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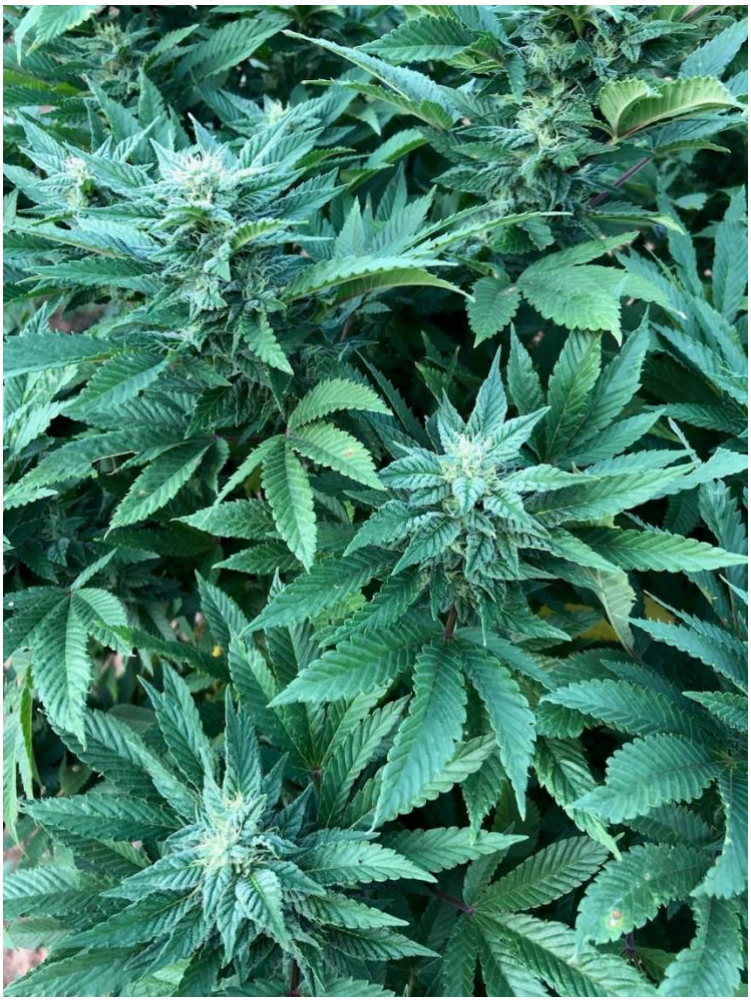

Integrated Pest Management of Hemp in Virginia

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CHAPTER 1: INTRODUCTION

Humanity has a long history of cultivating all forms of *Cannabis*, the past 70 or 80 years notwithstanding. Many scholars consider the crop foundational to the development of some human societies as it provided sustenance with grain, afforded numerous technological advancements with fiber, and met needs for medicinal and ritual use through flowers (containing cannabinoid and terpene compounds among others). From its origins in Central Asia, humans have carried hemp to all parts of the globe. The primary historic use of *Cannabis* in Europe and East Asia was as a fiber crop and these plants (often referred to as "*sativa*" types) typically were taller and often branched in form. The psychotropic forms (often called "*indica*" types) were more common to South Asia and the Middle East and typically smaller in stature with more compact or compressed buds.

Fiber hemp was essential for maritime powers, such as Great Britain, and was grown in the British Colonies in North America to make ropes and sails of canvas (a word derived from *Cannabis*). Hemp remained an important crop from the time of the Revolutionary War until about the turn of the 20th century when the decline of sail power and the availability of other, cheaper fibers began to supplant the crop. In addition to these market forces, hemp production faced political headwinds as cultivation came under federal control due to concerns about its use as a psychotropic drug.

After suffering the ups and downs of political fortune in the last century, *Cannabis* – particularly the non-psychotropic "industrial hemp" – is finally getting its time in the sun again. The recent legalization of industrial hemp production is allowing farmers to explore opportunities with this multi-purpose crop. However, our knowledge of hemp production and management has been constrained by the restrictions placed on growing the crop in the last century – and we are at the beginning stages of intensively studying the crop using modern scientific tools and methods. Moreover, while much of the traditional hemp cropping knowledge was rooted in a fiber production context, the vast majority of current US efforts with industrial hemp are focused on flower production for cannabinoids and terpenes. Thus, we are just at the front end of understanding how to manage this crop.

Purpose of this guide

Much new information - and many questions - is arising as hemp is restored to the landscape as an accepted agronomic crop. Knowledge of hemp diseases and pests has grown rapidly in the time since legalization and the issues surrounding management, control, and treatment often top the list of concerns expressed by hemp growers. Understanding these issues and knowing how to deal with them affects both quantity and quality of the crop produced and could make the difference in whether a crop is profitable – or even acceptable for sale.

The "newness" of hemp, coupled with the market and regulatory uncertainties it faces, presents challenges for providing crop protection guidelines. Many of the chemicals traditionally used for weed, insect, and disease control with other crops remain to be evaluated and approved for use with hemp. This may be further complicated by the fact that the regulatory framework for fiber or grain crops may be very different from that for flower production.

The purpose of this guide is to provide hemp growers with general information on crop production and, where possible, specific information and guidance on pests and corresponding crop management and protection. For all crops, proper pest management is important to maximize yield and quality. However,

with hemp in particular, good agronomic practices that support healthy, productive plants becomes more critical given the limited pest and disease control options.

General Agronomic Information

Growing conditions

Much of the currently-available information on hemp production has been generated in Europe where the crop largely has been grown for grain and fiber. Those studies indicate that an early planting date (as soon as soil temperatures reach 45 to 50 °F) helps grain and fiber hemp crops get ahead of summer annual weed emergence. Increasing seeding rate (from 20 lbs/a to >60 lbs/a) has also been shown to reduce weeds. (Typical planting rates for grain are about 30 lbs/a and about 60 lbs/a for fiber.) However, much of Virginia's climate, latitude, and likely its pest pressures differ from those in Europe, and region-specific information is needed for successful crop cultivation. Furthermore, hemp varieties currently available were not bred specifically for our region and may likely perform differently in Virginia compared to elsewhere.

Most hemp types exhibit photoperiodism. That is, the plant begins to produce flowers when nights (or periods of dark exposure) are long enough to elicit this change. The photoperiodism response differs markedly by hemp cultivar and in open settings is driven by latitude. E.g., a given variety will flower much later at northern latitudes, where summer days are long, than at lower latitudes. Thus, varieties bred for Canada, northern Europe, or even the Pacific Northwest can often be much shorter and smaller when grown in Virginia. The exception to this is with "auto-flower" varieties that flower based on triggers other than day/night length.

Research studies detailing grain and fiber production in other parts of the world can be informative, but they must be regarded with some care when applied to production in Virginia given differences in growing conditions. Though anecdotal information exists, published research that might inform CBD production in Virginia is essentially non-existent at this time.

Despite the limited research, our experience with hemp - whether feed, fiber, or flower crop - suggests some important realities. The mythology surrounding the crop is that hemp can be grown anywhere. That may be true, but plantings on marginal lands are likely to be marginal crops. Hemp does not grow well in wet sites, and our experience is that field crop plantings in wet zones are likely to fail. Hemp also is better-suited to fertile, well-drained loamy soils. Soils with heavy clay are less desirable but may be usable for hemp production, particularly when bedded.

Soil pH and nutrients

Hemp is not a low-input crop. Without knowledge of the soil's nutrient supply, growing hemp or any other crop will be a gamble. Thus, *the first recommendation before growing hemp or any other crop is to collect soil samples and have them analyzed for pH, nutrient, and contaminant concentrations.* Detailed studies of hemp response to nutrients in different soils are limited. (Indeed, initial recommendations for fertility have followed guidelines traditionally used for corn.) Recognizing the limited data on fertility responses, we give some general recommendations here based as much on common experience as on research.

