Diversified and integrated approaches to weed and sucker management for Midwest hop production

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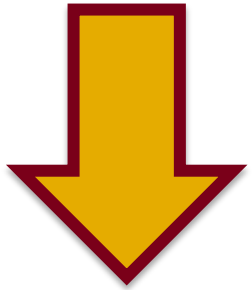
Outline

- Introduction to weed science
- Unique considerations for managing weeds and suckers in hop yards
- Pros and cons of chemical and non-chemical weed management
- Integrated weed management strategy and tactics

Shifting perspectives: What constitutes a “weed”?

Plant growing where it is not wanted



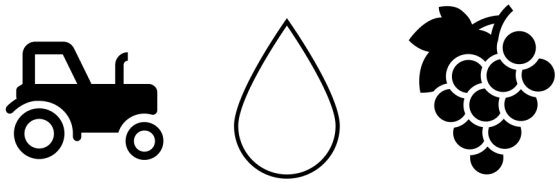
Plants that cause actual harm

Economic **Aesthetic** **Sustainability**

Merfield CN. 2018. Integrated weed management in organic farming. In: Sarath C, Unni MR, Sabu T, editors. Organic farming: global perspectives and methods. Oxford: Woodhead Publishing; p. 117–180.

Why weed management matters

Compete for water and nutrients

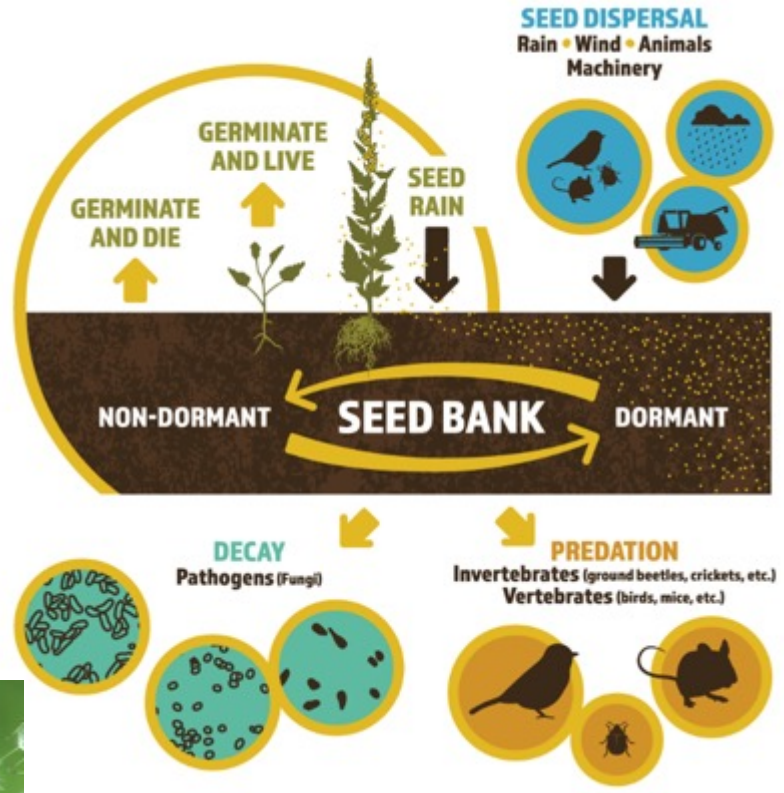


Get in the way of management, equipment, and harvest

Host for insect pests and diseases + rodent habitat

Weed science requires weed ID and knowing their unique life cycles…

- Where do weed seeds come from?
- How long can seeds survive?
- How can you prevent putting seeds in the “bank”?
- What resources are available to identify weeds?

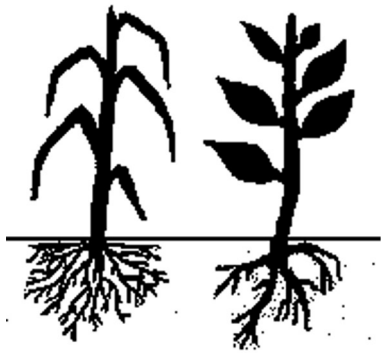


Washington State University


Cardinal Lawns

Ways to classify different weeds

- **Grasses**
  (monocots)
- **Broadleaves**
  (dicots)



Lifecycle

- Annual
- Biennial
- Perennial

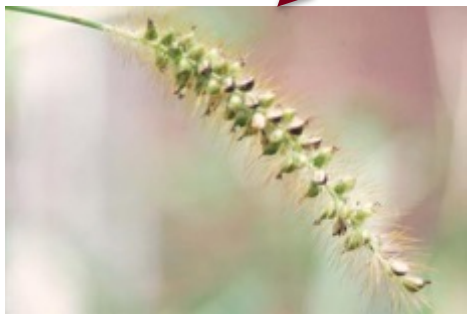
Morphology

- Upright vs prostrate
- Large vs small
- Root: tap vs fibrous
- Clumping vs spreading

Classifications continued…

Grasses

Broadleaves, aka “forbs”



