, Jiffy® pots, Oasis® cubes, and rockwool. Most professional cloners prefer rockwool, which promotes very fast rooting. Cloning machines use aeroponics or aerated water instead.

CLONING STEP-BY-STEP

EQUIPMENT NEEDED

- Scissors: choose comfortable ones. Spring loaded scissors are easy on the muscles because they do not have to be pulled back to open position.
- Clean, well-lit work area.
- Small jars or glasses filled with water to hold the cuttings before they are prepared for planting.
- Alcohol or hydrogen peroxide in a spray bottle and cloth or paper towels for sterilization.
- Root dip solution. It should contain naphthalene acetic acid (NAA), indole-3 acetic acid (IAA), and indolebutynic acid (IBA) or a combination of these three root stimulators. Many brands are available.

These cuttings were placed in a small styrofoam cup filled with vermiculite and water. They needed no more water before rooting; the water evaporated slowly, giving the roots more air.

- Containers with sterile medium, or cubes that are ready for clones. If you are using rockwool soak it in water pH adjusted to 5.5 for 24 hours. This removes the lime residue left from manufacturing.
- Lighted shelf with trays.

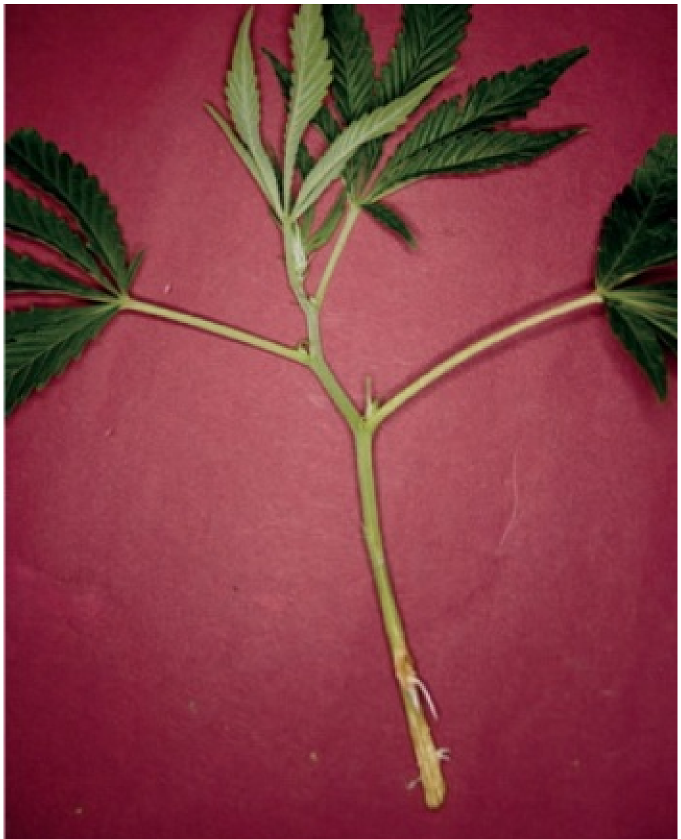

1


2

1. These cuttings have been trimmed of excess leaf and are ready to place. 2. These cuttings are set into Oasis® cubes. They are neutral, need no buffering, and provide plenty of air space for the roots. Place them 1" (2.5 cm) deep. 3. After setting, a dome is placed over the tray.

1. Domes keep the humidity high. It should hover between 70-80% the first week. 2. Cuttings in 2” (5 cm) square rockwool cubes. 3. The clones on the upper rack are young. Covers have been removed from the older clones. 4. About a week after setting roots have grown through the rockwool.

- Wipe the table you are to work on with hydrogen peroxide or alcohol to sterilize. Wipe the scissors, too.
- Wash your hands and put on a pair of latex gloves.
- Take cuttings from the plants and place the cut ends in a glass of water to prevent dehydration.
- Trim the cuttings. Place them in a second glass of water until they are ready to be placed.
- Line the clones up by the leaf canopy then cut the stems so that the clones are the same length.
- Wipe the scissors with sterilizer then cut the stems 1/8” (3 mm) from the end.
- Dip the cuttings in the solution to about ½” (13 mm).
- Place the clones at least 1” (25 mm) deep in the medium.



Roots grow from the side of the stem, not the bottom.

Close-up of the root section.

Cuttings have just undergone surgery and they have open wounds. They should be kept in an area where they are not likely to get infected. Sterilize the area, the tools, and your gloves, using alcohol or 3% hydrogen peroxide.

- Irrigate using water adjusted to a pH of 6-6.3. Various rooting enhancers are available. They contain plant hormones and nutrients and are added to the water solution. Compost tea or mycorrhizae-beneficial bacteria mixes can also be added. They contain organisms that develop symbiotic relationships with the roots as soon as they emerge.
- Spray the top of the medium with hydrogen peroxide as an antiseptic.

TRIMMING THE CLONE

The strongest clones are cut from the new growth at the ends of the branches. These starts are 4-6” (10-16 cm) long. Remove the large leaves and vegetative growth except for three medium size leaves surrounding the growing tip. At the end of the trim only about 1” (25 mm) of canopy should remain. The rest of the stem is bare. Care should be taken that at least one node, where leaves had been attached, is near the end of the stem, assuring that it will be placed in the planting medium. Cuttings with nodes in the medium root faster than node-less sites. Roots emerge from the node site faster than along the internode.

Clone preparation techniques vary. Larger or smaller clones can be taken. Both have advantages. Larger clones require less time in vegetative stage. Smaller clones allow you to produce more starts from a mother plant and to produce more of them in a small space.

If large numbers of cuttings are being taken, a system using less donor-plant material is preferred. Starts can be made from many of the internodes along the branch which have vegetative growth. These starts are at least an inch (2 cm) long, have some leaf material and a node to plant.

If your technique works well and you are satisfied with the results, then it is the right way.

ROOTING IN WATER

Marijuana cuttings can be rooted in room temperature water. Change the water every day to make sure it has enough oxygen. Shake the water before using it to oxygenate it. Several commercial units use oxygenated water as a rooting medium.

Another technique uses a piece of Styrofoam board with holes punched to hold the clones. The board floats in a tray with water heated and aerated using an air pump and a bubbler. When the cuttings begin to root, they are moved to a solid planting medium. Aerating and heating the water to 75° F (30° C) speeds up the rooting process.

AEROPONIC ROOTING

Most cloning machines use aeroponics for rooting. The plant canopy is held above the reservoir while the stem hangs down in a chamber or is held in a mesh cup. A pump or mister emits a fine spray that bathes the root in highly oxygenated water. Clone machines promote very fast rooting and take much of the guesswork out of it because they provide excellent conditions for the roots.

Cloning trays are an efficient way to utilize the cuttings you have taken from your mother plant. The GroClone has a built in pump to oxygenate the water, which allows the roots to thrive. Up to 53 cuttings can fit in a 12” x 24” x 4” (30 cm x 60 cm x 10 cm) tray.

The misters (red) constantly spray very fine oxygenated water at the cuttings.

This plant was treated with silver thiosulfate. It has flowers of both sexes. Photo: courtesy Dutch Passion

THE SILVER THIOSULFATE FORMULA

Mix 0.1g silver nitrate in 100 ml (3.5 oz.) distilled water. Stir rapidly until dissolved (Solution A). Mix 0.5g sodium thiosulfate in 100 ml distilled water. Stir rapidly until dissolved (Solution B). Pour Solution A into Solution B. Dilute Solution A/B 1:9 with distilled water. That is, add the 200 ml of solution to a 2-liter container and fill to the top with distilled water. The solution is now ready to spray.

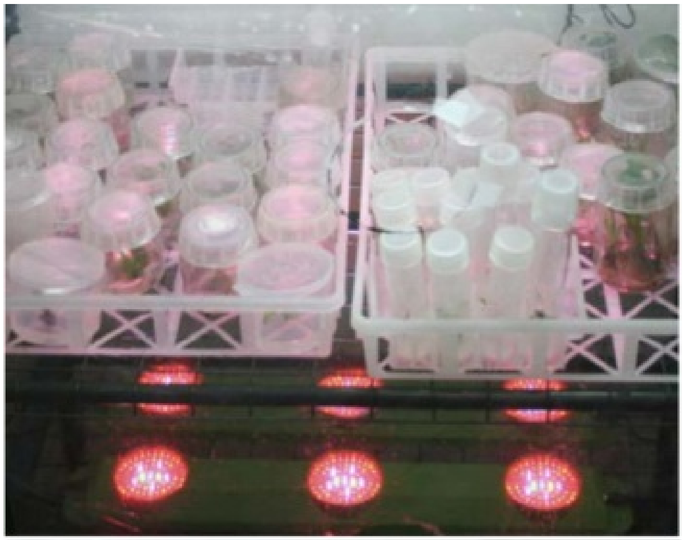
Cuttings rooting in water and aeroponic-based systems do not require as high humidity as plants in mediums. They can be kept at 50-60% humidity.

Transfer cuttings that are being rooted in aeroponic or water systems to other mediums as soon as roots appear. In both of these systems the plants develop “water roots” which are adapted to a wet environment. These roots grow without hairs, so they have a difficult time adapting to drier environments.

By transferring them to a solid medium as soon as the roots emerge, the plants are aeroponic and water systems get the cuttings past the most difficult phase, the first few days after being cut.

Change the water daily, or use a small air pump to supply air to the water, so that the submerged plant parts have access to oxygen. A water-soluble rooting agent containing B1 and the rooting hormone IBA promote root growth. A very dilute nutrient solution which is relatively high in phosphorus (P) is added to the water once roots appear. As soon as the cuttings begin to develop roots, plant it in a moist medium such as vermiculite, rockwool, Oasis® or peat pellets and water with a a dilute nutrient solution for 10-15 days.

One popular commercial cloning kit consists of a tray that holds peat pellets in a miniature greenhouse. The cuttings are placed one to a peat pellet. Fairly small-to-large-size cuttings can be placed in these pellets. Peat pellets are especially convenient to root plants in to be placed in soil mix, or outside in the ground.



Tissue culture cloning goes beyond breeding by producing thousands of plants from one great plant. Here, the clones are sealed inside multiplication jars where they root in culture. They will be ready in four to six weeks and are lit with four T-5 fluorescents, which provides 10 watts per square foot. This cloner also supplemented the T-5s with three 18 watt fixtures.

MAINTAINING TEMPERATURE AND HUMIDITY

In gardens where only a few clones or a few trays of clones are being propagated you can maintain high humidity and temperature in the trays using horticultural heat mats, or a heated propagation tray with a high dome.

Maintaining high temperature and humidity in a small room or even a closet sized space takes some effort. The lighting helps to raise temperature and humidifiers keep the humidity high. CO_2 generators burn propane or natural gas. They also produce heat and humidity. Use a thermostat to regulate the generator.

Even with the added moisture the room is likely to have humidity of less than 80%. Use a humidifier regulated by a humidistat. Five-micron misters are an efficient alternative. Once installed, they require little maintenance and are inexpensive to operate.

PLANT TISSUE CULTURE CLONING

Tissue culture cloning, or micropropagation, is an alternative to traditional cloning techniques. It eliminates mother plants and the resources they require. Instead, new plants are grown and rooted in small jars on a nutrient gel made of sugar, agar and plant hormones. Tissue culture clones can be prepared at home without a formal laboratory.

Tissue culture is being used by the agriculture, floriculture and horticultural industries. Rather than breeding to create a variety, generations of new plants are based on a “best plant” model. Once a particular specimen with superior characteristics is developed, it is regenerated asexually. Tissue culture is used to create millions of copies in a short time, very inexpensively.

Plant tissue culture is gaining popularity as a way to make rooted clones because of the availability of prepared kits and lab-quality supplies. Commercial greenhouses use this technique to clone their plants by the hundreds of millions. Most crops including houseplants, pineapples, fruit trees and agave plants begin life in these small jars and grow into full-size plants.

The plants start from small node cuttings put into a culture. Typical tissue culture cloning jars produce five to eight new plants every four to six weeks. When plants reach 0.75” (2 cm) or larger they are removed for rooting.

Smaller immature plants are put into fresh multiplication jars to grow all over again. These are called mother jars because they are like mother plants that don’t wear out. The clones are rooted in tissue culture using the same hormones growers use to take cuttings. The difference is that the clones are smaller and many more are produced in a small area. Once in the jars the plants have all of the resources they need to grow by themselves.

Tissue culture clones grow in sterile culture so they are pest-and disease-free. Only a small part of the mature clump of shoots is needed to grow a brand new jar full. When new plants fill the jar the contents are moved to a sterile plate where the largest plant pieces, the microclones, are cut from and planted in a larger rooting tub to give the plants room to spread out and grow.

The remaining base of undeveloped plants is planted in a new multiplying jar, where it continues to grow. The “deflasked” clones are treated like regular clones; they are kept under a humidity dome for a few days until they develop a protective waxy coating, or cuticle. The plants root over a few weeks until they are ready to transplant.

There are only two steps in the process to create tissue culture clones. First, the media is prepared in a process similar to making Jell-O® and then sterilized in a pressure cooker. The important second step is to ensure 100% sterile conditions. Handling is done with a scalpel and forceps in a protective plastic storage tote. All tools and surfaces are cleaned with alcohol.

The containers keep the plants small because they grow only to the size of their container. Sugar provides energy directly to the plant and supports growth; the hormones steer the growth towards branching or rooting; and the preservatives keep it all clean. It is an ideal automatic growing system not only for cloning and storing plants, but also for sharing and transporting crops. Tissue culture clones are shipped around the world every day by the thousands; tissue culture creates opportunities to improve cannabis crops genetically. For instance, tissue culture has the potential to induce polyploidy, a naturally occurring mutation that increases the number of chromosomes in a plant or animal. Polyploid plants tend to be larger and more vigorous; they may also reveal hidden genetics, create seed-like embryos without pollination, and even generate “synthetic” seeds.

The scale of tissue culture can be increased to create a tissue culture bioreactor, a vat of plants that multiplies like yeast in beer.

Chromosome doubling can be induced in tissue culture by adding chemicals such as colchicine or sulfluran. Although colchicine is the most commonly used, the chemical sulfluran is less toxic and can be purchased in farm supply and some hardware stores. The chemicals disrupt the cell division process. Instead of dividing as normal into two new cells after the chromosomes duplicate, the division pauses and the cell begins growing again but with twice as much DNA as it should have.

Plants that grow from polyploid cells have the potential to be bigger and stronger than their parents. Many cannabis plants have hidden genetics in them that may be revealed by polyploid tissue culture.

FEMINIZING SEED

Feminized seeds produce only female plants, and when they germinate there will be few males among them if they are produced correctly. The threat of accidentally pollinating crops by misidentifying a male is minimized. A male-free crop is only one reason to use all-female seeds: another might be the preservation of a particular characteristic or plant type.

The predominant way to preserve the exact genetics of a plant is by cloning. However, a plant crossed with itself produces seeds that retain its parent’s favorable characteristics. Another reason to use this technique is to create a hybrid of two female plants. If a branch of one female is turned “male,” there will be pollen to fertilize the other plant, and to create seed when no male is around. Feminized seeds are produced by inducing a normal female, not a hermaphrodite, to grow male flowers with viable pollen. The pollen contains only female, or X, chromosomes because the plant has no Y, or male, chromosomes. The progeny will inherit an X from the male flower’s pollen and an X from the egg donor female flower. The resulting seeds can only inherit two X chromosomes, which means that almost all the resulting seeds will be girls! Congratulations!

With the help of gibberellic acid 3 this female plant is expressing male flowers.

Male and female flowers on a treated plant.

FEMINIZED SEEDS | BY HENK VAN DALEN*

I started growing cannabis for myself outdoors in the Netherlands in 1972, and in 1987 I founded Dutch Passion Seed Company. Inspired by Ed Rosenthal and Mel Frank's *Marijuana Grower's Guide*, I dreamed of creating seeds that would produce only female plants. It wasn't until 1995 that I began developing a technique to produce feminized seed strains.

It became evident that almost all unpollinated female plants would inevitably produce some male pollen. This is a survival mechanism: when a female plant is not pollinated by a male plant, it generates male pollen to fertilize itself. After self pollination, the female plant bears seeds.

By systematically collecting pollen produced by these hermaphroditic female plants and fertilizing flowers on other females, I was able to produce feminized seeds. Seeing them all grow into female plants was a rewarding experience. I soon started selling feminized seeds on the German market, which was legal in the mid-90's. Customers were pleased with the results, and we sold out. But we couldn't produce more.

The process we were using meant that we were only able to produce and harvest a small amount of female pollen, which seriously limited production. It took a lot of effort to produce a few thousand seeds. The question then was, how do we get abundant "female" pollen to produce as many feminized seeds as the market demands?

I found the answer at the Agricultural University at Wageningen. Researchers there had done similar work with other plant species, such as cucumbers. They had discovered that plant hormones and less complex agents can drastically change the physiology and morphology of the cucumber. It then took us about two years to check which hormones and other agents could enhance pollen production in female cannabis plants without disrupting their normal growth pattern.

Feminized seeds are now the standard for all seed companies, which shows that feminized seeds work—which was widely doubted at first. Feminized seeds are an excellent choice for marijuana cultivation.

Close-up of plant treated with silver thiosulfate.

Getting only female plants was the motivation for creating feminized seeds, but they offer other advantages. Feminized varieties are more uniform (homogenous) than “regular” seeds. Plants from feminized seeds tend to look more like each other and produce a more uniform harvest.

Even when using feminized seeds, there is still a small chance that you will have a few plants that are hermaphrodites (truly both male and female) or males. You should monitor all your plants through the entire growth stage to check for these oddities. Maintaining stable growing conditions is the best way to prevent male or hermaphroditic plants. Environmental stresses such as light, disruption, or overpruning will encourage female plants to produce pollen. If you do find a male or a hermaphrodite, remove it.

Feminized seeds are not as mysterious or weird as they might seem. In mature human females, taking male hormones causes masculinizing changes such as breast shrinkage, muscle bulking, and a lowering in voice pitch. The primary sex organs have already been formed, but they shrink.

A similar thing happens when female plants are treated with masculinizing chemicals. The difference is that while a mature human has already formed her sex organs, every time a plant produces a new flower, it is growing a new sex organ. Plants under chemical influence grow viable male flowers, even though the plant is still a female with two X chromosomes, the pollen has only female chromosomes.

There are several methods used to produce feminized seed. By far, the noted breeder Soma developed the easiest method. He noticed that when colas of many varieties reached late ripeness (which, by the way, I prefer as the harvest-time) a few viable male flowers appear. This is also a sign that the buds are ripe. Harvest the pollen using a fresh watercolor brush and brush it directly on the flowers or store it in a small glass or metal container. Not all varieties produce male flowers at the end of ripeness, but many do, and they do it reliably. Very small amounts of pollen are produced using this method, but a little pollen applied properly goes a long way.

Some varieties flower normally outdoors but experience indoor growing conditions as stressful and produce hermaphrodite flowers. The pollen from these male flowers can be used for breeding, provided that the resulting plants are going to be grown outdoors, where they won’t exhibit the unwanted hermaphroditism. Plant stresses such as irregular light cycles and heat sometimes induce hermaphroditism. However, stress techniques are not reliable. They only seem to work when you don’t want them to, and I haven’t found a stress regimen that ensures masculinization. Should this happen accidentally in a garden with a valuable variety, be opportunistic and collect the pollen, even if you have no plans to use it.

Several light sprays of gibberellic acid (GA 3) induce hermaphroditism and stretch the plant.

Laboratories and commercial seed producers use three chemicals to induce male flowers in female plants: gibberellic acid, silver nitrate, and silver thiosulfate. They each inhibit the plant's production of ethylene, a hormone that promotes female flowering. Without ethylene, female flower production is reduced or stopped. The actions of these chemicals are localized. If only one branch of a plant is sprayed, that branch will be the only one affected. The rest of the plant will continue growing female flowers, not males.

Gibberellins are hormones that plants produce to regulate many phases of their growth. Several of the gibberellins, such as GA3, 4, 5 and 7, induce male flowers when they are sprayed on female plants before they begin flowering. GA3, which is the gibberellin most commonly available commercially, is the most effective. For best results, use a solution of 0.01% (0.1 gram GA3 in a liter of distilled water). Gibberellin must be used carefully. Lower doses result in fewer male flowers. Higher amounts have an inhibitory effect. Lightly spray the tops of the plant for five consecutive days and then force the plants to flower by increasing the uninterrupted dark period to 12 hours a day. The sprayed area will stretch a bit, but within two weeks, the first signs of male flowers will appear. They will be ripe and ready to release pollen in another two weeks.