Soil pH should be kept between 6 and 7. In some soils this range may prevent toxicities associated with high acidity, but in general, optimal nutrient availability across all nutrients occurs within this range. Soil phosphorus (P) and potassium (K) should be in the high range. Boron, a nutrient needed in low amounts and frequently associated with production of alfalfa or root crops, has also been limiting in many sites.

Nitrogen input recommendations vary by the type of production and the potential productivity of the site. Recommended inputs for fiber are typically in the 50-75 lbs/acre range. For flowers and grain, recommended application rates typically fall within the 100-150 lbs/acre range. In highly productive soils, nitrogen inputs (and thus plant outputs) can be higher than on less productive soils. Adding more nutrients is not a strategy that will overcome the limitations of less productive soils, however.

With grain and fiber production, initial studies from Europe suggest little if any benefit in splitting the nitrogen during the growing season. In flower production systems, where growers often have more control over nutrient delivery (through fertigation systems), it is common practice to provide greater nitrogen inputs at the beginning of the growing season and to transition to fertilizers with greater amounts of phosphorus and potassium as the plants go to flower. We do not have data for the practice, but fertilization based on practices as for a heavy tomato crop has worked for some. Nutrient application at the time of bedding (typically about 50 pounds of Nitrogen and Potassium) may be followed by routine inputs of nutrients in drip lines for those using drip irrigation. These systems allow growers to increase the fertilization application over time as plants increase in size and nutrient demand. Over a typical 12- to 14-week growing season, an additional 80 to 100 units of fertilizer may be applied. Some growers have also reported benefits from additions of calcium.

Excess fertilization may be common in hemp production systems and this has both economic and environmental costs. Knowing a soil's productive potential, along with its nutrient status and crop needs (by soil testing), provides a basis for avoiding costly inputs.

Flower production management - plasticulture or not

In a flower production context, two general models have emerged in Virginia. Data comparing the systems are essentially non-existent. Thus, we give simple descriptions here and discuss some of the implications.

Many tobacco growers are adapting the tobacco systems approach to hemp production. These systems often use beds for growing the crop. Smaller plants (whether clones or seedling starts) are needed to work with (flow through) the transplant equipment. These may or may not receive irrigation (through drip tape or other means), depending on need and available resources. Because of the limited herbicides acceptable for use with hemp, the rows of the hemp plants are often cultivated for weed control.

Alternatively, many producers have used a plasticulture model (similar to that used for tomato production). In such systems, the soil is bedded and covered with plastic, and a strand of drip tape is laid under the plastic. Plasticulture may be less conducive to mechanized transplanting, but it has benefits in terms of keeping weeds out of the rows and holding moisture in the soil (under the plastic). Weed management between the rows is likely to be an issue, regardless, and this may be addressed by planting low-growing ground covers or with mowing or herbicide application. In higher rainfall regions of

Virginia that have more moderate temperatures, the moisture retention benefits may be minimal. Plastic also presents issues in terms of cost, clean-up, and environmental impact, and some growers have had success with plastic mulches made from biodegradable material.

Flower production management – plant type and spacing

Suitable plant spacing for flower production will depend on many variables. These include plant variety, planting date, and alley/row spacing needs (to accommodate equipment) among others. These factors may also directly affect pest management requirements (described below). Common planting configurations are typically arranged on a grid pattern with 4 to 6 feet between plants within rows and 5 or 6 between rows. A common 6 x 6 planting configuration would result in about 1200 plants/acre. A 4 x 4 configuration would require 2700 pants/acre.

Hemp plants may be subject to a number of diseases, and disease incidence may be more likely to occur when the plants are grown too close in proximity to each other, reducing air flow. This issue is likely to be variety-specific both in terms of disease susceptibility – some varieties are more susceptible than others – and in terms of spacing considerations. Of course, this will also be affected by site conditions and management.

Producers planning to grow the larger sativa-type hemp varieties should provide more space per plant (e.g., consider likely plant size by the end of the season). More space between plants likely will also be needed for earlier plantings given the longer growing season provides more opportunity for plants to grow even larger. (This also has practical implications for harvest, as collecting buds from tall plants or cutting and drying them may be a challenge.) Too large a plant (too small a space, really), will minimize air flow around the plants and increase the likelihood for disease pressure. (The potential for disease development with low air flow is also an issue when weeds within the crop alleys get tall.)

Integrated pest management (IPM)

Integrated pest management (IPM) is a sustainable, ecological approach to managing pests. Rather than simply finding chemical solutions to pest issues, IPM considers how best to manage plants so that pest issues and chemical inputs to growing systems are minimized. IPM also involves regular scouting of hemp plants to identify and address pest issues in a timely manner and minimize their severity.

The requisite first step to proper pest management is correct identification of the pest (weed, insect/mite, or pathogen). Once identified, information on that specific species, such as life cycle, competitive ability, susceptibility to available pesticides, etc., will inform management options and thus a well-crafted management plan can be formulated. Resources for identification of insects, diseases, and weeds associated with hemp are listed in Chapters 2, 3, and 4 respectively. When deciding how to best manage a pest, it is important to consider multiple methods of management. Chemical management of pests is a useful strategy and is often needed to rescue a crop, but it should not be the first or default consideration.

Pesticides also can present challenges, particularly for flower production, because in some cases the chemicals applied prior to hemp planting – including pesticides applied to previous crops – can remain in soil. Herbicides, in particular, have potential to damage subsequent crops, including hemp. However,

even if the plants are not damaged, there is the potential for uptake and consequent contamination of the hemp flower crop.

If you are unsure of the risks from past pesticide applications, consult your local extension agent as well as pesticide labels. Private labs can test for pesticide residues in soil, but farmers should be aware that tests frequently are not useful. Tests may come back indicating that pesticide residues are "below detectable limits" but some plants may still be injured as they are more sensitive than analytical lab equipment. A bioassay is the best way to test for this and is explained in the Pest Management Guide: Field Crops (https://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/456/456-016/ENTO-288.pdf). Glyphosate, the active ingredient in Roundup and other products, can persist in the soil at detectable levels for over a month. Despite this persistence, glyphosate binds to the soil and is not taken up by plant roots from the soil.

CHAPTER TWO: INSECT AND MITE PEST MANAGEMENT

A wide diversity of insects and mites can be found on hemp and many of these are discussed extensively in a recent open-access publication (Cranshaw et al. 2019). Some insects and mites are generalists that come to hemp opportunistically to feed, such as corn earworm and spider mites. These insects and mites feed on a wide variety of plant species, including hemp. Because of this, it is likely that many of the insects and mites seen in hemp are incidental opportunists. Others, such as cannabis aphid and hemp russet mite, appear to be specialists that require cannabis to survive. The vast majority of insects and mites observed on the plant do not appear to be significant pests based on our work over the past three growing seasons (2017-19). A few species certainly have proven to be important pests and these will be discussed.

Insect and mite pests can be broadly categorized by their feeding behavior as either chewing or piercing-sucking types. **Chewing** pests damage plants by consuming foliage, flower, and/or seed material with mouthparts much like our own. They chew and devour portions of hemp plants, leaves, stems, flowers, or seeds. Beetles and caterpillars fall into this group. **Piercing-sucking** pests have syringe-like mouthparts that are used to pierce the plant. These insects feed from the plant's vascular fluids or they liquefy and suck out plant tissue. Because they do not chew holes in plant material, their injury to plants is not always discernible. Aphids and mites fall into this group.

