What type of crop is hemp?
There are at least 3 kinds of hemp crops from an Insect Management Perspective

• Hemp grown seed and/or fiber
  – Outdoor culture

• Hemp grown for CBD production
  – Outdoor culture

• Indoor culture of any Cannabis crop
What kinds of arthropods are we finding in North American hemp crops in this new era? And what is their association with the crop?
The only university–derived resources that give any mention of hemp insects in the United States date to the World War II period. The entomology details provided were cursory and appear to have little relevance to the present situation.
Key Arthropod Pests of Indoor Grown Cannabis

- Hemp russet mite
- Twospotted spider mite
- Rice root aphid
- Fungus gnats
- Cannabis aphid
- Onion thrips

Photograph courtesy of Karl Hillig
Key Arthropod Pests Emerging in Colorado Hemp Production

- Corn earworm
- Eurasian hemp borer
- Cannabis aphid
- Hemp russet mite
- Grasshoppers
Information collected on insect issues of hemp are made available through the Colorado State University Hemp Insect Website

Insect Management Considerations in Hemp Production

The **Hemp Insect Website** is designed to provide hemp producers a way to recognize and to better understand the insects, mites, and other “bugs” that are present when this crop is grown in North America.

The goals of the Hemp Insect Website are to:

1. **Provide description of all insects and mites observed in production of hemp;**
2. **Provide information on the habits of all insects that are associated with hemp production.**

At present the Hemp Insect Website does give particular attention to insects and mites that are present within the High Plains/Rocky Mountain area of the western United States. This is because, to date, the most extensive surveys of hemp insects have occurred in this region, mostly in Colorado from 2015 to the present. However, the goal of this website is to provide progressively more comprehensive treatment of insects associated with hemp production throughout North America. Submission of photos and inquiries about insects observed on hemp is encouraged from anywhere and the website should expand as the field of hemp insect pest management develops in the United States and Canada.
What is a Hemp Insect?
What is a hemp insect?

Zygogramma disparata – a leaf beetle of ragweed

Physiphora demandata – a commonly seen fly that develops on decaying OM

Argus tortoise beetles pupating on hemp

Western corn rootworm

Diamondback moth
Hemp may support a diverse and robust complement of natural enemy species.
Convergent lady beetle

The most common lady beetles found in hemp fields

Multicolored Asian lady beetle

Sevenspotted lady beetle

Also common were *Hippodamia parenthesis*, *Olla c-nigrum*, and *Coccinella novemnotata*
Three species of Green Lacewings have been observed in hemp fields.

*Chrysopa oculata, Chrysoperla floribunda, Chrysoperla nigricornis*
Some generalist hemipteran predators

Damsel bug

Spined assassin bug

Chlamyatus associatus

Minute pirate bugs
Damsel Bug

*Nabis alternatus*

A very common insect in hemp fields and a generalist predator of many insects, including caterpillars.
Spiders may often be very important natural enemies of insects associated with hemp
Hemp may be a very heavily used by many kinds of bees as a pollen source late in the season.

Many species of native solitary bees.
What is the potential value of hemp as a pollen resource for bees in agricultural regions?
Hemp grown for seed production with pollen producing male plants/flowers – potentially excellent resource for many pollinators

Hemp grown for extractable compounds (e.g. CBD) without male plants – not a potential pollen source
What kinds of arthropods will we find feeding on hemp plants in this new era?
Herbivores associated with Hemp

• Leaf feeding species (all crops)
• Stalk borers (all crops)
• Hemipteran seed feeders (seed crops)
• Insects that damage flower buds (CDB crops)
Insect/Mites with Sucking Mouthparts that Feed on Leaves

- Leafhoppers
- Spider Mites
- Aphids
- Thrips
- Russet Mites
There are some fluid feeding insects that occur on the leaves. Plus some treehoppers, planthoppers, and spittlebugs.
Most surprising insect associated with the crop?

Cannabis Aphid

*Phorodon cannabis*
Cannabis Aphid

- *Cannabis* spp. are the only plants on which cannabis aphid can feed and develop.
Outdoors, highest populations are seen late in the season, near harvest. These are often started by migrants that move to the crop in mid-late August and early September.
Asexual reproduction – giving live birth to a genetically identical daughter – is the norm for aphid reproduction, including cannabis aphid.

No males, no externally laid egg.
Starting in mid-September, special reproductive forms appear on hemp.
Sexual forms of cannabis aphid and eggs

- Egg producing form female mating with winged male
- Winged male
- Egg producing form female with recently laid eggs

Late September on a hemp leaf
Cannabis Aphid

- Beginning in September, with shortening day length, sexual forms are produced (holocyclic life cycle, monoecious)

Eggs are the stage that can survive outdoors between seasons
How will cannabis aphid survive between seasons in a place with hard freezing winters?