Silver thiosulfate is more effective than silver nitrate; that is, it induces more male flowers. Sometimes the two chemicals are used together. Spray the plant until the liquid drips off the leaves. Then immediately change the light regimen from vegetative to flowering. The leaves will droop and stop growing for a few days, yellow a bit and then regain turgidity. Male flower growth will become apparent in a couple of weeks. The flowers will ripen a few weeks later.

Silver thiosulfate is made by combining two water solutions, one containing silver nitrate and the other, sodium thiosulfate. Silver nitrate alone can also be used to induce male flowers. Spray a solution of 0.02-0.03% on the plant, and then turn the lights to a 12-hour flowering cycle. The leaves will droop for a day or so and then resume turgidity. Male flower growth will become apparent in a couple of weeks and ripen a few weeks later. To make a 0.02% solution, add 0.1 gram of silver nitrate in 0.5 liters of distilled water.

Because of market demand, almost all the seed companies offer most of their popular varieties as feminized seed. They are the best choice for most gardeners. The exception is gardeners interested in breeding.

POST HARVEST

TRASH BASICS

Leaves and trim, the natural byproduct of growing buds present an interesting paradox. The bud is the plant's crown jewel with 5-20% THC. However, cannabis produces THC throughout the plant. Sticky resin glands coat the leaves and bracts, creating a natural protective barrier against insects, disease, herbivores and the sun's UV rays.

Glands on the leaf and trim contain one-fifth to one-half the THC found in the buds. The fan leaves have a THC content of only 1-3%, and they are a harsh smoke. Trim, with 2-6% THC content, commands only a little more respect than the leaves.

Buds typically weigh four times as much as the leaf on a mature female marijuana plant, although this varies tremendously by variety and gardening technique. Still, when trim and leaves are tossed, 10-20% of the plant's total THC production may be thrown away.

Collecting and using the trash does not add greatly to the complexity of harvest. Leaves and trim are already being trimmed and bagged. Preparing to dry and store this material in advance makes the collection almost as simple as bagging it for the trash can. Once the trash is saved and stored properly, transforming the leaves and trim into stash can wait until the rush of the harvest is complete.

KNOW YOUR TRASH/COLLECT FOR STASH

When tossing it out, trash is everything that isn’t bud. If you are going to use it, it should be sorted. Stems and woody parts of the plant are not salvageable. The sticks and stems have little THC, so they really are trash.

GRADES OF TRASH

All leaves from mature female plants contain retrievable THC. Male plants contain THC as well, and are most potent at the budding, pre-flowering stage. In both cases, the small leaves near the flowers are the most potent, followed by the younger and then older fan leaves.

It may be useful to get a magnifying glass or photographer’s loupe and take a close-up look at the plant material. The glands on the fan leaves are often small and hug the surface of the leaf, while the glands on the flowers are stalked and look like mushrooms with bulbous caps. Material with visible glands is worth keeping. While immature material can also be collected, it is best to use leaf that has been collected from mature plants to get the intended results. In a recycling effort, a gardener may opt to trash material with the sparsest glands, such as the large fan leaves, while saving the smaller leaves, trim and buds for use.

Processing the leaf and trim for use as kief, hash, tincture, butter or food requires additional effort that may not seem worth it to a person floating on good weed. It creates another task at harvest time, when there is already a lot of work to be done. Danger of rip-offs or busts may limit the marijuana gardener from adding another step to the harvesting process. Perhaps it's best to transfer the job to a professional processor.

KIEF

Kief is an easy process, but a controversial word. Alternatively spelled as *kif, kief, kef, and kiff,* it appears in many languages around the world. Kief is a powder that consists of the loose glands removed from marijuana buds and plant material. It looks like minute grains of sand.

Some marijuana enthusiasts debate the use of the word kief, because this term was originally used in cultures such as Moroccan to mean a mixture of grass and tobacco. In Amsterdam and other parts of Europe, kief is sometimes called pollen or polm. In French and Afrikaans, the word kief is also a slang term that means cool or great.

Countries close to the 30th parallel, including Afghanistan, Lebanon, Morocco and Nepal have traditionally made kief as the first step to making hashish.

There are many techniques for removing the THC holding trichomes from the vegetative material to which they are attached.

The simplest way to make it is to use a silk scarf stretched tightly over a bowl. The fine weave of the cloth allows the THC glands to pass through, separating them from the vegetative material.

Screening works because glands are consistently within a certain size range and pass through the pliable holes in the silkscreen weave.

The gland heads are measured in microns, which is a metric measurement equal to one millionth of a meter. Glands range between 75-125 microns in size. Maturity, variety and environmental conditions determine gland size. Moroccan varieties' glands are usually under 80 microns. Sativa glands are also small. "Hash plant" varieties' glands are often 120 microns or larger. Most sinsemilla have glands in the mid-range, between 80-110 microns.

" Talk about your plenty Talk about your ills One man gathers what another man spills"

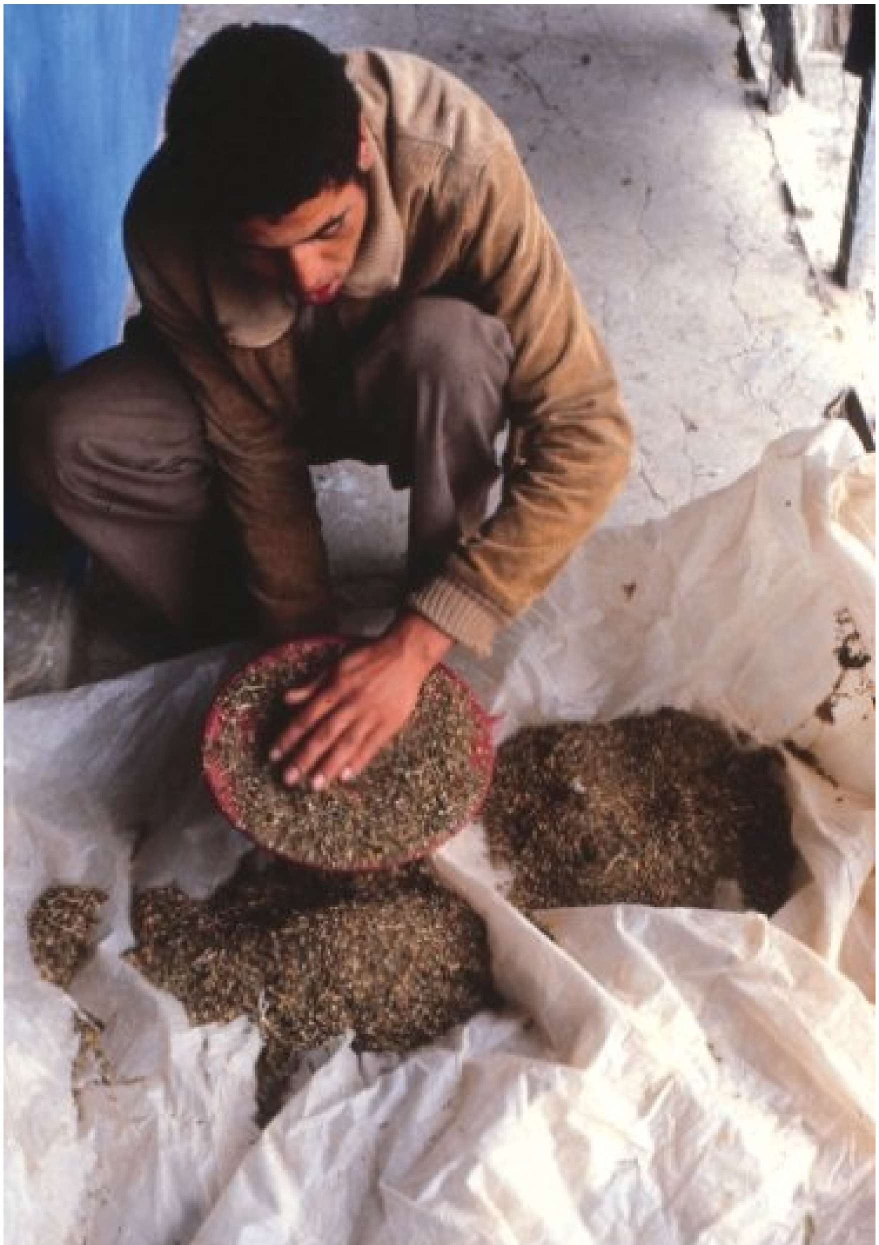
Lyrics: Robert Hunter The Grateful Dead, "St. Stephen"

THE LEAF HIERARCHY

This list prioritizes salvageable material according to its THC content.

1. **BUD BITS AND PIECES—cosmetically challenged “popcorn bud”**
2. **BAG SHAKE—the residue at the bottom of the bag**
3. **PRIMARY TRIM—the small leaves near the bud sites**
4. **MATURE FAN LEAVES—the large sun leaves**
5. **IMMATURE BUDS—these vary in THC content depending on stage of development**
6. **IMMATURE TRIM/IMMATURE LEAF—also variable depending on stage of development**
7. **VEGETATIVE LEAF—leaf from a plant that has not entered flowering phase of growth (has the lowest THC content)**

Plant material is shaken over a fine screen, which allows the glands to fall through with only minimal vegetation. Different grades of kief are produced depending on the amount of sifting time, the size of the screen and the pressure used when sifting. Often the same material is sifted a few times. With each repeated sift, a higher proportion of impurities, fine leaf powder, mixes with the glands, lowering the quality. The color ranges from blonde for the purest kief to green, which indicates that vegetative material containing chlorophyll has also filtered through the screen with the glands.



In Morocco, marijuana is aged for a few months and then pressed during the cold winter when little humidity is in the air. A silk scarf is stretched over a bowl and dry marijuana is rubbed over it. The result is kief.

PREPARING LEAF FOR SCREENING

Very little preparation is needed to sieve plant material for kief. In fact, kief making is so quick that small quantities can be done while the trash is being sorted or prepared for another process. It can also be done in large batches.

KIEF

Capture glands while manicuring by using a HarvestMore tray with a stainless steel screen.

www.harvest-more.com

The best kief comes from trim and leaf that is dry, but not crisp. Very dry material is brittle and crumbles into smaller pieces or dust that passes through the screen. Kief made from such material contains more vegetative matter. Pressed material or “brick” marijuana does not work as well for kief as loose material does because the gland caps are broken, spilling their contents, which congeal to the leaves.

On the other hand, in the mountains of the Hindu Kush region hash makers wait for cold, dry weather to sift plant material. The connection between the glands and the dry leaves becomes brittle so they break away easily when they are frozen.

Another advantage of using cold material is that the thick oils of the resin do not clog the screening material, however you should be careful because the cold also promotes crumbling so that finely ground plant material sifts through.

Excellent kief can be made in temperate, room temperature conditions. To make kief of the finest caliber, cool temperatures, less than 60° F (15° C) are best. Low to moderate humidity is okay, and the presence of a little humidity is even welcome if the material is particularly dry.

MANUAL SCREENING

Manual screening is cost-effective and no more labor-intensive than sifting flour. It is possible to buy ready-made screens or kief boxes from many sources and in many sizes. The screen, usually wire mesh, comes framed and often includes a solid bottom drawer where the kief is collected.

Screens are especially useful to use when manicuring. Glands that fall off the buds and would typically be lost fall through the screen and are conserved.

It is also possible to make your own screen. Wire mesh or silkscreen material can be bought from print supply shops or wire cloth sellers. Some resources are listed at the end of the chapter.

If you build your own screen or have a screen without a tray, a piece of glass or mirror is useful to catch the filtered material. A credit card, business card, or other straight edge can be used to gather the filtered material into a pile.

THE SCREENING PROCESS

Place the collection tray under the screen. Start with a handful of trim and leaf. Rub material softly against the screen. A softer touch allows the glands to pass through without scraping off much vegetative matter. This first layer of powder is the cleanest and most potent.

Even the cleanest kief contains some vegetative matter. Some people pass the material trough multiple screens to increase purity. In the first pass, they use a screen that is coarser, under 100 strands per inch (2.5 cm). This first screening cleans out the bulk of the vegetative matter. The sifted material is then placed atop a finer screen and shaken or tapped lightly. Since the vegetative material is only tapped through the second screen, not pushed, the multi-screening method yields cleaner results.

This rolling tray is made with 100 strands per inch (2.5 cm) of stainless steel mesh. It comes in handy for rubbing stray trim as well.

Kief makers usually sift the same material several times. The first sift is usually light and short in duration-from one to three minutes depending on the amount of material and size of the screen. The biggest, most mature glands are the first to break free and sift through. This is the highest quality kief, but the yield is fairly low.

The material is sifted again. The less mature glands fall, but so does some plant material that has crumbled into dust and is also small enough to pass through the screen. The second sift produces a large quantity of kief which contains more vegetative material and isn't as pure as the first screening. The color reveals this. The color is darker and greener.

Manual kief screening is good for making small amounts, and is cheap and easy to do. To process larger amounts of or to produce a cleaner product with less elbow grease, upgrading to a drum machine is a worthwhile investment.

MACHINE SCREENING

If you have a lot of leaf and trim that you'd like to screen for kief, manual screening can be tiresome. Luckily, some other folks have already discovered this and come up with inventions that take the labor out of kief making.

The Pollinator® turns much like a side loading washer. The marijuana tumbles against a screen and the glands fall through to the bottom of the machine for collection.

Drum machines are simple devices that gather a higher percentage of glands from the plant material than flat screening can.

THE POLLINATOR®

The Pollinator® is the original drum machine developed by Mila Jansen in the Netherlands. Mila is a natural innovator. A hash aficionado who was born in the Netherlands and lived for years in the Hindu Kush region, Mila has spent her fair share of time manually screening leaf and trim to make kief.

Many years ago, cold weather had set into the mountains of Northern India. Since it is believed that the trichomes snap more cleanly when the plant material is frozen, cold weather meant it was time to screen. She and friends spent several chilly days manually screening loads of trim for powder. The repetitive nature of screening was tedious and tiring.

1. Marijuana leaf is poured into the revolving drum of the Pollinator®. 2. The drum is placed in the machine. 3. After rotating for a few minutes the drum is removed and the contents are discarded or used for cooking. 4. The kief has dropped to the bottom and is ready for collection.

One evening after a long day of screening, Mila returned home and in the late hours, she stood, tired from the day's work, waiting for the laundry to finish. Suddenly her attention shifted to the clothes dryer. She was struck with the brilliant simplicity of her idea. The dryer was essentially doing what she'd been doing all day! Soon thereafter, she invented the Pollinator®.

Mila worked out a model for personal use, but it would be a few years before it occurred to her that this machine was marketable.

The Pollinator® is available in a few sizes. Resembling a clothes dryer, it is electrically powered. Trash is placed inside it and the machine is turned on. The material is softly tossed against a fine screen, around 130 strands per inch (2.5 cm). The amount of time it is allowed to turn determines the quality of the kief that is collected.

This machine makes creating kief or hash ridiculously simple. It can be used over and over. The same material can be reprocessed according to the collector's wishes. A+ hash can be collected by briefly pollinating the material and removing the powder. Then that same material can be screened again.

Screening for kief, whether manually or with the help of a machine, is a fabulous way to recycle plant material that was destined for the compost heap. It is less labor intensive, less expensive, and less time consuming for the yield than most other processes.

WATER HASH

Water hash has fast become a favorite worldwide. Its name comes from the efficient water process used to collect glands from the trim, leaf, and bud bits. Water hash is actually loose, kief-type product that can be smoked as is, or pressed into traditional hashish form. Either way, many people are quickly converted once they've experienced this pure and potent product.

Water hash can be made in small or large quantities. Ready-made systems can be purchased to simplify the process. These systems have increased the precision and efficiency of the water hash process and contributed to its surge in popularity. It is also possible to make water hash using home-gathered equipment.

HOW WATER HASH IS MADE

The quality of water hash, especially from the finest grade material, is impressive. Of course, as with the other processes, the high produced from water hash depends upon the quality of the plants being used. Processing plant material with water yields hash that has been washed free of contaminants: green plant matter, mold, fungi, and chemicals.

Any gland-bearing plant material can be used to make water hash, including leaf, trim, buds, shake, or a combination. Fresh or dried material can be used.

Water hash varies in color, much like kief. The finest grade is typically a light tan, while the coarser second-tier material is slightly darker and a little green from vegetative plant material. High quality water hash turns to liquid, melts and bubbles when it is smoked.

It is possible to extract a quarter to one ounce (7-28 g) of hash from every eight ounces (0.25 kg) of plant material. The yield depends in part on the number of glands present on the material. Buds and A+ trim have a higher concentration of THC bearing trichomes, so the yields are higher.

The water method uses agitation of grass with water and ice to separate glands from the plant material. The ice serves a dual purpose; it chills the material making it brittle so the connection between the glands and the plant easily snaps and it acts as an agitator that scuffs the material. After the plant material is agitated in ice water, it is allowed to settle, and then the bags are separated.

The filtration bags are similar to the screens used for making kief. They filter the glands by micron size, separating the trash from the hash. A micron is one-millionth of a meter, or .001 millimeters. The material is trapped and floats in the top bag, while the glands, which are heavy enough to sink are collected in the lower bag. After the water hash dries, it is ready to smoke.

The entire process takes three to six hours to complete. The bag method is kind of like doing the laundry; it does not require constant attention, but is something that you keep coming back to at regular intervals.

Some ready-made systems use multiple bags that sort the glands into grades, unlike kief making, the material is separated in one step rather than through repeated sieving. The process works best when the material is cold. In humid areas, it is a good idea to store dried material in the freezer to avoid deterioration or molds. When using material that has not been stored in this way, place material in the freezer until it gets cold.

Payload Bags (shown above) separate the grades of water hash using a color-coded bag system and varying grades of strong fiber. Many connoisseurs prefer water hash over screen kief. Using a combination of cold temperature and agitation, trim can be screened by quality.

Bubblebags have a series of finer and finer screens that are used to sort out different grades of kief.

Since glands reside on the surfaces of the plant, that material does not need to be ground to make water hash. Small cutting or coarsely chopped material is most convenient. Remove any big twigs or stems, as they could tear the bags.

Whether using a ready-made bag system or materials from your kitchen, the basic principles of making water and hash are the same. Aside from the caliber of the plant material, the quality of the filter determines the purity of the results.

READY-MADE BAGS

Several ready-made bag systems are on the market, but two have become the most popular systems for making water hash. These are the Ice-o-lator® from Mila at the Pollinator Company, and Bubble Bags® from Fresh Headies in Canada.

Both systems provide high-quality bags that are durable, and easy to clean and use. The bags are color-coded for convenience. Bubble Bags® may be more commonly known in North America because the company is based in Canada, while the Ice-o-lator® system hails from Amsterdam and is probably more widely known in Europe, but both products are available internationally.

THE ICE-O-LATOR®

Mila Jansen's first invention was the Pollinator®. Her interest in improving hash-making methods also lead her to develop the ready-made water extraction system called the Ice-o-lator®.

The Ice-o-lator® consists of two bags, which line a sealable bucket of the appropriate size. Ice and water are added and then dried material is placed in the bucket. A standard kitchen mixer affixed through the bucket's lid agitates the material. The top bag holds all of the vegetative matter. Glands filter through the silk screen of the first bag and collect in the finer screen of the second bag. The remaining water in the bucket has particulate vegetative matter, including some nutrients that make it good for watering houseplants or vegetable gardens.

