EXTENSION
College of Agriculture,
Biotechnology & Natural Resources

PEER REVIEWED

SP-21-98

Industrial Hemp White Paper
Growing Hemp in the American Southwest

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The purpose of this paper is to offer introductory guidance for those interested in growing legal, healthy hemp in the American Southwest. This paper is a summary of research done by the Southwest Hemp Educational Council, composed of the University of Nevada, Reno Extension Hemp Educational Committee, as well as commercial hemp growers and horticulturalists from other parts of the Southwest, namely New Mexico State University and the University of Arizona. The Southwest Hemp Educational Council formed to provide necessary educational resources to current and potential hemp growers in the Southwest. This paper is an introduction to hemp and is by no means a comprehensive, all-encompassing guide to its history, cultivation or commercial-use.

The 2014 U.S. Agricultural Act and 2018 Farm Bill changed the landscape of *Cannabis* politics in the United States, and many eager growers jumped at the opportunity to cultivate hemp as a cash crop. However, as 2020 statistics show, the difficult reality of cultivating hemp has discouraged some from expanding their hemp ventures (Drotleff, 2020). Our research indicates that most growers are losing money. To address this, our paper is a guide to navigating some of the legal, environmental and commercial aspects of hemp growing.

This paper covers the following topics:

- Introduction to the *Cannabis* plant itself-- breaking down its anatomy for beginners
- A brief history of *Cannabis* in the United States
- Explanation of the steps one must take to become a legal hemp grower in Nevada and other Southwestern states
- Discussion of proper cultivation procedures for healthy hemp plants
- Explanation of various commercial uses of hemp
- Examination of the performance of hemp and its products in the marketplace
- Questions and suggestions for further research
- Summary of needs assessment survey findings

Introduction to the Plant Itself

Humans have used *Cannabis* for thousands of years to make ropes, cloth, papers, foods, animal feed and medicines. Hemp, or industrial hemp, refers to *Cannabis sativa* that is grown as a crop for its fiber, seed, oil or chemically derived products. Its uses are vast, and its economic potential is enormous (ElSohly, 2010). Hemp, and all *Cannabis*, is generally considered a dioecious (male and female parts are on separate plants) annual. Hemp is usually planted in the spring and matures by the fall. Seeds usually germinate in three to seven days. Industrial hemp is defined in the Federal Farm Bill as "the plant *Cannabis sativa L.* and any part of such plant, whether growing or not, with a delta-9 etrahydrocannabinol concentration of not more than 0.3% on a dry weight basis" (Nevada Department of Agriculture). Tetrahydrocannabinol (THC) is a psychoactive cannabinoid found in most *Cannabis*, but is higher in that which is cultivated as marijuana (for use as a drug).

Typically, *Cannabis* is understood to be a genus of plants that contains about four species, *Cannabis sativa L., Cannabis indica*, *Cannabis sativa* and *Cannabis ruderalis*, though these distinctions are hotly debated, and new research has indicated that *sativa L., ruderalis*, *indica* and *sativa* are different subspecies within the same species (Colbert, 2015). Official scientific distinctions aside, *sativa L.* is most commonly cultivated as hemp, and has some visible differences from *Cannabis indica or sativa*, which is more often cultivated as "marijuana," defined in the Farm Bill as *Cannabis* harvested at >0.3% delta-9 tetrahydrocannabinol (THC) content.

Cannabis sativa L. is taller, and its leaves are composed of long, thin leaflets. The flowers are loose or "open flower structured," allowing them to yield higher extractions. *Cannabis sativa L.* has a longer flowering time than *indica* and may start to flower earlier than *indica* as well. *Cannabis indica* is a shorter plant, with fatter leaflets and dense, tight flowers or buds. It has a shorter flowering duration.

