Keeping the Weeds at Bay: Recommendations for Greenhouse Weed Control

Michigan Greenhouse Growers Expo (The Great Lakes Fruit, Vegetables and Farm Market Expo)

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What are Weeds?

- Undesirable plant in a particular situation
- “A plant in the wrong place”
- Can interfere with human activities
- Taxonomically, the term “weed” has no botanical significance
- A rose plant can be considered weed in a field of corn

Problem

- Persistent problem in greenhouses, hoop houses, enclosed structures
- Weeds can be found:
  - Within the containers of stock plants, liners, finished plants
  - In container holes
  - Under the greenhouse benches
  - Near walkways within structures

Problem

- Weeds reduce overall quality of ornamentals
- Affect growth and market value
- Competes for
  - Nutrients
  - Water
  - Space
  - Light
  - Oxygen

Problem

- **Harbor pests and diseases**
  - ❑ **Examples of insects: whiteflies and thrips**
  - ❑ **Examples of pests: mites, slugs, and snails**
  - ❑ **Examples of diseases: Bittercress and woodsorrel are hosts for impatiens necrotic spot virus and tobacco spotted wilt virus, which may be vectored to susceptible host crops by thrips**

Yellow woodsorrel

Hairy bittercress

Common Greenhouse Container Weeds

Yellow Woodsorrel (*Oxalis stricta*)

Habitat: Drain holes of containers or on container media surface; Found in full-sun and partial-sun areas; can be found in greenhouses and in container nurseries

Yellow Woodsorrel (*Oxalis stricta*)

Growth Habit: Usually upright and readily branching, but may also grow prostrate

Shoot: Stems light green in color and slightly hairy. Leaves are palmately compound, alternate and light green

Yellow Woodsorrel (*Oxalis stricta*)

Inflorescence: Three flower stalks branch from a single main stalk. Flowers are yellow, have 5 petals. Flowers from spring through fall

Fruit and Seeds: Capsule fruit, resembling the shape of okra pods. Mature capsules explosively dehisce when touched.

Hairy Bittercress (*Cardamine hirsuta*)

- **Habitat: In greenhouses, container pads, growing media, and nursery pots**
- **Often found in irrigated or shaded areas but can grow in full sun**
- **Found both in greenhouses and container nurseries**
- **Growth Habit: Dense basal rosette or upright growth habit**
- **Mustard family**

Hairy Bittercress (*Cardamine hirsuta*)

- Rapidly growing winter or summer annual
- Stems erect, smooth, angled stems branch mainly at the base
- Leaves are compound with 2 to 8 alternately arranged leaflets and larger terminal leaflet
- Leaflet margins are shallowly toothed to lobed
- Mostly hairy leaves initially develop from a basal rosette

Hairy Bittercress (*Cardamine hirsuta*)

- Flowers are very small, white with 4 petals
- Flowers arranged in terminal clusters
- Fruits are very narrow, about 1-inch long, upward-pointing capsules
- Fruits explosively eject numerous small seeds
- Seeds are very minute
- Multiple generations may be produced in a single year

Birdeye Pearlwort (*Sagina procumbens*)

- Grows well on sandy ridges, in open woodlands, rocky open ground
- either natural or disturbed areas where there is scant vegetation on the ground
- moisture is abundant and frequently irrigated such as nursery containers, roadsides, sidewalk cracks, usually on wet gravelly to sandy soil in coastal areas
- Found both in greenhouses and container nurseries

Birdeye Pearlwort (*Sagina procumbens*)

- Mat-forming plant
- Narrow leaves, ending in a bristle-like point
- Root system: Shallow slender taproot, divides very frequently into secondary roots.
- Leaves: Pairs of opposite leaves, ½" long, bright green, forms a rosette of leaves
- Stems: Bright green, glabrous, and tend to sprawl across other stems or the ground.

Other Important Weeds of Greenhouses

Large Crabgrass

Common Groundsel

Other Important Weeds of Greenhouses

Spotted Spurge

Common Chickweed

Liverwort

- Become highly competitive with ornamental crops for
  - Water
  - Nutrients
  - Space
- Can prevent irrigation water and fertiligation from reaching root zone of ornamentals
- Reduce overall quality and market value of ornamentals

Liverwort

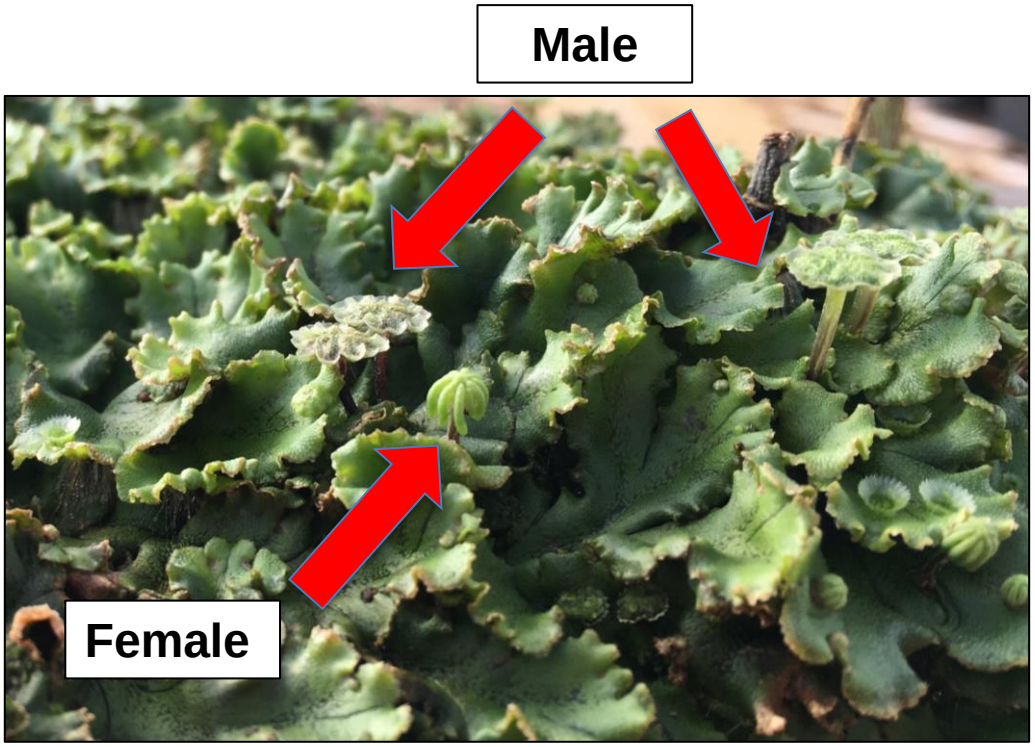
- Major weed in production nurseries and greenhouses
- 6,000 to 9,000 species
- *Marchantia polymorpha* is the most common in container nurseries and greenhouses
- Growing on container substrate, nursery ground cloth areas, poorly drained or moist areas