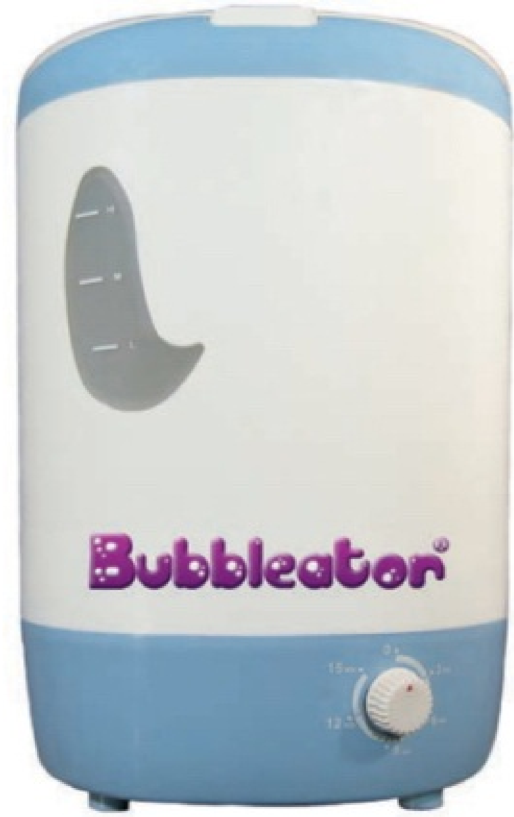
A PRESSING ISSUE: KIEF AND HASH

Once kief is made, it can be used in a number of ways. The glands are delicious smoked fresh and loose. However, some traditionalists insist that they be pressed into hash. Hash made from screened kief, especially using the first-screening, is excellent. Kief is also an excellent ingredient for cooking and use in capsules. Without the vegetative matter attached the glands do not impart the dominating "green taste" to edibles.

BUBBLE BAGS®

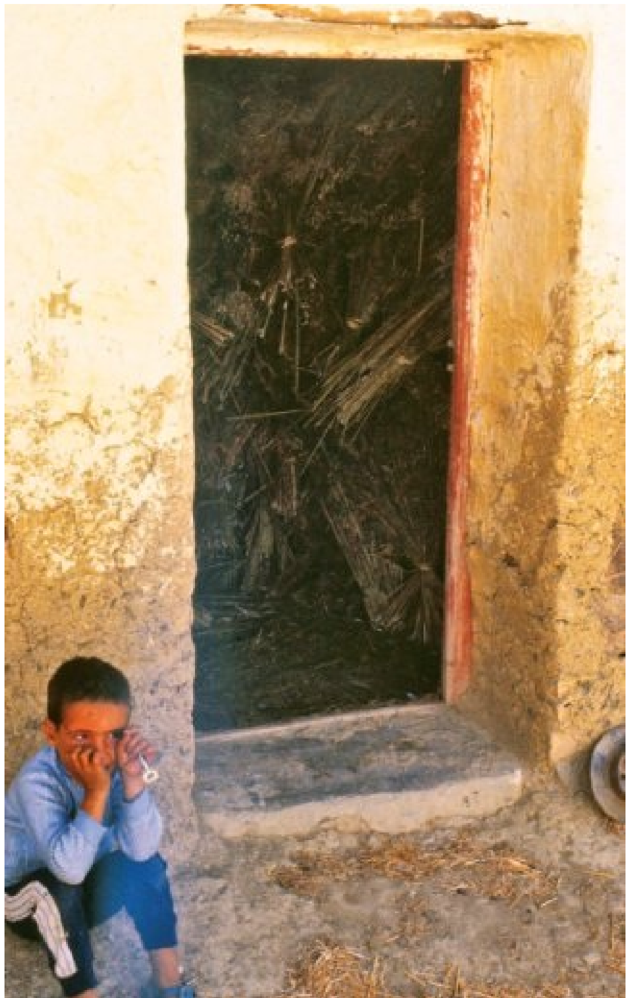
Bubble Bags are available in 1 gallon, 5 gallon, and 20 gallon sizes. Each size is available as either a 4 bag or an 8 bag kit. The 8 bag systems separate the hash into finer categories. The size difference between just-ripe THC glands and overly mature or premature ones allows them to be separated into grades. There is also some variation in THC gland size in different plant varieties.

To use the Bubble Bags, all of the bags are placed into a bucket, beginning with the 25 micron bag and ending with the 220 micron work bag on top. Plant material, ice and water are added and then mixed by hand using a wooden spoon. After mixing, the work bag is pulled out and squeezed back into the other bags. The material left in the 220 micron bag can be processed again later.



The Bubbleator® and Ice-O-Lator® (below) are convenient tools for making water hash. The Bubbleator® agitates the vegetation; glands wind up in the water and are filtered out.

The Ice-O-Lator® agitates the vegetation in ice water to remove the glands.



This ganja in Morocco is stored from harvest in September to January for processing. The time in storage and cold weather assures that the vegetation will be dry and crisp, maximizing yield.

The remaining Bubble Bags are pulled out one by one, and the material in the bottom of each one is collected and allowed to dry. The remaining water can be discarded or used for watering plants.

Alternative methods of mixing include using a a kitchen mixer or drill attachment to mix in a separate bucket before pouring the mixture through the Bubble Bags; or Fresh Headies also offers a Bubble Now machine in either a 5 gallon or a 20 gallon size. This machine performs the agitation part of the process.

The empty bucket is lined with the additional bags—either two or five, depending on the system. The finest bag goes in first, so it will be the bottom. Then the other bags are added, with the coarsest on top. The green water is poured into the second bucket, which is lined with the filtering bags. These bags are pulled out one by one, and the material in the bottom of each one is collected and allowed to dry. The water can be tossed out or used for watering plants.

HASHISH

Hashish is a collection of marijuana’s resinous glands that have been compressed into balls, cakes, or slabs. The origins of hashish date back millennia. It began along the 30th parallel latitude in the Himalayan foothills that include the famous hash making area near the many countries near the 30th latitude, including Afghanistan, Bhutan, India, Nepal, and Pakistan. Morocco and Lebanon, both hash making countries, also lie near the 30th parallel.

Making hashish is a two-step process. In step one, the glands are collected. All collection methods yield a consumable product, but it is not yet hashish. Hashish involves a second step: compressing the collected material into bricks or balls.

Sifting for kief is a primary method of collecting glands for hash. Once the glands are collected they are ready for pressing.

Water hash can be pressed using the same methods, but the water must be removed and it must be dried or the hash will mold. Press the water out by placing the hash between two absorbent towels and pressing down on it. Repeat this process several times.

Several kinds of hash including Nepalese Temple Balls, Blond Lebanese and Afghani slabs.

Another method of collection, hand rubbing, dates to ancient times. While low in yield it usually results in high quality hash. Hand-rubbed hash is collected fresh from the plant, and the resin is still sticky, so the method of pressing involves a slightly different process.

Pressing hash involves a combination of force and mild heat to condense the glands into a solid mass. The shape and size of hash can vary depending on the pressing method that is used. When hand pressed, it is often ball shaped. Flat pressed hash can look like thin shale rocks, with hardened shelf-like layers that chip along the creases. Mechanically pressed hash is usually neat cake, like a bar of soap. Hashish ranges in color and pliability. The variety of marijuana used, the pressing method, and the purity of the hash all influence its color, which ranges from light yellow-tan to charcoal black.

Aficionados often describe the high that hash produces as more complex than that of unpressed material. In the region of traditional hash making, kief is aged, from harvest in August or September to January or February. Sometimes it is stored for an additional year before it is pressed. Most modern or home hash makers don't wait that long.

Once pressed, hash suffers little from aging. As long as it is water free, so it doesn't mold, it can be stored for a long time. The outer surface oxidizes a little and forms a skin protecting the inner contents from deterioration.

Good quality hash is solid at room temperature. It can be supple, bending easily, or dense and brittle. Differences in color and density result from the quality of the starting material, harvesting method, pressing technique, the presence of impurities, storage method and aging. Hashish darkens from exposure to light, oxygen and heat. Regardless of its texture, high-quality hash should soften with the simple warmth of your hands.

COLLECTING FOR HASH

Before attempting to press kief or water hash, the material should be completely dry. Just before pressing, the material can be put through a last drying phase to ensure that all moisture has been eliminated. Place the kief or water hash in a food dehydrator set on the lowest setting, or microwave the material on low to remove the last vestiges of water.

These precautions against moisture improve the life span of hash so it can be stored without the threat of mold or spoilage because of trapped moisture.

COLLECTING BY HAND: RUBBING FOR HASH

There are many tales about collecting hash from fresh plants. Hand rubbing for hash has been a common gathering method for centuries in some parts of Asia, and it Is still a primary way of collecting hash in some parts of the world.

Because it requires no equipment, hand rubbing is a novel and spontaneous way to collect for hash, but this method also has several down sides

The effort required to produce a substantial yield is greater than the other methods. It can be messy and labor intensive.

Hash collected this way is subjected to more contaminants from plant debris and hands, and contains more water, making it more likely to spoil if it isn't dried.

Hand rubbing requires access to live mature plants rather than dried trim and leaf. Unlike other methods, it can only be made at certain times in the growing cycle and cannot be made from trash that has been collected and stored.

Removing the collected resin from the hands can be an involved task. One way to solve this is to use latex or plastic gloves. When you are finished collecting, place the gloves in the freezer and the hash will peel off.

Having pointed out these shortcomings, hand rubbing can be used when the goal is a small amount of quality hash that will be used shortly after it is collected. Hand rubbing is a good way to salvage some of the THC before or during harvest and manicuring.

The amount of material collected through hand rubbing is dependent on timing and good technique. It is best to collect for hash when the plants' stigmas have started to turn amber as they reach full maturity, but before the leafy material has become brown or dry. The more dead or dry the plant material, the more plant debris will be mixed in with the hash.

Removing dead or dried material before collection increases the quality of the hash. Collection should not be done when the plants are wet because this increases its water content. The morning is the best time for collection, before the terpenes evaporate.

Sticky resin builds up on tools and hands as the buds are trimmed. The resin is rich in cannabinoids shed by trichomes loosened from the bud. Don't wash your tools and hands until you've scraped off and collected as much of the resin as possible. This is what is referred to as "finger hash."

PRESSING HASHISH

Pressing transforms the collected material both chemically and physically. The glands are warmed and broken, releasing the sticky oils that contain the psychoactive cannabinoids, as well as the terpenes, the source of marijuana's smell and taste.

Terpenes lend fragrance to the hash. Smells and flavors characteristic to hashish range from spicy or peppery to floral in quality. Terpenes are also volatile and contribute to the lung expansiveness, i.e., cough factor, as well as the taste. Aged kief is both milder in smell and flavor, and less cough inducing, because some of the terpenes, not the THC, transform to new compounds.

Material can be pressed into hash manually or mechanically. Manual methods involve some labor, and work well for smaller amounts of hashish. Mechanical pressing is very fast, convenient and efficient.

To make a small amount of hash, wrap some kief in cellophane and place it on the innersole of your shoe. The gentle body heat and pressure will convert the kief.

CAPSULES

Maybe you've wondered if it were possible to take a marijuana pill. Just pop it in your mouth with a gulp of water and enjoy the therapeutic and mind-enhancing effects of cannabis. Marijuana capsules, or "maripills" are very effective and quite easy to make.

This heavy-duty unit presses large amounts of kief. The Trimpro Jack Puck is available in 2, 6, and 8 ton models.

Hash-press machines, such as the Piecemaker, use a combination of heat and pressure to form convenient hash blocks. This handy tool presses small amounts of kief into hash "coins" about 1.5" (37 mm) wide.

Gelatin capsules are not vegetarian—they are made from cows. Some vegetarian capsules dissolve when exposed to oil. Test a capsule before purchasing for maripill use.

Some people really enjoy the high that results from eating marijuana, but tainted foods are not always predictable. Maripills can be a convenient alternative. Medical marijuana patients find capsules more effective than smoking for pain management. Recent studies suggest that cannabis has stronger analgesic and anti-inflammatory qualities when eaten.

Marijuana capsules begin to take effect 30-90 minutes after being eaten. It is easier to monitor the exact amount of cannabis that is being ingested. Psychoactive effects typically last 5-8 hours, but the herb's medicinal effects may continue for as long as 12 hours.

Because maripills allow cannabis to be eaten without food, these capsules give the individual more choices. When taken on an empty stomach, the high is likely to come on more quickly, and may be more potent. When eaten following a meal, assimilation is slower and the effect is mellower but lasts longer. Medical users may find this increased control over effect reassuring.

The first-step in making marijuana capsules is grinding plant material to powder. The potency of the pill varies by the ingredients used to make it. The hierarchy of potency is kief, buds, trim and leaf.

If the stuffing material isn't crispy, dry heat it gently for a few minutes or place it in a microwave. Mix it with cooking oil to make a paste with the consistency of a dry roux. Olive oil is an excellent choice because it is unlikely to become rancid. Butter is not a good choice unless the pills are to be kept refrigerated.

DECARBOXYLATION EXPLAINED

Some THC in resin is present in the form of THC-A, also called THC acid. This form of THC has a carbonate molecule (COOH) attached to it, which is also called a carboxyl group or acid. THC is only marginally psychoactive when a carboxyl group is attached. To decarboxylate is to remove the carbonate molecule. This simply means breaking the bond between COOH molecule and the THC molecule. This is usually accomplished through mild heat. When the carbonate molecule is removed from the THC acid, the COOH evaporates away in the form of water vapor (H_2O) and carbon dioxide (CO_2), and THC is left behind. Converting THC-A through decarboxylation improves the available THC content, sometimes called "potentiating" the THC. Extractors such as the one from MagicalButter build decarboxylation into the process.

www.magicalbutter.com

Pack the roux into gelatin capsules using a capsule-filling device. They are available at many health food stores. Capsule filling machines are small (about the size of a brick) and inexpensive (under $40). They simply hold the gelatin capsule in place, allowing many pills to be filled at one time.

Size 0 capsules are recommended. This size is not too cumbersome to swallow, and can hold 325 milligrams of marijuana. Dosage may very between 1 and 5 capsules, depending on the potency of the material used.

COOKING

Eating cannabis foods is a healthy way to use marijuana without inhaling. It’s modern history dates back centuries before prohibition. In 19th-century Paris, the Club de Hachichins met for the express purpose of eating hashish. Authors and poets whose works we now consider to be classics were members. In the 1920s, Alice B. Toklas published her infamous brownie recipe that popularized brownies as the cannabis food of choice in modern times. More recently, “medicated” foods have become a common therapeutic alternative for medical marijuana use.

Eating marijuana is a different experience than inhaling it. It isn’t an immediate rush. Instead, the sensation begins gradually, about half-an hour to an hour after ingestion. The length of the lag time depends on a mostly on stomach contents. If you are full the high takes longer to come on and is not as intense. The high comes in “waves” reaching a peak an hour to two hours after the first effects were felt. Then it tapers to normal over the next hour. Altogether, the high usually lasts three to four hours.

Edibles are a good way to medicate.

Taking the right dose is more important when ingesting than inhaling. Since the onset of the high is rapid when marijuana is inhaled, it is easy to self tritrate, to find the proper level of high or medication. However, since the effects after eating take longer to occur, it is harder to adjust the dose.

If you are unfamiliar with the effects, it is best to err on the side of too little rather than too much. You can always eat more, but you have to wait out the effects if they are too intense. This can be an unpleasant experience, but it is not dangerous. Your body will continue to function, and you will come down in a few hours.

The secret to creating tasty and effective cannabis food lies in transforming the cannabis into a cooking ingredient.

Using cannabis preparations and a little ingenuity, can turn tried-and-true favorites and cookbook recipes into cannabis treats. Recipes designed specifically for marijuana-enhancement are available in cannabis cookbooks and on the web. If you aren't a consummate cook, you can always take the easy way out and use a ready-made mix. It is easy to make a good consumable once you understand how the THC is extracted and how the body processes eaten marijuana.

HOW IT WORKS

It's obvious that cooking with marijuana is not rocket science; still, following a few simple procedures in preparing the herb results in a better product and a more enjoyable experience. THC and the cannabinoids are not water-soluble. In order to create a satisfactory cannabis consumable, the THC-bearing plant material must be combined with an ingredient that can dissolve it. Ingredients with this capacity are alcohol, oil, butter or fat and lecithin-containing milk products.

Mild heat also plays a role in cannabis cooking. Some THC on the marijuana plant is in the form of THC-A. For THC-A to become psychoactive it must lose its carbonate molecule, COOH, which evaporates under low heat.

When heating cannabis the temperature should be kept below 100° F (38° C) so the terpenes do not evaporate. When all the water has evaporated and the vegetation feels crisp, it is ready to use.

THC has a boiling temperature of 392° F (200° C). Once it reaches or passes this temperature, it begins evaporating into the air. To activate the THC without evaporating it, pay attention to the cooking temperature used.

In recipes such as the ever-famous brownies, the oven temperature is often set at 400° F (205° C). This is okay. The batter never reaches this temperature. If you've ever roasted food, you know that if the oven is set at a temperature around 350° F (175° C), but it takes the thermometer inserted in the food several hours to reach a temperature of 200° F (93° C). Baking temperatures indicate oven temperature settings, not the temperature of the food.

The real danger of cannabinoid depletion comes with stovetop cooking. Sautéing or frying temperatures reach 400° F (205° C), above THC's boiling point, when cooking on high heat. At this temperature the cannabinoids boil off. Closely monitor stovetop cooking to avoid cooking away the THC. The best way to use marijuana in a sauté is to add it when the dish is almost done. Treat the cannabis as you would an herb like basil-use it last and only allow it to be under the heat briefly. This way the active ingredient doesn’t heat up and evaporate.

MAKING MARIJUANA EDIBLES

Making marijuana edibles is not difficult once you have prepared the appropriate cannabis infused base ingredients. With infused butter or oil on hand, it can be easily incorporated into any recipe.

THC is oil soluble so it dissolves in oils, fats and alcohol. To start most recipes you infuse the fat or oil with marijuana. If you do not want to use a fatty ingredient, you can sprinkle kief or ground trim in with the flour or dry ingredients of a recipe.

HOW TO MAKE BUTTER

To make edibles it is easiest to use infused butter. The key to making good, potent, butter is to cook on low heat for a longer amount of time. Both butter and clarified ghee can be used.

Making cannabis butter.

MAGICAL BUTTER

With medical and full legalization, techniques are being developed for producing marijuana-infused products of a consistent dose. Extraction is getting simpler using innovative equipment that is convenient to use.

The Botanical Extractor from MagicalButter is an example of a modern kitchen appliance. This self-cleaning extractor does all the work. You just add the ingredients and the machine makes the

extraction. It grinds and decarboxylates, which potentiates the THC while minimizing odors. It can be used with oils as well as butter.

www.magicalbutter.com

The Magical Butter Extractor can be used with oils as well as butter.

Grind the desired amount of cannabis in a coffee grinder or blender. Decide how many doses you are making, then add the right amount for each portion.

Cook the butter or oil and cannabis together on medium to low heat for at least an hour. A double boiler or a slow cooker conveniently maintains a low, steady temperature for about an hour. For stronger edibles, do not strain the leaf out of the finished butter. For lighter, more traditional looking treats, strain the leaf out with fresh pantyhose or a colander. The butter or oil is ready to be used.

You can also add powdered kief, bud or leaf or sprinkle them over foods. They will bind to the fats in the foods before or after being eaten.

CLEANING UP

You’ve harvested the crop, trimmed and dried the buds, and enjoyed your fresh hash and kief—but it’s everywhere! After harvest, inevitably everything in your home or greenhouse, from floors to windows, door handles and furniture, is covered with resin and leaves.

To clean hard surfaces such as counter-tops, cabinets, windows and floors spray a layer of diluted BioGreenClean© and allow the solution to sit a couple minutes before wiping away. The hash and resin will lift right off. Wipe down with hydrogen peroxide to sterilize surfaces and tools.

To clean your pipes, fill a bucket or vat with diluted BioGreenClean® and allow them to soak for at least a couple hours, depending on how much resin they have accumulated. They will just need a quick rinse to look as good as new!

PART V QUICK POINTS: HARVEST, RESTARTING & POST-HARVEST

HARVEST

When the bud is ripe it is time to harvest, and it is ready to be trimmed, or manicured. Manicuring is the process of removing the leaves that are growing around the buds. The best time to manicure is when the plants are freshly picked. Fresh vegetation is turgid with moisture, so it is easy to handle while it is being clipped. Just as important, the trichomes that hold THC and the terpenes are pliable rather than brittle and more likely to stay attached to the plant.

Once you have harvested, use plenty of light when manicuring so you can see clearly exactly what you are doing. There are four steps to trimming ripe marijuana: clipping the stem from the plant, clipping the buds from the stem, removing the large leaves and removing the small leaves from the bud. The steps can be performed as one integrated operation or in steps. The choice depends on the size of the crop, the number of people trimming and most importantly, your preference.

The trimming space should include three sections: the holding area, the processing area and the curing-drying area. Curing is the process after harvest but before drying, during which many of the cell's metabolic processes continue for a little longer. Save the trim from the processing area. While sun leaves and trim are unsuitable for smoking they can be used for making kief, bubble hash, and ingestibles.