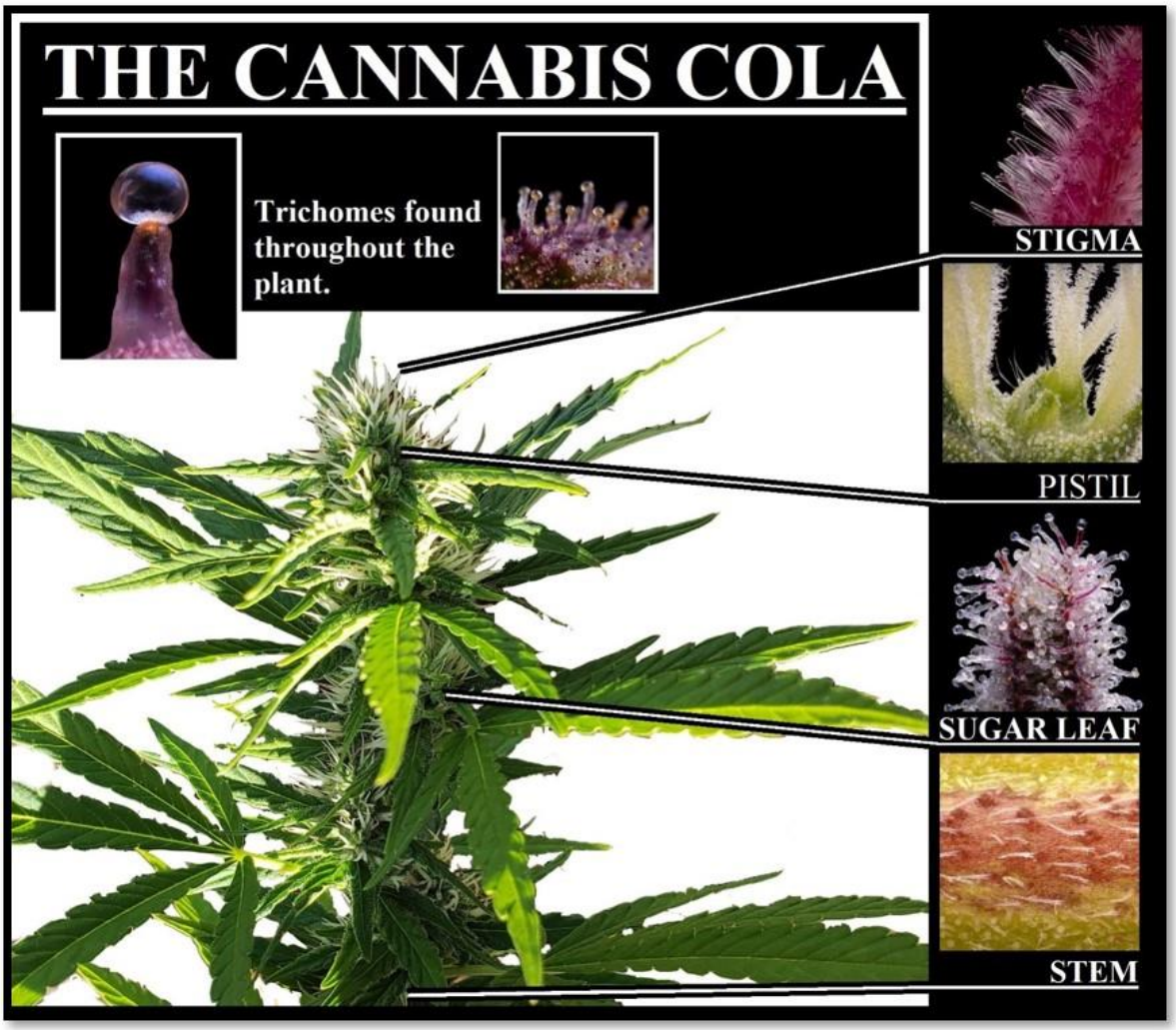

Figure 1. Anatomy of female *Cannabis* plant cola. Photo composed by Marysia Morawska using photos by IG: @zoom_gardens and Marysia Morawska.

Every female *Cannabis* plant is composed of eight main parts: cola, pistils, bracts, trichomes, sugar leaves, fan leaves, stem and roots. The cola is the flowering portion of the plant, which is composed of many small floral clusters covered in trichomes. The flowers are composed of pistils, structures composed of an ovule with two protruding styles capped with stigmas. The stigmas extend past the bract, the small leaves that surround the reproductive cells, to catch male pollen. Trichomes are hairlike appendages that contain cannabinoids and terpenes, the compounds currently most sought after by *Cannabis* growers. Sugar leaves are small leaves that grow out of the buds within the cola. Their trichome covering gives them a sugar-coated appearance.