Liverwort

- Gemma cups along middle of each lobe on upper surface
- Cups have circular membranous rims
- Each gemma cup can produce numerous gemmae
- Gemmae are released to immediate area when splashed by water from rain or irrigation.

Liverwort

- Temp between 50 and 59 F
- Sexual structures or fruiting bodies develop
- Male and female structures borne on separate thalli
- Antheridia (male) produce sperm; located on the upper surface of a flattened disc atop a narrow stalk called antheridiophore
- Archegoniophores (female) are also stalked
- Archegonia, produce eggs, are located on the underside of lobes



Nostoc sp.

- Slimy and slippery in presence of moisture
- Composed of aggregated and entangled trichomes (chains of cells)
- Macroscopic mats and gelatinous colonies
- Cause safety issue for nursery growers and workers
- Control:
  - Good sanitation
  - Chemicals such as TerraCyte PRO and Scythe have shown some effective control

Nostoc **growing container production**

Non-chemical Control

Prevention and Sanitation Practices

- Clean and sterile substrate or media and containers
- Avoid storing media under benches
- If reusing containers, wash thoroughly with pressurized water and chemical disinfectants to remove weed seeds, pathogens, and dirt
- Storage areas need to be free of weeds
- Concrete floor and weed barrier fabrics can help to reduce weed seed germination
- Weeds growing immediately outside greenhouse need to be controlled
- Regular scouting inside the greenhouse and inspection of new shipments need to be done

Prevention and Sanitation Practices

Chemical disinfectant products such as quaternary ammonium chlorides can be applied to hard and concrete surfaces to avoid algae, liverwort and moss growth

Cultural: Physical barrier or Mulching

- geo-discs, coco fiber weed discs etc.
- Loose organic mulch

Cultural: Organic Mulching

Topdressing larger containers with 1 to 2 inches of organic mulch materials, such as pine bark or rice hulls, is another strategy which can create a physical barrier and help reduce weed emergence and growth.

Benefits of Organic Mulching:

- Reduction of weeds
- Improved soil moisture
- Maintenance of optimal soil temperature
- Increased soil nutrition
- Reduction of pesticide contamination
- Improved plant establishment
- Enhance root establishment & transplant survival

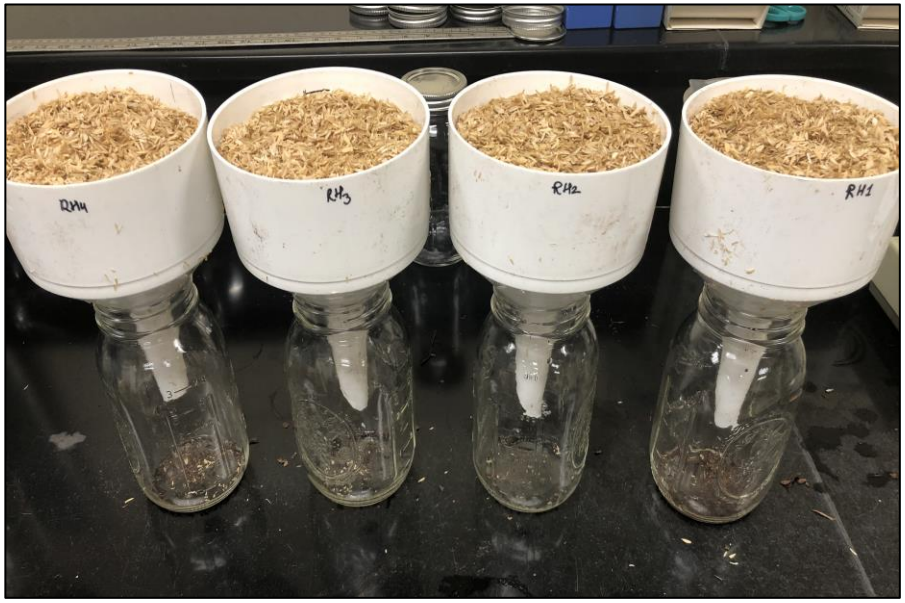
Problems related to mulching

- Acidification
- Diseases

- Pest problems
- Require re-applications

Liverwort control by mulching (MSU project)

Moisture holding capacity and percent moisture retention of 4 different mulches using Buchner funnels at 1, 4, and 24 hrs after 0.4 inches of irrigation