... mostly on indoor crops?
Feral hemp - and volunteers - can sustain significant numbers of cannabis aphid between seasons.

Photograph courtesy of University of Missouri
Cannabis aphids were collected from volunteer hemp sampled in mid-May.
Prevention of volunteers can reduce early season populations of cannabis aphid.
Outdoors, highest populations are seen late in the season, near harvest. These are often started by migrants that move to the crop in mid-late August and early September.
Hemp may support a diverse and robust complement of natural enemy species.

Lady beetles and other Coleopteran predators

Syrphid flies

Spiders and other arachnid predators

Predatory Hemiptera

Green lacewings
Leafhoppers

Insects with sucking mouthparts that feed on leaves

Damage potential of Colorado species to crop: Negligible, at most
Newly identified insect-vectored pathogen of hemp – **beet curly top virus**

Beet curly top virus is transmitted to plants by the **beet leafhopper** (*Neoaliturus tenellus*)
Beet Curly Top Virus symptoms on hemp
Beet Curly Top outbreaks are common in western Colorado. The main crops affected are tomatoes, peppers, squash and beans.

The only way a plant gets infected with this disease is if a beet leafhopper, which has previously fed on a BCTV-infected plant, feeds on the plant.

Essentially all BCTV infections occur from beet leafhoppers, carrying the virus, which migrated into the area in late spring from New Mexico/Arizona.

Beet leafhopper spends very little time in hemp and does not breed in the crop. It can transmit the virus after feeding for 10-15 minutes.
Bob Hammon with the Tri-River Extension office spent many years researching all the available options to manage beet curly top on tomatoes.

Results of this work can be found at the Western Colorado Insects website of the Tri-River Area Extension offices.
Mulch and Insects

Mulches can:

- alter light around plants
- affect temperatures on plants
- provide cover for insects around the base of the plants
Reflective Mulches for Control of Insect Vectored Plant Diseases

- Aphids
- Thrips
- Leafhoppers

NON-PERSISTENT VIRUS - PVY
Hemp russet mite

*Aculops cannabicola*

We will come back to this when discussing bud feeders.
More obvious can be insects that chew leaves of the plant (defoliators)

Caterpillars

Beetles

Grasshoppers
Various caterpillars chew leaves of the plant (defoliators)

- Yellowstriped armyworm
- Thistle caterpillar
- Beet armyworm
- Zebra caterpillar
- Yellow woollybear
- Beet webworm
Two late season “woollybear” caterpillars are most common.
Leaf Feeding Beetles

Palestriped flea beetle

Western black flea beetle

Southern corn rootworm adult and damage
Grasshoppers (at least five species)
Two species of grasshoppers appear to be particularly damaging to hemp, twostriped grasshopper and differential grasshopper.
Stem feeding seems to cause the most injury by grasshoppers
These two species roost on stems of the plants through the night – and gnaw on stems
Grasshoppers that damage hemp lay pods of eggs below ground in late summer. These hatch the following spring.
Egg pods of grasshoppers.

These are destroyed if the ground is tilled.
In most agricultural settings grasshopper problems originate from undisturbed field edges.
Field edges and grasshopper management

- Locate hemp some distance from field edge
- Manage grasshoppers in the field edge, before they move into the crop
Grasshopper baits can be used in off-crop sites (e.g., field edges).

They can not be used in hemp fields!
Nosema locustae
A microsporidian (fungus) disease of grasshoppers
If you use *Nosema locustae*, make sure the material is fresh

Apply it when the young grasshoppers are present
Poultry for management of grasshoppers?
Handpicking (or sweeping) early in the morning?

I got 247 in under 25 minutes when I tried it.
Hemp response to hail injury can give some insight on how the crop may respond to grasshopper injuries.
Research questions: What is the relationship between leaf loss (defoliation) and yield? Do plant injuries affect production of important compounds produced by the crop (e.g. THC, CBD)?
Perhaps hail simulation trials can also answer questions about effects of insect defoliators in hemp
Stem/Stalk Boring Insects

European corn borer

Eurasian hemp borer

Photograph from the website of the Canadian Hemp Trade Alliance
How important is European corn borer to hemp in the modern era?

Probably not very important anywhere – and it does not occur in western Colorado.
An insect that surprised me a lot when found in Colorado

**Eurasian hemp borer**

*Grapholita delineana*

This is most important to flower buds and developing seeds
Eurasian hemp borer stalk tunneling in hemp in Wisconsin.