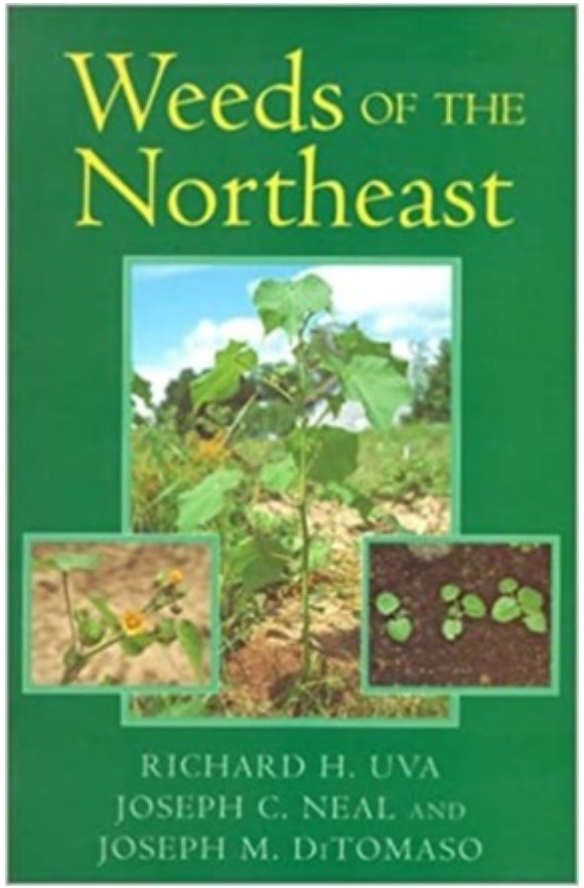
Annual grass

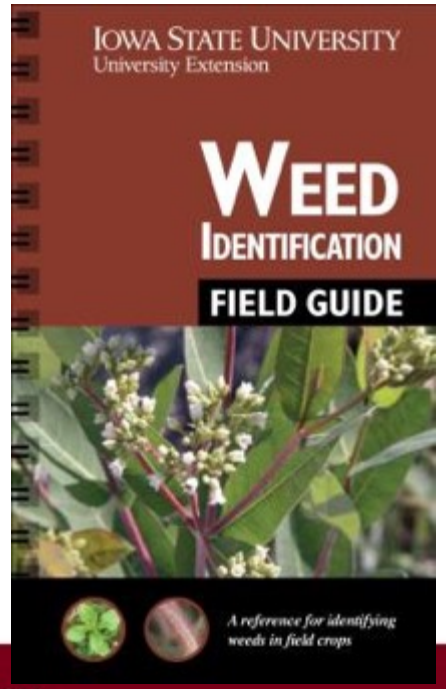
Perennial grass

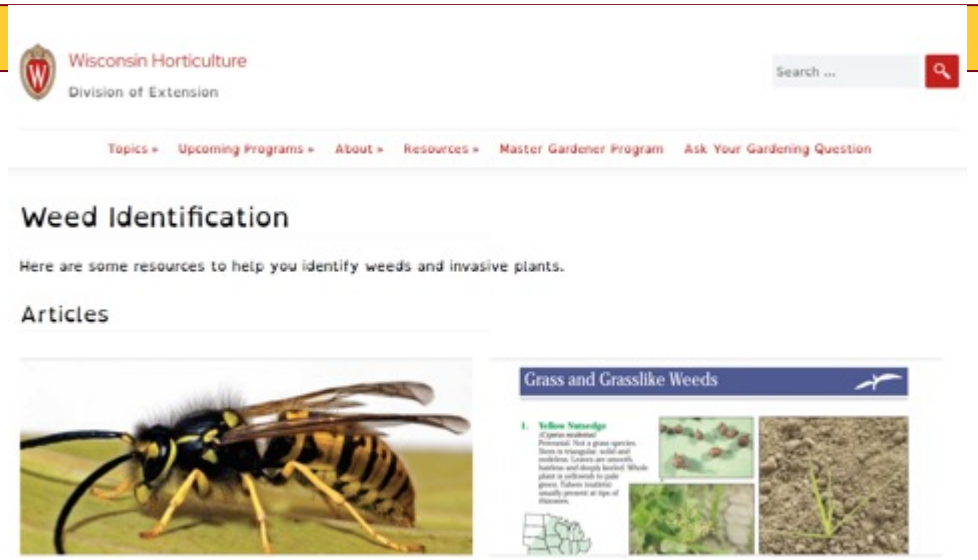
Annual forbs

Perennial forbs

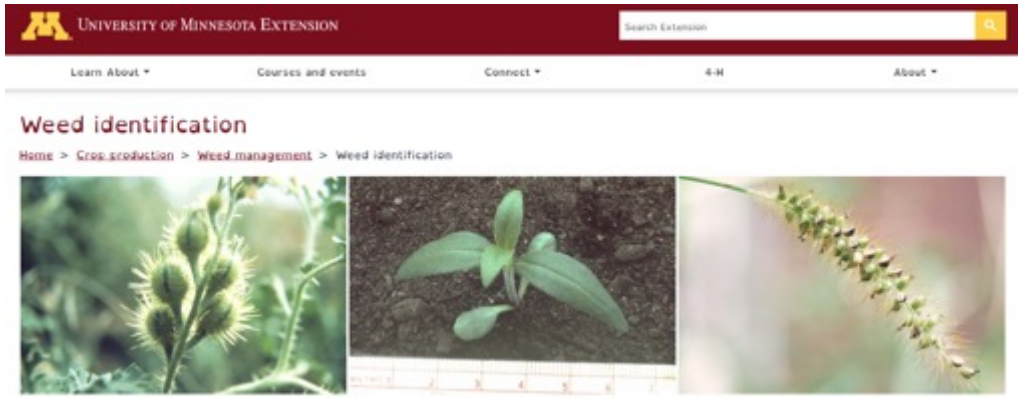
Resources for weed identification





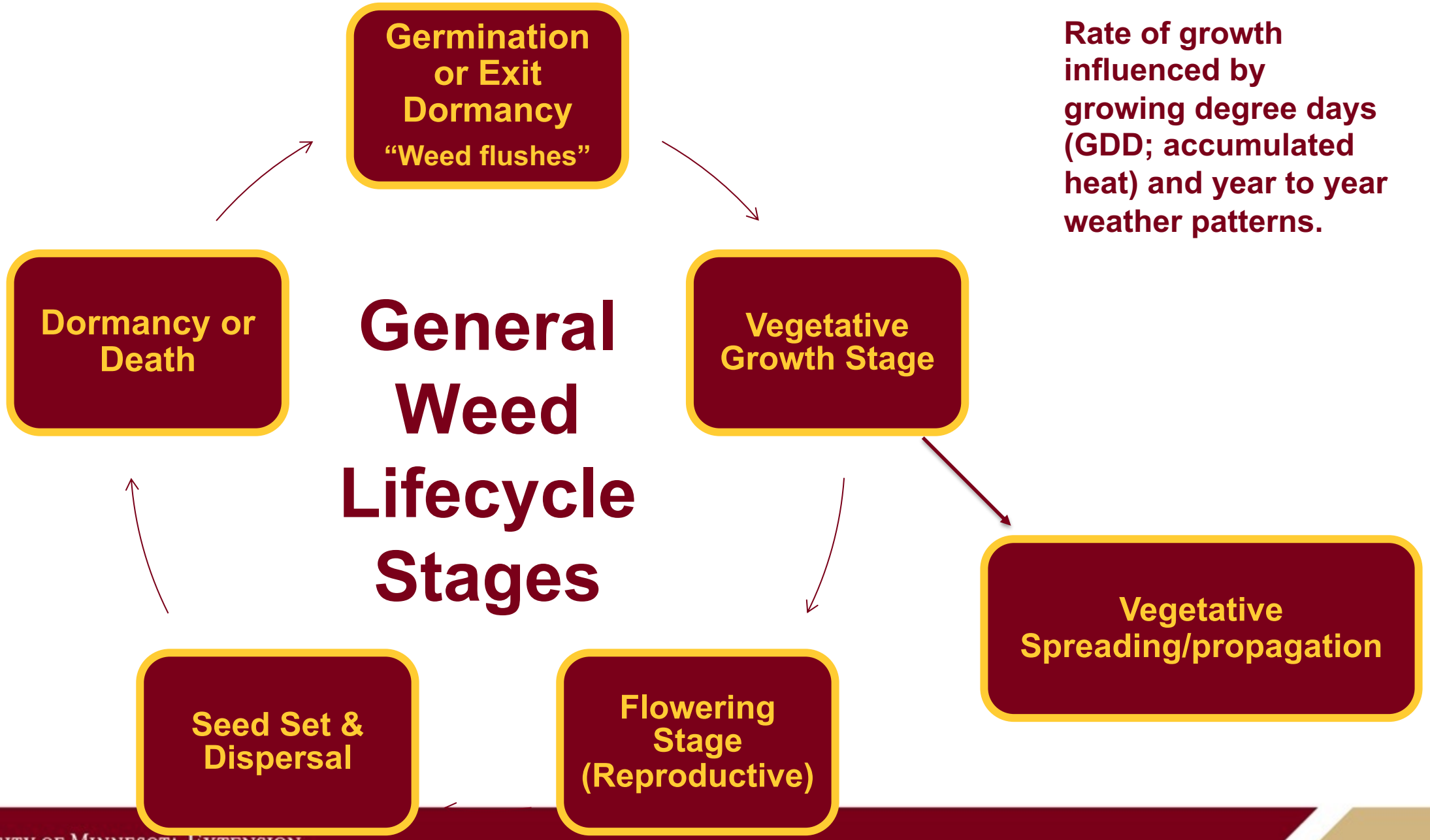


https://hort.extension.wisc.edu/article-topic/weed-identification/



https://extension.umn.edu/weed-management/weed-identification

General Weed Lifecycle Stages



Rate of growth influenced by growing degree days (GDD; accumulated heat) and year to year weather patterns.