Sugar leaves are harvested for their cannabinoid and terpene content. Fan leaves are the large, protruding leaves that cover the length of the plant. They are necessary for photosynthesis, but are often removed from the plant when harvested for derived products (The Different Parts of A Marijuana & Cannabis Plant, 2020). The stem, or stalk, is the main support structure of the *Cannabis* plant that transports fluids, nutrients and information from the roots to the rest of the plant. The points where stem and leaves intersect are called nodes. Lastly, the roots anchor the plant, absorb water, dissolve minerals, and conduct these to the stem.

These components are found in all *Cannabis* plants, but the focus of this paper is hemp. The following sections will cover hemp history, hemp regulations in Nevada, growing tips, information about derived products and much more.

Introduction to Hemp in the U.S.

Hemp, alongside tobacco and cotton, was considered a vital crop in the colonial United States and its cultivation predates the formation of the U.S. itself. As hemp historian Robert Deitch explains, "The Virginia Company, by decree of King James I in 1619, ordered every colonist (property owner) to grow 100 plants specifically for export" (2003, p. 16). Only in the 20th century, when competing industries pushed to illegalize it, did hemp cease to be produced legally in this country.

The potential of hemp in the U.S. was stifled for decades by the restrictions imposed by the Federal Bureau of Narcotics, the Marijuana Tax Transfer Act of 1937, and many other illegalization efforts that followed. The legal history of hemp is so layered and complicated that we cannot feasibly recount it all here, but our reference page contains helpful books on the subject.

Thanks to the 2014 U.S. Agricultural Act, 2018 Farm Bill, Senate Bill 305 (SB305) and Senate Bill 396 (SB396), growing, producing or handling industrial hemp in Nevada is legal through the State of Nevada Department of Agriculture Industrial Hemp Program. Rather than import hemp from other states or countries as our state does with food, the in-state cultivation of hemp is not only possible but will cut the unnecessary costs of importing, and will avoid the struggle of navigating interstate *Cannabis* laws, which oftentimes do not match one another.

How to Grow Hemp in Nevada Legally

Entering the hemp industry in Nevada requires approval from the Nevada Department of Agriculture (NDA), attainment of specific certifications and payment of fees. The first step is to decide in which category of the industry one wishes to enter; this will determine the

appropriate certification to acquire. As of the time of this publication, the three certification categories and associated fees for the State of Nevada are as follows, however it is recommended to check with your state's Department of Agriculture website, as these are subject to change (Nevada Department of Agriculture, 2019):

Grower: a person who is registered by the Department and cultivates industrial hemp.
- Application Fee: $500-900
- Acreage Fee: ~$5/acre or, Square Footage Fee: ~ 33 cents/1,000 square feet

Producer: a person who is registered by the Department and produces agricultural hemp seed for replication.
- Application Fee: ~$100
- Acreage Fee: ~$5/acre or, Square Footage Fee: ~ 33 cents/1,000 square feet

Handler: a person who is registered by the Department and receives industrial hemp for processing into commodities, products or agricultural hempseed.
- Application Fee: ~$1,000

Applicants may be subject to a law enforcement background check, and cannot have a criminal record relating to possession, production, sale or distribution of a controlled substance within the last 10 years of the application date (NDA, 2019). The NDA may inspect and sample as they see fit at any time and at the expense of the applicant. Inspection costs, at the time of publication, run at $50/hour/inspector for drive time, inspections and sampling, and may include an additional fee for any analysis they conduct (NDA, 2019).

For assistance navigating the regulations, licensing and applications, one may reach out to the NDA Hemp Program coordinator for answers to any additional questions. Hemp production laws may vary by county, and it is recommended to check with regional and local governing agencies to ensure compliance with all regulations. Likewise, each different state also possesses their own specific laws. For general information regarding Utah, New Mexico, Arizona and California, please refer to the Appendix of this publication.