When strategizing how to appropriately manage insect and mite pests in a crop system, it is best to utilize multiple management tactics via integrated pest management (IPM). One of the key elements of IPM is the establishment of economic thresholds for insect or mite injury to plants. By relying upon evidence-based economic thresholds, growers can address pest problems before they become a financial burden. Virginia hemp presents a unique pest management challenge because the crop has not been grown long enough for research to be done to establish the injury levels at which economic loss can occur. Although we have not yet established the important economic information that will help with managing pests, we have identified several insects that are likely to be problematic in hemp and are beginning to conduct studies to address the injury and damage that can result from their presence and feeding. Hemp does appear to be a more robust crop than others and can withstand a considerable amount of insect and mite feeding before crop injury occurs. However, it is certainly not exempt from insect and mite pest injury.

Hemp clones (rooted cuttings taken from mother plants) and seedling starts commonly are purchased for transplanting into the field in hemp flower production systems. Before introducing these transplants into your greenhouse or planting in a field, they should be briefly quarantined to prevent accidental pest introductions. Transplants often come with pests already present on plant material, such as aphids or mites. These pests can reproduce rapidly and once a population is established in a confined area, such as a greenhouse or warehouse, they are extremely difficult to manage or eradicate. Inspecting plants thoroughly prior to planting is an important preventative step in managing pests.

The following section outlines a few important insect and mite pests in hemp. At the end of this chapter, there are color photos to supplement the text.

MAJOR INSECT AND MITE PESTS IN HEMP IN VIRGINIA

Corn earworm, *Helicoverpa zea*

Without a doubt, corn earworm is the most damaging pest of hemp grown in outdoor environments as it targets the marketable portions of hemp plants – floral regions of CBD and seeds of grain variety hemp. Corn earworm is a generalist chewing pest that feeds on a variety of economically important crops. Hemp is attractive to this insect and is a late season source of sustenance after most other crops have been harvested. Even though we have yet to establish economic thresholds and injury levels for corn earworm in hemp, this insect has caused economic loss for hemp growers. Corn earworm feeding and injury to hemp plants has most frequently been associated with elevated occurrences of bud rot on floral portions of CBD hemp (**color photo 1**). Bud rot results from the grey mold pathogen *Botrytis cinerea.* Corn earworm feeding does not directly cause bud rot; rather, the wounds on plants as a result of its feeding activity allow this opportunistic pathogen to invade and infect plants.

Corn earworm moths (**color photo 2**) have two periods of migration north to Virginia from more southern areas. In Virginia, corn earworm flights occur from mid-July to late August and during this time, female moths actively lay eggs in host crops. Cream-colored, spherical eggs are laid singly on plants. In hemp, eggs can typically be found on younger tissue in the flower bud or seed head. Neonate larvae emerge from eggs in 3 to 4 days and immediately begin feeding on plant material. Eggs and freshly-hatched larvae are so small in size that they typically go unnoticed. As larvae grow and develop, their coloration may change. Younger larvae are typically dark in coloration with prominent black bristles (**color photo 3**). Later stage larvae can vary in color from pink, yellow, green, brown, or even two-toned (**color photo 4**). Larvae molt (or develop) through 6 to 8 instars (or growth stages) in a 2 to 3-week period, depending on environmental temperature; growth can be accelerated in areas with warmer climates. When fully developed, larvae drop from plants to the ground and burrow into soil to pupate (or develop into an adult moth). Pupae are dark red to brown in coloration. This insect overwinters (or goes into a type of hibernation) as a pupa. In Virginia, many generations of corn earworm can be expected during a growing season. In most areas of Virginia and states further north, relatively few pupae survive the winter due to low temperatures; however, it is possible for corn earworm to successfully overwinter in warmer areas of Virginia.

Regular scouting of hemp is important so that this insect can be spotted early and when worms are young. In some cases, environmental biological control will occur by organisms such as parasitic flies, spiders, predatory stink bugs, or pathogens. Hemp seems to be so attractive to corn earworm that it will preferentially lay eggs and feed on hemp regardless of the surrounding crops. In terms of chemical management, options are extremely limited. Of the few products currently approved for use on hemp in Virginia, those containing the active ingredient *Bacillus thuringiensis kurstaki* or *Bacillus thuringiensis aizawai* (Bt) are the best options for managing this insect (see pesticide table in Chapter 5). These products have selective activity against worms or caterpillars. If the choice is made to use Bt products, it is best to apply at the first sight of corn earworms as young worms are more susceptible to this product. Keep in mind that good plant coverage with Bt products is important because the worm must ingest the active ingredient to be killed. Corn earworm mortality from Bt will not be instant, but rather will occur after a few days. In 2019, efficacy trials conducted in Virginia showed that the Bt *aizawai* strain (found in the product XenTari) provided the best control among Bt products. The product Gemstar LC can also aid

in reducing corn earworm infestations. Gemstar contains occlusion bodies of a nuclear polyhedrosis virus that is specific to only corn earworm.

Hemp russet mite, *Aculops cannabicola*

Hemp russet mite is perhaps the most injurious pest to indoor-grown hemp and is near impossible to eradicate once populations have established. This mite can attack outdoor plants, but in these cases, populations are usually more scattered and may impact only a few plants throughout a field. In indoor environments, every plant can quickly succumb to hemp russet mite injury. This mite is extremely small and is not visible to the naked eye. For perspective, hemp russet mite is less than half the size of twospotted spider mite. Additionally, multiple hemp russet mites can fit on the body surface of aphids. Hemp russet mites have four legs on their white- to beige-colored, cigar shaped bodies. Mites can only be seen under magnification (**color photo 5**) – microscopes are sufficient but hand lenses used to inspect hemp usually are not strong enough. Hemp russet mite is not easily managed and, due to its extremely small size, populations can quickly get out of control. Mites feed primarily on leaves, petioles, and shoot tips of hemp plants. Because hemp russet mite does not produce webbing on plants, its presence usually goes unnoticed until plants exhibit physical symptoms of stress. Advanced symptoms from extremely high populations can include upward curling of leaf edges (**color photo 6**), bronzing/russeting of leaf tissue (**color photo 7**), or a brown/tan powder appearance on leaf edges and stems which is actually an extremely heavy mite infestation. By the time plants express physical symptoms, irreparable damage to plants has already occurred.

There are few legal options available to manage hemp russet mite. Of the chemical products that we have tested, Venerate (Marrone Bio Innovations) has had the greatest efficacy. Current commercially-available predatory mites or other natural predators have not shown any promise at managing hemp russet mite. Prevention is the best tactic. Regular scouting of plants is a necessity. If any plants show signs of hemp russet mite, they should be moved away from other plants and quarantined until an accurate diagnosis can be made. Since hemp russet mite is so small, it is highly mobile and can easily spread throughout plants in close proximity. This is particularly a problem with indoor grow operations where fans are used to improve air flow.

Cannabis aphid, *Phorodon cannabis*

Cannabis aphid is a specialist, piercing-sucking insect that feeds exclusively on hemp. They can reproduce asexually, so populations can rapidly increase in favorable environments (**color photo 8**). Although these insects feed on sap from hemp plants, thus far, we have not observed direct plant injury by cannabis aphid presence or feeding. However, this insect excretes excessive amounts of honeydew (sticky, sugary waste) which creates sticky surfaces on plants. As aphids grow and molt (shed skin to grow), their shed skins can get caught in the sticky honeydew that remains on plant surfaces (**color photo 9**); this is undesirable for consumers of raw plant material. Honeydew is also an excellent substrate for sooty mold growth. The honeydew and sooty mold both present contamination issues in the raw plant material and mechanical issues during plant processing for cannabinoid extraction.