Drying large amounts of buds requires air circulation and ventilation. Fans create a draft that promotes evaporation, and ventilation exchanges moist air for dryer air.

The quality of marijuana improves for several weeks after it is dried because THC acid loses its water molecule and becomes psychoactive. Buds that are cured properly and dried slowly have the smooth draw of fine herb. Fast-dried pot has a harsher, rougher smoke. Buds should be disturbed as little as possible before they are smoked. Every time they are moved, unpacked, or handled, resin glands fall off.

Things to Know

- The advantage to harvesting buds as they ripen is that those previouly hidden in the lower canopy are also allowed a chance to fully mature.
- The loose trichomes that are broken off while manicuring are known as kief. Because kief contains cannabinoids but little vegetation, it is much more concentrated and potent by volume than buds. A screen with a mesh count of about 100 strands per square inch (100 strands per 6.5 sq cm) allows glands to drop through for collection while retaining the plant material on the screen.
- Many gardeners raise the temperature of the curing-drying space to hasten the drying process. However, many terpenes evaporate between 70-85° F (21-29° C). When they evaporate, the buds taste stale and loses their personality. For this reason, it is important to control the temperature of the curing-drying space.
- There are two good ways to determine bud dryness, the "stick" test and the joint test. For the stick test, bend the little stem that holds the bud together and if it snaps, it is dry enough. For the joint test, roll a thin joint to see if it stays lit between puffs, if not the bud is still too wet.

POST-HARVEST

Leaves and trim, the natural byproduct of growing buds, present an interesting paradox. The bud is the plant's crown jewel at 5-20% THC. However, cannabis produces THC throughout the plant. Sticky resin glands coat the leaves and bracts, creating a natural protective barrier against insects, disease, herbivores, and the sun's UV rays.

When trim and leaves are tossed, 10-20% of the plant's total THC production is thrown away. When tossing it out, trash is everything that isn't bud. It you are going to use it, it should be sorted. Stems and woody parts of the plant are not salvageable. The sticks and stems have little THC so they can be trashed.

The small leaves near the flowers are the most potent, followed by the younger, and then older fan leaves. Any material with visible glands is worth keeping. There are many uses for trash, the most popular being kief, hash, maripills and cannabis food.

Kief is a powder that consists of the loose glands removed from marijuana buds and plant material. It looks like minute grains of sand. Once kief is made it can be used in a number of ways. The glands are delicious smoked fresh. Kief is also an excellent ingredient for cooking and use in capsules. Without the vegetative matter attached the glands do not impart the dominating “green taste” to edibles.

Hashish is a collection of marijuana’s resinous glands that have been compressed into balls, cakes, or slabs. Pressing hashish transforms the collected material both chemically and physically. The glands are warmed and some are broken, releasing the sticky oils that contain the psychoactive cannabinoids, as well as the terpenes-the source of marijuana’s smell and taste.

Eating cannabis foods is a healthy way to use marijuana without inhaling. However, eating marijuana is a different experience than inhaling it. It isn’t an immediate rush. Instead, the sensation begins gradually, about half an hour to an hour after ingestion.

Things to Know

- Maripills are capsules filled with processed marijuana and ingested orally. For patients, they are an easy way to measure dose, and a safer alternative to smoking dried buds.
- In 19th-century Paris, the Club de Hachichins met for the express purpose of eating hashish. Authors and poets whose works we now consider classics were members. In the 1920s, Alice B. Toklas published her infamous brownie recipe that popularized brownies as the cannabis food of choice in modern times.

GLOSSARY

Aeroponics: is a technique of growing in which the roots hang in the air of an enclosed chamber. A continuous spray of fine mist irrigates the roots with droplets that cover them with a thin film of highly oxygenated water.

Anti-transpirants: are compounds applied foliarly that reduce transpiration (see transpiring), and preserve and protect plants from drying out too quickly. Anti-transpirants can also be used to protect leaves from salt burn and fungal diseases.

Apical Meristem: is the growing tip of the stem. Cells in the apical meristem are capable of dividing indefinitely and their main function is the production of new growth.

Auto-flower: is a plant that flowers without environmental cues such as light period or heat.

ATP (Energy Molecule): stands for adenosine triphosphate, and is the energy currency of cells.

Auxins: are hormones that regulate or modify the growth of plants, including form or shape as well as root formation and bud growth.

Ballast: is an attachment that converts electrical current to the appropriate current needed to power the light.

Calyx: are the outer leaves that envelope the bud.

Cannabidiol (CBD): is a cannabinoid found in cannabis. CBD is not intoxicating. It relieves convulsion, inflammation, anxiety, and nausea, as well as inhibits cancer cell growth. It does not dock on the brain's CB1 receptor, but only on the CB2 receptors located in areas outside the brain.

Capillary Mats: are about 0.25" (60 mm) thick. They are made from soft polyester covered with opaque polyethylene perforated with small holes. They have great wicking ability and are used in sub-irrigation systems.

Chlorosis: is a reduction in or loss of the normal green coloration caused by a lack of chlorophyll.

Clorophyll: is the green pigment in plants that photosynthesizes by absorbing light. Chlorophyll absorbs blue and red light.

Chloroplast: is a semi-autonomous organelle which holds the chlorophyll. It contains some of its own genetic material and has some ability to direct the synthesis of its own proteins.

Consemilla: refers to a mature marijuana bud with seeds. From the Spanish “con” for “with”, and “semilla” for “seed”, meaning “with seed”.

Cotyledons: are the pair of embryonic leaves that appear at germination.

Crimping: a method of bending branches by damaging the tissue to make it easier and create a stronger stem.

Cytokinins: are plant hormones that work with auxin to promote cell division (general growth) and lateral growth.

Dopamine: is an essential brain chemical that regulates movement and emotion. A lack of dopamine in the brain contributes to Parkinson’s Disease.

Fan leaves: are large leaves that collect sunlight. The leaf symbol is commonly associated with cannabis.

Fertigation: is the application of fertilizers to planting mix using an irrigation system.

Foot-candle (fc): is a unit used to define the amount of illumination the inside surface of a 1’ (30 cm) radius sphere would be receiving if there were a uniform point source of one candela in the exact center of the sphere.

Friable: refers to the consistency of the soil; friable soil forms a clod when squeezed into a fist but easily crumbles when it is poked.

Ganja: is the term for marijuana in Jamaica and is the same as in India. Indian immigrants brought the tradition with them.

Gibberellins: are plant hormones that stimulate the growth and stretching of leaves and shoots. Unlike auxins they tend to affect the whole plant.

Hemp: is the common name for plants of the entire genus cannabis, although the term commonly refers to cannabis strains cultivated for industrial (non-drug) use. Hemp is cultivated for oil and fiber.

Incandescents: are common screw-in lamps powered by an electrically heated filament.

Hermaphrodite: is a plant which has both male and female flowers. This may be caused genetically, by stress, or by using hormones and chemicals.

Hydrocarbons: are compounds that contain carbon and hydrogen.

Kali: is the traditional Jamaican term for the best weed and is named for the Indian killer goddess.

Light Movers: move lights along a track or circularly for better light distribution.

Limonene: is a terpene found in citrus rind and many other fruits and flowers, including cannabis. Limonene has anti-bacterial, anti-fungal, anti-cancer and anti-depressant properties.

Lumen: is a unit for measuring light.

Lux: is a metric measure of light.

Macronutrients: are the nutrients that are used in large quantities by the plant. They are nitrogen (N), phosphorous (P) and potassium (K).

Micronutrients: are the nutrients that are used in smaller quantities by the plant. They are calcium (Ca), sulfur (S), magnesium (Mg), iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), and boron (B).

Myrcene: is the most prevalent terpene found in most varieties of marijuana. It smells clove-like, earthy, green-vegetative, citrus, fruity with tropical mango or minty nuances. It is a potent analgesic, anti-inflammatory and antibiotic.

Necrotic: are dead patches of tissue on a leaf.

Node: is the spot where the leaf joins the stem.

Organelles: are specialized bodies within the cell that have a specialized function. In most cases, the organelle is separated from the rest of the cell by selectively permeable membranes and maintains its own DNA.

Over-winter: describes techniques used to live through the winter season. Insects over-winter as adults, pupae, or eggs.

PAR (Photosynthetically Active Radiation): refers to light in the range of 400-700 nanometers.

Petiole: is the stalk or support that attaches the blade of a leaf to the stem.

Photosynthesis: is the chemical reaction, powered by energy from light, by which the plant uses light energy to combine water and CO_2 to make sugars and release oxygen.

Phytochrome: is a photoreversible pigment that controls flowering. It exists in two forms: red and far-red sensitive.

Pinene: is a terpene with an odor associated with pine trees. It is found in many plants including cannabis, rosemary, sage and eucalyptus. It improves memory, increases focus, self-satisfaction and energy.

Pistil: is the ovule-bearing organ of a flower.

Rhizosphere: is the area of soil immediately surrounding the plant roots which contains many organisms living in a community.

Ruderalis: is a variety of cannabis that is not dependant on the light cycle or other environmental cues to flower.

Serotonin: is a neurotransmitter involved in sleep, depression, memory, and other neurological processes.

Short Day Plant: flowers based on a critical dark period.

Sinsemilla: is Spanish for “without seeds”, this refers to a seedless female flowers.

Stretching: is the elongation of the stem caused by a combination of heat and inadequate light.

Supercropping: is a technique of training top branches to grow horizontally so that the primary bud is exposed to more light.

Terpenes: are the essential oils of plants which create the odors we smell. Plants produce terpenes for three reasons, to attract pollinators, to attract predators of herbivores and to repel or kill herbivores. Marijuana is wind pollinated so it doesn’t need to attract pollinators and outdoors it is resilient to insect predation.

Tetra-hydrocannibinol (THC): is the main psychoactive substance found in cannabis.

Transpiration: is the loss of water vapor from a plant to the outside atmosphere. It takes place mainly through the stomata of the leaves. Although its function is disputed, it may reduce leaf temperature, but what is definitely known is that water vapors are emitted through the leaves and water is lost.

Trichomes: are glands growing off of the leaves and buds that contain THC.

PEST & DISEASE APPENDIX

PESTS

Pests are among the most annoying and difficult problems facing gardeners. The best way to deal with them is to prevent them from entering. No matter the growing method, pests will infect your garden if they are given a chance. Here are some ways of prevent ing them from getting in:

Pets: Pests enter using pets as transportation. Don't let your pets in the garden. Their fur also accumulates on sticky buds

Clothing: Clothing worn outdoors can carry in pests. Even a single pest can be a vector for a fast growing colony. After going outside, wash and dress in freshly laundered clothes.

Plant Quarantine: Before letting a plant enter a pest-free garden, place it in quarantine and use a pesticide/fungicide spray or dip just to be sure.

Planting Mix: Make sure the planting mix is composed of inert or pasteurized ingredients. Planting mix that is not inert or pasteurized may contain pests and diseases.

Pest Highways & Airways: Make sure all air coming into the garden space is filtered. Repair any cracks, holes or other open spaces.

The larger an insect infestation the harder it is to eradicate. It is easier to deal with a small infection rather than a large one. This section provides information that allows you to recognize and eradicate pests that commonly affect cannabis. In this guide, pests are listed in alphabetical order, but the ones that are most likely to attack your plants are—aphids, fungus gnats, mealy bugs, spider mites, thrips and whiteflies. A description of each pest is provided so that you can detect it both from the pest itself and by the damage that is done. Preventative and control methods are provided to both keep the pest away from the plants and get rid of an infestation.

ANTS

Ants are abundant both indoors and outdoors. Most of the species that affect marijuana use it for grazing their herds of aphids and mealy bugs.

Ants can be found in the soil or planting medium, where they nest. They climb the stalk and graze their herds of aphids and mealy bugs on the leaves. They nest in underground colonies causing damage to the roots. The aphids and mealy bugs they herd are severe threats to plants because they suck vital juices.

Ants are attracted to plants that already have aphids, whiteflies, mealy bugs, and scale. Then they take these pests to new grazing areas. First they spread out on the plant, then move the herd to new plants. Aphids, mealy bugs, and whiteflies secrete a sticky substance known as “honeydew,” a sugar concentrate of the plant’s sap. Ants eat it, but it also supports sooty mold. It is important to exterminate ants because they herd insects, and their nesting results in root damage.

Ants are social creatures, living in colonies of queens and supported by workers. Some species have only one queen per colony, while others may have several. The ant life cycle begins with an egg laid by a queen, then progresses through a larval and pupal stage, then adulthood. In many species only the oldest adults work outside the colony. 90% of the ants work in the nest. Colonies reproduce when a newly hatched queen selects several males and either walks or flies to a new location.

Ants regulate their reproductive rates depending on conditions in the colony and the outside environment. They do this partly by regulating the length of the pupal stage and partly by varying how many larvae or pupae are transformed into queens. With suitable weather and ample food and water reproductive rate increase. To protect the plant you need to eliminate the colony, rather than the few ants you see because lost workers are rapidly replaced.

ANTS HERDING APHIDS

PREVENTION

There are many ways to deter ants from wandering into the grow area and getting to the plants.

+ Moats: ants don't swim so moats prevent them from crawling from floor or table to the container. A simple moat can be made using a wide tray and a support such as a thick piece of Styrofoam or a block of wood. Place the plant container on top of the support. Fill the tray with water. Alternately, place the table legs in a moat.
+ Ants are repulsed by cinnamon, cloves and bay leaves. Make a perimeter of ground spices around the garden that ants will not cross. Teas brewed from these spices also repulses ants.
+ Boric acid, which is sometimes used as an eyewash, also makes a good barrier.
+ Ground diatomaceous earth is often used in swimming pool filters and kills insects with its sharp points, which puncture insects crawling over it. It is effective when it is dry, but not when wet.
+ Sticky cards, flypaper, or petroleum jelly are effective when they are wrapped around the stem. Don't apply it directly. Instead wrap paper around the stem and then apply the sticky substance to the paper. It is an easy nontoxic solution to ants. Two products that are designed for this are sticky traps and Tanglefoot, a stickum that is spread on surfaces. Sticky cards also make good barriers.

CONTROL

+ Spices: Use a cinnamon-clove tea to flush ants from planting mediums. Ants vacate the premises in the presence of either dry powdered spice or spice tea. Other natural substances repulsive to ants include cayenne pepper, citric extracts, mint extracts, and cream of tartar.
+ Boric Acid baits: Ants are attracted to either in greasy or sugary foods. Sweets and fats mixed with boric acid make a toxic ant lunch.
+ Pyrethrum: Pyrethrum is natural and harvested from chrysanthemum which is lethal to ants. It is available as powders and liquids.
+ Commercial ant baits and stakes use minute amounts of poison to kill ants and carry the toxic substances back to the nest. Many brands are available.

+ Saccharopolyspora spinosa is a beneficial bacteria that kills fire ants and some other species.

APHIDS

Aphids are a common indoor pest. They attack plants outdoors in warm weather.

Aphids are small pear-shaped soft-bodied insects about 1-3 mm long. There are thousands of species that vary in color from green to yellow, black or brown. Depending on the species and the stage of life the aphid is in, it may have wings, wax or “wool” made from webbing they secrete, or other unique features.

A common trait of apids which ditinguishes them from all other insects is the pair of tailpipe-like cornicles which extend from their abdomen.

Aphids colonize the stems and undersides of plant leaves. Some species, such as the black bean aphid, are quite noticeable because their color stands out from the plant. Others, such as the green peach orchid, are often colored spring green and blend in with young leaves.

Aphids puncture stems, branches and leaves and suck sap from them using a straw-like mouth, called a cornicle. To obtain enough protein, aphids suck a lot of juice, refine the protein and excrete the concentrated sugar solution referred to as “honeydew,” which attracts ants that herd the suckers, protecting them from predators. Honeydew is a growth medium for sooty fungus, which causes necrosis of plant tissue.

Heavy aphid infestations cause leaf curl, wilt, stunted and delayed growth.

Aphids are vectors for hundreds of diseases and can quickly cause an epidemic. They transfer viruses, bacteria and fungi from plant to plant.

During warm weather each generation takes only 7 to 14 days, and each aphid can produce as many as 100 young, depending on the species. This high reproduction rate lets aphids seem to appear overnight. Indoors, with no predators to keep them in check, they can overrun a garden very quickly.

PREVENTION

+ Air Filtration: Aphids are airborne for part of their life cycle, so a fine dust filter in the air intake prevents aphid entry.

APHIDS, photo courtesy Nature's Control

+ Monitoring: Check the plants regularly for aphids—at least twice weekly when plants are growing rapidly. Most species of aphids cause the greatest damage when temperatures are warm but not hot (65° to 80° F) (18° to 26° C). They are most prevalent along the upwind edge of the garden, close to outside sources of aphids; check leaf undersides, where many species hang out.
+ Check for ants: when they are present aphids are much more difficult to control, so they must also be eliminated.
+ Catch infestations early. Once their numbers are high and they have begun to distort and curl leaves, aphids are hard to control because the curled leaves shelter them from insecticides or natural enemies.
+ Outdoors, aphids are usually not a problem because of natural enemies such as lady beetles, lacewings and syrphid fly larvae.

CONTROL

Outdoors: Sometimes aphids must be controlled outdoors. This is often accomplished by spraying them off with water. If they remain a problem consider one of the controls listed in the indoor section.

Indoors: Aphids have an easy life indoors and in the greenhouse. They are not threatened by weather, and predators. Without nature's calamities, aphid populations grow exponentially.

+ Aphid Parasites and Predators: Parasites are most effective before an outbreak has reached epic proportions. Predators are recommended for heavy infestations. However, this may just be a prejudice caused by the subtlety of parasites as compared to the aggressive moves of the predators. Predators spend a portion of their life eating and killing aphids and close-up their actions can be as vicious and dramatic as an alligator's. Parasites inject eggs into aphid larvae. The egg hatches and the parasite larvae feasts inside. It emerges as an adult, "Alien" style, from the mummy. Not quite as dramatic as rampaging predators, except when the newborns crawl out of the corpse, but every bit as effective.

LADYBUG EATING APHIDS, photo Courtesy Nature's Control

+ Two species of parasitic wasps, (Aphidius matricariae and Aphidius ervi) lay their eggs inside aphid larvae. The parasitized larvae turns brown or black, referred to as a mummy. The generation time of most parasites is quite short when the weather is warm. Once mummies appear on the plants, the aphid population is likely to be reduced substantially within a week or two.
+ Aphidoletes aphidimyza, which are available commercially, are predatory gall midges, that are effective indoors and in greenhouses. They are delicate looking black flies, less than 1⁄8" (3 mm) long, that live for an average of 10 days, feeding on aphid honeydew. They hide beneath leaves during the day and are active at night when the female deposits her eggs in aphid colonies. In two or three days, tiny, bright-orange larvae emerge and begin feeding on the pests for two weeks. Then they pupate in the ground and an adult gall midge emerges 7 to 14 days later. For this reason they cannot be used in conjunction with beneficial nematodes, which eat the pupae.
+ Beauveria bassiana is a beneficial fungus fatal to many insects including aphids.
+ Herbal oil pesticides contain essential oils distilled from plants that are effective and safe for people and pets but not pests. Several brands are available. Zero Tolerance®, made from cinnamon, clove, rosemary and thyme oils is highly effective as are other brands.

- Herbal teas that include capsaicin, cinnamon oil, cloves, coriander oil, garlic and Italian seasoning are also effective. Mix 1 tablespoon spices per quart of water. If the plant has necrosis from the strength, dilute it. The herbs can be mixed to make your own concoction.
- Insecticidal soap sprays coat and smother aphids.
- Neem oil smothers insects but leaves an oily residue.
- Pyrethrum is a natural plant based pesticide that is widely available.

CATERPILLARS (CUTWORMS, CABBAGE WORMS, LEAF-EATERS, CORN BORERS)

In spring and summer caterpillars are common outdoors, but rare indoors.

Caterpillars are the larval stage of butterflies and moths. They have soft, segmented bodies with a head, thorax and abdomen. The thorax contains three pairs of jointed legs that have hooks and the abdomen has five pairs of stumpy legs. Caterpillars are often the same color as the leaves so they are hard to spot. In addition to this general outline, here are some specifics on the types of caterpillars that commonly infest Cannabis:

Cutworms: The adults are grey to dark brown moths with wingspans of 1.25-1.75 inches (3-4.5 cm).The caterpillars grow to 1 to 1.5 inches (2.5 to 3.75 cm) long. Colors include brown, green, gray and black. Eggs vary widely by species but are usually laid on the stems or the upper sides of leaves.