Photograph by Steve Tomlins.
Adults were found in fields from 5 of the 6 eastern Colorado counties visited in 2018. These constitute a known range extension to the west of 600+ miles.

Recent reports of it in Western CO! – from human assisted transfers.
Several hemipterans ("true bugs") feed on flowers and developing seeds of hemp.
Hemipteran seed feeders

Species of interest where there is continuous culture of seed-producing crops?
Seed Feeding Bugs and Hemp

• Feeding concentrated on flowers and developing seed
• Potential damage
  – Aborted seed, damaged seed
• Significant damage??
Insects that Damage Flower Buds

A particular issue of crops grown for CBD production
Hemp russet mite

*Aculops cannabicola*

Photograph courtesy of Karl Hillig
Is an upward leaf curl a symptom of hemp russet mite injury?
Yes – and no. Some cultivars seem to produce an upward leaf curl in response to hemp russet mites. Some do not.

Some genotypes normally produce upward leaf curling in the absence of mites (“taco leaf”).
Symptoms of hemp russet mite infestation on developing buds of hemp
Reduction in bud size and quality is the effect of HRM injury
Hemp russet mites could be collected from glass slides placed above the crop canopy.

Wind-blown dispersal occurs, as with other eriophyid mites.
What are the populations of hemp russet mite in the crops?
What is eating hemp russet mites in the field?

Minute pirate bugs were the only species regularly observed that could credibly be considered a hemp russet mite predator.
Predatory Mites?

Extremely low populations were present in fields. Attempts to augment populations with release of *Amblysieus andersoni* were not promising.

- Direct release on plants
- Release with hanging sachet
No. Russet Mites/Terminal following 3 applications at one week intervals

- SuffOil-X 12.8
- TetraCURB 61.4
- Green Cleaner 67.7
- Untreated Check 239.4
Hemp russet mite is a problem in indoor production – and in field plantings using HRM infested transplants.

Key to control:
Eliminate HRM from mother plants.
Sulfur is an excellent product for eliminating hemp russet mite from hemp

- Only two, retail products are allowed for use on the crop (in Colorado)

- **Key HRM pesticide registration need:**
  - Commercial producer formulation allowable for use on hemp (young plants, well before flowering)
    - Indoor use is critical
    - Outdoor use would be a bonus
  - Certified organic formulation would be nice
Eurasian Hemp Borer

Grapholita delineana
Volunteer hemp examined June 18 were infested with larvae in late stages of development.
The last stage larva changes from cream colored to pinkish, as do some other *Grapholita* species.
Exterior symptom of stalk tunneling – leaf flagging
Eurasian hemp borer stalk tunneling in hemp in Wisconsin.

Photograph by Steve Tomlins.
Serious damage to buds was observed in one field located in northeastern Colorado.
Eurasian Hemp Borer – Potential key pest of crop in North America on cultivars grown for seed?

Photograph by Steve Tomlins
Management Options for Eurasian Hemp Borer at Present

• Destroy all crop residues at the end of the season that could contain living stages that survive between seasons

• Rotate the location of consecutive hemp crops a considerable distance

• Insecticides???
  – Azadirachtin???????
Most significant potential pest of the crop in Colorado

Corn earworm

*Helicoverpa zea*
Corn earworm shows wide range in coloring and patterning on hemp (as with most crops)
Corn earworm tunnels into and can extensively damage developing buds of hemp
In 2016, 2018 and 2019 corn earworm caused serious losses to CBD hemp in southeastern Colorado

Adults of the corn earworm

One night’s light trap capture, September 8, 2016
Corn Earworm

The insect that has shown the most potential to damage hemp in Colorado is the corn earworm (Helicoverpa zea). This is one of the most widespread and commonly damaging insects in much of the United States, affecting both field crops and vegetable crops. Evidence of its importance is indicated by it having three accepted common names: corn earworm (when in corn), tomato fruitworm (when feeding on fruits of peppers, tomatoes, etc.), and bollworm (when feeding on cotton bolls).

In hemp the primary damage occurs when they tunnel into buds and developing seeds. Damage to hemp by corn earworm has potential to cause significant damage, particularly to crops grown for production of large buds to extract CBD or other pharmaceutical compounds. Potential damage to fiber or seed producing cultivars is likely to be minimal. Populations of this insect vary greatly from season to season in Colorado and will usually peak in hemp during late August and/or September.