On outdoor plants, cannabis aphid eggs are laid in late fall. Overwintering eggs survive on crop debris and volunteer seedlings that sprout in fields the following spring will be colonized shortly after egg hatch occurs. At the end of the growing season, crop residue remaining in fields should be destroyed via

tillage, burning, or another comparable method. This will aid in getting rid of any eggs that may have been laid in the late fall period. If eggs still happen to be present and aphids hatch out in early spring, there will be a reduced chance for survival if there is no leftover plant material for them to develop and feed on. Tillage helps, especially in grain hemp fields where seed shatter and dispersal occurs quite frequently and volunteer plants are most likely to be present.

Cannabis aphid is a much greater concern for indoor or greenhouse hemp production, especially in operations with perpetual harvests. These insects often are present on transplants that are acquired from indoor propagation. If you are growing plants to distribute to other growers, inspect plants prior to sale to make sure that they are clean and free of aphids. If you are receiving plants from an indoor facility, inspect your plants before planting them in the field or moving into your greenhouse. If planting indoors, it is of the utmost importance to quarantine the plants to ensure that they are free of aphids. If cannabis aphid is observed on any indoor plants, those plants should be removed from close proximity to other plants. Moving infested plants at least 10 feet or more away from clean plants would be a good start. Promptly addressing a few problem plants is far easier than attempting to control a widespread infestation, even if some plants must be destroyed. If this insect establishes a population indoors, it can be problematic and difficult to manage.

Outdoors, this insect is less of a concern due to the presence of natural enemies and environmental conditions. Predators, such as lady beetles (**color photo 10**), help manage aphid populations naturally and are excellent at finding aphid infestations to consume. Additionally, sufficient rainfall or dew aids in the removal of sticky honeydew from plant surfaces and helps prevent sooty mold problems. However, aphid outbreaks can occur and may require short-term mitigation in order to prevent excess sticky honeydew deposition on plants. Fortunately, a wide range of insecticides are available that can help reduce aphid numbers. These include pyrethrins, insecticidal soaps, neem oil, azadirachtin, and the bacteria-derived products Grandevo and Venerate (see pesticide table in Chapter 5). The risk of honeydew contamination is greater indoors since there is no natural rainfall to aid in removing the sticky substance. Predatory insects typically must be purchased for use in indoor growing environments because these insects do not typically live in such environments. Lady beetles are a feasible option for indoor use since the larval stage does not fly and adults are less likely to fly away from the crop. Adult lady beetles are not recommended for release in field settings as they are more likely to fly away in outdoor environments, but supplemental eggs or larvae may help provide some aphid management.

Twospotted spider mite, *Tetranychus urticae*

Twospotted spider mite is a generalist, piercing-sucking mite pest usually found on the undersides of plant leaves. Feeding injury to plants causes white stippling marks on leaves (**color photo 11**). This mite is small and oval in shape, has 8 legs, and can be orange/red or brown with two distinct dark spots on the body (**color photo 12**). Mites can be seen with the naked eye but microscopy can assist with proper identification. When mite populations are extremely high, webbing can be observed on leaves or in hemp flower buds or seed heads.

Twospotted spider mite is a concern for indoor hemp production. This mite thrives in dry, arid environments and, given the high humidity levels throughout Virginia, plants grown outdoors are not as suitable for twospotted spider mite feeding and development. This pest can be found in a variety of indoor plant production situations. If twospotted spider mite is observed on any indoor plants, those

plants should be removed from close proximity to other plants. Moving infested plants at least 10 feet or more away from clean plants would be a good start. Promptly addressing a few problem plants is far easier than attempting to control a widespread infestation, even if some plants must be destroyed.

Biological control of twospotted spider mite can be an extremely effective form of management indoors. In greenhouse trials from North Carolina State University, the predatory mite *Phytoseiulus persimilis* was very effective at managing twospotted spider mite. This mite can be purchased from any commercial biological control company. Other biological control agents include minute pirate bugs, *Orius* spp., and lacewing larvae, *Chrysopa* spp. (described in the next section). For chemical control, insecticidal soaps or oils should be considered.

References

Cranshaw, W., Melissa Schreiner, Kadie Britt, Thomas P Kuhar, John McPartland, and Jerome Grant. 2019. Developing insect pest management systems for hemp in the United States: A work in progress. Journal of Integrated Pest Management, Volume 10, Issue 1, 2019, 26, https://doi.org/10.1093/jipm/pmz023

NATURAL ENEMY/BENEFICIAL INSECTS AND MITES

Many beneficial insects and mites are present in outdoor hemp fields. It is important that these species are conserved. If pesticides must be used to manage pest presence, try to use products that will not be harmful to beneficial insects and mites. Below is a list of beneficial insects and mites that can be commonly seen helping to manage pests in hemp.

- Lady beetle adults and larvae. Convergent lady beetle, *Hippodamia convergens*, multicolored Asian lady beetle, *Harmonia axyridis*, and spotted lady beetle, *Coleomegilla maculata*
- Green lacewing adults and larvae, *Chrysopa spp.* or *Chrysoperla spp.*
- Minute pirate bug adults and nymphs, *Orius spp.*
- Damsel bug adults and nymphs, *Nabis spp.*
- Big-eyed bug adults and nymphs, *Geocoris spp.*
- Predatory stink bug adults and nymphs, *Podisus spp.* and *Euthyrhynchus floridanus*
- Spiders
- Parasitoid wasps for aphids – at this time, we are not sure of particular species.
    - Many times, aphid 'mummies' can be found on hemp leaves (see photo below). These are shiny tan/brown in color and look like bloated aphids. Mummies are excellent confirmation that aphids that have been parasitized by a very small, predatory wasp. Parasitic wasps lay eggs in aphid bodies. Wasp eggs use the aphid body as a source of food and site for development. The aphid will be killed by this and a parasitic wasp will hatch out.
    - Parasitoid wasps are very small (gnat-sized) and will not harm humans.
- Predatory mites for twospotted spider mite, *Phytoseiulus persimilis* or *Amblyseius fallicus*

INSECT AND MITE CLASSIFICATION

The most concerning insect and mite pests for hemp production have been outlined. However, many other species can be found in hemp. This insect and mite classification list has been compiled based upon field and indoor observations of hemp grown in Virginia. Sporadic or fleeting infestations of insects and mites can and will occur. Populations of these pests may reach levels where feeding can be injurious to hemp, but their presence is not as consistent as the major pests outlined above. Below, the insects and mites observed in hemp are classified by host plant preference (generalist or specialist), type of mouthparts (chewing or piercing-sucking), and area of plant impacted by feeding (leaf/foliar, stem/stalk, flower bud/seed, or root).