Non-chemical weed tactics go beyond weeding

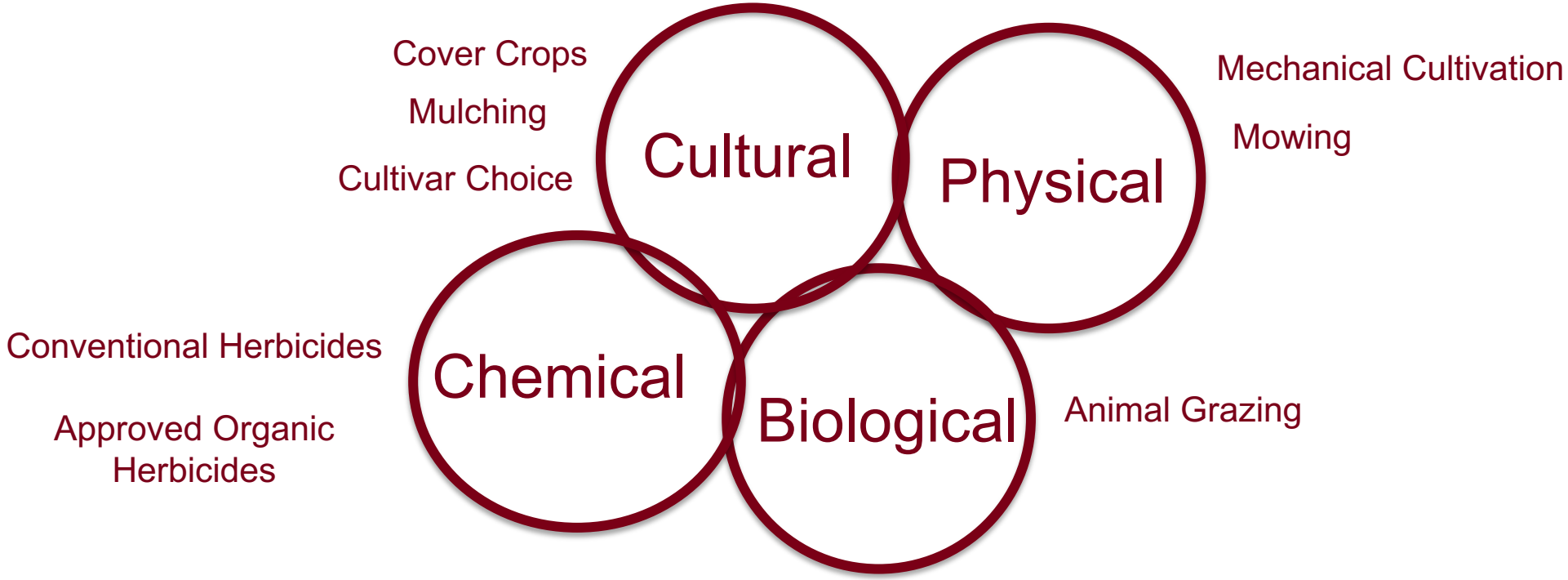
- Can influence soil temps, microbes, and moisture
- Can be a part of nutrition program and nutrient bioavailability
- Some are reflective
- Overwintering plants (straw)

When reading the literature….

Recommendations can vary based on region, crop being studied/managed, and what was being tested.

When a resource claims XYZ works best, ask yourself, “**where, for which soil type & crop, and compared to what**”?

Strategy 1: Integrated Weed Management



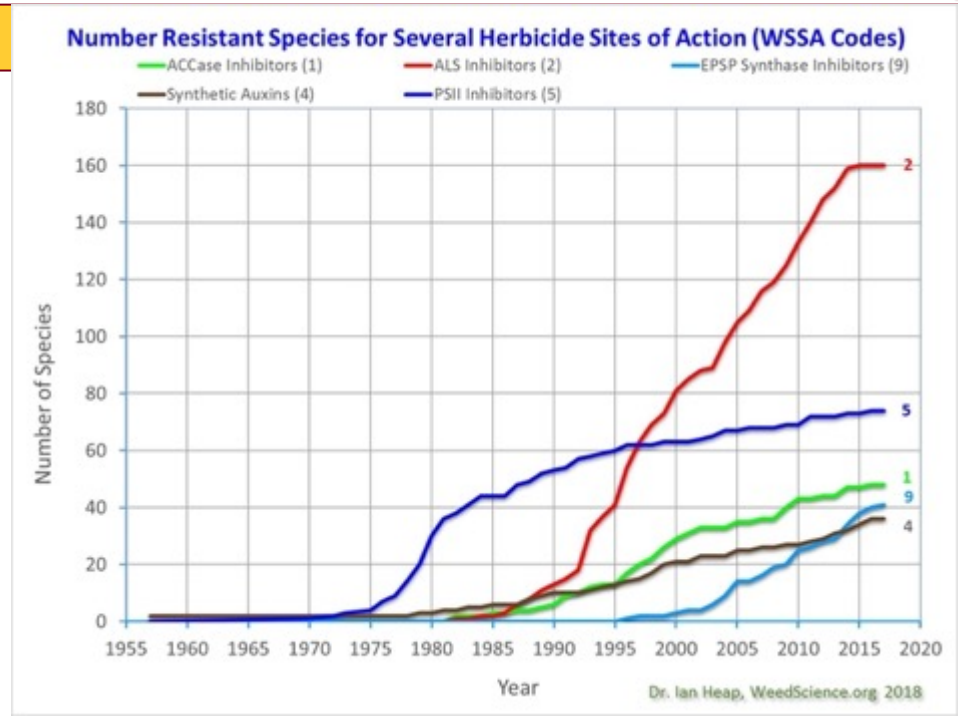
Five IPM Principles

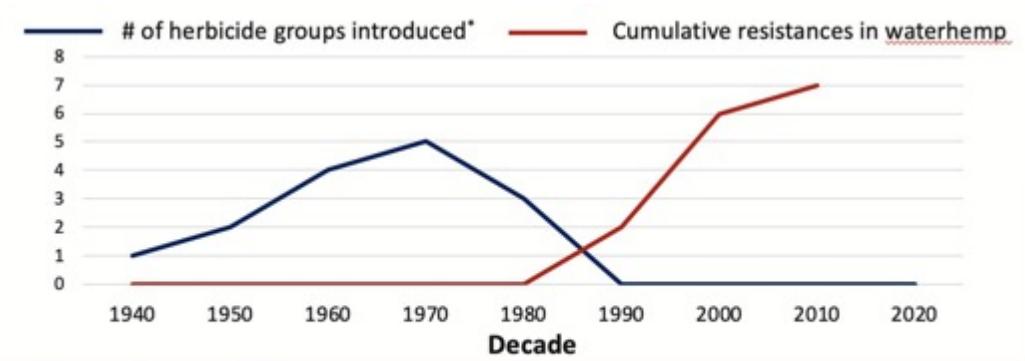
1. Prevent
2. Identify
3. Monitor
4. Utilize thresholds
5. Implement control strategies

How do these principles apply to weed management in hops?

Strategy 2: Diversified Weed Management

- Herbicides have multiple groups/chemical classes/targeted modes of action
- Rotating chemicals with different groups can prevent herbicide resistance





*Only herbicide groups used in corn/soybean included

Conventional Herbicide Disadvantages

- Potential to **leach** unwanted chemicals into soil and water systems
- **Herbicide resistance** occurrences
- Risk to **human health** with improper mixing, loading, and application
- Often only **effective** at certain growth stages
- **Herbicide damage** to young or older fruit crops or drift to adjacent crops
- Bare ground year-round can affect **soil structure** and **biology**
- $$$

Organic growers adhere to stricter regulations

Code of Federal Regulations: Part 205.206 Subpart (c)

(c) Weed problems may be controlled through:

(1) Mulching with fully biodegradable materials;

(2) Mowing;

(3) Livestock grazing;

(4) Hand weeding and mechanical cultivation;

(5) Flame, heat, or electrical means; or

(6) Plastic or other synthetic mulches: Provided, That, they are removed from the field at the end of the growing or harvest season.

OMRI Restricted

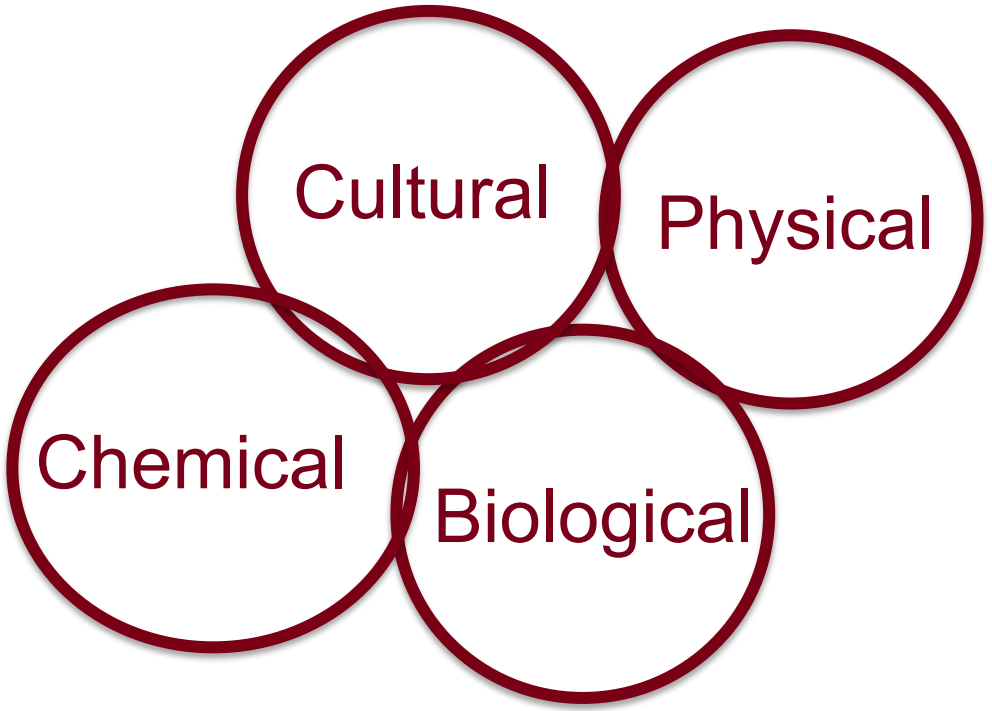
- Weed oils
- Most herbicides
- Glossy paper and colored ink newspaper (for homemade spray on mulch)
- Improperly disposed plastics and plastics that cannot be removed
- GMO sourced materials used to make mulch