Parts of Colorado include areas of the northern range of where corn earworm has historically been able to survive through winter (as a pupa in the soil). However, mild winters will allow this pest to become a problem in new growing areas.
Present proposed IPM program for corn earworm in hemp

An IPM Implementation Phase effort

Proposed Management Plan for Corn Earworm in Hemp

Background. Corn earworm (*Helicoverpa zea*) is a key pest of hemp grown in Colorado. Damage is caused by the larva (caterpillar) that tunnels through and destroys maturing buds. This insect is present every growing season in Colorado, where it may be found on a wide variety of crops and weed hosts. However, population size, and associated damage, can vary greatly from season to season and by location.

Traps (light, pheromone) can be used to capture the adult stage of this insect, a night flying moth. When used over a period of time these traps can provide information on in changes in abundance of the insect, with high trap captures being associated periods of peak egg laying on plants.

The insecticides that have the most potential to control corn earworm - and are allowable by the Colorado Department of Agriculture for use on cannabis crops – are certain strains of the microbial insecticide *Bacillus thuringiensis* (Bt). These are best applied at times coinciding with periods of peak egg laying by the adult moths and subsequent egg hatch, which occurs a couple of days after eggs are laid.

Use of Traps for Monitoring Corn Earworm

Two types of traps can be used to capture the night flying moths of the corn earworm, light traps or pheromone traps.

Basic design of a light trap uses a light, preferably UV, to attract insects that fly at night. The insects then hit a vane and are funneled into a collecting container below. Usually a killing agent (often a dichlorvos Pest-Strip) is placed in the collecting container to minimize damage to the collected insects, particularly damage to the delicate wings of moths, which may be torn by “June bugs” and other other active insects that come to these traps.

Light traps will capture a wide variety of insects, mostly various kinds of moths and beetles. Traps should be mounted slightly above ground level to prevent the number of insects that are of interest in this program from being underestimated due to these "natural" insect predators.
Outline of Corn Earworm Management Program in Hemp

• Establish a program to monitor flights of adult corn earworms using pheromone traps
  – This should begin by midsummer to establish baseline of adult captures
  – Traps should be checked twice a week and the number of new moths recorded
Pheromone trap used to monitor corn earworm
Outline of Corn Earworm Management Program in Hemp

- If very high numbers of moths are discovered during flowering, treatment should be considered
  - *Bacillus thuringiensis* var. *aizawi*
    - Agree WG, XenTari Biological Insecticide
  - *Helicoverpa NPV*
    - *HelicoVex*
Colorado allowed insecticides that can be used to control corn earworm in hemp.

**Bacillus thuringiensis (aizawi strain)**

**Helicoverpa Nuclear Polyhedrosis Virus**
Pollinator use may complicate controls if there are insects that are pests of the crop during flowering.

Fortunately, the *Bacillus thuringiensis* (Bt) and HelicoVex products used for corn earworm are compatible with pollinators.
Colorado allowed insecticides that can be used to control corn earworm in hemp

**Bacillus thuringiensis** (aizawi strain)

**Helicoverpa Nuclear Polyhedrosis Virus**
The Pesticide Conundrum with Cannabis

• All registered pesticides can only be legally applied to sites (e.g., crops) on which they are labeled

• Presently the agency overseeing pesticide labeling (EPA) does not recognize cannabis as a crop site

Are there pesticides that can be used on this crop now?
In Colorado, the Colorado Department of Agriculture maintains a website of *pesticides that may be applied to hemp grown within the state*. Not all states that allow hemp production have established guidelines regarding pesticides.
Criteria for Pesticides Allowed to be Used on Cannabis in Colorado

• Pesticides that require federal registration under Section 3 of FIFRA
  – Active ingredient is exempt from the requirements of food crop tolerance, *and*
  – Label has directions for use on unspecified food crops, including unspecified food crops grown as bedding plants
  – EPA and CDA registration is required
  – Pesticide is registered on tobacco

• Section 25b minimum risk pesticides (exempt from most federal registration)
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Example of pesticide label with a very broadly described Crop Site