Hemp seed growers and producers must submit a harvest report to the NDA at least 15 days prior to harvest, but new federal rules permit 30 days prior (Agricultural Marketing Service 2021). At that point, an inspection will be scheduled, at the cost of the producer, and a lab analysis will be taken to ensure the crop tetrahydrocannabinol (THC) concentration is below the federally mandated threshold of 0.3% total THC on a dry weight basis (NDA, 2019). Producers are not to dispose of or relocate any crop material prior to NDA approval. Once they have passed inspection, they can then move or sell harvested material at the producers'

own risk (NDA, 2019). If harvested material exceeds the threshold, the producer will be instructed by the department on disposal methods and will not be allowed a second test. The Hemp Harvest Report can be found on the NDA website and must be mailed to:

Nevada Department of Agriculture
Attn: Industrial Hemp Program
405 S. 21st St.
Sparks, NV 89431

Or, reports faxed to 775-353-3638, or scan and email them to ajeppson@agri.nv.gov.

Experienced growers know to test their hemp "early and often" so as to not lose too much of their crop. We recommend sending samples to labs for cannabinoid testing every other day when harvest approaches, which usually arrives in late September or early October. We advise growers to harvest their plants not based on physiological maturity, but on test results. Once test results demonstrate the desired and legal cannabinoid balance, the crop should be harvested. Harvesting earlier is advised to avoid excess THC.

Growing Healthy Hemp in the Southwest

Controlled environments, such as greenhouses, can be an easy way to ensure quality, as the plants are not exposed to weather, and their exposure to pests is limited. However, this method is costly and unsuitable for the cultivation of hemp that does not prioritize cannabinoid content for human consumption, such as growing for fiber and grain (M. Morawska, personal communication, Oct. 29, 2020). Many hemp growers grow outside and produce large, quality yields. Doing so is possible with the right horticultural knowledge. In addition to reading this paper, we encourage growers to contact their local Extension and/or community college for horticulture and botany classes to prepare them for this work.

To optimize their yields, growers must take care to plant their hemp at the right time, and in the right conditions. Hemp seedlings can be started indoors during the winter using artificial light before the seedlings are transplanted. To get larger plants that contribute to larger yields, growers should transplant seedlings two weeks after the latest frost date. Planting early allows the plants to grow large enough to create a cool, healthy microclimate for their root zones, which they need to continue growing during the extreme heat of July and August. As hemp is a new crop for the Southwest, information is sparse on optimal growing conditions. New growers should try successful varieties from similar climates/growing conditions. Hemp seeds are never 100% guaranteed to be female. Growers who want sinsemilla must monitor their crop and remove male plants and/or those exhibiting rhodelization (when female plants develop pollen sacs due to external stressors).

A number of growers in the Southwest have produced several hemp varieties successfully, despite the fact that hemp is not a desert-adapted plant. While varieties are tested and promoted by growers in the Southwest, there is not much research to support these claims. The most popular varieties include Berry Blossom and Cherry Wine, though we cannot yet vouch for their success. Extension is conducting variety trials to provide growers with data on hemp growing in the dry, hot conditions of Las Vegas.

Before planting, growers should test their soil, or send samples to a lab. The more soil samples, the better, as a larger sample size will better capture the true composition of the whole plot in which one desires to plant hemp. Hemp grows best in soft, sandy, well-draining loam with a pH between 6 and 6.5. It does not grow well on wet soils or heavy, clay soils, and it is sensitive to soil crusting and soil compaction (PennState Extension, n.d.). Growers desiring more organic matter may amend their soil with compost or soil amendments, such as worm castings. Sulfur may be used over an approximately two-year period to condition alkaline soil to be more acidic.

Hemp thrives in sunny summer days, (greater than 14 hours), but requires shorter (approximately 12-hour days) to produce mature flowers or seed. Summer day high temperatures from 80 to 90 degrees Fahrenheit are optimal for healthy hemp growth. Nighttime temperatures should be about 10 to 15 degrees lower. In the winter, daytime temperatures of 65 F to 75 F and nighttime temperature above 60 F are adequate. The plant will continue to grow until it flowers, which naturally happens as days get shorter.Hemp thrives in abundant sunlight, but the high heat of Southwestern summers can stress the plant. During the hottest days growers, can start watering at sunrise and repeat every four to six hours through the afternoon to keep the root zone cool. Ideally, the top ¾ inch of soil should dry before watering again (J. McCoy, personal communication, Aug. 17, 2020). When plants are seedlings, or if planting in poor draining soils, growers must be careful not to overwater. The roots need a good supply of oxygen, and drowning seedlings do not grow!