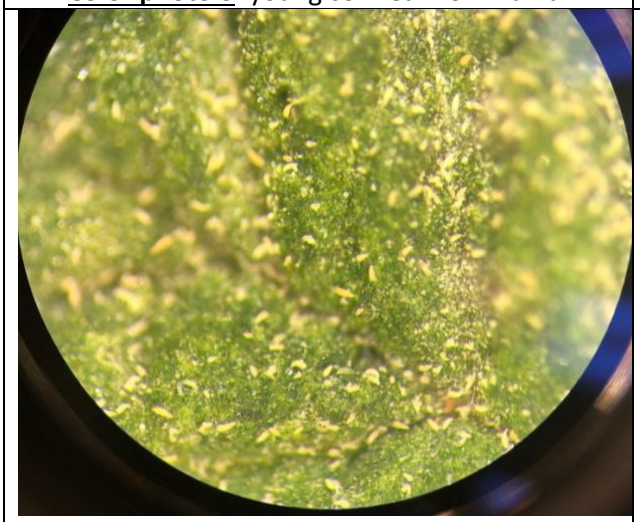
	Host plant preference		Type of mouthparts			Area of plant impacted by feeding			
Pest	**Generalist**	**Specialist**	**Chewing**	**Piercing-sucking**	**Borer**	**Leaf/foliar**	**Stem/stalk**	**Flower bud/seed**	**Root**
Corn earworm	✓		✓					✓	
Hemp russet mite		✓		✓		✓		✓	
Cannabis aphid		✓		✓		✓	✓	✓	
Twospotted spider mite	✓			✓		✓			
Armyworms	✓		✓			✓			
Cucumber beetle	✓		✓			✓			
Japanese beetle	✓		✓			✓			
Grasshoppers	✓		✓			✓	✓		
Leafhoppers	✓			✓		✓			
Tarnished plant bug	✓			✓		✓		✓	
European corn borer	✓		✓		✓		✓	✓	
Stink bugs	✓			✓				✓	
Rice root aphid	✓			✓					✓
Termites	✓		✓				✓		✓
Fire ants	✓		✓				✓		✓
Wireworms	✓		✓						✓
Other caterpillars	✓		✓			✓			

Color photo 1: bud rot in floral hemp bud from corn earworm feeding.

Color photo 2: adult corn earworm moth on hemp plant.

Color photo 3: young corn earworm larva.

Color photo 4: later stage corn earworm larvae.



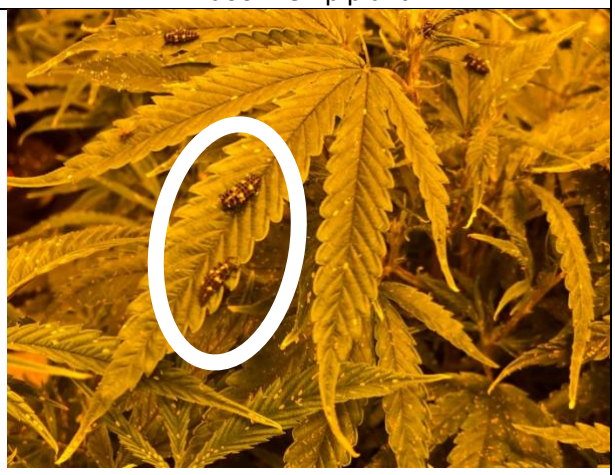
Color photo 5: hemp russet mite population seen on hemp leaf under microscopy.

Color photo 6: upward curling of hemp leaves as a result of hemp russet mite feeding.

Color photo 7: bronzing/russeting of hemp leaf tissue as a result of hemp russet mite feeding.

Color photo 8: cannabis aphid infestation on indoor hemp plant.

Color photo 9: cannabis aphid skins caught in honeydew on surface of hemp leaves.



Color photo 10: lady beetle larvae consuming cannabis aphids (seen inside white oval).

Color photo 11: twospotted spider mite feeding injury – stippling on hemp leaf.

Color photo 12: twospotted spider mite seen under microscopy.

CHAPTER 3: DISEASE AND PATHOGEN MANAGEMENT

Before legalization and reintroduction, a widespread myth about hemp was that it was resistant to or would not succumb to disease pressure. Unfortunately, that has not been the experience in Virginia, or in any of the other states in the US where industrial hemp has been grown over the past few years. Although 2019 was the first year in which hemp could be grown commercially in Virginia in many decades, our experience with diseases last year was similar to experiences in North Carolina, Kentucky, and Tennessee, and those states have had similar disease issues in multiple previous years. One hemp disease encountered in Virginia in 2019 was first reported from the Commonwealth in 1915, over 100 years ago. These facts teach us that we will need to deal with hemp diseases each and every year in order to profitably produce the crop. So far, the most common and important hemp diseases in Virginia (and elsewhere) have been:

- Root and Stalk Rot diseases that eventually kill all infected plants: *Pythium* crown and root rots, *Fusarium* stem canker, *Fusarium* foot and root rot, *Rhizoctonia* crown and root rots, Charcoal rot, and Southern Blight;
- Leaf Spot diseases that reduce the photosynthetic efficiency of infected plants and often cause defoliation: Hemp leaf spot, Frogeye leaf spot, Hemp Rust, and Powdery Mildew;
- Tip Blight or Die-Back diseases caused by fungi such as *Botryosphaeria*/*Lasiodiplodia* that infect and kill terminal and lateral plant stems, particularly those that contain flowers or colas; and
- Flower Blights that kill the flowering parts of hemp plants where seeds or CBD are produced, such as *Botrytis* blight, Brown blight, and others.

Numerous other disease problems have also been observed on hemp in Virginia and elsewhere in the US, including plant-parasitic nematodes, bacterial rots, and viruses.

The Virginia Tech Pesticide Programs office is coordinating with the Virginia Department of Agriculture and Consumer Services Office of Pesticide Services to provide Virginians with a list of pesticides legal to apply to industrial hemp in Virginia (see Chapter 5). While a valuable resource, the products on this list as of early 2020 have very rarely, if ever, been tested for effectiveness on hemp. Research with these materials on other crops has also shown *very little* effectiveness. While a very large number of hemp varieties are being tried in Virginia, the characteristics of these varieties seem to be highly variable. A few research trials have compared hemp varieties for their resistance or susceptibility to disease, but as of early 2020 no clear, consistent trends have been identified that growers could use to select a better variety. Although not definitive, growers should consider the origin of their plant materials – varieties developed in drier climates will potentially have less resistance to diseases found in humid environments such as Virginia's. However, in the absence of well-defined resistant varieties or effective disease control products, hemp producers are forced to focus on disease prevention as much as possible.

As with any transplanted crop, a good field growing season starts with healthy, uninfected transplants. The disease management options for hemp produced in greenhouses are the same as for hemp fields. Transplant producers must rely on greenhouse sanitation, organization, and environment control to minimize disease, and hemp producers need to work with their transplant sources to ensure that the plants they receive are as healthy as possible. In both settings, questionable plants should be discarded or segregated to avoid potential disease spread.

DISEASE MANAGEMENT IN HEMP GREENHOUSES

GREENHOUSE SANITATION

- Remove weeds and volunteer plants between hemp crops, *including their roots!*
- Clean and sanitize all surfaces in a greenhouse with a commercial disinfectant before starting to grow plants, removing excess soil and plant debris from floors and benches. Remember that bleach and Lysol are corrosive.
- Footwear should be disinfected before entering the greenhouse. Cover greenhouse entries and walkways with gravel, concrete, or landscape cloth.
- Avoid using EPS (Styrofoam) trays, but if they must be used, steam-sterilize trays before use, maintaining steam at 160F-175F for at least 30 minutes. All plastic pots, trays, and tools must be disinfected using a commercial disinfectant.
- Never reuse soil or potting media or bring field soil into a greenhouse.
- Use municipal or well water in the greenhouse. Never use surface water from ponds or streams.
- Don't drag hoses and tools along floors.
- Prune infected plant parts and discard heavily infected plants and those that can't be treated. Dip pruning tools in a commercial disinfectant before and between each use, rinsing and oiling pruning tools if bleach has been used. Prune stems several inches below the first signs of infection, cutting at intersecting branches when possible. If plants can't be discarded, isolate them from healthy-appearing plants as much as possible. Cuttings and culled plants should be placed at least 100 yards from the greenhouse, downwind, and should be buried or burned (composting will not kill pathogen propagules).
- Empty the greenhouse between crops or seasons and re-sanitize all surfaces.