Cabbage worms: Also called cabbage loopers. The adult moths are off-white with one or two black spots on each wing. They have a wingspan of about 1.5-2 inches (3.75-5 cm). The caterpillars are green, usually with narrow white stripes along the body, and may grow up to 1.5 inches (3.75 cm) long. Cabbage worms move by arching their backs to bring their hind legs forward, then extending their bodies. Eggs are ridged and dome-shaped and usually laid singly on the undersides of leaves.

Leaf-eaters: Many different species. The adults are usually moths, varying widely in color and with wingspans ranging from 1 to 1.75 inches (3 to 4.5 cm). The caterpillars are usually green, but range from gray to brown, and up to 1.5 inches (3.75 cm) long. Some leaf-eaters are “wooly bear” caterpillars, their bodies are covered with long hairs that look much like fur. The eggs may be found anywhere on the plant, depending on the species.

CATERPILLARS

Corn Borers: The adults are yellow or tan-colored nocturnal moths with wingspans of about 1 inch (2.5 cm). The caterpillars are about 1 inch long, light brown in color with a brown head and spots on each segment. Eggs are white to pale yellow in color, laid in clusters of 20 to 30 on the undersides of leaves.

Some caterpillars eat leaves. Others bore into the stem and eat the pith, the stem's soft inner tissue. Cutworms feed at night, and spend the day in shallow burrows near the plants. Corn borers attack mature plants - they need a stem large enough to hold their bodies. After the eggs laid on the leaves hatch, the young larvae eat the leaves around the eggs for two weeks to a month, leaving close clusters of tiny holes. To catch borers early, look for these small holes. Later in the season look for small holes in the plant stalks, possibly covered with thin silky webbing. After borers have been at work for a while they sometimes cause the stalk to develop "fusiform galls." These are bulges in the plants' stalks that widen in the middle and taper at both ends. The borers may leave visible trails on the stalks leading to the galls.

Caterpillars eat both leaves and the soft stems. Borers pierce the stem and eat the soft inner tissue. The branches and leaves above the caterpillar wilt, since they receive no water or nutrients. If it is a main stem the whole plant dies. If it is a side stem, only that branch succumbs. In addition to the direct damage they cause, caterpillars leave behind damaged tissues that are vulnerable to infection.

Caterpillars are voracious eating machines and can savage plants very quickly. They chew continuously to support their high growth rate. They can destroy a tray of seedlings overnight.

Leaf-eaters leave large holes as calling cards in the leaves they dine on. Cabbage worms and other caterpillars also infest buds. A bud that turns brown and wilts "for no reason" may house a cabbage worm consuming it from within.

Cutworms are perhaps the most obvious of all caterpillars: plants damaged by cutworms are literally chewed through at the soil line, causing the plant to topple. Seedlings and young plants are completely consumed.

Moths usually lay one to two batches of eggs each year, though some species produce up to six generations per year in warm climates. Each female lays several hundred eggs. The adults mate in spring to early summer, and the caterpillars emerge in the early summer to fall. The caterpillars feed until they are ready to enter the pupal stage. Then they spin cocoons or dig burrows and hibernate until they emerge as adult moths. The generation that emerges in late summer and fall often overwinter as caterpillars, emerging in early spring to begin feeding again. This is especially common with cutworm species.

Caterpillars reproduce slowly compared to many pests, but they have large appetites and each one can cause a lot of damage.

PREVENTION

Caterpillars vary widely in their habits, so preventative methods must be adapted to the pest.

+ Planting indoors all but eliminates caterpillar predation of young plants. Keep seedlings indoors as long as possible before transplanting.
+ Clear the garden of weeds, grasses, and plant debris throughout the year, but especially at the end of the growing season. Use electric "bug zappers" with blue or ultraviolet light to attract and destroy nocturnal moths.
+ Garlic: repels egg-laying moths.

Cutworms: Plant seedlings as large as possible. Turn the soil two weeks before planting and destroy any larvae you find. Put a "cutworm barrier" around each seedling. Use a cutworm barrier that is at least 1 inch (2.5 cm) into the soil and 4 inches (10 cm) above the soil and is laced with Tanglefoot.

+ Cabbage worms: Use row covers in spring, when the adult moths breed, to prevent them from laying eggs on the plants.
+ Leaf-eaters: Use row covers to block egg-laying adults. Wrap stems with aluminum foil above and below major branches and apply a layer of Tanglefoot or similar stickum to the foil. Turn the soil before planting, especially in the spring, and destroy overwintering larvae and pupae.
+ Corn Borers: Destroy stalks and other plant debris after harvest.

CONTROL

- If you have only a few plants and you spot cutworm damage you can usually find the caterpillars within about 10 inches (25 cm) of the damaged plants. Other caterpillars can be shaken off plants or handpicked.
- Water sprays wash away and drown caterpillars, a vacuum cleaner can remove them as well.
- BT, Bacillus thuringiensis, is a living bacterium that the caterpillars ingest. They sicken the caterpillars so they stop eating and die within a short time. When they die they release new generations of bacteria that are hungry for caterpillars. They are harmless to humans and pets. The insecticide should be used at the first sign of caterpillars.
- Cinnamon: brew a cinnamon tea using about an ounce of cinnamon to a gallon of very hot water. Let it cool, then strain and spray. Direct hits are best.
- Insecticidal soap works best when sprayed directly on the pests.
- Neem oil: diluted neem oil can be sprayed on plants every 10 days. It makes them unappetizing to caterpillars. Direct hits are toxic to the leaf-eaters. The oil leaves a residue on the leaves.
- Pyrethrum is a natural plant derived pesticide harmless to humans and other warm-blooded animals.
- Spinosad: Spinosad’s active ingredient is derived from a soil-dwelling bacterium, Saccharopolyspora spinosa. The bacterium produces a variety of insecticidal compounds when cultured in fermentation tanks. Spinosad must be ingested, so it has no effect on sucking insects and predators but is deadly to chewers such as caterpillars. Once they ingest the substance insects sicken and die. It is nontoxic to wildlife, pets, and humans with minimal impact on the plants. However use Spinosad with caution around honeybees.
- Trichogramma: Several species of tiny stingless wasps that attack and destroy caterpillar eggs before they hatch. They must be released at the earliest sign of infestation, and cannot be used with most insecticides (BT and Spinosad are exceptions). Consult the supplier for recommended species and coverage rates.
- Special note on stem borers: If you do not control stem borers quickly, your yield will be greatly decreased or even non-existent. Before they bore into the stalk they can be eliminated using the same techniques as for caterpillars. It is a different story once they are situated in the stem’s enclosure. Sometimes you can yank the borers right out of the holes they’ve

chewed. Another method is to bore a hole in the stem above the borer and inject one of the recommended caterpillar insecticides into the stem using either a syringe or an eyedropper.

DEER

Deer populations vary widely, both geographically and by habitat. Deer favor light forest and grasslands near forested areas, as they dislike getting more than a few hundred yards from cover. Gardens in suburban areas built near suitable forestland may have problems with grazing deer. Garden plots set up in wild or rural areas are very likely to be visited by deer if the habitat supports them.

What does the pest look like?

Deer are grazers with graceful bodies, thin legs, and long necks. They vary greatly in size depending on species, age, and sex, but usually fall between 4 ft. and 6 ft. (1.2 and 1.8 m) long and weigh 80 to 220 lbs (35 to 100 kg). Usually the heavier races are found in the north and the smaller lighter ones in the south. The males carry antlers beginning in late summer, and usually shed them in very late winter or spring.

Deer emerge from forest cover at night to browse on plants, but flee quickly when approached. They have excellent senses so most of the time the gardener knows them only by their tracks and the damage they leave. Some deer have become accustomed to humans and don’t flee on sight.

Deer prefer fresh leaves, fruit, and other rich plant matter. In the marijuana garden they tear up and eat entire small plants, strip plants of leaves and trample them. Marijuana evolved cannabinoids in part as protection against herbivores. Most mammals find the leaves and flowers unpleasant. Deer are among the few exceptions. This means that in areas that have large deer populations they may be attracted to your garden simply because it’s a food supply that most other herbivores leave alone. Even so they prefer young, tender plants. As marijuana plants mature and cannabinoid levels increase, they become less palatable to deer.

Deer lack upper incisor teeth. They do not bite plants the way a rabbit or similar animal might. Instead the deer takes hold of leaves with its lips and lower teeth, then tears them off. This makes for ragged browse damage, very different from the neatly clipped leaves left by rodents. Look also for deer tracks and droppings near the garden.

Reproduction rate and life cycle: Deer follow a normal mammalian life cycle. Adults mate in the late fall through mid-winter, and the female gives birth to one or occasionally two fawns in late spring to early summer. Deer usually mature in one to two years, and live for 10-20 years if not killed by predators or disease.

PREVENTION

+ Deer pose little threat to plants grown indoors. However, all outdoor gardens near deer habitats are vulnerable.
+ To prevent deer damage they must be kept away from the plants. There are two main ways of doing this: repellents and fences. Repellents are less expensive, and may be the only option if discretion is important. But fencing is more certain when it is practical.
+ Deer find the odors of garlic, capsaicin, and rotten eggs offensive, and several brands of commercial repellents containing these ingredients are available. Other materials also repel deer by smell:
    + Anything that carries a human's scent, such as worn clothing or human urine.
    + Urine or scat from dogs or other predators. Predator urine is available commercially.
      Scat is sometimes available from your local zoo.
    + Scented bar soap, suspended in a net bag near the plants.
+ If you are not certain that a repellent is safe for use on food plants, then surround the marijuana plants with other plants that you don't plan to inhale or ingest. Replace the repellent according the manufacturer's instructions, or every few days for the other scent repellents listed above.
+ Anything that startles or frightens deer is effective. Buy several home motion detectors at a hardware store and set them up in a perimeter around the grow site. Depending on the resources at the site, motion detectors can be rigged to trigger high-pressure water sprinklers (these are sold as "scarecrow sprinklers"), bright lights, battery-powered radios or ultrasonic noise when a deer approaches. Remember to set up lights to point away from the plants, and if discretion is important then shield the lights or lower the radio volume so the deer can detect them but nearby watchers cannot. Deer can become accustomed to most sounds, sights, or smells. Once they realize that the repellent isn't harming them they'll learn to ignore it. This means that you need to change your repellent from time to time, and not just from one brand to another, but from one ingredient or method to

another. Combining methods is also useful. For example, setting up an odor repellent and a scarecrow sprinkler together.

+ Fencing must be constructed with the abilities and habits of deer in mind. A deer can jump any fence less than 8 ft. (2.5 m) high, if it can get close enough. Fences must also be built tight to the ground, or deer can slip under them. One alternative to an 8 ft (2.5 m) fence is an electrified fence. Deer prefer to slip through a barrier rather than jump over it if that looks possible. A standard electric fence built from 2 or 3 strands of 20-gauge smooth wire on insulated posts often deters them. Once they try to slip between the strands and get shocked they generally keep several feet away from the fence - too far for them to jump it. A variant called a “Minnesota fence” actually uses an attractive bait such as peanut butter to get the deer to lick the fence or a foil tag attached to the fence. The deer get a mild shock and avoid the fence completely after that.

CONTROL

+ There is no practical means of controlling deer, in the sense of eradicating them, and this would not be a good option even if there were such a means. The outdoor marijuana gardener should leave the deer’s natural predators (mainly coyotes and wild dogs) alone, as these provide some check on the deer population. However aside from that, prevention is your best choice.

FUNGUS GNAT

FUNGUS GNATS

Fungus gnats are common indoors. They are found outdoors occasionally in moist warm areas.

Fungus gnats are ¹⁄10–¹⁄12 inch, (3-4 mm) in size, dark grayish black in color and have a slender build with delicate long legs and long wings. The larvae are clear to creamy-white in color with a shiny black head and can be up to ¼ inch (6 mm) long.

Adults fly close to the soil level and through the lower region of the plant canopy. Fungus gnat larvae live at the root level, usually from 1 to 3 inches (2.5 to 7.5 cm) below the soil line. In shallow containers the larvae may be found wiggling in the drain tray after watering. Outdoors, adults and larvae live in moist, shady areas.

Fungus gnats' larvae weaken the plant by eating roots, root hairs and organic matter growing in planting mix, rock wool, soil and other planting mediums. They are also vectors for disease. Adult gnats do not eat. They live only to reproduce.

Adult females lay eggs at the surface of moist soil, near the plant stem. The larvae hatch out in four to ten days, depending on temperature, and feed off fungus and plant matter (including plant roots), then pupate in the soil and emerge as adults. The total time from egg to reproductive adult is about four weeks, and females lay several hundred eggs in small batches over their lifetime. Indoors, they breed continuously throughout the year and reproduce very rapidly.

PREVENTION

+ If plants are outdoors, check the soil for adult gnats or larvae before bringing them indoors.
+ Prevent indoor entry of gnats by keeping screens on all open windows.

PREDATORY NEMATODE, photo courtesy Nature's Control

+ Place a barrier over the soil so the gnats have no place to lay their eggs. A piece of cloth, cardboard or a layer of sand, cocomat pot covers and plastic covers for rockwool all work.
+ Fungus gnats need moist soil near the surface to reproduce. Let the soil dry between watering as much as the plants will tolerate (usually to a depth of about 1 inch (2-3 cm). A layer of light, well-draining soil such as vermiculite, perlite, or diatomaceous earth at the top helps with this. This disrupts the larval gnats' food supply and makes it difficult for an infestation to take hold.

CONTROL

+ Bacillus thuringiensis (beneficial bacteria.)
+ Barriers (sand, cloth, cardboard, etc.)
+ Cinnamon oil and tea.
+ Diatomaceous earth has sharp points that puncture and desiccate small soft-bodied creatures such as fungus gnat larvae. Diatomaceous earth is composed of fossilized diatom (a type of algae) shells made of 86% silica, 5% sodium, 3% magnesium and 2% iron.
+ Predatory mites (Hypoaspis species): These carnivorous soil dwelling mites seek out any prey they can catch.
+ Predatory nematodes (Heterorhabditis and Steinernema species) are microscopic carnivorous soil-dwelling worms that enter their host and eat it from the inside out. Then they reproduce and burst out of the corpse.
+ Pyrethrum can be used as a spray or can be injected into the plant stem to reach borers.
+ Spinosad

GOPHERS

Gophers are a very occasional problem in the garden. They are found mainly in the central and western United States, in Florida, and in Mexico.

Gophers are medium-sized rodents ranging from about 5 to nearly 14 inches (13 to 36 cm) long (not including tail). Their fur is very fine and ranges in color from nearly black to pale brown. The forepaws have strong claws. The head is small and flattened, with small ears and eyes and very prominent incisor teeth.

Gophers tunnel underneath gardens and lawns.

Gophers feed on plants in three ways: 1) they feed on roots that they encounter when digging their tunnels; 2) they may venture short distances (only a body length or so) from their tunnels to eat vegetation on the surface; and 3) they pull vegetation into their tunnels from below. Gophers may also attract badgers (which eat them), and the badgers may cause considerable damage when digging for their food.

When gophers are suspected, the first task is to make sure that they aren't moles instead. Moles cause little direct damage to gardens, and as a result they're seldom worth the trouble to eradicate. It is rare to see either one on the surface, so the best ways to distinguish them are the signs they leave behind.

First, check their diggings: a molehill tends to be a rough cone with a hole or an earthen "plug" near the center. A gopher mound is more fan-shaped, with the hole or plug near one edge. Next, look for damage. Moles generally cause very little damage. Gophers may chew the plants' roots, causing them to wilt and making it possible to pull them up with just a slight tug. If plants are chewed off completely at the soil line, or completely gone, roots and all, then chances are good that there is a gopher problem.

Reproduction rate and life cycle: Gophers mate once a year, in the spring, and produce a litter of up to five young in late spring to early summer. They live for up to 12 years.

Containers, indoor gardening, and hydroponic systems offer complete protection against gophers. If you are planting directly in the soil, minimize weeds; line the planting hole on the bottom and sides with hardware cloth. A border of oleander plants around your garden may repel gophers. Commercial gopher repellents (most include castor oil, garlic, or capsaicin) placed in the mouth of the mound may drive them off.

CONTROL

+ In general, it is best to try repellents first, as they are by far the easiest way to deal with gophers. However sometimes the only solution is to eliminate them.
+ The simplest means of exterminating gophers is fumigation. Commercial fumigants are generally paper or cardboard cartridges filled with charcoal and potassium nitrate. They're ignited and dropped into the tunnel openings, and the gasses they produce as they burn kill the gophers. Watch for wisps of smoke rising from the ground—these may mark other exits from the gopher's tunnel. Seal the exits with packed earth or heavy rocks,

so the gopher cannot flee. Carbon dioxide (CO_2) is a fumigant. Use a CO_2 tank by placing the delivery hose in the tunnel opening or drop 8 to 16 ounces (225 to 450 grams) of dry ice into the tunnel. If fumigation is not effective, try trapping them. Traps are available at garden shops.

LEAF MINERS

Leaf miners are not common in indoor marijuana gardens. Outdoors leaves are occasionally attacked, but they are not usually a threat to the plant or yield.

Leaf miners are usually the larval form of various fly species although a few species of moths and beetles also produce leaf-mining larvae. These larvae are very small maggots, seldom more than $^1/10$ in (3 mm) long and range in color from white to pale green. The adult flies resemble tiny houseflies, about $^1/12$ in (2 mm) long.

Leaf miners are found under the surface and in the tissue of leaves

The leaves look like someone carved scribble lines into them. At the same time they plant their eggs deep inside, and they keep multiplying. When they hatch, the larvae feed off of the leaves until they get big enough to pupate. Pupation occurs within the leaf or in the soil beneath the plant. Once they emerge they repeat this cycle and cause a bigger infestation.

Leaf miners leave the plants open to pathogens and fungi. Leaf damage causes low yields. When the females dig to lay eggs, plants secrete a sap that attracts ants and flies, thus inviting more infestations and problems.

There are many species of leaf miners, and an expert can distinguish between species by the characteristic appearance of the tunnels which evolved to provide them more protection than the surface of leaves.

LEAF MINER DAMAGE

Females implant one egg at a time close together. Species vary in fecundity. Some produce up to 350 eggs each. Eggs hatch in two to six days, and larvae begin tunneling. Eventually they become pupae, either dropping to the ground or remaining in the leaf, depending on species) The pupae develop into adults and the cycle repeats. Expect two to six generations per year outdoors, but indoors a single generation can take as little as a month, and they reproduce year-round.

PREVENTION

+ Outdoors, plant deterrants such as lambsquarter, columbine, and velvetleaf.

CONTROL

+ If only a few leaves are affected, remove and discard them.
+ Naturally occurring parasitic wasps usually help control the population.
+ Beauveria bassiana (beneficial fungi)
+ Capsaicin
+ Herbal teas
+ Herbal oil based pesticides, such as Ed Rosenthal's Zero Tolerance®
+ Horticultural oil
+ Neem oil
+ Parasitoid Wasps
+ Pyrethrum
+ Spinosad

MEALYBUGS AND SCALE

Mealybugs and scale occasionally attack Cannabis. They are more often a problem with long-lived mother plants.

These pests are closely related to one another, but take their names from their appearance. Mealybugs are named for the white, “mealy” wax that covers their bodies. On plants they look like tiny puffs of cotton, usually in crevices and joints between branches. The adult female insects beneath the wax are 0.1 to 0.2 inch (2-4 mm) long, with flat, oval, segmented bodies. Males are tiny flies that do not have the females’ waxy covers.

SCALE

Scale derive their name from the hard shells that adult females produce, which look like bumps or "scale" on the stems and leaves of the plants. Scale vary widely within this general model: from round to oval in shape, from white to dark brown in color, and from 0.1 to 0.5 inch (3 to 15 mm) in diameter. As with mealybugs, adult male scale resemble tiny flies.

Female mealybugs plunk themselves at the nodes close to their hatching site. Scale are found on leaf surfaces, especially the undersides and on stems and in crevices. Occasionally scale or mealybugs colonize the stem right at the soil level, where the stem joins the roots.

Female scale and mealybugs feed on plant sap. They live only long enough to fertilize the females.