OMRI Approved

- Recycled newspaper
- Untreated wood sources
- Plastic mulch and covers (petroleum-based other than polyvinyl chloride (PVC))
- Biodegradable biobased mulch film as defined in § 205.2. Must be produced without organisms or feedstock derived from excluded methods.

Integrated and diverse weed management gives growers flexibility

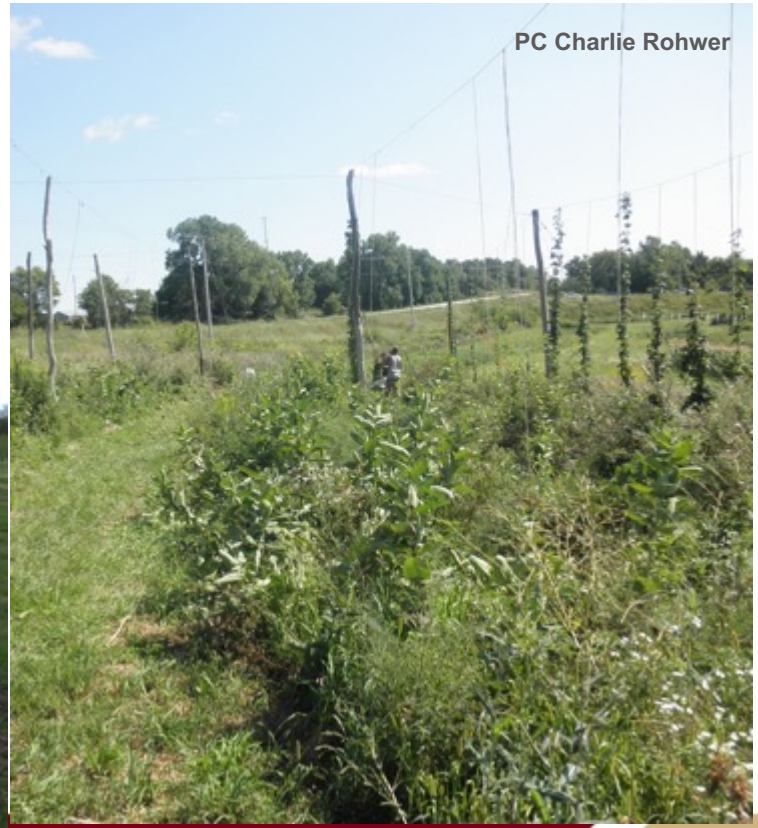
- Organic certification can rule out the need for precision herbicide usage
- Everyone can benefit from reducing herbicide usage
- Spray smarter, not harder
- Change your management plan based on your needs (growth stage, pre vs post planting)



Pre Planting Management is Key!

Pre establishment approaches for weed management:

- Herbicides (watch out for persisting herbicides)
- Stale seedbed technique
- Strip tillage NOT recommended
- Solarization of planting rows using plastic (effective in hot climates and eliminating annual weeds)
- Whole field tillage, repeated
- Cover crops
  - e.g., Sorghum



Post hop planting weed and sucker management

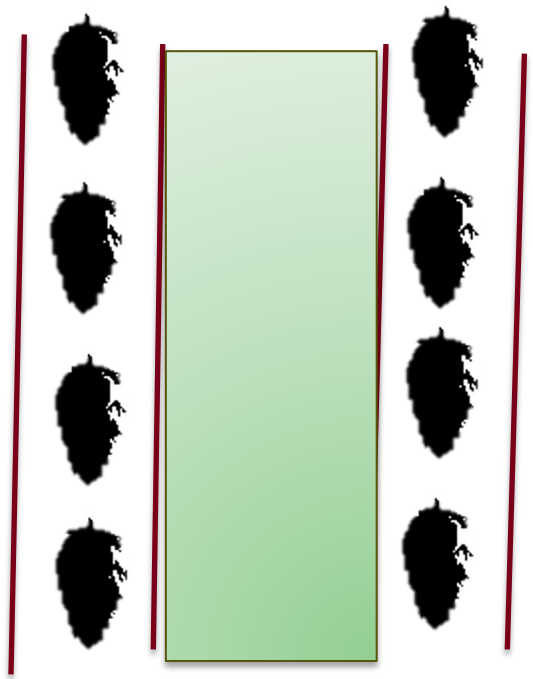
Part I Non-chemical Management

Understand your plant management zones

"Planting Row"

"Adjacent to Planting Row"

"Between Row"/Alleyway



Mowing

- Retractable mower head
- Can stop plants from going to seed
- Less effective for removing grasses (lower growing point and increased need for nutrition to grow back)
- Grass clippings may be blown into rows (low C:N ratio)
- Caution with string trimmers
- **Viruses can spread when using mechanical means to trim suckers or mow crowns.***

*Information and pictures from Charlier Rohwer

Mechanical Cultivation

- 4-6in tillage can be done as soon as weeds appear
- 2-4in, shallow cultivation can be done until lateral hop branches have appeared
- Overtime, cultivation can lead to issues in soil quality and texture
- Be mindful to not injury hop crowns

PC Sean Trowbridge

*Information from Diane Brown, MSU

LIVING MULCH

- Consider vigor of cover crop
- Annual vs perennial
- Bloom time competition with fruit crop grown
- Pollinator trap when pyrethrins or other Organic approved insecticides sprayed
- Home for rodents and other animal pests
- Helps prevent erosion compared to bare soil

Benefits

VS

Harm

Living mulch Continued

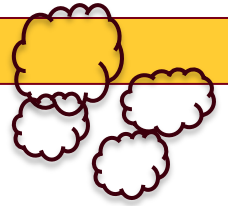
- If you plant a cover crop between rows, like clover, treat it like you're growing an actual crop.
- Irrigate it for germination, for example, and use herbicides if needed.
- Otherwise, you'll grow weeds (like purslane).

Information and picture from Charlie Rohwer

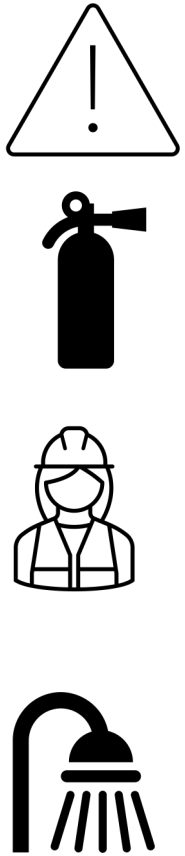
Thermal weeding

Flame

Steam



- Works by rupturing plant cell walls
- Maybe be less effective for rhizomatous perennial weeds (timing!)
- **Steam** takes a lot of water
- Reapplications needed once every few weeks
- Consider hazards of working with **fire**, especially during dry seasons (shields required, not compatible with plastics- tree guards, grow tubes, irrigation lines, etc.)



Animal Grazing

- Sheep can eat lower hop leaves and weeds*
- Best to keep animals out when bines are young and tender
- Food safety concerns less relevant because hops grow up high and will have a “kill step”
- Can be difficult to control what animals eat
- May not work well for an herbaceous perennial like hops!