GREENHOUSE MANAGEMENT

- Promote rapid seed germination and root production by cuttings.
- Optimize moisture in growth medium around lower stems and roots.
- Correct drainage problems around and in the greenhouse – cool, wet conditions can predispose plants to damping off.
- If at all possible, use drip irrigation to minimize overhead watering in the greenhouse and splashing media from one tray cell or container to another.
- Condensation on leaves and flowers promotes disease. Minimize moisture on leaves and foliar plant parts (to avoid condensation) by maintaining humidity at 60% to 80% and ensuring good air flow through the greenhouse. Remember that greenhouse air tends to be humid near dusk.
- Temperatures between 70^{o} F and 85^{o} F may be less favorable for disease.
- Maintain optimum fertilization schedule, avoiding too little or excess nitrogen.
- Avoid physical damage to plants, whether from excess soluble salts in growth media, rough handling of plants, or insects (fungus gnats and root aphids, for example).

DISEASE MANAGEMENT IN HEMP FIELDS

- Select fields with well-drained soil and no history of diseases common to hemp such as *Fusarium*, Southern Blight, *Phytophthora,* or *Pythium*. Avoid sites where poor air movement and dark, humid conditions can be expected.
- Prepare fields for transplanting to optimize good soil drainage, transplanting into raised beds for CBD hemp. Orient rows to encourage good air flow and drainage.
- Discard heavily infected plants and those with untreatable diseases such as root rots and vascular wilts. If removing plants from a field, dig out entire plants when possible.
- Culled leaves, stems, and plants should be removed from the growing area, placed downwind and at least 100 yards from the nearest hemp field, and buried or burned. Composting cuttings will not kill pathogen propagules as temperatures don't reach the necessary 160°F.
- Maximize weed control to reduce disease spread from alternate hosts and to improve air flow to help keep leaves and flower parts as dry as possible.
- There are no products that can save plants in the field from *Fusarium* or Southern Blight. These diseases probably don't spread within a field after planting but most likely occur only where individual plants encounter the pathogen where it is already in the soil in the field. Remember fungicides don't/can't bring dead tissue back to life; they only protect new growth from new infections.
- The question in choosing any disease management method is, "Will the likely result cost me more than my best alternative?" or, *"Will the likely result cost me more than doing nothing?"* If the decision is made to apply a fungicide or other pest control product for foliar disease, etc., even when you understand that it "might not work", select an option that has been tested against the pathogen damaging your crop.
  - Don't wait until a disease reaches a highly damaging level to start spraying.
  - Do not shave the rate. Higher rates/acre are usually needed for poor versus highly effective products.
  - Do not try to save money by limiting spray volume (water in the spray mix) and pressure. Very few of the materials for hemp are systemic in plants; their effectiveness is critically dependent on covering as close to 100% of above ground plant parts as possible.
  - One spray rarely manages a disease issue effectively – especially with marginally effective products; short intervals between sprays is often critically important, especially important with products like Oxidate 2.0 and Perpose Plus, that have virtually no residue on crops after application.
  - Products that induce resistance to plant diseases are like shots to induce immunity. These must be applied 3-5 days before expecting that they are needed and must be repeated or supplemented on at least a 10-14-day interval until disease no longer threatens.
- If possible and practical, remove diseased plant parts from infected plants. Make sure to prune several inches below the signs of first infection at intersecting branches when possible. Pruning tools should be dipped in a commercial disinfectant before and between each use. Rinse and oil pruning tools if bleach has been used as a disinfectant. Cuttings and culled plants should be placed at least 100 yards from the field, downwind, and should be buried or burned; composting will not kill pathogen propagules. Where possible and practical, remove plants infected with a systemic disease (*Fusarium* wilt, for example).
- Plow-under fallen leaves. Woody stems decay slowly and should be removed from hemp fields if possible. Fall plowing should be conducted as soon after final harvest as possible.

RELIABLE HEMP DISEASE MANAGEMENT INFORMATION FROM OTHER STATES

A number of states near Virginia began work on industrial hemp production before Virginia, and land grant university scientists in those states have produced accurate and useful information on the hemp diseases observed in those states, particularly Kentucky and North Carolina. The links below should direct those interested to clear, accurate, and useful information on identifying hemp diseases in the greenhouse or field, with some guidance regarding the best current strategies and tactics to avoid or minimize these diseases.

Hemp Diseases in North Carolina (NC State)
https://growingsmallfarms.ces.ncsu.edu/wp-content/uploads/2019/03/Hemp-Diseases-Lindsey-Thiessen.pdf?fwd=no

The Basics of Hemp Disease Management (University of Kentucky)
http://www.kyhempdisease.com/disease101---hemp-disease-management-basics.html

Diseases Affecting Hemp in New York (Cornell University)
https://hemp.cals.cornell.edu/hemp-resources/our-research/diseases-affecting-hemp-new-york/

A cultural calendar for Hemp Disease Management (University of Kentucky)
http://www.kyhempdisease.com/cultural-calendar-1.html

Sanitation for Hemp Disease Management in Greenhouses (University of Kentucky)
http://www.kyhempdisease.com/sanitation-for-disease-management-in-greenhouse-hemp.html

Managing Gray Mold (*Botrytis*) on Hemp in Greenhouses (University of Kentucky)
http://www.kyhempdisease.com/gray-mold--botrytis--in--the-greenhouse.html

Managing Powdery Mildew on Hemp in Greenhouses (University of Kentucky)
http://www.kyhempdisease.com/powdery-mildew-of-hemp.html

University of Kentucky Hemp Variety Powdery Mildew Susceptibility Results
http://www.kyhempdisease.com/variety-screening-for-susceptibility-to-powdery-mildew.html

Managing *Pythium* root rot on Hemp in Greenhouses (University of Kentucky)
http://www.kyhempdisease.com/pythium-root-rot.html

Sanitation for Hemp Disease Management in Small Fields (University of Kentucky)
http://www.kyhempdisease.com/sanitation-for-disease-management-in-field-hemp.html

Root Diseases Prevalent in Hemp (NC State)
https://plantpathology.ces.ncsu.edu/2019/08/root-diseases-prevalent-in-industrial-hemp/

Southern Blight of Hemp (University of Kentucky)
https://kentuckypestnews.wordpress.com/2019/07/16/southern-blight-of-hemp/

http://plantpathology.ca.uky.edu/files/ppfs-gen-16.pdf

***Pythium* Root and Crown Rot of Industrial hemp (NC State)**
https://content.ces.ncsu.edu/pythium-root-and-crown-rot-of-industrial-hemp

Overview of Leaf Spot Diseases of Hemp (University of Kentucky)
http://www.kyhempdisease.com/leaf-spot-diseases--an-overview.html

Hemp Leaf Spot (NC State)
https://plantpathology.ces.ncsu.edu/2019/08/exserohilum-leaf-spot-causing-problems-in-nc-hemp/

Managing Septoria Leaf Spot on Hemp (University of Kentucky)
http://www.kyhempdisease.com/septoria-leaf-spot.html

Dieback diseases of Hemp (NC State)
https://cherokee.ces.ncsu.edu/2019/09/dieback-symptoms-in-industrial-hemp-2/

CHAPTER 4: WEED MANAGEMENT

Weeds of concern in hemp fields

Weeds in hemp fields are the same weeds that commonly infest other field crops. These are mostly summer annual weeds. For grasses, concerns include crabgrass (*Digitaria sanguinalis*), goosegrass (*Eleusine indica*), barnyardgrass (*Echinochloa crus-galli*), foxtails (*Setaria* spp.), and others. For broadleaf weeds, concerns include pigweeds (*Amaranthus* spp.), common lambsquarters (*Chenopodium album*), smartweeds (*Polygonum* spp.), jimsonweed (*Datura stramonium*), morning glories (*Ipomoea* spp.), and others. Sedges (*Cyperus* spp.) may also be problematic and are well known for infesting plasticulture production systems. The Virginia Tech Weed identification website contains many pictures: https://weedid.cals.vt.edu/.