Some species have developed a symbiotic relationship with ants, similar to that of aphids. Ants protect and herd them to collect the “honeydew,” concentrated sugars that they exude as waste. If there are no ants to eat it, it’s quickly colonized by sooty mold.

The plant is weakened by the insects’ leech-like action on their vital juices and the honeydew droppings create mold infections on the stems and leaves. Scale and mealybugs are often vectors for plant diseases.

Mealybugs are considered a specialized scale. Both are in the same order as aphids and whiteflies, and are true bugs in the biological sense: they have specialized probing and sucking mouthparts that they use to drain plant juices.

Female scale and mealybugs tend not to move much as adults. They attach themselves to the plant and produce a protective layer to ward off predators while they suck the plant juices. Mealybugs cover themselves with a web of cottony wax that some potential predators avoid. Scale produce hard shells as armor against their enemies.

Reproduction rate and life cycle: The overall life cycle is the same for both mealybugs and scale. The females produce 200 to 1000 tiny eggs that they shelter either on or beneath their bodies. When the eggs hatch (in 1 to 4 weeks) the very small (less than 1 mm) nymphs spread out over the plant and begin to feed. In a few weeks they develop into either winged males or stationary females. The entire generation takes 1 to 2 months, and depending on the species they produce anywhere from one to six generations in a year.

CONTROL

+ Mealybugs are relatively easy to eliminate on marijuana plants because the plant's structure does not offer easy places for them to hide and protect themselves.
+ Hand-wipe with a sponge or a Q-Tip: Mealybugs tend to locate in plant crevices and other hard to get to spots. A Q-tip moistened with isopropyl alcohol is an ideal tool for reaching them.
+ Alcohol Spray
+ Limonene products kill mealybugs and scale on contact.
+ Herbal sprays such as Ed Rosenthal's Zero Tolerance® which contains cinnamon, clove or other insect repellant herbal oils are effective exterminants. They kill both on contact and by their evaporates, especially in the protected areas mealybugs choose as habitats.
+ Pyrethrum
+ Neem oil
+ Parasitoid wasps that are specific to various species of mealybugs and scale are available. Some wasp species include Leptomastix dactylopii, Anagyrus pseudcocci, and Metaphycus helvolus.
+ Mealybug destroyer: Cryptolaemus montouzieri is a ladybug that preys on many species of mealybugs.
+ The minute pirate bug (Orius species) eats mealybugs and scale, among other pests.
+ The lady beetle Ryzobius lophanthae is a voracious soft scale predator. It is opportunistic and also eats aphids and mealybugs when it encounters them. However, it is most effective on scale.
+ Horticultural Oil, especially sesame oil products.
+ Insecticidal Soaps

MOLES

Moles are common in temperate rural areas, less so in cities and suburbs. They may gravitate to outdoor hemp fields because cultivation loosens the soil and makes it more hospitable to the insects that moles eat.

Moles are burrowing mammals about 5 to 7 inches (13-17cm) long, weighing 3 to 4 ounces (85-115 g). They have soft dark fur, very small eyes, pointed snouts, and strong digging claws on their front feet. Moles seldom appear on the surface, though. The gardener usually notices their burrows instead.

Moles build tunnel complexes in rich soil. They eat insects and earthworms, and therefore favor moist soils with a lot of soil-dwelling insect life.

Moles seldom damage plants directly. However their tunnels and mounds may allow plant roots to become dry, or create a hazard for careless walkers.

Generally the most important consideration in dealing with moles is distinguishing them from gophers, which are much more destructive. The marijuana farmer has little to worry about from moles. The clearest distinction between them is the shape of their diggings: a molehill tends to be a rough cone with a hole or an earthen “plug” near the center. A gopher mound is more fan-shaped, with the hole or plug near the narrow end.

Reproduction rate and life cycle: Moles generally have one litter of two to five pups per year, in mid to late spring. Except for the spring breeding period they tend to be solitary and highly territorial. They fight other moles even to the death if one invades another’s tunnel system.

PREVENTION

+ If you are planting directly in the soil, line the planting hole on the bottom and sides with hardware cloth. Repellents may work in outdoor gardens. The best-attested repellent is castor oil, sold in various brand-name formulations. Odor repellents such as predator urine also work.

CONTROLS

+ If moles aren’t causing root damage then there is really no need to get rid of them. However if it is necessary to rid the garden of moles then the methods are the same as for gophers: fumigation or trapping. The commercial fumigant cartridges sold for gophers also work against moles, as does carbon dioxide from dry ice or a tank. Garden supply shops sell many kinds of mole traps, both the live-trap and lethal kind.

RATS

Rats are not common pests in marijuana gardens, but may sometimes kill plants by gnawing or digging. They are an environment-specific problem, as they view cannabis as a target of opportunity. Rats are rodents ranging from 10 to 16 inches (25 to 40 cm) in length, not including their long tails. They weigh 6 to 12 ounces (170 to 340 grams), and have dark fur ranging from brown to black. Their heads are long and taper to a snout with long whiskers, and their ears are rounded and prominent.

Rats are common wherever humans live, although they are not always visible. Some rats live in the wild, feasting on insects, other small animals, nuts, fruits, and nature's detritus. They lair in burrows, walls, piles of trash, dense brush, attics, wherever they can build a secure nest.

Marijuana is not a primary food source for rats, but they like to chew the woody stalks of plants. This cuts the plants down. Rat teeth grow constantly and gnawing behavior is instinctive. Cannabis is chewing gum for rats.

Rats are a problem for the marijuana garden only when the grow site is close to something that they like to eat. Gardens near cornfields, orchards, food warehouses, areas with nuts or berries growing wild, and other similar places are at risk. Food at campsites draws rats close to the garden, so secure all food and destroy or remove all food scraps.

Rats are prolific breeders. They breed year-round if they have sufficient food and a warm place to keep their young. A female produces four to nine litters a year. Litters average 8 pups so a fecund female can produce 12 to 60 a year. They adjust their population automatically to the local food supply.

PREVENTION

Rats do their damage in a matter of minutes, and a single rat can destroy several plants in one night. By the time you know you have a rat problem it is often too late.

+ Eliminate tasty rat-food and nest sites in the area. Clear away brush and trash. Cannabis isn't a primary food for rats so they won't try as hard to get it as they would if they actually liked to eat it.
+ Plant as far as you can from attractions such as fruit trees or berry bushes,

and other food sources.

- If there are stray cats in the neighborhood of your garden, put out food to attract them. Rats avoid areas that smell of cats.
- The most effective prevention is a physical barrier to keep the rats away from the plants. It needs to be at least 18 inches (45 cm) high and have no opening larger than 0.5 inch (12.5 mm). A simple way to meet these requirements is to wrap a tomato cage in chicken wire or hardware cloth and put one of these around each of the plants when you set them out. Another is to buy coarse steel wool (sold in bulk at hardware stores) and wrap it around the stalk of each plant, securing it with twist ties.

CONTROLS

- Traps and poison provide protection. Hardware and garden stores carry a variety of effective rat traps. Place traps around the plant cage, and use an attractant bait such as peanut butter. Once a few rats have been trapped, predators may come to enjoy the carrion, making the area unattractive to the rodents.
- Rats have begun to develop resistance to warfarin, the classic anticoagulant “rat poison.” Another problem with this poison is that it can kill predators that eat the dead rats. A newer poison is cholecalciferol (Vitamin D3). Another is zinc phosphide. Both are available in various brand name rodent baits. Place any such poison bait in a tamper-proof bait station.

SLUGS AND SNAILS

Snails and slugs occasionally attack outdoor gardens, especially young plants with leaves close to the ground. They are rare indoors.

Slugs range in color from pale gray to tan, and grow to as long as 2 inches (5 cm) long. Their bodies are soft and fleshy, and glisten with a clear slime that the slugs secrete to retain moisture and help their movement. Two small “horns” atop the slug’s head are actually the slug’s “eyes”, which sense light, (slugs have no sense of sight).

Snails are slugs with shells. They are built almost identically to slugs, except for a coiled shell of calcium carbonate that protects most of a snail’s body. Snails can withdraw completely into their shells when threatened. Shells of common garden snails can reach up to 1.5 inch (3.75 cm) in diameter, and are colored gray, brown, and black.

Snails and slugs are found on the leaves and edges of leaves and flowers when it is moist out, usually after dusk. When it is dry or light they hide in dark moist areas such as piles of fallen leaves, crevices and moist shady areas.

Snails and slugs eat leaves. Holes in leaves and/or clipped edges of leaves and flowers, accompanied by a silvery, slimy trail, indicate snail or slug damage. A single snail can savage many small plants in one night.

These pests thrive in moist, dark environments. They hide in mulch, short and stubby plants, under boards, in soil, and they avoid sunlight, so they are seldom seen during the day, but come out to feast at night.

There is one particular kind of snail that you should leave alone. Decollate snails sometimes attack plants, but their main food is other snails and slugs. The fastest way to tell a "good" snail from a plant-eating pest is the shape of the shell: common garden snails usually have round shells that coil in a simple spiral. Most species of decollate snails have cone-shaped shells. If these are the only snails you ever see in your garden, then go ahead and get rid of them, because they eat plants if there is no other food in their habitat. But if you have other snails as well then the decollate snail is your friend.

Reproduction rate and life cycle: Slugs and snails are hermaphroditic so every individual lays eggs in clutches of 30 to 120 eggs, 1-2 inches (2.5 to 5 cm) deep in moist soil. When conditions are suitable (not too dry or too cold) slugs and snails can lay eggs as often as once a month, so their numbers can increase rapidly during damp spring and fall weather.

PREVENTION & CONTROL

+ The best way to prevent and kill snails and slugs is with iron phosphate, sometimes called ferric phosphate. It is completely effective and requires little effort. It comes as a powder or granules and is not harmful to plants, pets or humans. Sprinkle on the ground as directed. Many brands are available including Escar-Go, Sluggo, Slug Magic and Worry Free.
+ Copper wire, tape or mesh protects the garden or the base of the plants. Copper shocks the pests and deters them. Dimes and quarters contain copper so they can be used as well. When enclosing the garden or plants with copper, make sure not to trap snails inside.
+ Reduce damage dramatically by watering in the morning instead of the evening. The soil has time to dry out and become less attractive to the pests.
+ Snails and slugs can be trapped. Construct a cool moist area for them to retreat to during the heat of the day and then collect the refugees.

+ Firefly larva, toads, frogs, fireflies, snakes, birds, and black iridescent beetles prey on snails.

SPIDER MITES

Spider mites are very common and are the most serious pests in the Cannabis garden.

Spider mites are barely visible to the naked eye since they are only 0.02 inch (0.4 mm) long. They are arachnids (relatives of spiders), and like other arachnids they have four pairs of legs and no antennae. Unlike spiders, though, mites have only a single body segment. Their color range includes red, brown, black, yellow and green. It depends on the food they are eating, species, and the time of year. Spider mites are so tiny that most of these details are visible only with a magnifier.

They live on the plants, mostly on the underside the leaves, but can also be found around the buds. They can also be found moving from leaf to leaf and plant-to-plant using their silvery webbing as highways.

Spider mites pierce the surface of leaves, then suck plant juices from them. These punctures appear on the leaves as tiny brown spots surrounded by a yellow ring.

As the population grows the mites produce webbing that they use as a pedestrian bridge between branches or plants.

Spider mites are also vectors for disease, since they travel from plant to plant.

Spider mites are sap-feeders, like many other garden pests. They are more of a threat than most though, due to their high rate of reproduction.

Spider mites are by far the most fearsome of all plant pests. They suck plant juices, weakening the plants. Spider mites multiply quickly. They are most active in warmer climates than cold ones.

Reproduction rate and life cycle: Newly hatched mites have a 3:1 ratio of females to males, and each female lays up to 200 eggs. This life cycle can repeat as often as every eight days in warm, dry conditions–such as a grow room. This means that a spider mite population can explode with shocking speed, and this rapid reproduction is what makes them so troublesome.

SPIDER MITE, photo courtesy Nature's Control

SPIDER MITE

Mite Webbing

PREVENTION

+ Almost all spider mite infestations enter the garden on an infested plant or through the ventilation system, or are introduced by gardeners who carry the hitchhikers into the garden.
+ Quarantine all plant introductions.
+ Use a fine dust filter in the ventilation system so all incoming air is cleaned. Never enter the grow space wearing clothing that has recently been outdoors, especially in a garden.
+ Look for webbing and for yellow-brown spots that result from mites sucking. Infected mother plants transmit mites to their clones, so it is especially important to watch for mites in a mother room. When you spot mite symptoms take action immediately.
+ Neem oil is often used as a preventative, but it leaves an oily residue that builds up with regular spraying.

CONTROL

+ Spider mites thrive in dry climates. High humidity slows spider mite development and reproduction. This can be used in vegetative and early flowering stages to slightly slow population increase.
+ Insecticidal soap smothers many of the mites, lowering the population and the damage, but does not eliminate the population. Even using it twice a week, the mite population may increase.
+ Pyrethrum is effective against some mite populations, but others have developed an immunity to it.
+ Cinnamon-clove tea can be brewed using powdered cinnamon and cloves. Start using about an ounce of each per gallon of water (0.75 ml per liter). Boil water. Let stand a couple of minutes. Add the herbs and let brew until the water is cool. Strain.
+ Predator mites: There are many varieties. Get those best suited to the environment in your garden. Apply predator mites at the earliest sign of infestation. Most predator species reproduce faster than spider mites, but if the mites get a good head start the predator population can never catch up. Even in optimal conditions control with predator mites is very difficult.
+ Beauveria bassiana (beneficial fungi) are somewhat effective—brands are Mycotrol and Naturalis.
+ Herb and spice pesticidal oils are effective mite killers. They can be used as a protective spray to keep the plants from being attacked and fully

evaporate leaving no residue. There are several products available. Ed Rosenthal's Zero Tolerance® blends cinnamon, clove, rosemary and thyme oils for fast results.

+ Fish Oil is an effective mite killer but it leaves a slight residue. One brand is Organicide® which is composed of edible fish and sesame seed oils.
+ Neem oil comes from the neem tree, native to west Asia. It has many protective qualities including both repelling and killing arthropods, including mites. It can be used as a protective spray to keep the plants from being attacked.
+ Sesame oil is toxic to spider mites. Use 1 tablespoon to a quart (15 ml per liter) of water. To facilitate the mix, add 1 teaspoon (5 ml) dry lecithin granules to the water and mix them in a blender. The spray is then ready to use.
+ Sulfur has been used to kill mites for many years. Sulfur candles and boilers produce vapors that kill mites and other pests. It is very effective but should not be used near people. The space should be aired out before people re-enter. Do not use it near residences.

THRIPS

Thrips are not commonly considered pests of marijuana. However, in some greenhouse conditions they can be serious pests.

Thrips are tiny, no more than 0.06 inch (1.5 mm) long, but can still be seen by the naked eye. Adults have wings but do not fly well; they jump when startled. The head and body range from yellow to dark brown. The larvae are about half the size of adults, lighter in color, and wingless.

Thrips attack the leaves and are usually found on the top surface of the leaf.

Thrips use a saw-like structure to pierce and scrape the flesh until sap begins to flow. They then suck up the juices, and leave a surface of patchy white or silvery scrapes. The leaf surface looks scarred or scabby. Eventually the leaves look like all the chlorophyll has been drained, and they turn white. Thrips leave behind greenish black specks of poop on and under leaves. The scar tissue shows up in silver patches. Thrip damage can resemble that of spider mites or leaf miners at first, but more severe cases result in the color-stripped leaves.

Damaged leaves can’t be healed and their ability to absorb light is compromised. If the thrips are not controlled the plants die. Thrips also carry pathogens that they transfer.

Outdoors, thrips hibernate over the winter in soil and plant debris. Thrips become active when the temperature climbs above 60 °F (16 °C). The warm, stable temperatures of indoor gardens allow them to be active year-round. Thrips are a more serious problem indoors because of this, and also because a natural soil-dwelling fungus that infects thrip pupae is not present indoors.

Reproduction rate and life cycle: Females lay eggs (anywhere from 40 to 300 depending on species) in plant crevices or actually insert them into the leaves and stems. The larvae feed until they enter the pupal stage, when they fall to the ground (and when the soil fungi provide some biocontrol outdoors). Depending on the species and temperature (optimum is 77 to 82°F (26 to 28°C), the larval thrips hatch, pupate, and mature into egg-laying adults in 7 to 30 days.

PREVENTION

Thrips are drawn to the colors blue and yellow, so it's best to avoid having yellow walls or items around your Cannabis gardens. Yellow and blue sticky cards can be used as indicator traps to detect an infestation of thrips. Use garlic in outdoor gardens to deter/repel thrips.

CONTROL

+ Barrier: Thrip pupae live in the soil after they drop from the plant. By placing a barrier around the top of the container, the pupae can't get to the soil and they die. As with fungus gnat larvae, a layer of diatomaceous earth on top of the soil also helps to destroy the thrips pupae.
+ Beauveria bassiana (beneficial fungi)
+ Beneficial Nematodes: Beneficial nematodes attack the pupae in the soil.
+ Capsaicin
+ Herb and Spice Oil Pesticides such as Ed Rosenthal's Zero Tolerance®
+ Insecticidal Soaps
+ Minute Pirate Bugs (Orius): these tiny insects attack adult thrips. They work well in combination with beneficial nematodes.

THRIPS, photo courtesy Nature’s Control

- Neem oil
- Predatory mites (amblyseius cucumeris) are a mite that loves to feast on thrips. Use large numbers to make sure the predators control the pests quickly.
- Pyrethrum is an effective pesticide against thrips. Spray the leaves thoroughly.
- Saccharopolyspora spinosa (Spinosad)

WHITEFLIES

Whiteflies are a common pest indoors and outdoors. Whiteflies resemble tiny moths but are neither moths nor true flies. They are relatives of aphids and scales. They are 0.04 inch (1 mm) long and their soft bodies are covered in a powdery wax which gives them protection and their white color.

Whiteflies infest the undersides of leaves. If the plant is disturbed they take flight and a mass of tiny white flies can be seen fluttering around the plant.

They suck sap from the plants, and are vectors for viruses. The plants release sticky honeydew and this can contribute to mold problems on the plants. Leaves appear spotty, droop, and lose vigor.

Whiteflies are sap-feeders, like their relatives, aphids and scales.

Whiteflies are pests that quickly build up a large population and suck the life out of the plants, but are not difficult to get rid of. If you think the plants might have whiteflies shake them. If they are present they’ll fly off, then settle right back onto the leaves.

Reproduction rate and life cycle: Females each lay about 100 tiny eggs on the undersides of leaves. Eggs hatch in about seven to ten days, and the larvae drain sap from leaves. Larvae mature in 2 to 4 weeks and the adults live for 4 to 6 weeks after that. The reproductive rate is temperature dependent: most whitefly species do best in a temperature range of 80 to 90°F (27 to 33°C).

WHITEFLIES, photo courtesy Nature's Control

WHITEFLY PARASITE, photo courtesy Nature's Control

PREVENTION

+ Keep the temperature of the garden below 80°F (27°C) to slow whitefly reproduction. Clear out plant debris quickly. Install a fine dust filter in the air intake for the grow space to prevent whiteflies from entering through the vents.

CONTROL

+ Yellow Sticky Traps-Whiteflies are attracted to yellow sticky cards. These trap a small proportion of the population, but are good indicators of infestations.

+ Shake plants to dislodge whiteflies and then suck them out of the air with the hose attachment of a vacuum cleaner. Heavily infested plants should be removed from the garden or grow room before treatment.
+ Encarsia formosae are tiny wasps that lay their eggs inside immature whiteflies. They are antisocial, they don't make hives and are so small that once they are released you may never see them again. Indoors and in greenhouses one introduction may be all that is needed because their numbers increase much faster proportionally than their prey.
+ Beauveria bassiana (beneficial fungi)
+ Beneficial insects (lacewing larvae, minute pirate bugs)
+ Capsaicin
+ Carbon dioxide
+ Herb and spice oils
+ Insecticidal soap
+ Neem oil
+ Pyrethrum
+ Sesame oil

DISEASES

Disease can strike marijuana plants at any stage. Most diseases that affect marijuana fall into two broad categories: fungal and bacterial. The spores and bacteria that cause plant diseases are ubiquitous. A garden's susceptibility to disease is often traceable to environmental imbalances in temperature, moisture, light conditions, airflow, and pH, among others.

