

Pest Management

Weed Management

No farmer wants to spend precious time combating weeds. Besides competing with crop plants for light, nutrients and water, weeds may serve as reservoirs for plant pathogens and arthropod pests such as thrips, aphids and spider mites. These pests may also find crop plants attractive. They often act as plant disease vectors, too. Weeds can also turn harvesting and processing of certain crops like salad greens into an aggravating task. For these reasons, and because weeds that produce seeds will cause trouble later, allowing weeds to grow is not a good idea.

Weed problems are compounded by the enhanced microclimate of a high tunnel. Its longer season and more moderate cold season conditions provide a perfect habitat for many weeds. For instance, chickweed, a winter annual that flourishes under the mild winter conditions present inside a greenhouse, can cause serious difficulties for winter salad greens growers.

Whether inside a high tunnel or in the field, reducing the weed seedbank in the soil is a key principle in weed management. Unless preventative measures are taken, high levels of weed seeds are likely to translate into high weed pressure. The good news is that within the finite boundaries of a high tunnel, farmers have found it possible with vigilance and timeliness to regain the upper hand on weeds, even after they have raged out of control.

High tunnel growers use hand hoes, stale seedbed techniques, and plastic and organic mulches to manage their

weeds. Hand hoes are particularly well suited to the intimate environment of a high tunnel. If used when weeds are very small, hand hoes provide fast and effective weed control. Often, a single well-timed hoeing will produce a weed-free salad or cut flower crop. If given a weed-free start and good growing conditions, these fast-growing crops should out-compete weeds. Hand hoes are available in several configurations (e.g., oscillating stirrup hoes, push-pull hoes and collinear hoes), and in sizes ranging from 3" to 12" wide. (See "Tools" section on page 70.)

Stale Seed Bedding

Stale seed bedding is a versatile approach that allows the grower to nip weed pressure in the bud. The idea is to encourage weed seeds to germinate and then to kill the emerging weed seedlings before they can take hold. This process is repeated up to several times in rapid succession typically before the crop itself is planted.

As a new grower, David Zemelsky at Star Light Gardens in Connecticut experienced an incremental build up of the weed seedbank in his high tunnel beds. Weediness ultimately impacted yields in his greens. As a result of his struggle with weeds, he has become a believer in the value of stale seed bedding.

As an example, consider stale seed bedding for a winter crop of baby brassica greens following tomatoes. First rip out the tomato vines, add soil amendments, and renovate the bed. To avoid bringing up new weed seeds, do not invert the soil! Instead, loosen the bed with a broad fork as one of several ways to achieve this end. After the bed is readied for planting, firm it and, if necessary, irrigate to encourage weed seeds to sprout. When the new weed seedlings are still in the white

thread stage, use a propane flamer or very shallow tillage with a stirrup hoe to destroy them. Take care not to bring up more weed seeds from lower in the soil profile when tilling.

Carrying out stale seed bedding requires a several week break in the cropping cycle. Because high tunnels are an expensive horticultural environment compared to open fields, it is worth making this sacrifice to optimize growing conditions before weed pressure gets out of hand. The farmer must be an effective manager to take advantage of the narrow window available in the crop sequence for stale seed bedding.

Another weed problem that growers may face is the encroachment of perimeter vegetation, including quack grass, into a tunnel. If regular mowing is not sufficient, try landscape fabric as a weed barrier. It should be well secured on bare ground along the outside perimeter of the tunnel. Mow right up to it. A foot wide barrier of landscape fabric on a tunnel's inner perimeter is also an option.

Mulching

Mulching with organic materials such as rye or oat straw is an option for weed prevention in crop beds for tomatoes and the like, especially if additional soil warming is not essential. Straw retains soil moisture and eventually breaks down into soil organic matter, with no disposal needed.

However, straw left in place indefinitely can attract mice and other unwanted rodents. Organic mulches can exacerbate slug infestations. Straw mulch may also interfere with the functioning of precision seeders. Andy Jones of Intervale Community Farm experienced this problem when he direct seeded greens after a straw-

mulched tomato crop. He warns, “Even a fine toothed landscape rake leaves behind enough bits to give the planter (and me) conniptions.”

Straw has another role between beds. Ted and Jan Blomgren at Windflower Farm use straw to prevent weeds between beds, whether they are mulched with plastic or left bare.

For long-lived crops such as tomatoes, peppers, melons, and cucumbers, many farmers opt for synthetic mulches to stymie weeds and heat the soil. Their use in tunnels is no different from field situations. Black (or other colored) plastic can be applied with a mulch layer or laid down by hand. U-shaped ground staples—6" galvanized steel or plastic staples—are one way to pin down this plastic film.

After amending the soil in preparation for planting, Tim and Janet Taylor, at Crossroads Farm in Vermont, cover the ground in their high tunnels from wall to wall with a solid sheet of heavy black plastic mulch. Steve Groff, at Cedar Grove Farm in Pennsylvania, plants tomatoes into heavy-duty landscape fabric. At Cramer’s Posie Patch, white plastic mulch does double duty—it suppresses weeds and cools the soil for cool season cut flowers.

One way to make planting holes in landscape fabric is to use a propane torch. Minor (or major) mishaps can occur, as the material is flammable, and care should be used. Cutting an “X” in the fabric is another method. Both approaches have their proponents and detractors.

Plastic mulch can harbor plant pathogens, some of which may overwinter in folds of the material so its reuse can be risky. The bacterium that causes Bacterial Canker in tomatoes, for example, is thought to overwinter on tomato stakes and mulches. Where possible, rotate

landscape fabric for use with other crops that do not host the same diseases.