Perennial weeds may also be problematic, especially since many hemp fields in Virginia were previously pastures or hayfields. Perennial weeds are generally more difficult to control since underground perennial plant parts, such as rhizomes, stolons, bulbs, etc. must be controlled in addition to seedlings. Proper perennial weed control also requires more time than controlling annuals and may require action such as tillage or herbicide application the season prior to hemp production. Examples of perennial weeds include horsenettle (*Solanum carolinense*), Johnsongrass (*Sorghum halepense*), and others.

Resources for Weed Identification:

- Websites
  - https://weedid.cals.vt.edu/
  - https://weedid.missouri.edu/
- Send in a sample to the Virginia Weed Identification Clinic through a county extension agent.
  - Find your agent here: https://ext.vt.edu/offices.html
- Mobile apps:
  - id weeds
  - seek by iNaturalist
  - Scouting by Xarvio
- Books:
  - Weeds of the Northeast; Richard H. Uva, Joseph C. Neal, and Joseph M. DiTomaso; ISBN: 978-0801483349.
  - Weeds of the South; edited by Charles T. Bryson and Michael S. DeFelice; ISBN: 978-0820330464

Management

The adage “start clean, stay clean” exists for a reason. Regardless of CBD, grain, or fiber production, the field should be completely weed free at planting (or transplanting) which can be achieved through tillage or nonselective herbicide use. However, few legal herbicide options exist for use in hemp at this point. A stale seedbed approach should be considered, which is when the soil weed seed bank is reduced by purposefully stimulating germination through tillage and sometimes irrigation. Subsequent tillage passes kill the weed seedlings and the process can be repeated until planting or bedding. The method can be time-consuming. Converting pastures or hayfields into hemp fields presents some

unique challenges that need to be considered. Breaking up well-established sod requires a plow followed by secondary tillage; rhizomes and other perennial structures can be difficult to kill and require multiple tillage passes with sufficient time between passes to allow plant material to dry out. After starting clean, practices vary by production system.

For grain and fiber production, quickly achieving crop canopy (when leaves shade out row middles) is very important. Practices that promote rapid crop canopy include optimizing planting date, ensuring sufficient soil fertility and optimal pH, using high quality seeds, and selecting a well-adapted variety. Using as narrow row widths as possible will result in more rapid crop canopy. Additionally, increasing the seeding rate when feasible is another practice that will help the hemp compete with weeds.

For CBD/flower production, farmers with experience in tobacco production should mimic those tillage, bedding, and cultivation practices, which was successful for many growers in 2019. One difference between cultivating in tobacco and hemp is to avoid burying or throwing soil on the base of hemp plants. New farmers or farmers experienced with 22lasticulture should use plastic covered beds. Regardless of plastic or no plastic, weeds between beds need to be managed as they can harbor insects and diseases as well as interfere with other maintenance and harvest operations. Mowing, shielded nonselective herbicide (if available) applications, and cultivation passes are all options to manage weeds between beds. Mowing operations should avoid throwing debris into hemp plants by closing the discharge shoot. Herbicide and cultivation tactics should target small weeds. Using nonselective herbicides within a growing hemp crop should be done with care to completely avoid herbicide contact with hemp and thus resulting in its injury or death. Use of a shielded spray should be considered. Using cover crops between beds may also be an option. No research has been conducted to recommend any of these options over another, so growers should choose the option they have comfort, experience, or equipment to properly execute.

Hand weeding is an option in any production system and may be the best option in many cases.

CHAPTER 5: PESTICIDES

The Virginia Department of Agriculture (VDACS) has provided guidelines for determining what constitutes a legal pesticide for use on hemp grown in VA. Virginia Tech Pesticide Programs (VTPP) personnel have determined what pesticides are currently legal, based on the VDACS guidelines. The list provided is the best determination of VTPP, but does not imply any determination about the comparative safety or efficacy of any of the listed pesticides on hemp crops. This list has been compiled based on label language of the products reviewed. When using or applying any chemical product to hemp, make sure to review the label prior to use to ensure that your application is legal and safe.

The VDACS published criteria for hemp pesticides is presented in full in the form of a September 5, 2019 communication (http://www.vdacs.virginia.gov/pdf/pesticide-use-on-hemp.pdf). However, the brief list of requirements for determining the legality of a pesticide for use on hemp that will be consumed is as follows:

1. The active ingredient is exempt from the requirements of a pesticide tolerance on all food crops as established by the Code of Federal Regulations 40 Part 180, Subpart D
2. The label has directions for use on unspecified food crops
3. The pesticide is registered by the EPA or exempted from registration;
4. The pesticide is registered by VDACS; and
5. The label language is sufficiently broad to include hemp and does not specifically prohibit its use on hemp.

Pesticides permitted for use based on the VDACS criteria

The list developed by VTPP is intended to assist Virginia hemp growers in identifying which pesticides can legally be used in accordance with the criteria set forth by VDACS. It is not an endorsement or recommendation to use these products in the production of hemp in Virginia. These products have not been tested to determine health effects if used on hemp that will be consumed and, thus, the health risks to consumers are unknown. Therefore, VTPP makes no assurances of their safety or effectiveness when used on hemp and is not responsible or liable for any such use.

The pesticides were approved for use on hemp because the label language was considered sufficiently broad to encompass hemp. Examples of that language include phrases like “for use on crops, including, but not limited to…”; “for use on (greenhouse or field-grown) …. bedding plants...”; “for use on [unspecified] growing crops”.

The tables on the accompanying two pages are subdivided into broad categories for ease of use. This list is NOT a substitute for reading and following the label on the pesticide container, which is subject to change. Ultimately, the applicator is responsible for complying with the directions for use on the label they have in hand.

The list also includes the signal word associated with the pesticide label reviewed and the primary active ingredient in the product.

PESTICIDE SAFETY

As can be seen from the list, the majority of permissible pesticides have the signal word "Caution" associated with them. For the most part, this means that the minimum personal protective equipment (PPE) required for mixing, loading, and applying these pesticides includes:

- Long-sleeved shirt and long pants
- Shoes and socks
- Chemical-resistant gloves
- Goggles or face shield when handling undiluted concentrate

For pesticides that have the signal word "Danger", additional PPE is required and can include language such as:

- Handlers who may be exposed to the undiluted product through mixing, loading, application, or other tasks must wear: coveralls over long-sleeved shirt and long pants, rubber gloves, chemical resistant footwear plus socks, and protective eyewear (goggles or face shield).
- Additional PPE can always be worn when working with a pesticide.

Pesticides that are categorized as "minimum risk pesticides"

The EPA has determined that certain "minimum risk pesticides" pose little to no risk to human health or the environment and has exempted them from the requirement that they be registered under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). These products are often referred to as 25(b) pesticides. While these products are exempt from registration with the EPA, in order to be used on hemp, the state of Virginia requires that they meet ALL of the criteria outlined above (and in the full communication). The pesticide MUST be registered for use in Virginia and the product MUST be labeled for "Agricultural Use". Very few "minimum risk pesticides" are currently labeled for agricultural use, therefore it is not legal to apply these products to hemp grown in Virginia. Read the label to ensure that you are making legal applications to your crop.

Who can apply pesticides to commercially growing hemp?