*Information from Small Scale and Organic Hops Production

MULCH, MULCH, MULCH

Photo by Lisa DeVetter

Wood Mulch

- Block sunlight from weed seeds
- Help moderate soil temperatures and moisture levels
- Best applied to weed-free soil
- Most effective up to 1-2 years post application
- Carbon-Nitrogen ratios affected (N can be tied up)
- Be cautious to not cover hop crowns with mulch

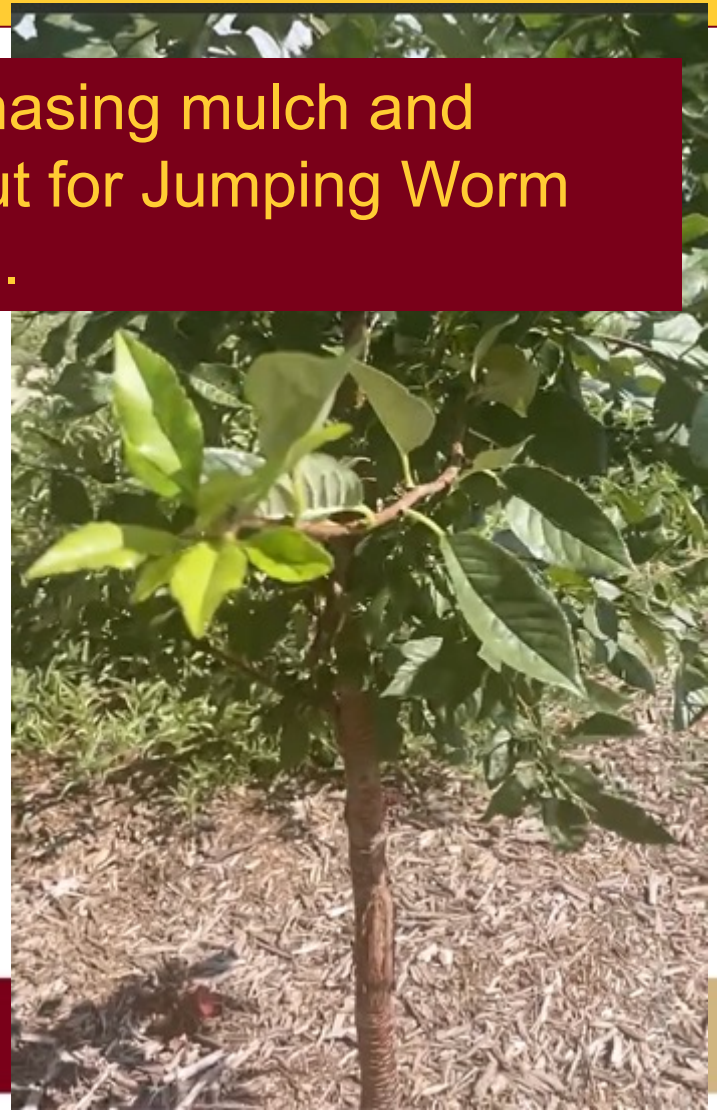
Wood chips	700:1
Cardboard (corrugated)	560:1
Sawdust	500:1
Wood bark	300:1
Newspaper	150:1
Pine needles	80:1
Straw	75:1
Cornstalks	60:1
Peat moss	60:1
Leaves	55:1
Horse manure	25:1
Coffee grounds	25:1
Compost	20:1
Food waste	20:1
Grass clippings	15:1
Cow manure	15:1
Pig manure	15:1
Alfalfa hay	12:1
Poultry manure	6:1
Blood meal	4:1

Idowu, O. & Pietrasiak, Nicole & Hoellrich, Mikaela. (2023). Soil Biological Processes - Guide A-153 New Mexico State University ACES Cooperative Extension Service •.

Wood Mulch

- Optimal thickness ~10cm, or 4in
- Total cost (purchase cost + shipping + application)
- Reapplications necessary
- By itself, can struggle to prevent creep of weeds like quack grass
- Combinations
  - Wood chips + green mulch (mowed grass clippings)
  - Wood chips + landscape fabric

Note: Purchasing mulch and watching out for Jumping Worm introduction.



Straw mulch

- Often used in June bearing strawberries and raspberries
- Can also be used as an overwintering strategy for strawberries and marginally hardy grapes
- Tends to be less effective at blocking out light than other mulches
- Be cautious with straw source

Plastic mulch

- Modify moisture and temperature in soil environment
- Change in plant growth habit
- Environmental impact
- Different plastics are more suitable for specific crops, circumstances, soil environments, etc.

Comparing plastic mulches

Color

- White (reflective and cooling)
- Black (warm soils, blocks light and suppresses weed growth)
- Clear (may warm soils more than black due to light transmission)
- White on black (reflective and blocks light)
- Other colors

Material

Woven vs single sheet

Mulch type	Color	Thickness or weight per area[z]	Longevity[y]	Average price per square meter[x]	Suitability for organic production[w]
PP	Various colors, but commonly in black, white, silver, or green	85 g/m^2	3–7 years	$1.4	Yes
PE	Various colors, but commonly in black, white, clear, green, or white-on-black	23–39 μm	1–2 years	$0.1	Yes
BDM	Black, white, clear, or green	12–25 μm	<1–2 years	$0.1–0.7	Different across countries

Huan Zhang, Carol Miles, Beverly Gerdeman, Deirdre Griffin LaHue, Lisa DeVetter, Plastic mulch use in perennial fruit cropping systems – A review, Scientia Horticulturae, Volume 281, 2021

Landscape Fabric

- Non-biodegradable
- Thicker and durable
- Strength from weaving
- Landscape fabrics made from polypropylene *can* last for years- upfront cost higher, but can provide control for establishment years
- Reflective properties can positively impact fruit production for lower canopy fruit crops
- Soil warming?

Installation and Care

- Tuck plastic into soil to prevent weed creep
- Determine hole size for each individual plant (varies for tree vs shrub vs vine)
- Fertigation can ensure proper plant nutrition
- Planting hole weed management
- Disposal can be tedious and difficult as years go on

Biodegradable Plastic

- Degraded by soil microorganisms, UV radiation, “weathering”
- Degrades into water, CO2, and microbial mass within 2 years
- Meant to avoid environmental and economic costs of disposal
- Some products may not actually meet standards for degradation
- Helpful for establishment year w/wood mulch on top
- **May not be compliant with Organic standards**

OMRI
vs
Environmental Benefits

Other mulch sources

- Shredded paper: idea pre hydro mulch
- Felted paper mulch
- Peat moss: ideal for lowering pH for crops like blueberries (environmental impact)
- Other materials

Photos by Sarah Foltz Jordan, Xerces Society

Post hop planting weed and sucker management

Part II Chemical Management

Note: Herbicide damage on hops is real

Glyphosate
Symptoms: chlorosis, leaf crinkling, leaf strapping, stunting

Prevent accidental drift by…

- Spraying appropriate rates
- Spray at the appropriate time
- Spray when wind levels are low
- Follow the label (The label is law)
- Clean out equipment thoroughly after using herbicides like 2-4,D

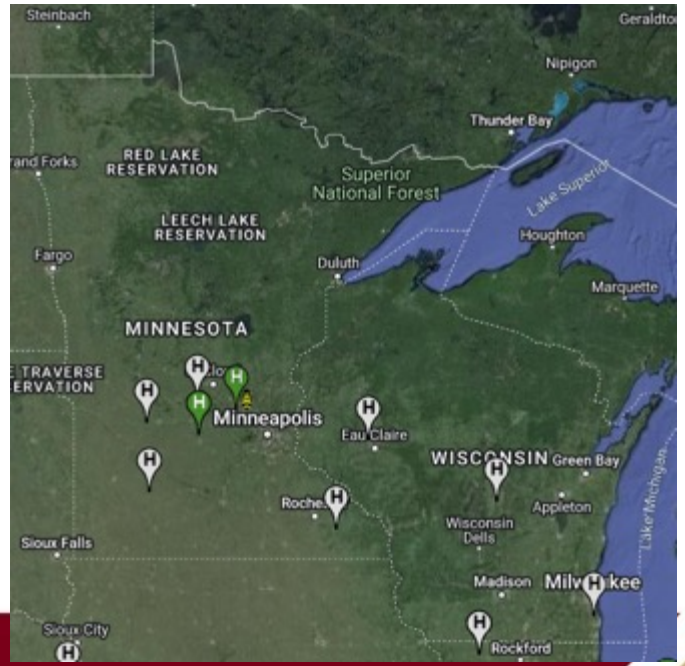
Sign up for DriftWatch

- Put yourself on the map
- Be in touch with your county about roadside spraying

FieldWatch
Communication. Cooperation. Collaboration.

driftwatch
Specialty Crop Site Registry by FieldWatch

beecheck
Apiary Registry by FieldWatch



What to do about external herbicide drift

MDA can potentially help- contact immediately

- Crop can be tied up until case is concluded
- Organic Cert. can be disrupted

Herbicide usage for weed control: Caution

- Mention of a pesticide or use of pesticides is for educational purposes only. Always be sure to read and follow directions on the label attached to the pesticide. The label is the law.
- Be sure your selected pesticide is indeed labeled for grapes.
- Be sure to observe number of days between application and 1. **re-entry interval** and 2. **harvest interval**

Diversified Weed Management Note: Do not rely on one chemical alone for control. Remember to rotate and combine tactics when possible.