Fungus grows when it finds the right levels of moisture, temperature (the range varies by species), acidic conditions, and a reliable source of food.

Bacteria are much more likely to invade when the environment has been compromised, in conditions such as oxygen deprivation, which make their attack more successful.

Once disease hits, it is important to act quickly and restore balance to the environment. However, prevention by providing a balanced environment for the plants is the best solution.

AIR FILTRATION AND SANITATION

Fungal spores often enter a grow space on air currents. Use a hepa filter in the air intake system to capture these spores and reduce the chance of fungal infections. Another option is a UVC lamp in the intake duct. The light from these lamps kills microbes and destroys spores. These two methods can be combined.

ALGAE

Algae are plant like microscopic organisms. They conduct photosynthesis like larger plants, but lack stems, roots and leaves.

Algae occasionally grow in hydroponic and aeroponic systems. They thrive in environments that provide warm temperature, light and nutrients. The water temperature should be 72° F (22° C), which is best for maximum plant growth. Unfortunately it is also a good temperature for algae.

When light shines on nutrient-rich water, algae are almost guaranteed to grow. Algae can grow anywhere in your system. Algae are commonly found inside tubes, nutrient reservoirs, buckets, on exposed rock wool cube surfaces, and DWC buckets (mainly if the containers allow light in).

All containers should be opaque.

Some algae attach to surfaces such as tubes and reservoir surfaces as well as roots. They form a green film that looks and feels either velvety or slimy. When it covers the roots it starves them of oxygen. It also competes for nutrients and can clog your system lines, motors, and sprayers in aeroponics systems.

Other algae are free-swimming and don’t attach themselves to surfaces. These algae can also clog up tubing.

Both kinds of algae photosynthesize during the day, using CO_2 dissolved in the water and releasing oxygen (O_2). However, during the dark period algae use oxygen dissolved in the water and release CO_2. This depletes the oxygen in the water, which the roots require to maintain health.

PREVENTION

+ The best way to prevent algae is to deprive it of light. This is a safe, non-chemical method of prevention. Use black tubing, rather than clear or translucent to prevent light from coming into the lines. Use a black or opaque reservoir to hold your water and nutrients. Make sure the cover is light-tight. Potting containers should be opaque.

+ Everything should be light-proof. Rock wool cubes should also be covered. You can use landscape sun-block fabric, white-black plastic (white side up) or plastic rock wool cube covers made for the purpose.

CONTROL

+ The best method of algae control is to prevent the problem by excluding light. This should be the main emphasis in systems with algae problems. If you already have algae growing, clean the system and replace or cover light transmitting tubing and reservoirs with opaque materials.
+ These are some products you can use to control or prevent algae from attacking the system:
+ Hydrogen Peroxide (H_2O_2)—A ½ to 1% hydrogen peroxide solution stops algae and other organisms but must be used regularly. It should not be used with mycorrhizae because H_2O_2 kills both good and bad micro-organisms.
+ Colloidal silver—A solution of a few parts per million (ppm) colloidal silver prevents algae growth, and like H_2O_2 it kills all micro-organisms.
+ UVC light—This is considered a germicidal light and is often used to keep hot tubs, fish tanks and other water free from micro-organisms.
+ Grapefruit seed extract-—Grapefruit seed extract kills algae without harming plants. This method is used by water supply systems for keeping drinking water, fish ponds and lakes algae free.
+ Barley straw rafts are used for algae control in ponds, lakes and other waterways. They can also be placed in hydroponic reservoirs, yet have limited effectiveness.

GRAY MOLD AND BROWN MOLD (BOTRYTIS)

Gray mold, botrytis cinerea, is found almost everywhere and can cause disease on most plants, including marijuana. It causes damping off and stem canker and bud rot.

Gray mold is one of the most common fungal diseases that attack marijuana.

The fungus can germinate only on wet plant tissue when the temperature is between 55-70° F (13-21° C). This often happens in dry weather as dew accumulates on the leaves. Once it starts growing it can tolerate a wide range of humidity and temperatures but high humidity and cool temperatures help it thrive. Lowering the humidity often stops it from continuing to grow.

Gray mold, like most other fungi, enters and easily infects any part of a plant that is either wounded, damaged from pests and pruning, or beginning to die. Thus it is very important to sanitize pruning equipment between cuts.

Cuts and lesions are a normal part of plant life, so all plants are subject to attack when conditions are favorable to the mold. Unhealthy or shaded areas of plants or crevices in buds are ideal conditions for the mold. Spores travel mostly via wind and rain and even in tap water, but they can be brought into grow rooms on clothing and pets.

GRAY MOLD

Shaded areas of the plant that do not get a lot of light are usually infected first. Then the disease spreads quickly through growth and spores.

Gray mold does the greatest amount of damage during flowering. It attacks the flowering tops, leaves, and stalks. Seedlings and seeds can also be infected and killed.

The mold starts out whitish like powdery mildew, but then darkens to a smoky gray or brown color. It has a fuzzy appearance, and light to dark brown rot forms in the damaged tissue.

Leaves and buds yellow from being suffocated by the mold. In higher humidity, the gray mold leaves a brown slimy substance on the leaves and turns the bud to rot, especially when the tissue is dense late in flowering.

Stems with unhealed breaks can be infected with B. cinerea causing stem cankers, which then affect the rest of the plant by depriving it of nutrients and water.

PREVENTION

+ Indoors, avoid conditions favorable to the mold by controlling humidity and temperature. Brown mold can be considered an environmental disease created by excess moisture. Keep humidity under 50%. Water when your grow lights are on or during the day. Remove and discard dead or dying plant tissue. Make sure there is no moisture on leaves and buds when the lights go out. Gray mold indoors is usually caused by high humidity.
+ Outdoors, you can't control the weather but you can prevent bud rot. Bacillus subtilis is a bacterium that attacks B. cinerea. It can be sprayed on the plant as a preventative. Several brands, including Serenade® are available
+ Potassium bicarbonate ($KHCO_3$) and pH Up change the pH of the environment from alkaline to acidic. Alkaline environments inhibit the germination of molds and fungi including gray mold. There are many brands available.
+ Neem oil and sesame oil form a barrier and inhibit mold germination.

CONTROL

+ If you see the mold or stem wounds, apply a fungicide. The mold is particularly difficult to remove from plants in late flowering.
+ Removing the mold from living bud to prevent its spread may do more harm than good unless done carefully. The very act of fiddling with them may help transfer the mold to new sites. Sterilize tools by dipping them in alcohol or hydrogen peroxide after curing a bud.
+ Bacillus pumilus (beneficial bacteria)
+ Clove oil
+ Compost and compost tea
+ Copper
+ Coriander oil
+ Neem oil

+ Potassium bicarbonate
+ Pseudomonas (beneficial bacteria)
+ Quaternary amines
+ Sesame and fish oil
+ Sodium bicarbonate
+ Sulfur: spray, vaporizer, or burner
+ Trichoderma (beneficial fungi)

LEAF SEPTORIA

Leaf septoria is also known as yellow leaf spot. It is not common indoors but occasionally attacks marijuana grown outdoors. The fungus interferes with leaf processes, including photosynthesis, inhibiting a plant's ability to thrive. Though it is not deadly, it can greatly reduce yield.

Origin: Two closely related fungi, Septoria cannabis and S. neocannabina, cause yellow leaf spot. Yellow leaf spot is a wet and cloudy warm weather infection. Warm water and rain trigger the release of spores from the storage structures so it usually appears mid to late season. Infections occur when the temperature is in the 60's (15°-20° C), but the fungi grow faster and are more destructive as the temperature rises, with its ideal temperature just below 80° F (25° C).

The spots first appear on the lower leaves of the plant. The fungus may also attack the stem.

The spots can be yellow, white, or gray-brown. They may remain small and round, but usually grow larger in an irregular pattern. Spots sometimes have reddish-brown perimeters. The infected tissue eventually dies, dries out and falls off, resulting in holes in the leaves. Severe infections result in defoliation, with no leaves left on the bottom of the plant.

PREVENTION

+ The septoria fungi are specific but ubiquitous. Only two species attack cannabis. As a result, plants are more likely to be infected if there is marijuana, or perhaps hops, growing outdoors near the garden. The spores overwinter on fallen infected marijuana leaves and debris and spread in three ways: wind, water and walking, either by humans and animals. Indoors, plants are not likely to come in contact with the spores unless they are trekked in or there are infected outdoor plants nearby.

+ Outdoors, infections are most likely to occur in gardens and spaces where marijuana has been grown before. To lessen the likelihood of infection remove all residue from the previous garden and then spray the area with a fungicide. Clean and decontaminate all tools after working with infected plants. If possible plant the garden in a different space each year.
+ Try one ounce (0.75 ml per liter) mixed spices and herbs in one gallon of hot water, let brew and cool. Strain. The fungicide is ready to use. Ed Rosenthal's Zero Tolerance® Fungicide contains both herb and spice oils and potassium bicarbonate.
+ Compost tea is an effective control of molds. Use it as a spray.
+ Copper has been used as a fungicide for more than 100 years. It is very effective. Many brands are available.
+ Neem oil
+ pH Up changes the pH of the leaf surface making it harder for the mold spores to germinate. Use a solution with a pH of 9.
+ Potassium bicarbonate is a fertilizer as well as a fungicide. Use a 1% solution to change the leaf surface pH to alkaline.
+ Sesame and fish oils destroy the molds and mold spores.
+ Sodium bicarbonate, baking soda, changes the pH of leaves but it contains sodium, which can harm leaves if it builds up. Potassium bicarbonate is preferred.
+ Sulfur
+ Trichoderma (beneficial fungi) These beneficial fungi attack all kinds of fungal pathogens. Brands include Plant-Shield, Rootshield, Trichodex and BioTrek.

POWDERY MILDEW

Powdery mildew is a fungal disease that affects a wide range of plants, composed of a wide variety of species. Each species of powdery mildew has a very limited host range, but are all characterized by an easily recognizable white or gray powdery growth. The races that attack hops also attack marijuana.

Mildew spores can be found everywhere. Powdery mildew is a common problem for both indoor and outdoor growers whenever the temperature and humidity fall into its favored range.

Mildew spores are ubiquitous and endemic. In areas where marijuana or hops is being grown, wind and air ventilation are the main vectors. Another major factor is contaminated cuttings. However, clothing, pets, and outdoor animals can also deliver spores to the garden.

Spores can remain dormant until triggered by environmental factors, which include a suitable host, adequate humidity, moderate temperatures, low light intensity and acidity.

Powdery mildew is most likely to attack young leaves, up to two or three weeks old. The infection spreads over the plant and spreads to other plants in the garden. It affects buds, stems, stalks, and leaves.

The first signs of an infection are raised humps on the upper leaf surfaces. Plant leaves look like they've been dusted with flour or confectionary sugar. At first it might appear on just a small portion of the leaf in an irregular circle pattern. It quickly spreads and soon the entire leaf is covered as if it had been powdered.

Infected plants prematurely yellow, brown, and eventually die. If untreated, black specks can arise in the white powdery mildew. Buds have a stale, moist smell and are coated with the white powdery-looking mildew substance that can't be removed. Powdery mildew hinders photosynthesis, causing your harvest to cripple to little or no yield.

Infected buds and leaves are not acceptable for smoking.

PREVENTION

+ Powdery mildew in vegetative growth is easier to treat than in the later stages of flowering. Quarantine all new plants in a separate area where they can't infect other plants. If your plants get infected during flowering, especially far into the flowering stage, the buds will eventually become infected.
+ Dip new acquisitions and cuttings in a solution of potassium bicarbonate and milk on a routine basis. Filter incoming air with a hepa filter to prevent spores from entering the room in the airstream.
+ A germicidal UVC light like the ones used in food handling kills airborne powdery mildew spores. Ionizers and ozone generators precipitate and inactivate spores, lessening the chances of infection.
+ As with other fungi, restrict humidity and spore production by not watering or foliar spraying at night or with lights off. Water plants when lights first come on or with at least five hours of remaining light time. Keep humidity

in check; anything over 50% may trigger problems. Even so, powdery mildew may attack since it often thrives in fairly low humidity. Keep plants spaced apart to allow for maximum airflow.

POWDERY MILDEW, photo by Sean M.

+ Ampelomyces quisqualis (beneficial fungi) This is available under the brand name AQ-10
+ Bacillus pumilis (beneficial bacteria)
+ Bacillus subtilis (beneficial bacteria)
+ Compost tea
+ Herb and spice fungicidal oils
+ Milk is an effective fungicide. Milk should be used as 1 part milk to 5 parts of water.
+ Neem oil
+ Potassium bicarbonate
+ Sesame and fish oils
+ Sodium bicarbonate

CONTROL

+ Remove infected leaves from the grow room, this is critical. Carefully remove them without knocking spores into the air. Place a bag over infected leaves and tie it shut; then remove the leaves. Use a fungicide on wounded stems from which you've removed the leaves.

+ The following product list will work for indoor and outdoor plants.
  + Vinegar
  + Bacillus pumilis (beneficial bacteria)
  + Bacillus subtilis (beneficial bacteria)
  + Cinnamon Clove, Coriander Rosemary and Oregano oils and teas
  + Copper
  + Horticultural oils containing jojoba or cottonseed oil use 1 tablespoon per gallon (15 ml per 4 liters) of water
  + Milk
  + Neem oil
  + pH Up
  + Potassium bicarbonate
  + Sesame oil
  + Sodium bicarbonate
  + Sulfur

ROOT DISEASES

Every plant must have a healthy root system. Pathogens can attack and damage the roots of one plant, then rapidly infect other plants in the garden. Fusarium, Verticillium and Pythium are common and destructive root aggressors known to all growers, whether soil gardeners or hydroponicists.

FUSARIUM

Fusarium inhabits the soil. Fusarium fungi vary across many species and subspecies, and a given strain of the fungus targets only a few plant species. Several strains target cannabis. Fusarium is so devastating that the US government has developed special strains to target cannabis and coca as part of the "War on Drugs." The coca strain has been released on coca plants in Colombia.

Different fusarium species produce somewhat different diseases in cannabis. These diseases, primarily fusarium wilt and fusarium root rot, present different symptoms but respond to similar prevention and control methods.

It is not commonly found in marijuana gardens. However residual spores are more common in soil where hemp was once grown or where it still grows as a weed. Growers using hydroponic systems or sterile or pasteurized planting mix seldom see it. Fusarium infections are most common in warm weather, but overall the frequency varies. Because it is soil-based and species-specific it may be extremely common in one area but rare in another where the soil is not infected.

Fusarium spores can remain dormant in soil for years, and infected soil is nearly impossible to disinfect. The fungus can also spread from seed taken from infected plants.

Damage from Fusarium wilt is most evident on the leaves and stems. Fusarium root rot affects the roots first, then the disease works its way up the stem.

Fusarium wilt initially appears as small, dark irregular spots on lower leaves, which quickly become chlorotic (yellow-brown). Leaf tips curl upward, and wilted leaves dry and hang on plants without falling off. Stems turn yellow, then brown, and finally collapse. In Fusarium wilt the roots show no outward symptoms if the diseased plant is pulled up.

Fusarium root rot begins below the soil line, turning the roots rotten and necrotic and giving them a characteristic red color. The first visible symptom usually appears as the rot works its way up the stem, producing a red-brown discoloration at the soil line. This discoloration may progress to swelling and the stem may split open. The plant soon begins to wilt, then collapses as the decay spreads up the stalk.

In both wilt and root rot the fungus spreads through plant cells and clogs the xylem vessels, inhibiting water and nutrient transport. This vascular clogging inside the plants causes the external symptoms of wilt and collapse. Infected plants usually die. Fusarium survives in the plant debris, so infected plant debris should not be buried, composted, or placed on uninfected soil.

PREVENTION

+ If an outdoor Cannabis crop falls prey to Fusarium, that patch of ground can no longer be used to grow Cannabis at all, although other plants will do fine there. Likewise seeds produced by infected plants should not be used. The pathogen stays dormant on the seed and attacks the plant when the seedling emerges, causing damping off and likely killing it.

+ Avoid planting marijuana in the same ground for many years in a row. Even though none of the plants show symptoms, multiple successive plantings can cause the fungus to build up in the soil until it reaches destructive levels.
+ Certain soil types have been found to be less conducive to the growth of Fusarium than others. Clay soils have fungistatic properties due to their high pH. Loamy soils with healthy and diverse plant growth often harbor native microbes that suppress Fusarium. These soils do not stop the fungus, but they slow it down, and may be helpful in combination with other preventive measures.
+ Properly aged compost, and tea made from compost, help protect plants from all sorts of fungal infections.
+ Container gardening is one of the best ways to avoid Fusarium, because it gives the gardener complete control over the soil. If an area that would otherwise be ideal (weather, sun, etc.) is known to be infected with Fusarium then containers allow you to take advantage of the site's strong points while avoiding the disease issues. In order to prevent Fusarium infections, use sterilized or pasteurized soil mixes and sterilized or new pots. Do not over-fertilize. Make sure the soil drains.
+ Mycorrhizae (beneficial fungi) help improve plants' disease resistance.
+ Streptomyces griseoviridis, Bacillus pumilus, and Bacillus subtilis (all beneficial bacteria) or Gliocladium (beneficial fungus) can be applied as pretreatments for seeds, as a soil drench, or as a foliar spray.
+ Make sure the soil pH doesn't get too low. Neutralize acidic soil with dolomite lime or greensand. Fertilizers enhanced with potassium and calcium can help fight off and prevent Fusarium, while excess nitrogen and phosphorous may make the disease worse.

CONTROL

+ The only truly effective control is the removal and destruction of infected plants. After removing any affected plants use hydrogen peroxide (H_2O_2) to clean all the tools that touched those plants before using them again.

VERTICILLIUM WILT

+ Verticillium wilt is caused by soil-borne fungi that are common in many soils, and it attacks hundreds of herbaceous and woody plant species, including cannabis.
+ Verticillium wilt thrives in moist soil that is rich in clay or otherwise poorly drained.
+ Verticillium wilt starts by attacking stressed roots then proceeds to affect the leaves as well.
+ The lower leaves turn yellow along the margins and between the veins before turning a gray-brown and wilting. The stem turns brown near the soil line; symptoms can resemble Fusarium wilt. Once the roots have been affected, it spreads through the xylem, which exhibits a brownish discoloration. The vascular system becomes plugged up, which reduces the flow of water through the roots and causes the wilting.

PREVENTION

+ Sterile planting mix or hydroponic growing systems prevents Verticillium infection. However any amount of soil in the growing containers may carry the fungus. Many soil bacteria and fungi help to suppress Verticillium, so if sterile soil isn't an option then amending your soil with alfalfa meal or aged compost may offer some protection. Keep the planting beds well drained, as excess moisture in the root zone greatly increases the risk of Verticillium.
+ Properly aged compost, and tea made from compost, help protect plants from all sorts of fungal infections.
+ Regular use of a 1% hydrogen peroxide solution kills many soil organisms.

CONTROL

+ There is no chemical control available. The best thing to do is pasteurize the soil. A fertilizer that is low in nitrogen and high in potassium may help. Some possible biocontrols include:
+ Bacillus subtilis (FZB24 strain)
+ Trichoderma fungus

PYTHIUM

Pythium is a destructive parasitic root fungus. Under favorable conditions Pythium multiplies very rapidly and releases microscopic spores that infect the roots and deprive the plant of food. It attacks mainly seeds and seedlings, which have little resistance to disease. Larger plants can be treated and saved, if they are identified early, although your crop will be stunted.

Pythium is a common problem in field, container, and hydroponic cultivation.

Pythium exists everywhere in the plant's environment. It is present in your growing area, no matter how clean it is. Sanitation still helps: Pythium is often described as a "secondary infection," because it attacks plants that have already been weakened by stress: disease, damage, pests, nutrient deficiencies or poor growing conditions. Providing a healthy growing environment helps to prevent infection.

The best conditions for Pythium development include high moisture levels in the soil, high humidity, and a temperature between 70° and 85° F (20 to 30° C). Lack of oxygen in hydroponic nutrient solutions also helps Pythium take hold.

Pythium generally affects the entire plant, but mainly the roots and foliage. Young plants and seedlings in both soil fields and hydroponic gardens are the most susceptible.

Look for an overall yellowing of the foliage, sometimes accompanied by browning leaf edges. The plant appears wilted or stunted. The roots become discolored, soft, and watery. As the infection advances, the outer part of the roots comes off exposing a stringy inner core. In soil gardens and containers the roots will not be visible, but Pythium often advances from the roots to the "crown" of the plant, just above the soil line, causing the same browning and softening that it produces in the roots.