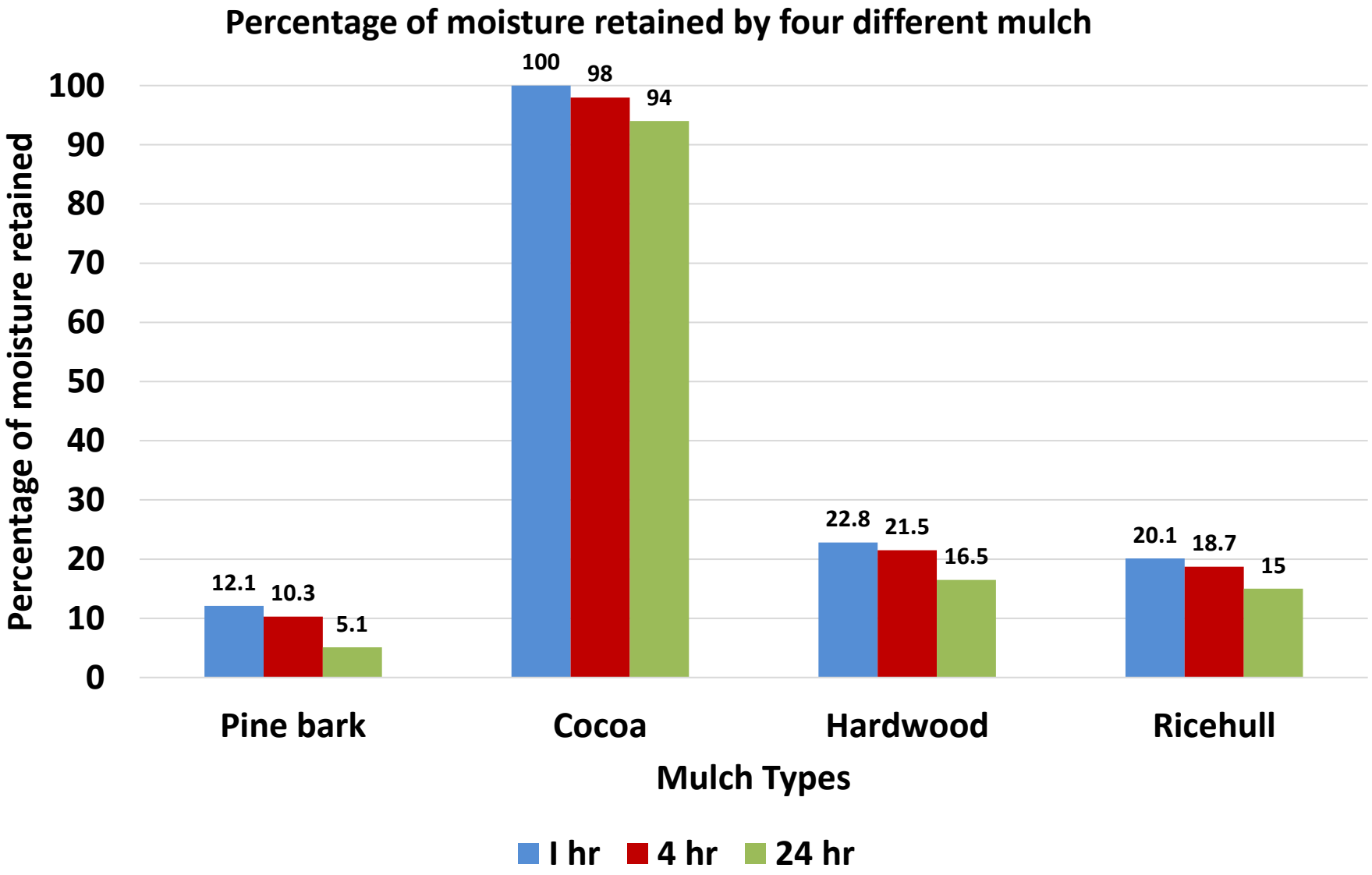
Pine bark

Cocoa shell

Rice hull

Red hardwood

Results: Laboratory Experiment



Methods: Greenhouse experiment

Ornamental plants:

- *Hosta* sp (2 varieties)

Curly Fries

Pandora Box

Methods: Greenhouse experiment

Nursery pots filled with substrate

↓

Hosta plants were potted

↓

Mulch types (RH, HW, CH, or PB) were added

↓

At depths of 0.25, 0.5, 1,or 2-inches depths

Irrigation at 0.4 inches

↓

After 1 day, liverwort gemmae were applied to each pot

↓

Gemmae application continued bi-weekly for 12 weeks

↓

Daily irrigation continued at 0.4 inches

Methods: Greenhouse experiment

Data collection:

- **Percent of container surface covered by liverwort thalli [2, 4, 6, 8, 10, and 12 weeks after treatment (WAT)]**
- **Fresh weight of thalli (12 WAT)**
- **Growth indices (height and two widths) of the *Hosta* sp (At beginning and 12 WAT)**