Labels written in this manner can be interpreted as allowing use on hemp

Such labels are rare

<table>
<thead>
<tr>
<th>CROPS</th>
<th>APPLICATION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomatoes, lettuce, cucumbers, peppers, sweet corn, broccoli, cauliflower, cabbage; peas, beans, beets, celery, onions, garlic, leek, asparagus, okra, eggplant strawberries, grapes, escarole ornamentals and flowers</td>
<td>Rate: 1.0 - 2.5 fl. oz. per acre</td>
<td>Repeat application as above every 6 - 8 sunny days (counting 2 partially sunny days as 1 sunny day) if monitoring indicates that reapplication is necessary.</td>
</tr>
<tr>
<td></td>
<td>Method: Sprayer, Aircraft</td>
<td>Lower rates (every 6 sunny days) may be used during vegetative stages of the crop or when tank mixed with other insecticides.</td>
</tr>
<tr>
<td></td>
<td>Equipment: Sprayer, Sprinkler</td>
<td>When flowers, fruits or other harvested structures of the plant are present or when infestation becomes strong, use the higher rates.</td>
</tr>
<tr>
<td>Cotton, alfalfa, soybeans, peanuts, potatoes, corn, wheat, sweet potatoes, tobacco, sunflowers, sugar beets, sorghum, floriculture, and border plants</td>
<td>Irrigation, Mist Sprayer</td>
<td>Sweet corn and corn: For very sunny regions (e.g., California), use 0.5 to 1.25 fl. oz./acre every 3 days; for less sunny regions, use 1 to 2.5 fl. oz./acre every 6 to 8 days.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cover the whole larval hatching period of the treated generation until harvest.</td>
</tr>
</tbody>
</table>
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- Section 25b minimum risk pesticides (exempt from most federal registration)
In Colorado, the Colorado Department of Agriculture maintains a website of pesticides that may be applied to hemp grown within the state.
Website page to access what Colorado Department of Agriculture considers to be *not not allowable* (= allowable) for use on Cannabis in Colorado

Pesticides Allowed for Use on Cannabis

Each time we update the Cannabis pesticides list or have industry news we will send out an email blast and you can [sign up here](#) to be included. As of March 30, 2016 all past lists will be removed from the CDA website and updates will be made only to the list of approved pesticides that may be used in accordance with Pesticide Applicators' Act Rule - Part 17.

The list developed by CDA is intended to assist Colorado Cannabis growers in identifying which pesticides can be used legally in accordance with the Pesticide Applicators' Act and its Rules in the production of Cannabis (marijuana and industrial hemp), it is not an endorsement or recommendation to use these products in the production of Cannabis in Colorado. These products have not been tested to determine their health effects if used on Cannabis that will be consumed and thus the health risks to consumers is unknown. by including products on this list, therefore, CDA make no assurances of their safety or effectiveness when used on Cannabis and is not responsible or liable for any such use.

To view or download the current list, click the link below:

- Pesticides allowed for use in Cannabis production in accordance with the PAA Rule: Effective June 29th, 2016
  - PDF
  - Excel
- This link provides a list of products that have been removed from the list of pesticides that may be used on Cannabis. These products were either removed from the list prior to the effective date of the rule or were removed as a result of them not meeting the rule criteria as of March 30th, 2016.
  - Excel
- Selected Examples of pesticides that cannot be used in marijuana production January 13 2016
  - PDF

Products added since the last update are now highlighted in red on the PDF version of the file. The Excel version has the date that each product was added and can be sorted or filtered by name, date, active ingredient, etc.
A page listing the current products that are allowed for use on all Cannabis (including hemp) grown in Colorado

Most all of the CDA allowable pesticides are also allowed in production of Certified Organic crops
Whether or not a pesticide is allowed to be used in Certified Organic production does not mean it is legal to be used in hemp!!
When hemp “grows up” as a crop, addressed by federal laws and regulations as are all other crops - how will the pesticides issues work out?

It will very likely vary by the type of hemp crop, and end use
Hemp Grown for Fiber and Seed

For seeds, perhaps this would be considered under Crop Group 20 (Oilseeds, such as sunflower, cotton seed and canola/rape seed)

For a strictly fiber grown crop?
Hemp Grown for CBD

This poses some more serious registration problems
This poses some obvious registration problems.

This produces an extracted product that is consumed by humans, and in different manners (e.g., ingested, inhaled)
Hemp Grown for CBD

This poses some obvious registration problems.

This produces a product that is applied to humans, and in different manners.

Extraction methods used will affect potential for residues, and these must be studied.
You may wish to check out the Colorado Hemp Insect Website for periodic updates on this subject.

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Note: This website is limited to insect issues involving hemp, defined as Cannabis grown for seed, fiber, or non-THC pharmaceutical products. This is not a forum for marijuana industrial hemp.
Insects/Mites found in Hemp: Pest Management Needs

Questions?????
This presentation will be posted at the Colorado State Insect Information Website

- Housed at Department of Bioagricultural Sciences and Pest Management
  - Search “BSPM CSU”
- Within “Entomology”
- “Insect Information”
  - Extension presentations are posted at the bottom of the page, most recent at end