Resources for weed control in hops

Registered herbicides

Registered herbicides for use on hops in Michigan, 2023

Application timing[1]	Broadleaf or grasses	Active ingredient (WSSA code[2])	Products labeled	REI/PHI[3]	Notes
Post- emergent	Both	glyphosate (9)	Abundit Edge, Buccaneer, Buccaneer Plus, Cornerstone Plus, Credit 41 Extra, Credit 5.4 Extra, Credit Xtreme, Duramax, Durango DMA, Envy, Envy Intense, Envy Six Max, Gly Star Original, Glyphogan, Gly Star Plus, Gly Star K Plus, Honcho K6 Herbicide, Makaze, Honcho Plus, Razor, Roundup PowerMAX, Roundup WeatherMAX, Showdown, Wynca USA Sunphosate 41% Herbicide	see label/14d	Apply only when green shoots, foliage or canes are not in the spray zone. Best combined with a pre-emergent early in spring for control of emerged annual and perennial weeds.
	Both	ammonium nonanoate	Axxe*	4h/0d	OMRI listed.
	Both	pelargonic acid (27)	Scythe	12h/see label	Uses prior to crop emergence, dormant or post harvest spray.
	Both	caprylic + capric acid	HomePlate 80L*	24h/	Avoid contact with crop stem and foliage. OMRI listed.
	Broadleaf	carfentrazone (14)	Aim EC[4], Antik EC	12h/7d	Use with shielded or hooded sprayers to control small broadleaf weeds and hop suckers and lower
	Broadleaf	2,4 D (4)	2,4 D Amine 4, Clean Amine, Drexel De-Amine 4, Radar AM 4, Rugged, Shredder Amine 4, Tenkoz Amine, Weedar 64,WeeDestroy AM-40 Amine Salt, Weed RHAP A 4D	see label	Controls most annual and perennial broadleaf weeds. Restricted in areas of Berrien, Van Buren and Cass County.
	Broadleaf	clopyralid (4)	Spur	12h/30d	Controls Canada thistle. Some activity on horsenettle at high rate.
	Grasses	clethodim (1)	Arrow 2EC, Avatar, Avatar S2, Ceridian 2 EC, Cleanse, Cleanse 2EC, Clethodim 2E, Clethodim 2EC, Dakota, Intensity One, Intensity Post-Emergence, Omni Brand Clethodim 2 EC, Section Three, Select Max with Inside Technology, Select 2EC, Shadow, Shadow 3EC, Tapout, Tide USA Clethodim 2EC, Vaquero, Volunteer	see label	Controls annual and perennial grasses.
Pre- emergent	Annual grasses/ broadleaf	trifluralin (3)	Cornbelt Trifluralin EC, Treflan 4L, Treflan HFP, Treflan TR-10, Trifluralin 10G, Trifluralin 4EC, Triflurex HFP, Trust	12h/see label	Rate determined by soil type- see label. Apply during dormancy.
	Broadleaf	isoxaben (21)	Trellis SC[5]	12h/see label	Apply banded applictions prior to emergence. Product is water activated.
	Both	flumioxazin (14)	Chateau Herbicide SW, Chateau EZ, Flumi 51 WDG, Flumi SX Herbicide, Flumioxazin 51% WDG, Tuscany, Tuscany SC Herbicidem, Varsity, Venue, Zaltus SC	12h/30d	Apply banded to dormant hops. Controls most broadleaves and grasses, weak on horseweed.
	Both	dimethenamid-P (15)	Outlook Herbicide	12h/60d	Apply in a band over the row preemergence or directed next to rows postemergence. Use low rates on light soil.
	Both	indaziflam (29)	Alion[5]	12h/see label	Do not apply to baby hops or on sandy soils. Dormant application
	Both	pendimethalin	Prowl H20	24h/90d	Apply as a broadcast or banded treatment using ground equipment. Do not apply over the top of vines, leaves or cones.
	Both	norflurazon (12)	Solicam DF	12h/60d	Rate determined by soil type, wait 6 months after planting for first application.

1. Pre-emergent herbicides should be applied to control weeds before germination takes place. Post-emergent herbicides may be applied to actively growing weeds. **2.** WSSA = Weed Science Society of America mode of action code listed for resistance management planning. **3.** PHI-preharvest interval, REI-restricted entry interval, expressed as h-hours or d-days. **4.** Growers must print and retain a copy of supplemental or local need labels. **5.** Supplemental label required.

* OMRI approved for organic production.

Michigan State University Extension, 2023

Herbicide registration for hops in MN/WI

Conditions for a Section 24(c) Special Local Need Registration

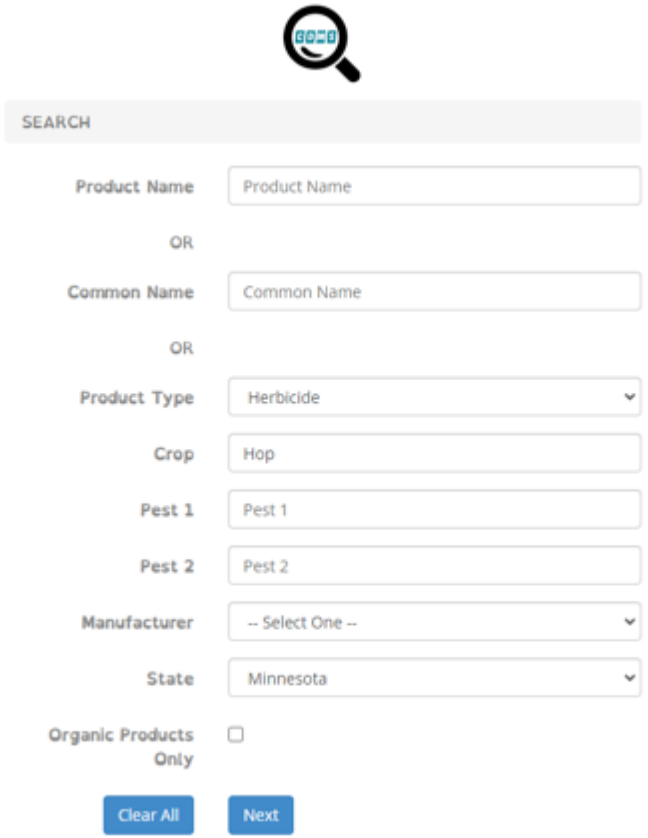
1. **There is a special local need for the use within the state**