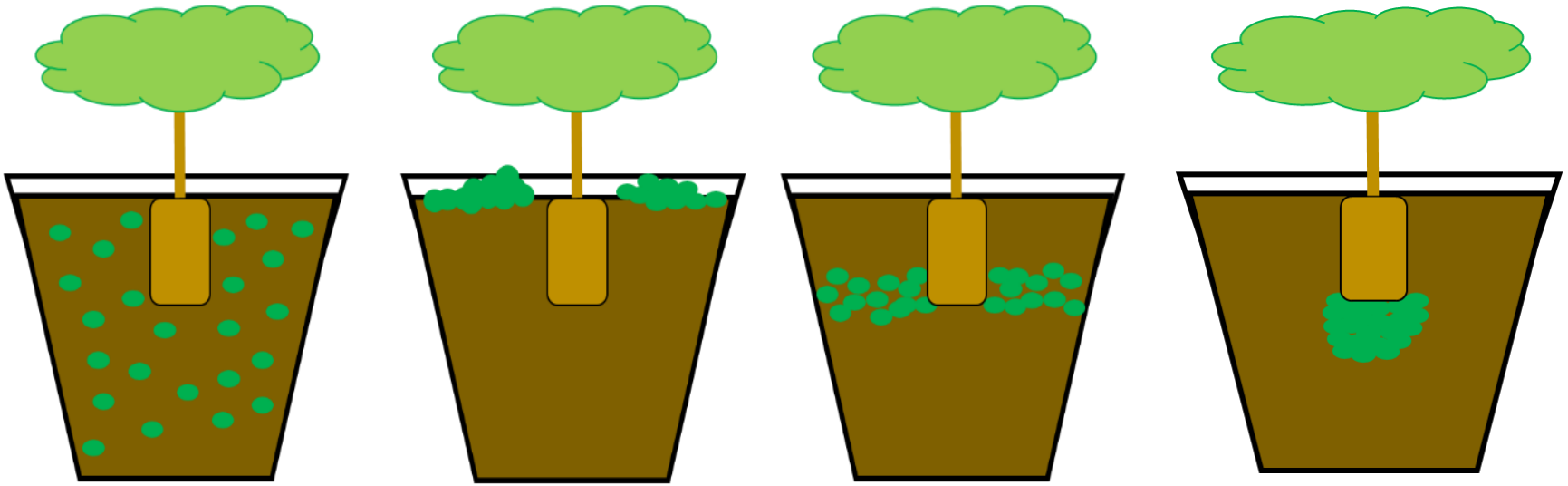
Conclusions

- **Cocoashell mulch retained highest amount of moisture among all 4 mulch types**
- **For Curly fries:**
  - **Ricehull and hardwood at depths of 0.5 in. or more provided excellent liverwort control.**
  - **Cocoashell provided least liverwort control**
- **For Pandora box, all mulch at depths of 0.5 in. or more have shown excellent liverwort control**
- **Two inches of cocoashell and hardwood mulch caused reduction in growth of Curly fries and Pandora box, respectively**

Take Home Message

Ricehull and pinebark mulches at depths of 0.5- 2 inches can provide an excellent liverwort control and no reduction in growth of Curly fries and Pandora box varieties of Hosta sp. as these mulch types retained very less moisture.