Hemp growers are encouraged to read the Virginia Cooperative Extension (VCE) publication "Applying Pesticides Correctly" (pub #456-210), aka "the Core Manual", and consider becoming a certified applicator with the state. The Core Manual provides valuable information to educate yourself and your employees about safe pesticide handling practices. While none of the pesticides on the approved pesticide list are currently restricted use products, which requires applicators to be certified, it is still a good idea to pursue certification.

The requirements to become certified can be found on the VDACS website at https://www.vdacs.virginia.gov/pesticide-applicator-certification.shtml

The core manual can be found at https://sites.google.com/a/vt.edu/virginia-tech-pesticide-programs/home/virginia-pesticide-applicator-training-manuals.

Pesticide application techniques to maximize efficacy

As many of the approved pesticides are biologicals, or require direct contact to the target pest to be effective, it is recommended that applicators select application nozzles that will deliver an appropriate volume in the correct pattern to cover all exposed vegetation to ensure effective management of the targeted pest.

Additional information

The list of approved pesticides will continue to be updated as more pesticides are reviewed by Virginia Tech Pesticide Programs. Updates will be made available immediately to Virginia Cooperative Extension agents for distribution to growers. Future versions of this publication will contain the most up-to-date lists. If growers have questions regarding how and why a specific pesticide made the list, while some other pesticide was excluded, please contact your VCE county agent, or Extension Associate Tim McCoy at timm@vt.edu.

Fungicides, Algaecides, Antimicrobials, & Products with multiple modes of action		
Product Name (EPA Number)	**Signal Word**	**Primary active ingredient**
Double Nickel LC (70051-107)	Caution	*Bacillus amyloliquefaciens* strain D747
Double Nickel 55 (70051-108)	Caution	*Bacillus amyloliquefaciens* strain D747
General Hydroponics Defguard Biofungicide/Bactericide (91865-3)	Caution	*Bacillus amyloliquefaciens* strain D747
Stargus Bio-Fungicide (84059-28)	Caution	*Bacillus amyloliquefaciens* strain F727
Serenade Soil (264-1152)	Caution	*Bacillus subtilis* QST713 strain
Pvent (64137-13-70299)	Caution	*Gliocladium catenulatum* strain J1446
Regalia CG Biofungicide (84059-3)	Caution	*Reynoutria sachalinensis*
Actinovate AG Biological Fungicide (73314-1)	Caution	*Streptomyces lydicus* WYEC 108
Mycostop Biofungicide (64137-5)	Caution	*Streptomyces* strain K61
PreFence Biofungicide (64137-5-68539)	Caution	*Streptomyces* strain K61
Bio-Tam 2.0 (80289-9)	Caution	*Trichoderma asperellum* strain IC012
Rampart Fungicide (34704-924)	Caution	Phosphorous Acid, Mono- & Di-Potassium Salts
Sysstem-K Blue (4822-10)	Caution	Phosphorous Acid, Mono- & Di-Potassium Salts
General Hydroponics Exile Insecticide/Fungicide/Miticide (91865-2)	Caution	Potassium Salts of Fatty Acids
Kopa Insecticidal Soap (67702-11)	Caution	Potassium Salts of Fatty Acids
Sil-Matrix (82100-1)	Caution	Potassium Silicate
Triact 70 (70051-2-59807)	Caution	Clarified Hydrophobic Extract of Neem Oil
Trilogy (70051-2)	Caution	Clarified Hydrophobic Extract of Neem Oil
Banish (25b)	Caution	Geraniol
Suffoil-X (48813-1-68539)	Caution	Mineral Oil
TriTek (48813-1)	Caution	Mineral Oil
Oxidate 2.0 (70299-12)	**DANGER**	Hydrogen Peroxide
Perpose Plus (86729-1)	**DANGER**	Hydrogen Peroxide
TerraClean 5.0 (70299-13)	**DANGER**	Hydrogen Peroxide
ZeroTol 2.0 (70299-12)	**DANGER**	Hydrogen Peroxide
ZeroTol HC (70299-16)	**DANGER**	Hydrogen Peroxide

Nematicides and Plant Growth Regulators		
Majestene (84059-14)	Caution	*Burkholderia* spp. Strain A396
Neemix 4.5 Insect Growth Regulator (70051-9)	Caution	Azadirachtin
Optify/Stretch (33270-40)	Caution	Complex polymeric polyhydroxy acid (CPPA)

Herbicides		
Homeplate (67702-54-70051)	Caution	Caprylic acid
Suppress Herbicide EC (51517-9)	Caution	Caprylic Acid

Insecticides		
Aza-Direct Biological Insecticide (71908-1-10163)	Caution	Azadirachtin
AzaGuard (70299-17)	Caution	Azadirachtin
AzaMax (91865-4)	Caution	Azadirachtin
AzaSol (81899-4-74578)	Caution	Azadirachtin
Azatin O Biological Insecticide (70051-9-59807)	Caution	Azadirachtin
Azatrol EC Insecticide (2217-836)	Caution	Azadirachtin
Debug-Optimo (70310-7)	Caution	Azadirachtin
Debug-Tres (70310-8)	Caution	Azadirachtin
Debug Turbo (70310-5)	Caution	Azadirachtin
Ecozin Plus 1.2% ME (5481-559)	Caution	Azadirachtin
General Hydroponics Prevasyn Insect Repellent / Insecticide (91865-1)	Caution	Azadirachtin
Debug-On (70310-11)	Caution	Neem oil
TerraNeem EC (88760-5)	Caution	Neem oil, Cold Pressed
XenTari Biological Dry Flowable (73049-40)	Caution	*Bacillus thuringiensis* ssp. *Aizawai*
Crymax (70051-86)	Caution	*Bacillus thuringiensis* ssp. *Kurstaki*
Dipel DF Biological Insecticide Dry Flowable (73049-39)	Caution	*Bacillus thuringiensis* ssp. *Kurstaki*
Javelin WG Biological Insecticide (70051-66)	Caution	*Bacillus thuringiensis* ssp. *Kurstaki*
Venerate CG or XC (84059-14)	Caution	*Burkholderia* sp strain A396
Captiva (10163-326)	Caution	Capsicum Oleoresin Extract
Captiva (10163-326)	Caution	Capsicum Oleoresin Extract
Grandevo CG or WDG (84059-27)	Caution	*Chromobacterium* Sub Strain PRAA4-1 Cells
Bonide Diatomaceous Earth Crawling Insect Killer (73729-1-4)	Caution	Diatomaceous Earth
PFR-97 20% WDG (70051-19)	Caution	*Isaria fumosorosea*
Gemstar LC (70051-45)	Caution	Polyhedral occlusion bodies (Obs) of the nuclear polyhedrosis virus
Des-X Insecticidal Soap Concentrate (91865-1)	Caution	Potassium Laurate
Pyrethrum TR Total Release Insecticide (499-479)	Caution	Pyrethrins
Xpectro OD (82074-5)	Caution	Pyrethrins

CHAPTER 6: CONCLUSIONS

This guide is a first edition and contains all of the information gained from the limited work with hemp in Virginia thus far. Knowledge will continue to evolve in the coming years as more is learned about pest management and best practices for hemp growth and production. As more studies are conducted and data are collected, the specificity and detail of recommendations will increase significantly.

Management options are currently still extremely limited for hemp. The market for hemp products is rapidly changing and evolving in real time. Thus, this crop is very risky to grow. Be aware of these issues and proceed with caution as you choose to grow the crop and implement any form of pest management.

DISCLAIMER: Commercial products are named in this publication for informational purposes only. Virginia Cooperative Extension does not endorse any of these products and does not intend discrimination against other products which also may be suitable for pest management.

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