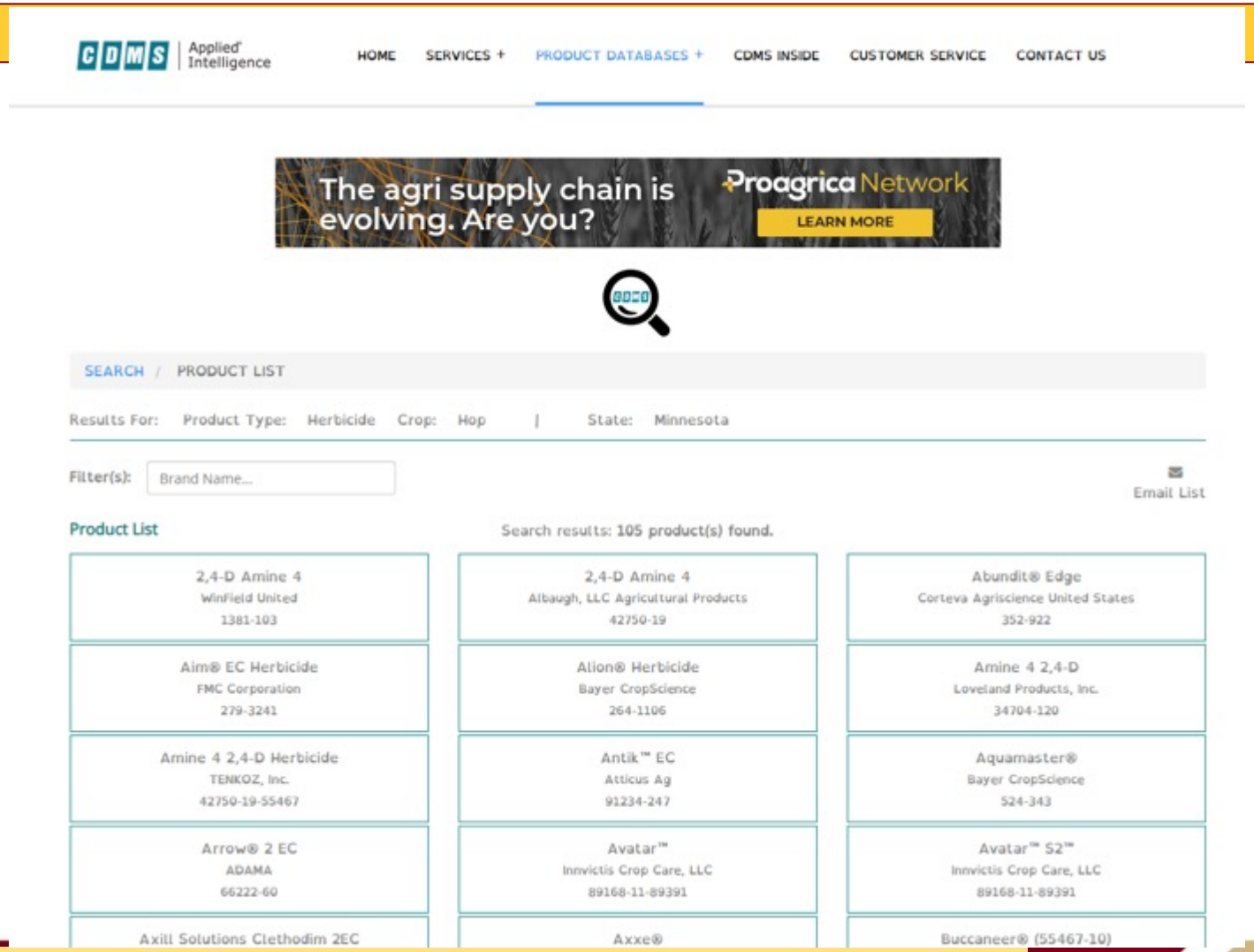
Special local needs may include a new method or timing of application, new crop/new site, new pest, changed rate, application in particular soil type, new product/different formulation, and products useful in managing pesticide resistance in a particular crop.

Haley Johnson w/MDA is lead on pesticide registration in Minnesota

https://www.mda.state.mn.us/fifra-section-24c-special-local-need

Herbicide registration for hops in MN/WI: CDMS





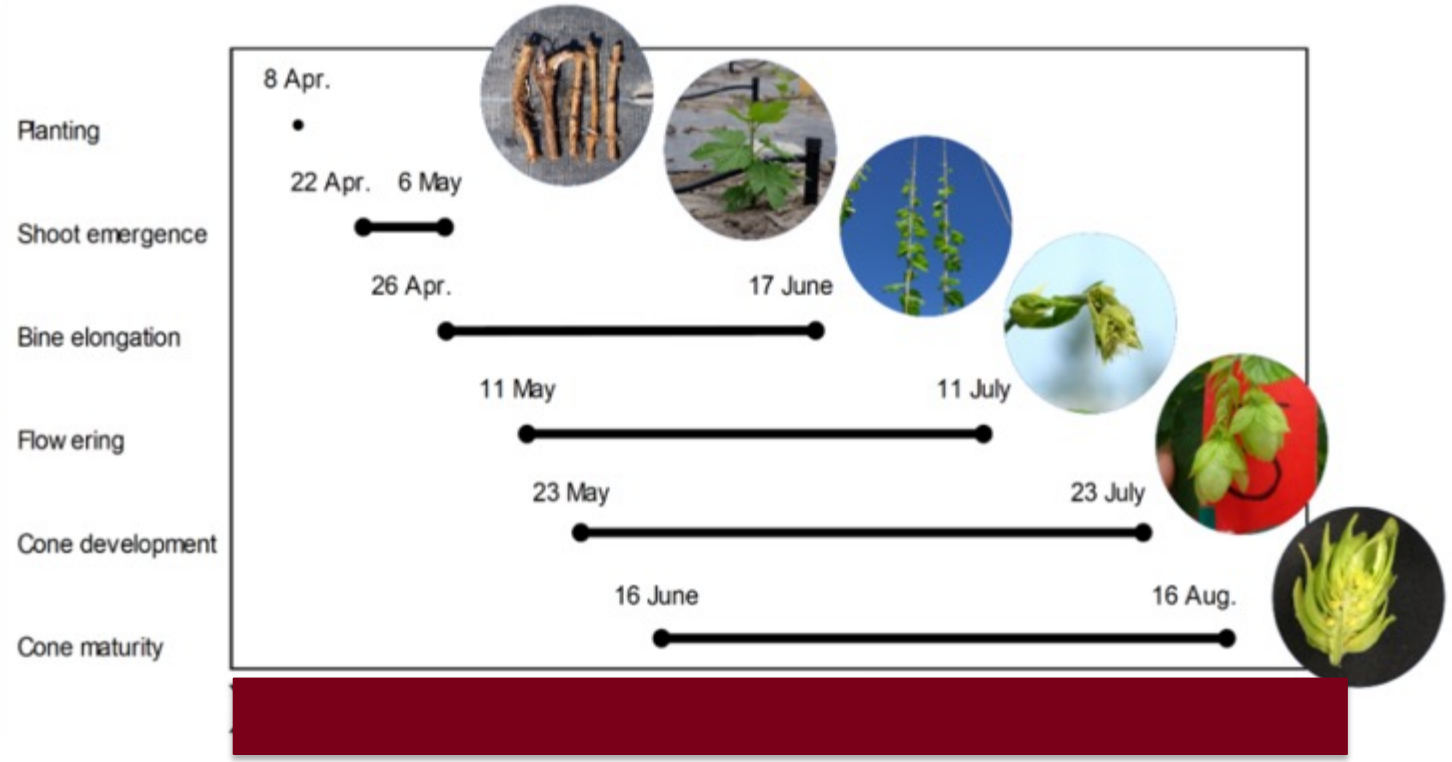
Herbicide usage for weed control: Grasses

With grass herbicides, be sure to use appropriate adjuvant per label

Information and pictures from Charlier Rohwer

Herbicide usage for weed control

The phenological stages of hops.



Herbicide application in-row/banded rates calculated based on areas of hops rows

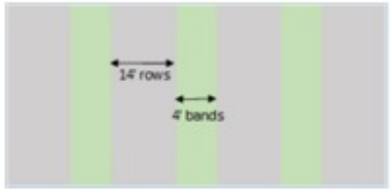
- Exclude area of alleyways to accurately follow label rates
- This means more total area coverage from less product than field crops

Example for determining banded rates.