Cultural: Strategic Fertilizer Placement



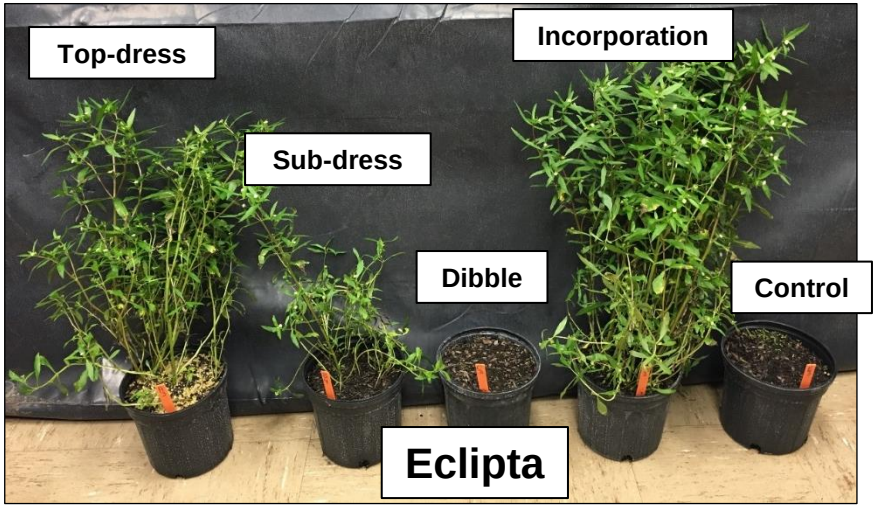
Incorporation

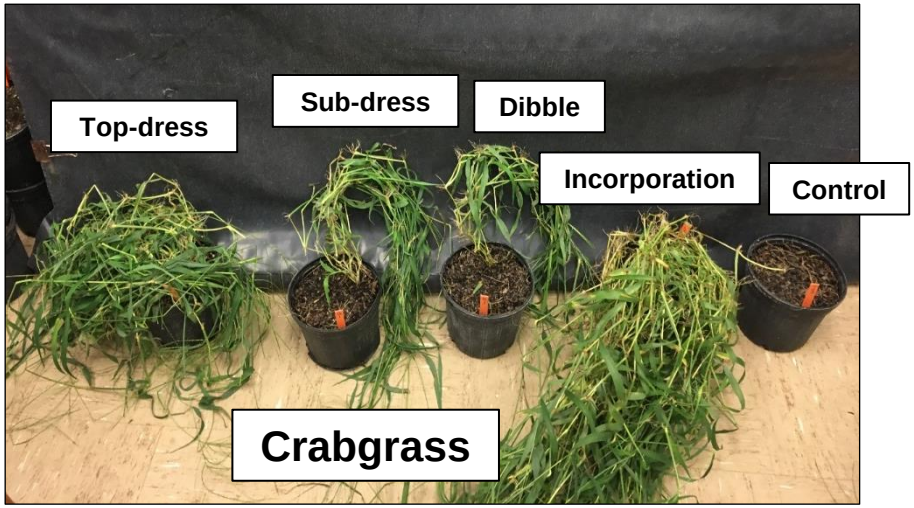
Top dressing

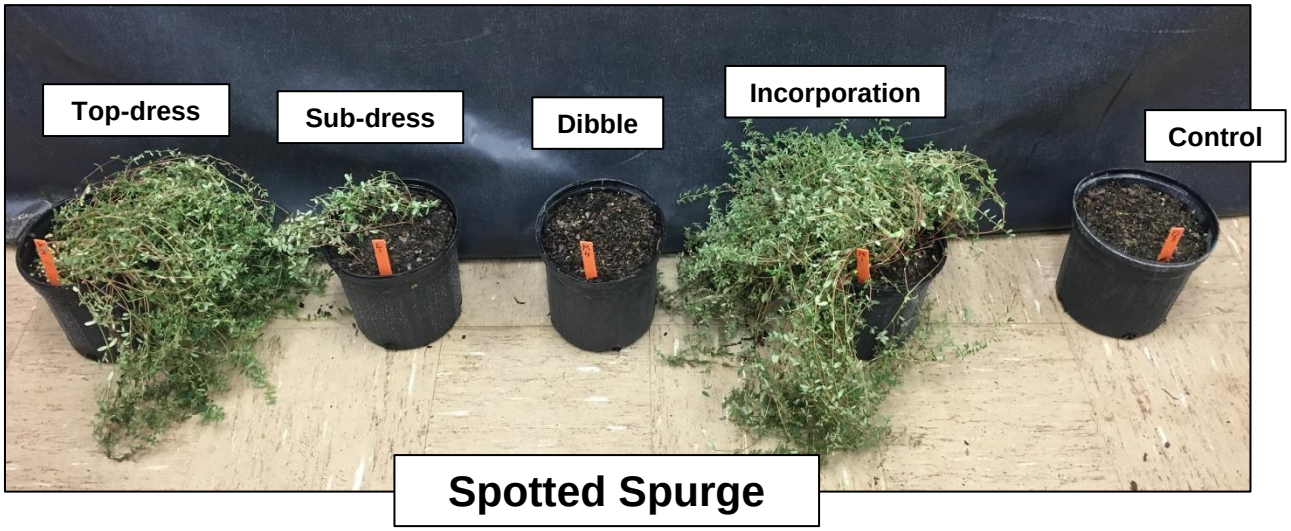
Sub dressing

Dibble

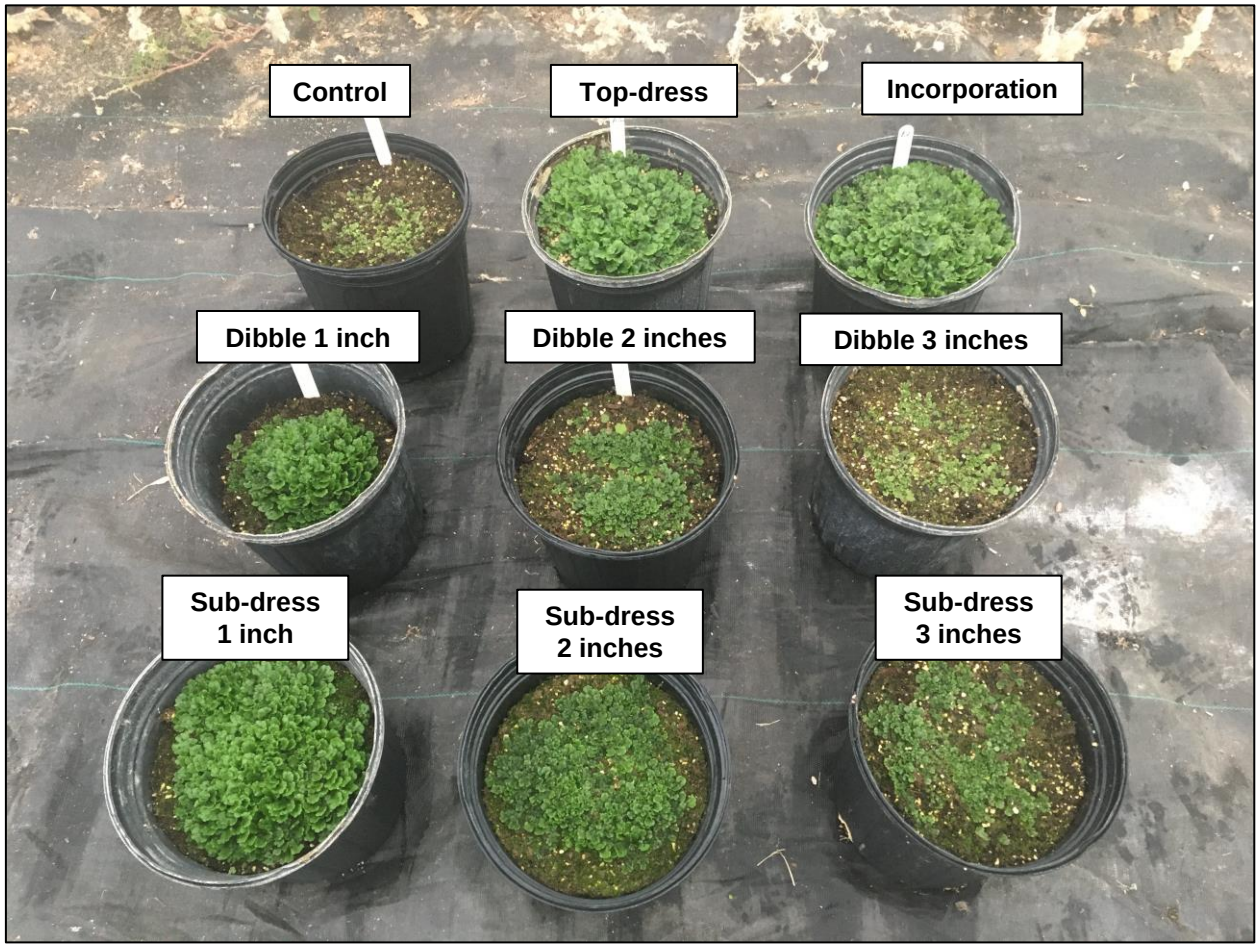
Cultural: Strategic Fertilizer Placement Study on Weed Growth and Reproduction