Growers who are interested in small, boutique hemp gardens may hand water, but irrigation systems are a helpful tool for hemp cultivation. There are many types of irrigation systems, but ground-level drip irrigation works well for cannabinoid cultivation. Overhead and center-pivot watering systems can get water into hemp flowers, which can lead to mold or unwanted bacteria to develop that could damage plant health.

Avoiding pests, injury, and pathogens is necessary for healthy hemp production. *Cannabis* plants do not require insects or mites for pollination, so these organisms mostly act as parasites, causing injury that can lead to infection and disease. We encourage growers to practice Integrated Pest Management (IPM). IPM means prevention, not just reaction, and it saves growers money in the long term. We encourage growers to research IPM and develop their own practices best suited to their growing conditions. A common IPM practice is to purchase ladybugs and/or green lacewing larvae, which will organically help control pest populations. Removal of dead or diseased plant material will also reduce undesired pathogens.

Common pests include aphids, thrips, caterpillars of various species and spider mites, all of which can infest indoor grow houses (McPartland et al., 2000). In Arizona, white flies, flea beetles, spiders, beet armyworm, corn earworm and the beet leafhopper are other common pests.

Beet leafhopper is a vector for beet curly top virus (BCTV), a common disease (Masson, 2020). BCTV. Is a common pathogen in the Southwest, mainly due to the endemic nature of the insect in the desert Southwest. BCTV symptoms include vein swirling, leaf curling, yellowing of leaves, and stunting. Growers should also look out for powdery mildew. Plant samples may be sent to state plant pathologists for diagnosis. In Nevada, send samples to:

Shouhua Wang, Ph.D.
Plant Pathology and Diagnostic Laboratory
Plant Industry Division
Nevada Department of Agriculture
405 South 21st St.
Sparks, Nevada 89431
phone: 775-353-3765
email: shwang@agri.nv.gov

Lastly, hemp growers should note that large hemp plots can give off an odor that some may find unpleasant, and some growers often deal with complaints of "weed smells" from neighbors. A buffer crop may be planted around hemp fields to offset the odor. A cover/companion crop can be planted to integrate IPM tactics, create a dual crop use of the land, and to offset odors of *Cannabis* growth.

The Many Uses of Hemp

Some of the most coveted products of hemp are the cannabinoids. Cannabinoids are compounds found in all *Cannabis* plants, the most known of which is tetrahydrocannabinol (THC), but hemp plants have been cultivated to have lower THC levels and higher cannabidiol (CBD) levels. There are more than 130 known cannabinoids, but the hemp cannabinoids with the highest consumer demand are CBD and Cannabigerol (CBG).

Cannabinoids have been used for years to help people sleep, deal with pain and movement disorders, cope with anxiety, and improve cognition. More recently they have been used to treat a number of diseases, such as inflammatory bowel disease, glaucoma, bladder dysfunctions, Huntington's disease, bacterial infections, colon cancer and appetite loss. However, clinical research on cannabinoids is still insufficient, and thus we cannot conclusively state that it is effective for these conditions and purposes.

Though many people know hemp for the products of its derived compounds, the rest of the plant can be used in various beneficial ways. Hemp has been grown for its fiber for centuries throughout the world, and was once grown on a large scale in the U.S. for this

purpose. The decortication process for hemp mechanically removes the tough woody interior (the hurd material), from the softer, fibrous exterior of the stalk. The bast and hurd of the stalks are extracted to use for a number of commercial products. Hemp fiber is durable and keeps its shape, making it an ideal material for clothing (Vivek, 2020). Hemp fiber contains cellulose which can be made into a biodegradable bioplastic, unlike the petroplastics. The Ford Motor Company constructed a hemp plastic car in 1941 and claimed the hemp plastic panels were stronger than steel.

Hemp stalks hold much market potential, but in the U.S., the commercial processing infrastructure for hemp stalk-use is lacking. Hopefully, this will change in the near future, and hemp's full potential may be unleashed. Hand-decortication requires much labor time and is not cost-effective enough for most hemp growers.