1. Divide 1 acre in sq. ft. by row spacing in ft. to determine feet of row per acre. *43,560/14 = 3,111ft*

2. Multiply the feet of row by the band width to get the area to be treated. *3,111' x 4' = 12,444 sq. ft.*

3. Divide the treated area by the area of an acre to get the percentage of acre treated. *12,444/43,560 = 0.28 = 28%*



4. Multiply the herbicide broadcast rate by the percentage of an acre as determine in step 3.
1 lb. x 0.28 = 0.28 pounds

5. Multiply the recommended volume of water for an acre by the percentage of an acre as determined in step 3. *30 gallons x 0.28 = 8.4 gallons.*

PRE Emergent Herbicides

- Must be applied to bare ground
- Stops new weeds from emerging
- Active for several weeks
- Can be combined with POST emergence herbicides

POST Emergent Herbicides

- Kill weeds that are actively growing
- Most do not contain residuals (will not carry over to new plants that germinate)
- Some are “burn down” (e.g., glyphosate) vs others that are slower to act
- Some are selective, others are more general
- Consider risk and active target of each herbicide (weed ID)

WEED MANAGEMENT IN WISCONSIN HOPS

D. HEIDER AND J. COLQUHOUN, UNIVERSITY OF WISCONSIN-MADISON

A number of herbicides are registered on hops in the Pacific Northwest only. This guide includes the herbicides that are registered for use on hops in Wisconsin as of March 2016. Pesticide labels change often. This guide is not a substitute for the label. Always read the pesticide label prior to use.

Herbicide active ingredient	Commercial product rate/A	Application timing	Days to harvest	Remarks and suggestions
norflurazon	2.5 – 5.0 lbs Solicam DF	PRE	60	Controls several broadleaves and grasses. Apply as a directed spray. Wait at least 6 months after planting hops before applying. Apply to clean soil surface either in fall after tillage or in spring. Use lower rate on coarse soils and higher rate on fine soils.
trifluralin	Several trade names, such as Treflan	PRE		Controls several annual grasses and a few broadleaf weeds. Apply and incorporate 1 to 2 inches when crop is dormant. Do not spray over hop crowns. Will not control emerged weeds. Rate varies by soil texture.
flumioxazin	6.0 oz Chateau SW	PRE and sucker control	30	Controls several broadleaf weeds and some annual grasses. Sucker control: Apply as a directed spray after hops are at least 6 ft tall. Direct spray to the lower 2 ft of hops. PRE weed control: Apply to dormant hops November through February as a 1 to 1.5 ft band to each side of the hop row. Don't apply with an adjuvant or allow spray to contact green stems (unless for sucker control), foliage, flowers or cones or unacceptable injury may occur.

https://z.umn.edu/uw_hops_herbicides

carfentrazone	2.0 fl oz Aim EC	POST and sucker control	7	Available in Wisconsin through December 31, 2019 as a Special Local Needs (24c) label. For sucker management and control of some young, actively growing broadleaf weeds. Sucker control: Apply to the bottom 1.5 ft of the hop plant and to the sucker mat that extends from the base of the plant to 1.5 to 2 ft into the row. See label for adjuvant requirements. POST weed control: weeds need to be newly emerged and actively growing. Apply using shielded or hooded sprayers. Avoid upward spray drift to new hop growth. Avoid applications until newly trained hops have developed sufficient barking and are high enough up the string to avoid contact with the apical bud. Allow 14 days between applications and don't exceed 7.6 fl oz per acre per season.
glyphosate	Several trade names, such as Roundup	POST	14	Apply to actively growing weeds as a row middle, shielded, wiper, directed or spot treatment application. Glyphosate will injure or kill hops. Do not allow contact of spray with green hop stems or foliage.
2,4-D	Several trade names, such as Weedar 64	POST	28	Make directed applications to row middles for control of small broadleaf weeds. Up to three applications per season are allowed with at least 30 days between applications. Avoid drift – do not allow spray to contact hop foliage or apical buds.
clethodim	Several trade names, such as Select, Select Max	POST	21	Controls most annual grasses and several perennial grasses, but not broadleaves. Apply to actively growing grasses, including appropriate adjuvant as directed by the label. Rate depends on targeted grass species. Wait at least 14 days between applications and don't exceed total seasonal maximum use rates.

Weeds typically become more herbicide tolerant as they grow

Success happens when POST herbicides are applied…

- At the appropriate rate
- At the appropriate time (weed less than 6-12in tall)
- “Pop can rule” (Soda can rule for Wisconsin?)

Herbicide usage for weed control: Glyphosate

- Glyphosate can be applied in spring just as or before shoots start to emerge.
- Timing is important to avoid hop damage.
- Damage is more likely in the fall, when green tissue moves the glyphosate into the roots.

Glyphosate Damage

Healthy Hop Bines

Herbicides used for sucker control

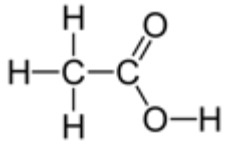
Apply before sucker mat becomes woody

- Flumioxazin (Chateau SW; Group 14)
  - 6 oz/A POST after hops have reached a minimum of 6 ft, apply to lower 2 feet of bines and sucker mat
- Carfentrazone (Aim E; Group 14)
  - .5-2 fl oz/A, requires non-ionic surfactant or crop-oil-concentrate, basal portion of bines and sucker mat
- Pelargonic acid (Scythe; Group 27)
  - 5-10 gal/A of 2-2.75 quarts/10-gallon water solution, basal portion of bines and sucker mat

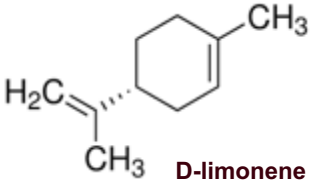
ORGANIC HERBICIDES

About

- Non-systemic
- Efficacy varies between regional climates, weed types, stage of growth when applied
- Most effective on annual broadleaf weeds (Brainard et al., 2013)



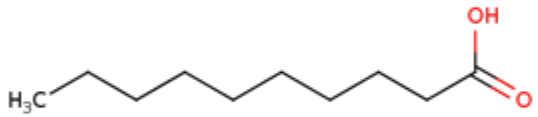
Acetic acid (Vinegar)



D-limonene

Examples

- Acetic Acid (i.e., Vinegar)
- Essential oils (e.g., clove, pine, D-limonene)
- Fatty acids (e.g., caprylic & capric acid)

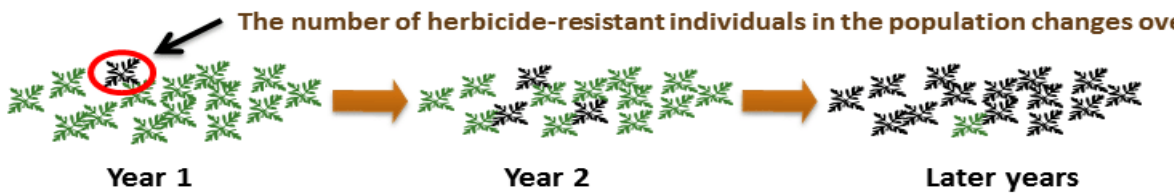


Capric Acid

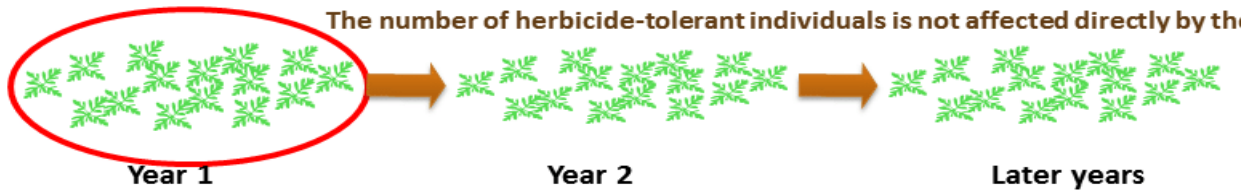
Herbicide Resistance

Herbicide Resistance Defined

Herbicide resistance can be defined as the acquired ability of a weed population to survive a herbicide application that previously was known to control the population.



Herbicide tolerance is the inherent ability of a species to survive and reproduce after herbicide treatment. There has been no selection acting on the tolerant weed species, and there has been no change in the weed species lack of response to the herbicide over time.



Avoiding Herbicide Resistance

Tips:

- 1) If you used an herbicide more than 2-3x last year, use something different next year
- 2) Alternate herbicides of different chemical groups/modes of action between applications
- 3) Avoid heavy reliance on glyphosate. Glyphosate resistance is common.

Concluding statements

- Start with an **integrated weed management** perspective
- **Timing** matters, pre planting management helps a lot!
- When using herbicides, adopt a **diversified weed management** approach and rotate herbicides- timing cannot be ignore either
- Know your resources and keep them close

Thank you!

Questions/discussion welcome!