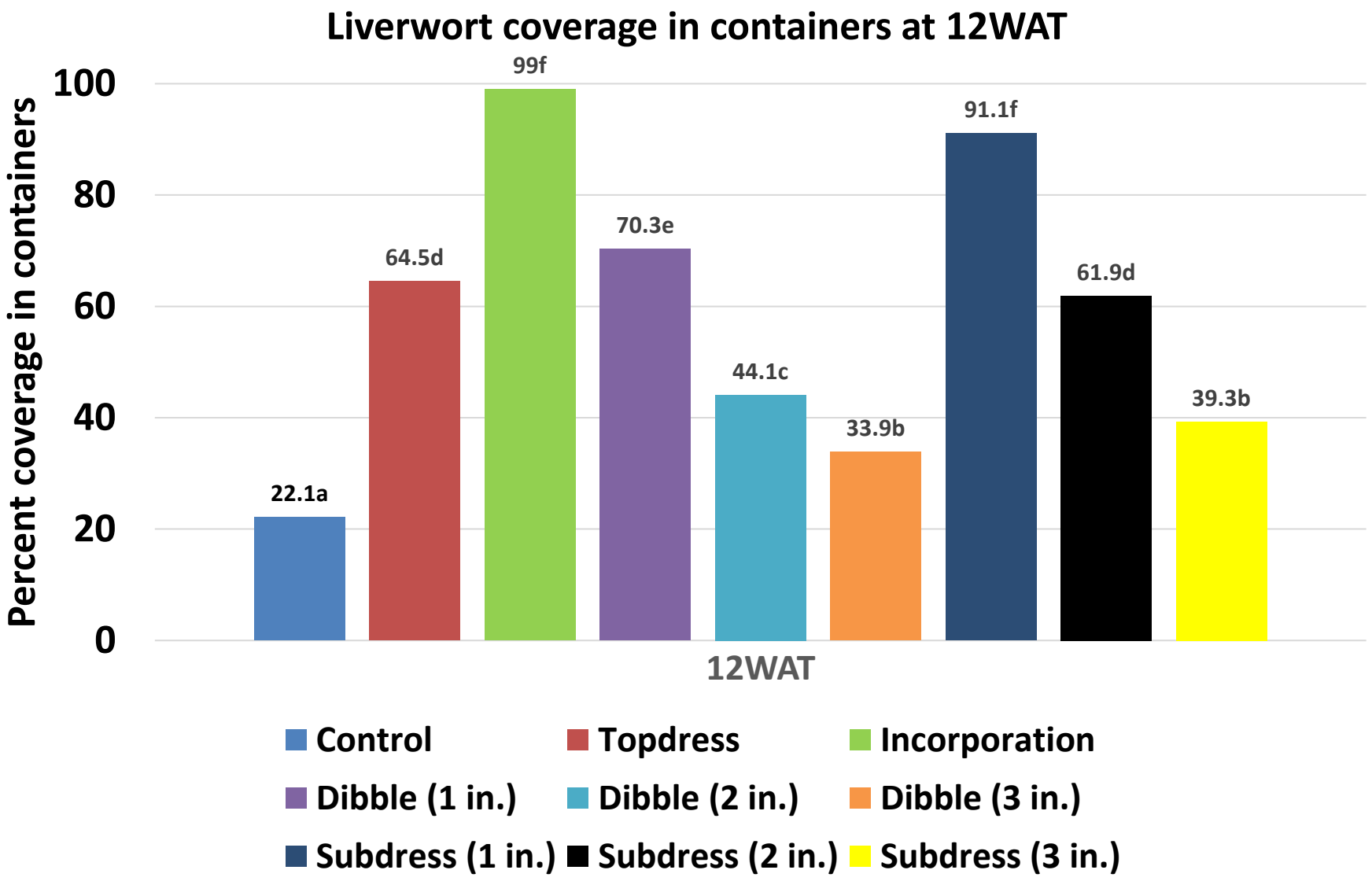




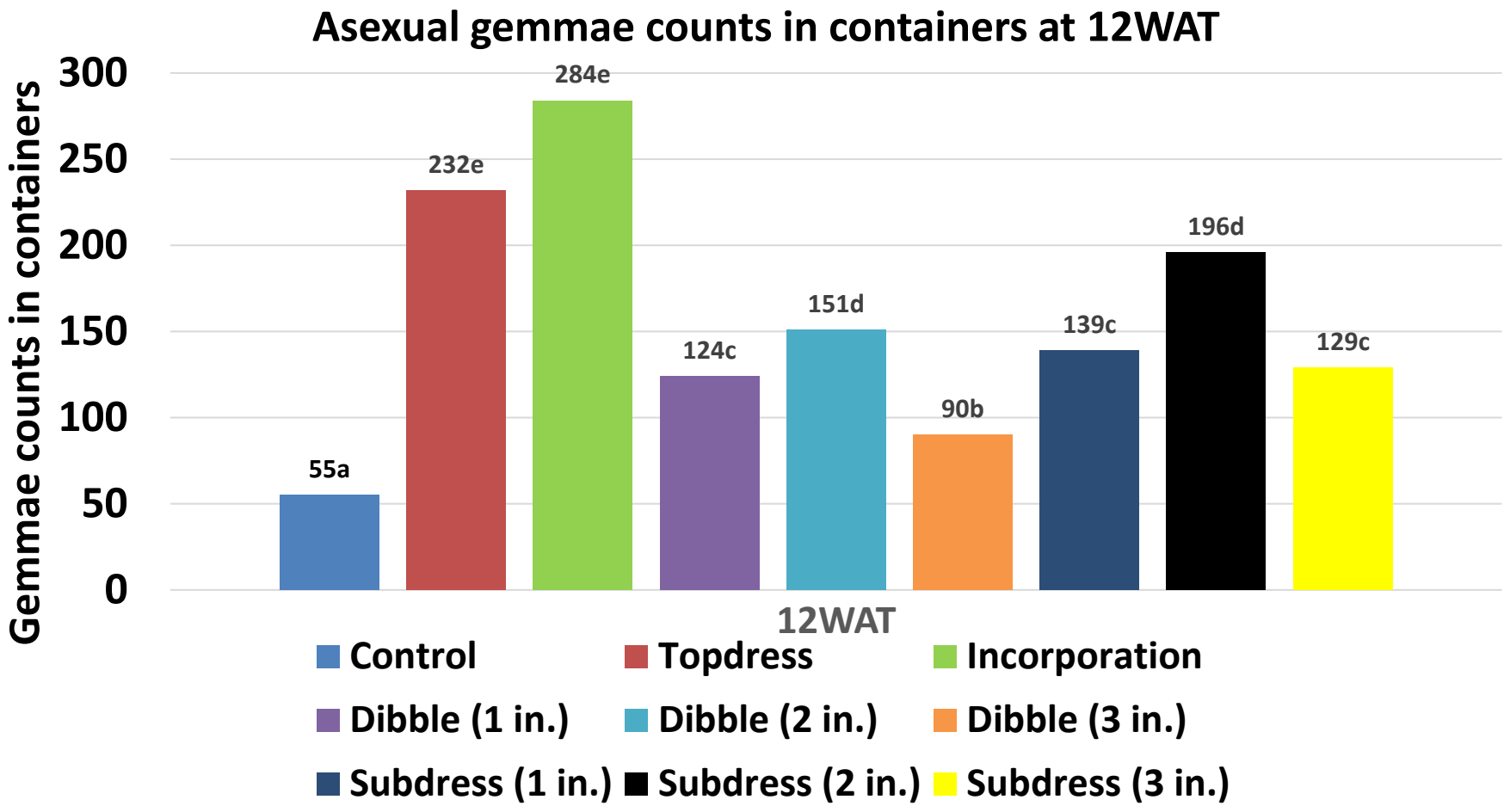
Cultural: Strategic Fertilizer Placement Study on Liverwort Growth (MSU Project)



Results: Liverwort Growth at 12WAT



Results: Liverwort Asexual Reproduction at 12WAT



Take Home Message

- **Dibbling can lead to phytotoxicity of ornamental root ball as the fertilizer is placed in a small pocket and it can come in direct contact with the ornamental root ball.**
- **Subdressing of controlled-release fertilizer at a depth of 3 inches is recommended, to control the liverwort in the container production maintaining the safety of the ornamental crops.**

Cultural: Irrigation Practices

- Ensure that irrigation systems are uniformly applying water
- take weather patterns that decrease water demand by the crop (cool, cloudy weather) into consideration to avoid overwatering.
- Properly maintaining greenhouse drains will also prevent water collection on the floor and surfaces.
- Reduce humidity levels, when possible, through ventilation and plant spacing as high humidity may increase weed germination rates

Manual Removal (Handweeding)

- Frequent scouting and hand-pulling of weeds inside the greenhouse can minimize the chances of the weeds to become established and generate more seeds.
- Weed species such as yellow woodsorrel and bittercress can produce thousands of seeds per plant and have nearly a 100% germination rate.
- Therefore, it is highly recommended to hand-pull these species when young, prior to flowering.