Hemp's market potential is also seen in the animal feed industry, which has expressed interest in utilizing hemp as an animal feed ingredient due to its fiber content, and omega-3 fatty acid and protein profile. However, due to its recent entrance into U.S. production, there is little research available to support the safety of consumption for animals or humans, nor is there a valid definition of ingredients. The Association of American Feed Control Officials (AAFCO), one of the regulating agencies of hemp as an animal feed ingredient, has asked the hemp industry to come forward with research establishing definitions for animal feed ingredients from industrial hemp for scientific review (AAFCO, 2020). The Food and Drug Administration (FDA) has prohibited the use of CBD in any potential animal feed product, as CBD falls within the scheduled drug category, therefore limiting the parts of the hemp plant deemed suitable as a feed additive (AAFCO, 2020).

However, hemp seed oil, hemp seed meal and whole hemp seed have been deemed suitable as potential feed additives and are currently being researched. While hemp is not legal for use in animal feed, hemp seeds, hemp milk and hemp oil are sold in many grocery stores for human consumption. Research has demonstrated that hemp oil can help treat acne, eczema and psoriasis (Callaway et al., 2005; Oláh et al., 2014; Millsop et al., 2014). Hemp oil can even be used to power vehicles, as it can be transformed into a biodiesel through the process of transesterification.

Beyond the uses of its derived products, hemp has major potential for use in bioremediation of tainted soils. An experiment in Chernobyl has shown hemp's remarkable ability to remove radioactive elements from soil (Charkowski, 1998). Due to hemp's superb ability to remove pollutants from the soil, we emphasize the importance of multi-testing your entire plot before planting. We hope to see or conduct experiments with hemp's phytoremediation abilities in the Southwest.

Hemp's Performance in the Marketplace

To date, production costs for hemp are typically higher than profits. Like other agricultural commodities, the industry structure will evolve as hemp markets develop (Mark et al., 2020). As the demand for hemp plants, CBD and hemp products have increased since the implementation of the 2018 Farm Bill, the markets have been flooded with industry newcomers, as well as international imports as various other countries legalize hemp production. This increase in supply may prove to be detrimental to young companies, as the demand has decreased due to saturation. However, it is difficult to predict how the market will react. While the USDA requires all hemp growers to report acreage planted and production information, it does not require reports on pricing and sales data, causing a lack of pricing transparency for the overall market.

Due to this lack of reliable information, those wishing to enter the market will have to rely on speculative decision-making for pricing and marketing their product (Mark et al., 2020). Based on available information, the prices of CBD raw biomass, dried CBD flower, crude hemp oil, refined hemp oil and CBD isolates have all dropped since 2019. However, the global hemp fiber market size is expected to grow in the forecast period of 2020 to 2025, with a compound annual growth rate (CAGR) of 4.9%, and is expected to reach $264 million by 2025, from $218.2 million in 2019 (Marketquest, 2020).

The current state of the hemp market has caused most hemp growers to lose money. Those who are successful find buyers before they start growing, consult attorneys when they create or sign contracts, have existing farm equipment and processing facilities they can use, are vertically integrated, and focus on a specialized market. There are newsletters available from several companies with information about market trends.

Further Research and Necessities for the Future of Hemp

Horticultural research on hemp in the Southwest is needed, and Extensions are stepping up to fill this void. We encourage growers to reach out to their local Extension office about emerging hemp research. Hemp has much potential beyond its derived products, and further research on its phytoremediation abilities is needed, and could prove beneficial for areas with polluted soils in the Southwest and beyond. Much support can be offered from Extension offices, and Extensions are interested in collaborative research projects with farmers.

More clinical research on the health impacts of hemp consumption is needed to dispel myths. We encourage all stakeholders to regard emerging research with scientific skepticism, paying attention to the methods and sources of funding. Additionally, hemp grown for cannabinoid consumption should be cultivated with the utmost cleanliness, and we endorse organic practices to minimize potentially dangerous chemical content.

Needs Assessment Results

A survey was conducted of 123 people from eight states concerning their interest in a training for growing hemp. Responses from 118 people indicated that they had previous experience in growing hemp. The responses to the hemp needs assessment also indicated that most people would prefer an online certificate program. Respondents would prefer two-hour weekday classes, once per week, which could be a mix of live and recorded sessions. They were eager to see our course cover the topics of hemp horticulture, soil and soil amending, IPM, irrigation, and marketing. There was also interest in navigating regulations, desert growing and weed control. Extension will assess all of our needs assessment data as we create our curriculum to address the needs of growers in the Southwest and beyond. We encourage interested parties to reach out to Extension with any hemp questions. Further needs assessments will explore the problems growers have faced.