Pythium moves through soil or water to the plant roots where it germinates before entering the roots. Once in the roots it spreads through the tissue and produces resting spores, which further germinate and can infect the roots indirectly.

PREVENTION

+ The best prevention is keeping the plants healthy and free of other pests that might give Pythium an opening. Use well-drained, pasteurized soil or soilless mixes in containers and avoid over-fertilization and over-watering. Address pests, other diseases, and nutrient deficiencies promptly, as these stresses make plants more susceptible to Pythium.
+ Properly aged compost, and tea made from compost, help protect plants

from all sorts of fungal infections.

- Keep fungus gnats in check, as they can carry Pythium spores into containers with pasteurized soil. Note that one of the preventive measures for fungus gnats is to let the soil dry to a depth of about 1 inch (2-3 cm) between waterings, which reduces Pythium growth.
- Prevention is especially important in hydroponic systems. Once Pythium infects these systems it may spread through the water too quickly to stop. Keep your system as clean as possible to avoid infection.
- An option for very thorough cleaning is to treat the water with hydrogen peroxide (H_2O_2) at each nutrient solution change. UVC water disinfection systems kill water-borne spores. However, these methods kill beneficial organisms in the nutrient solution as well as pathogens like Pythium. The value of this trade-off varies from one system to the next, but it is worthwhile for some growers.
- Biocontrols such as those listed below are effective if applied before the plant shows any symptoms. Note that disinfection measures such as peroxide and UVC in hydroponic systems will also kill off these biocontrol agents.
- Bacillus subtilis (beneficial bacteria)
- Gliocladium (beneficial fungus)
- Pseudomonas (beneficial bacteria)
- Streptomyces griseoviridis (beneficial bacteria)

CONTROLS

- Pythium presents very similar symptoms to Phytophthora root rot in plants other than Cannabis. However while Phytophthora is a common problem in many other plants, no species is known to infect cannabis. Therefore marijuana gardeners should verify that any control they use is listed for use against Pythium. Controls that are specific for Phytophthora are not effective.
- Copper
- Clove oil
- Coriander oil
- Quaternary amines
- Sesame oil

+ Trichoderma (beneficial fungi)

STEM ROTS—DAMPING OFF

Damping off is a condition rather than a specific disease: the rotting of seedlings either underground, at the soil line, or at the crown. It is caused by several seed-and soil-born fungi, especially Rhizoctonia and Pythium. Damping off mainly affects soil growers and generally kills any seedling it affects.

Damping off is a common problem. It is often blamed on bad seeds, as it may destroy the seedlings even before they emerge from the grow medium.

Damping off occurs in warm, nitrogen-rich soil that stays wet for long periods. Even hydroponics systems can get damping off when the growing media become too saturated.

The infection begins below the soil line and affects seedlings with up to eight sets of true leaves or three leaf nodes. Leaves, roots, and stems can be affected.

Damping off begins as a yellowish-brown discoloration on the lower portion of the stalk. Stems have brown lesions and eventually a dark reddish-brown sunken canker. Cankers form mostly on the stems, between nodes. The third, fourth, and fifth nodes are affected most frequently. As the disease progresses, the lower part of the stem becomes soft and brown. Eventually the underdeveloped plant simply falls over.

The wilting may resemble root rot when the plant first starts to wilt and the leaves turn yellow, but stem canker has not yet appeared. The key difference from root rot is that in damping off the roots are not affected.

In the later stages of damping off in vegetative seedlings, the leaves droop and turn yellow, as if the plant was over watered. As lesions extend up the plant, it begins to wilt due to vascular damage (see the entry on Pythium for more information on this).

Damping-off can easily be mistaken for excessive fertilization (nutrient burn), high levels of salts in the soil, nutrient solution buildup in hydroponic systems, excessive heat or cold, or excessive or insufficient soil moisture. A key diagnostic sign is the brown discoloration near the soil line.

PREVENTION

+ The best preventives for damping off all focus on keeping your soil from getting too wet. Although it is always possible to over-water, these measures greatly reduce damping off.

+ Use a planting mix that includes a generous amount of perlite or vermiculite. This gives the excess water a chance to drain.
+ Make sure the soil surface is dry before watering. Use a moisture meter or a “finger test” to test soil moisture. Testing the soil near the edge of the pot is less likely to disturb root development.
+ Place the seeds no deeper than ¼ inch (6 mm). Soil is wetter further down.
+ Apply a fungicide to the seeds before planting to minimize post-emergence damping off. Don’t transplant seedlings outside until they have several sets of leaves, as younger plants don’t yet have a robust root system or resistance to disease.
+ Properly aged compost, and tea made from compost, help protect plants from all sorts of fungal infections.
+ Nitrogen-rich soils hinder root growth and aggravate damping off. Soilless planting mixtures drain well and deter fungus growth. Using sterile soil helps greatly.
+ Keep the grow room and tools clean, and keep the plants free of pests. This helps to prevent damping off just as it helps against other fungal diseases.
+ Bacillus subtilis (beneficial bacteria)
+ Gliocladium (beneficial fungus)
+ Pseudomonas (beneficial bacteria)
+ Streptomyces griseoviridis (beneficial bacteria)
+ Control
+ There is very little chance of saving seedlings that are struck by damping off soon after they germinate. Vegetative-stage plants with a few sets of leaves have a better chance of fighting it off with the help of fungicide.
+ Catching the problem early makes your growing life easier. As with other fungal diseases, remove infected areas of the plant entirely and treat the resulting wounds with hydrogen peroxide (H_2O_2). If the stem canker becomes severe then foliar feeding is a must to maintain the plants’ vigor, strength, and stamina for the fight.
+ Copper
+ Clove oil
+ Coriander oil
+ Quaternary amines
+ Sesame oil

+ Trichoderma (beneficial fungi)

ABOUT THE AUTHOR

Ed Rosenthal has been cultivating and studying marijuana for 40 years. His “Ask Ed” marijuana advice column has been relied on by generations of marijuana growers and enthusiasts. His most recent edition of Marijuana Grower’s Handbook has revolutionized the field of marijuana cultivation with techniques and findings that were previously unknown to the general public or other so-called marijuana grow experts. Additionally, Rosenthal is well known as a marijuana legalization activist and his 2003 trial for medical marijuana cultivation is regarded as a major victory for the legalization movement.

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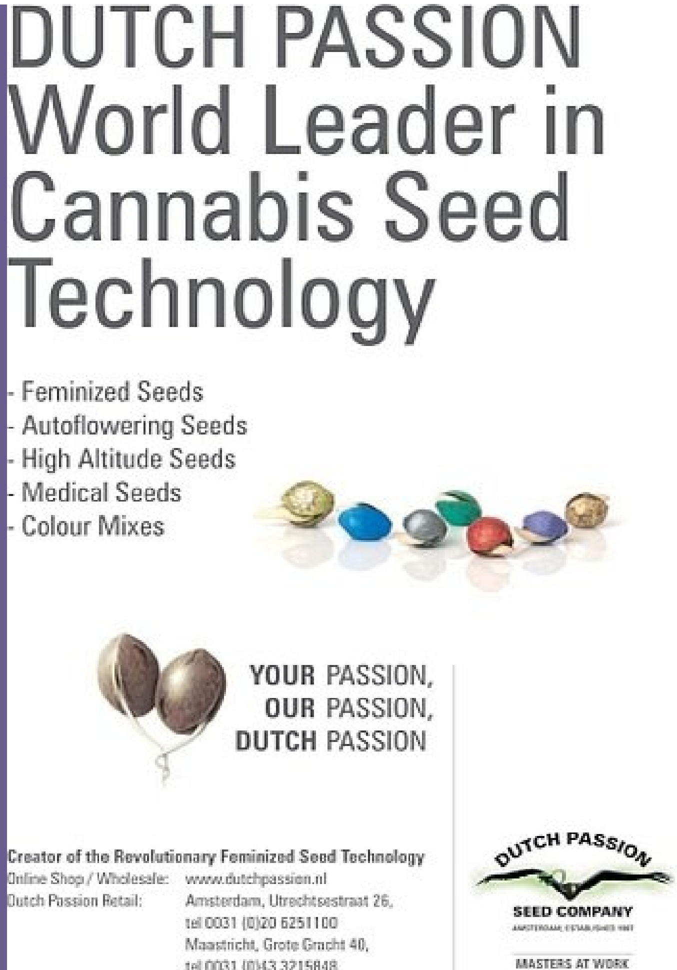
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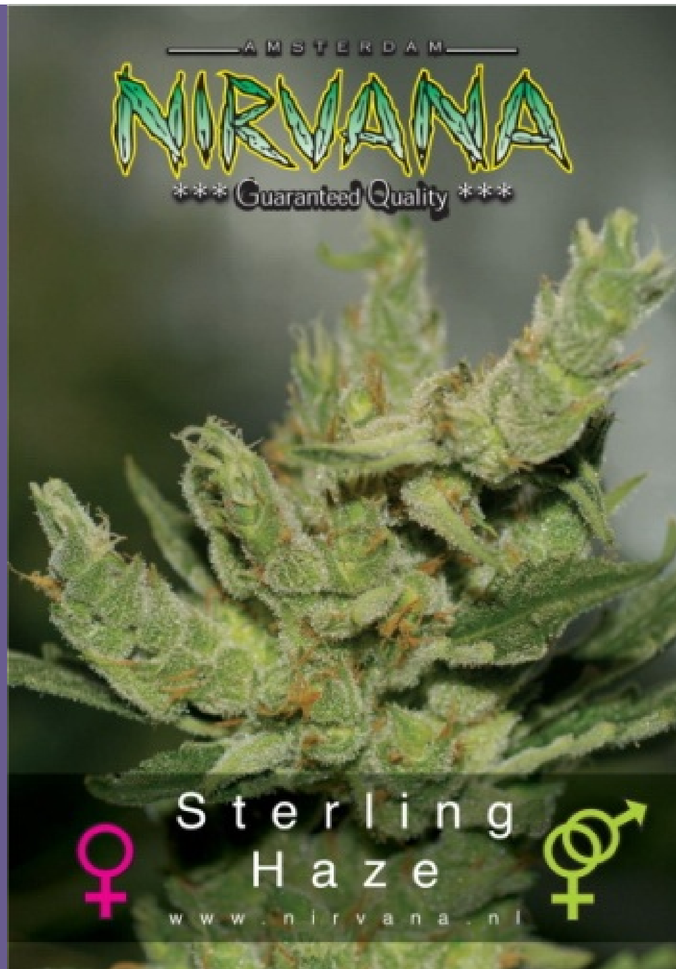
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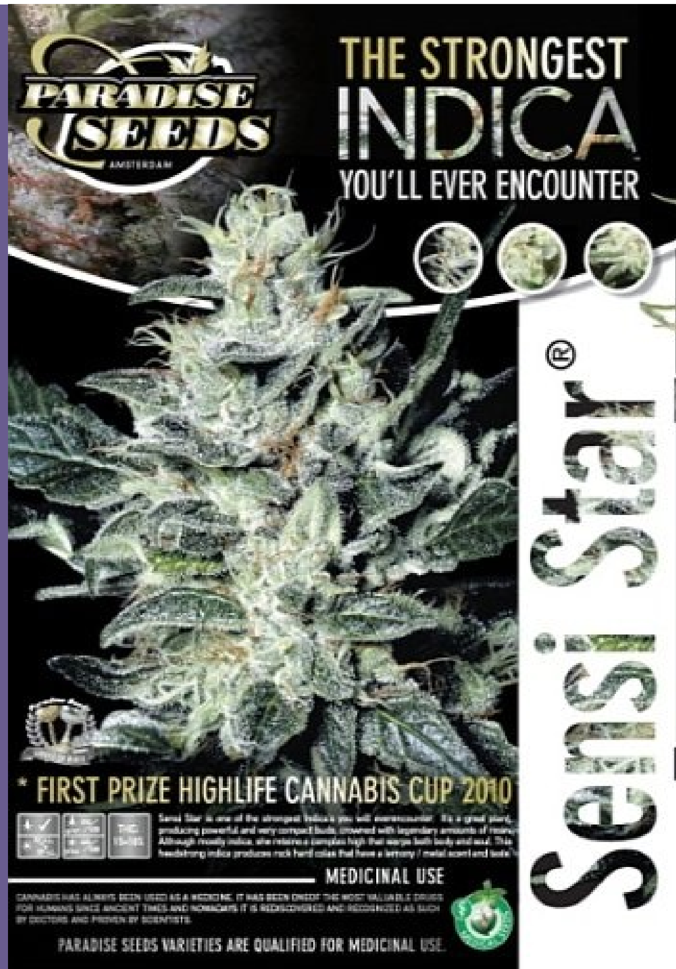
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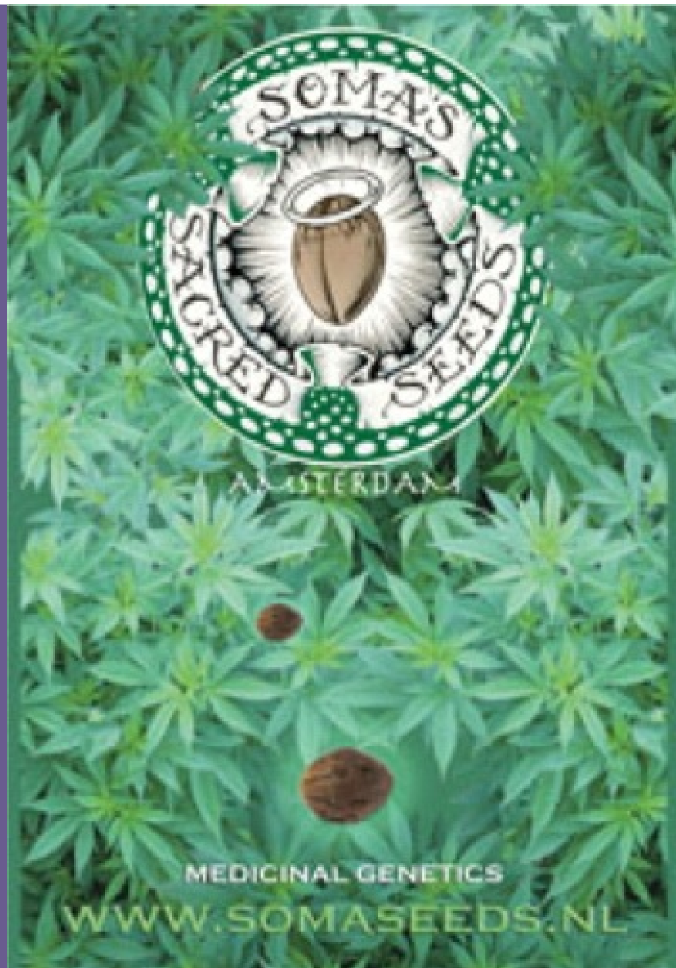
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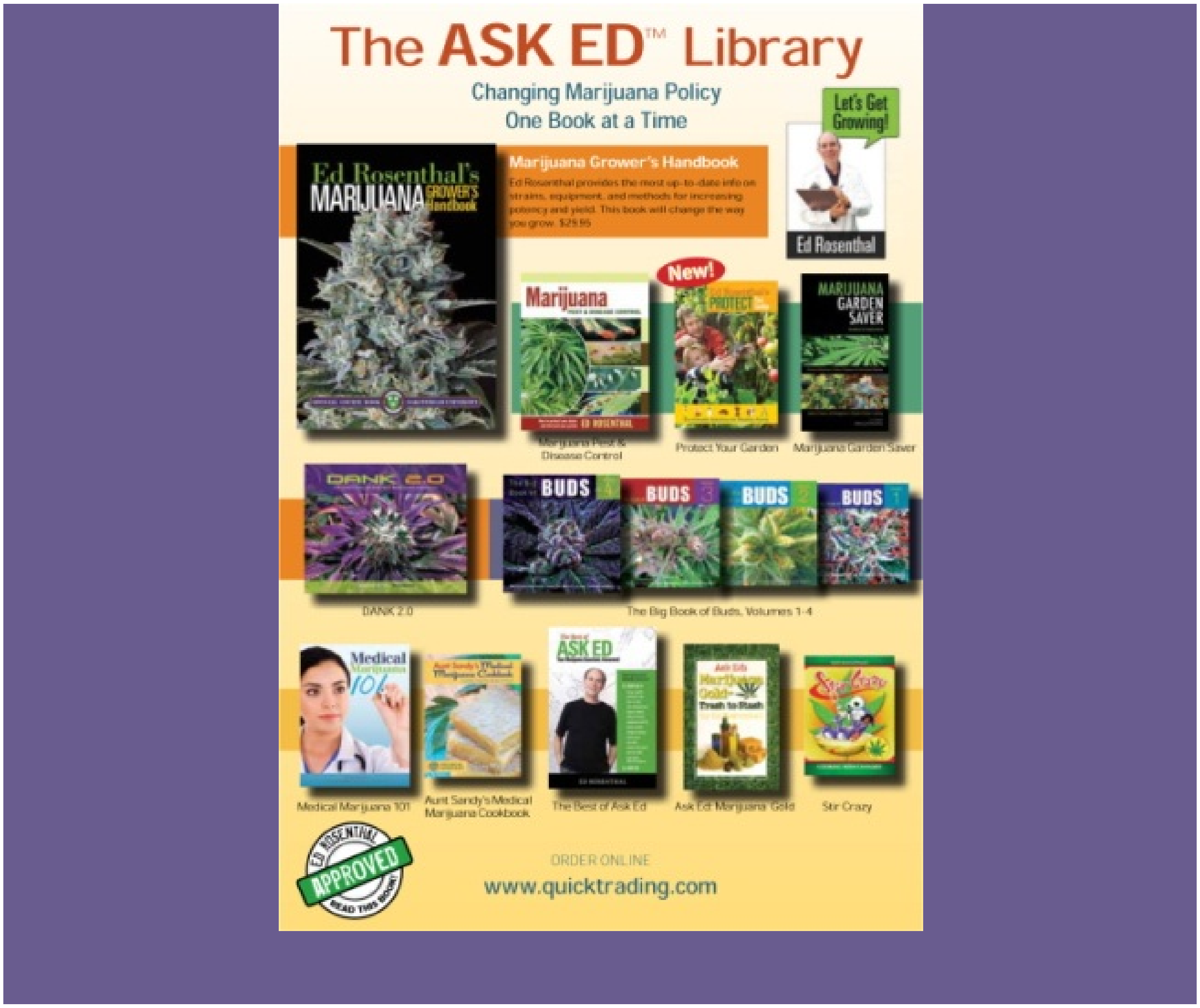
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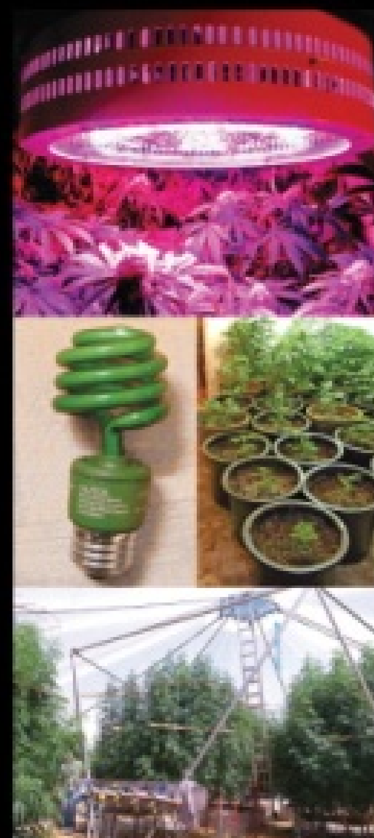

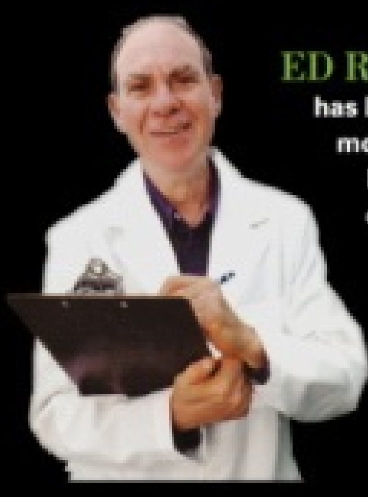

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