- After hand-pulling weeds, remove weed materials from the greenhouse floors as these weeds are resilient and can re-root in the humid conditions

Chemical Control

Chemical Control

- Very few herbicides labeled for use in greenhouses
- Injury can occur from spray drift if fans are operating at the time of herbicide application or from volatilization
- Vapors can easily buildup within the enclosed greenhouse and injure the crop plants
- Some organic herbicides can be used inside greenhouses when crops are present (Table 1).
- Products are non-selective, they will injure or kill plant material with which they come into contact;
- Products must be used as directed sprays to avoid crop injury

Chemical Control

Table 1. Organic products for effective weed control that are labeled for use inside greenhouses and enclosed structures.					
Trade name	**Active ingredient**	**Activity**	**Weeds controlled**	**Use with crop**	**REI[1] (hrs)**
Axxe®	ammonium nonanoate	Contact (postemergent)	Non-selective	Yes	24
GreenMatch®Ex	lemon grass oil	Contact (postemergent)	Non-selective	Yes	0
Scythe®	pelargonic acid	Contact (postemergent)	Non-selective	Yes	12
WeedPharm, other vinegar products	acetic acid	Contact (postemergent)	Non-selective	Yes	48
[1]REI= Restricted entry interval. It is the time period after a pesticide is applied when employees may not enter the pesticide treated area without required personal protective equipment.					