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Appendix

State regulatory information

- Nevada
  - Nevada Department of Agriculture website: http://agri.nv.gov/Plant/Seed_Certification/Industrial_Hemp/Producer_Information/
  - Contact: ablondfield@agri.nv.gov or 775-353-3675.
  - Those who wish to grow, produce or otherwise handle industrial hemp in the state of Nevada must register through the Nevada Department of Agriculture, as well as check with other local governing agencies.

- Arizona
  - Arizona Department of Agriculture website: https://agriculture.az.gov/plantsproduce/industrial-hemp-program/industrial-hemp-license-applications
  - Contact: azhemp@azda.gov or 602-542-0955.
  - Those who wish to produce, harvest, transport and process industrial hemp must register through the Arizona Department of Agriculture prior to taking possession of any hemp seeds or propagative materials. All documentation and instructions can be found on the ADA website.

- California
  - California Department of Food and Agriculture website: http://www.cdfa.ca.gov/plant/industrialhemp/
  - Contact: industrialhemp@cdfa.ca.gov or 916-654-0435.
  - The state of California requires those who wish to cultivate industrial hemp to register with their local county agricultural commissioner, as regulations vary from county to county. Applications and further instruction can be found on the CDFA website. The provided FAQ pages on the website are helpful in navigating through the application process.

- New Mexico
  - New Mexico Department of Agriculture website: https://www.nmda.nmsu.edu/hemp-registration/
  - Contact: hemp@nmda.nmsu.edu or 575-646-3207.
  - New Mexico Environment Department website: https://www.env.nm.gov/hempprogram/applications/
  - Contact: hemp.program@state.nm.us
  - Those wishing to produce hemp must acquire a license through the New Mexico Department of Agriculture. Those wishing to process hemp following harvest, such as extraction, distillation and manufacturing, must register through the New Mexico Environment Department. Further instructions and application documents can be found on the given websites.

- Utah
    - Utah Department of Agriculture and Food website: https://ag.utah.gov/industrialhempprogram/
    - Contact: udaf-commissioner@utah.gov or 801-982-2375.
    - Those who wish to cultivate, process or market industrial hemp or its products must be registered through the state. Applications and requirements can be found on the Utah Department of Agriculture website.

- Tribal laws
    - As tribal reservations possess their own governing agencies, each reservation must determine their own regulations for growing hemp. As of the time of this publication, there is growing interest within the tribes located in Nevada, but set regulations are still developing.
    - According to the Arizona Department of Agriculture, when applying for a state license to grow hemp, if the applicant is a member of an Indian tribe or is a tenant on Indian tribal lands, the applicant must provide a resolution from the tribe that authorizes the licensee to grow hemp.

Additional resources

- Hemp farming timeline and budget planner from Hemp Farming Academy https://s3.amazonaws.com/kajabi-storefronts-production/sites/51692/downloads/prr8q7lsR1Kf4Y1VvZx9_Hemp_Farming_Infographic.pdf

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Zoom Gardens [@zoom_gardens]. 2020, December 12. Pistols poppin out of this ☒ Saturn v (Locomotion x Apollo 13) bred by PEEJ in the lab :) week 5 10 um-300 frame stack. [Instagram photo].

Zoom Gardens [@zoom_gardens]. 2021, March 10. @the_herring_chokers TERPNADO x BLACK TRIANGLE. [Instagram photo].

Zoom Gardens [@zoom_gardens]. 2021, April 3. ✿ A lone purple trichome ❀ with a rather beautiful secretory cell configuration. A recent diagram I was studying referred to the secretory cells at the base of the gland as a " rosette of gland cells " something I've never heard before..seems fitting. [Instagram photo].

Zoom Gardens [@zoom_gardens]. 2021, August 31. it's a stigma. [Instagram photo].

Zoom Gardens [@zoom_gardens]. 2020, December 11. Stem slide of a fresh clone rooted shown are cystolithic trichomes running down the middle red cuticle cells and bulbous trichome on the top and bottom . [Instagram photo].

Zoom Gardens [@zoom_gardens]. 2021, April 28. ❄ Sugar leaf. [Instagram photo].