Chemical Control

Table 2. Synthetic herbicides for effective weed control that are labeled for use inside greenhouses and enclosed structures (Adapted from Marble and Pickens, 2015; Neal, 2015)

Trade name	Active ingredient	Activity	Weeds controlled	REI[1] (hrs)
Marengo®	indaziflam	Residual (Preemergent)	Annual and some perennial weeds	12
Fusilade® II	fluazifop-butyl	Systemic (Postemergent)	Grasses	12
Finale®	glufosinate	Systemic[2] (Postemergent)	Non-selective	12
Envoy® Plus	clethodim	Systemic (Postemergent)	Grasses	24
SureGuard	flumioxazin	Residual (preemergent with some postemergent activity)	Broadleaf and grasses	12
TerraCyte®	sodium carbonate peroxyhydrate	Contact (Postemergent)	Moss, algae, liverwort	0
Reward®	diquat	Contact (Postemergent)	Non-selective	24
RoundUp® Pro	glyphosate	Systemic (Postemergent)	Non-selective	4
BareSpot Monobor Chlorate	sodium chlorate and sodium metaborate	Contact/ residual (postemergent)	Non-selective	12

[1]REI= Restricted entry interval. It is the time period after a pesticide is applied when employees may not enter the pesticide treated area without required personal protective equipment.

[2]Glufosinate is minimally translocated and can act as a contact herbicide. Thorough coverage is needed.

Chemical Control

- **Using herbicides in and around greenhouses:**
- **BareSpot:**
  - **Kill existing vegetation and prevent weed growth in ground areas within greenhouses**
  - **Should not be used in crop pots**
- **Sureguard/ Marengo:**
  - **Can be applied to gravel or ground under benches, around the foundation or to the ground**
  - **Before crops are placed in the house**
  - **House should be empty at the time of treatment**
  - **Do not move plants into greenhouse for at least 24 hrs after Sureguard treatment.**

Factors to Consider for Successful Chemical Weed Control

- Right identification of target weed species
- Choosing the right herbicide
- Rate of application
- Time of application
- Phytotoxic effect (whether the ornamental plant is on the herbicide label or not)

Herbicide Resistant Weeds

Common Ragweed resistant to clopyralid (Stinger) herbicide

Pigweed resistant to glyphosate (Roundup) herbicide

Common groundsel resistant to atrazine herbicide

Strategies to Avoid Herbicide Resistance

- Try to follow cultural and preventive methods (non-chemical)
- Rotate herbicides with different modes of action
- Use herbicides at their labeled rates and timing
- Follow integrated approach
  - Combine two or more control methods
  - Example: Combining organic mulch with herbicides

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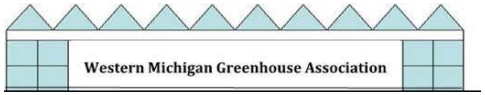
- Western Michigan Greenhouse Association



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Thanks

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Debalina Saha

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Weeds are a persistent problem in greenhouses, hoophouses, propagation houses and other enclosed structures. Hairy bittercress (*Cardamine hirsuta*), yellow woodsorrel (*Oxalis stricta*), spotted spurge (*Euphorbia maculata*), liverwort (*Marchantia polymorpha*) are some of the most common weeds that are found in these structures. Weeds can be found growing within the containers of stock plants, liners, and finished plants, in container drain holes, under benches, and near walkways within the structures. Weeds growing within the containers compete with crops for space, nutrients, water, light, and oxygen; thereby reducing the overall growth and market value. Any weeds growing within the structure can also harbor pests and diseases.

Proper sanitation and the adoption of preventive measures are the first and foremost step in an effective weed control program. The use of clean and sterile substrate or media and containers are recommended for growing ornamentals. Avoid storing media under the benches and if reusing containers, wash them thoroughly with pressurized water and chemical disinfectants to remove weed seeds, pathogens, and dirt. Make sure the storage areas for bulk goods and racks are not infested with weeds or debris. Concrete floors and weed barrier fabrics can help to reduce weed seed germination. Chemical disinfectant products such as quaternary ammonium chlorides are available in the market which can be applied to hard and concrete surfaces to avoid algae, liverwort (*Marchantia polymorpha*), and moss growth. Strategic placement of controlled released fertilizers in containers can further help to reduce weed germination, emergence, and growth. Instead of topdressing with fertilizers, incorporation or subdressing is recommended as it reduces weed access to fertilizers in the top 0.5-1” of media where they germinate. Topdressing larger containers with 1 to 2 inches of organic mulch materials, such as pine bark or rice hulls, is another strategy which can create a physical barrier and help reduce weed emergence and growth. Ensure that irrigation systems are uniformly applying water and take weather patterns that decrease water demand by the crop. Frequent scouting and hand-pulling of weeds inside the greenhouse can minimize the chances of the weeds to become established and generate more seeds.

There are very few herbicides labeled for use in greenhouses due to the potential for crop injury or death. Injury can occur from spray drift if fans are operating at the time of herbicide application or from volatilization. Some organic herbicides (naturally derived) such as ammonium nonanoate (Axxe) and pelargonic acid (Scythe), can be used inside greenhouses. All of these products are non-selective, meaning they will injure or kill any plant material with which they come into contact; therefore, these products must be used as directed sprays to avoid crop injury. Synthetic herbicides labeled for use inside greenhouses are still limited but allow for additional types of activity and in some cases selectivity of particular groups of weeds. Most of the synthetic herbicides are labeled for postemergence use, though there are some preemergence options as well (targeting the germinating seedling) that have residual (long-lasting) activity. The ability to utilize the synthetic herbicides while a crop is present is variable. As an example, flumioxazin (SureGuard) is a preemergent product, however there can be no crop plants present at the time of application. Plants can be moved back inside the closed structure after 24 hours and after the site has been irrigated. Indaziflam (Marengo) is a newer preemergence herbicide that has been labeled for using inside greenhouses and enclosed structures. This herbicide can only be applied to greenhouse floors in absence of crops. Regardless of whether the herbicide is naturally or synthetically derived, it is always recommended to carefully read and follow the manufacturer’s label before

application to achieve the best weed control and to avoid crop, environmental or personal harm. The integration of strategies for weed control, both nonchemical and chemical, is recommended to ensure successful control and prevent crop injury and the development of herbicide resistance in weeds.