Chris Lincoln at New Minglewood Farm used 6' wide pieces of landscape fabric to cover the ground in and between four 10' x 100' walk-in tomato tunnels. With 2' between each tunnel and two rows within each tunnel spaced 6' apart, he was able to plant the tomato transplants at the intersection where one piece of fabric ended and the next started.

Managing Diseases in High Tunnels

Many growers have chosen high tunnels, in part, because they offer protection against the diseases their field crops encounter. Septoria leaf blight, (one of the most troublesome diseases of tomatoes in New York State), for example, is virtually unheard of in high tunnels. Crops inside high tunnels usually experience much shorter periods of leaf wetness than crops in the field. Diseases will not occur in the absence of the environmental conditions necessary for the existence of the pathogen that causes them.

Nevertheless, disease is not eliminated in high tunnels. Leaf mold (*Fulvia fulva*) on tomatoes, for example, has become increasingly commonplace. The danger of an infestation is highest when airflow inside the tunnel is low and relative humidity is high. Selecting resistant varieties, reducing plant populations, increasing tunnel ventilation (by adding gable-end vents, etc.) and promoting improved air circulation inside the tunnel (e.g., adding fans) are each parts of a potential solution to the problem.

Growers have reported other disease problems as well. These include

bacterial canker and Verticillium wilt in tomatoes; powdery mildew in tomatoes, cucumbers, squashes, late season lettuces, and flowers; Alternaria leaf spot in brassicas; Fusarium root rot in lisianthus; and leaf spot in Bells of Ireland, among others.

Tomato growers should pay careful attention to variety selection. Disease-resistant varieties with good yields and eating qualities are increasingly available. Where the incidence of soil-borne diseases has been high, some growers have turned to grafting. Mike Collins, who grows greenhouse tomatoes in southern Vermont, grafts ‘Buffalo’ scions onto a vigorous and disease-resistant rootstock. The practice increases his cost of production but it also provides him with superior yields of excellent tasting fruit.

A preventative approach to disease management is the best strategy. In general, it is best to take steps to enhance air movement and reduce relative humidity. The following tactics are also recommended:

- Provide adequate plant-to-plant spacing to avoid excessive shading and enhance air circulation.
- Select disease-resistant varieties.
- Maintain a pest-free environment. Keep high tunnels free of the weeds that harbor diseases and the insects that transmit them.
- Practice good sanitation. Remove diseased crop residues, and sanitize mulches and trellises.
- Provide the nutrients and water necessary for optimal crop growth.
- Utilize a good crop rotation.
- In the absence of a winter crop, open the tunnel so that disease spores can be killed by winter temperatures.

Ecological Insect Management in High Tunnels

By Steve Moore

Insect pests generally cause less damage in high tunnels than they do in the field, in part, because the crops inside are growing at a time when pests are less active. The tunnel itself functions as a barrier to insect pests, at least until temperatures warm to the point that the tunnel sides are open much of the time. Nevertheless, insects in high tunnels can cause economic losses. Aphids and thrips, both of which have fairly broad host ranges, can be particularly troublesome in high tunnels. And high tunnels can also harbor pests and allow them to hatch earlier than outside.

Years of experience have proven the effectiveness and shortcomings of a biologically-based high tunnel pest control program. Here are some important considerations to achieve good control of potential “pests.”

Develop Healthy Soil

Healthy, balanced soil is the single most important factor in attaining healthy plants. Our most important amendment is well-made biologically active compost. We also use this medium for our flats and transplants. We avoid excess nitrogen as it compounds pest and disease problems and it makes the food less nutritious.

A research project reinforced my intuition that healthy soil leads to healthy plants. As part of a three-year beneficial insect project, we reared beneficials in our own greenhouse. We acquired aphid-infested tomato plants, re-potted several of them, and placed them in insect cages. A colleague who was counting the insects remarked that only certain plants had any aphid egg deposition.

After a few weeks, we took a minute together to look at the plants. We found that only the plants in prepared, sterilized media were hosting the aphids while those in our compost were free of aphids.

Encourage Beneficial Insects and Other Arthropods

According to the old adage, “diversity leads to stability,” we are aiming for a balance between the “good” and “bad” organisms. Eliminating all of the bad (pest) organisms invites trouble, and in the absence of beneficial insects, pests can quickly become a problem.

Avoid synthetic pesticides and use natural and botanical pesticides sparingly. As a general rule, beneficial insects are more sensitive to pesticides than pests. Synthetic chemicals often have long residual effects. You will be amazed at the number of beneficial insects indigenous to your greenhouse when you don’t suppress them.

Don’t bring in plants that may have pests or pesticide residues. We learned this the hard way by accidentally bringing in tomato plants sprayed with the insecticide, Lannate (active ingredient methomyl). The long-lasting residues of this insecticide are lethal to most beneficial insects for 8 to 12 weeks. Because the Lannate-treated tomatoes wiped out beneficial populations that came in contact with them, we were unable to introduce beneficial insects in a timely fashion. Although we applied other strategies, the aphids almost got ahead of us. (*See “Koppert Side Effect Database” on page 74.*)

Another high tunnel grower reports that pests come along with every shipment of plugs. For example, fungus gnats arrived with lisianthus plugs almost every time they order them.

Remove weak and injured plants. Just as wolves following deer herds will cull the weak and old, insect pests and plant disease organisms will hone-in on those plants that are best not left in the gene pool. As farmers, we select for traits such as yield, climatic adaptability, or taste. Yet we often ignore pest susceptibility traits by substituting chemical controls instead.

Know, Scout, and Monitor

Know your insect neighbors at all stages of their life cycles. If you have ever looked at the larval stage of a ladybug, you will agree that they look anything but helpful. Yet even in this stage, they are aggressive pest controllers. A good insect identification book (*see page 74*) that shows the various insect life stages and lists their primary food sources is indispensable.

Careful scouting will enable you to discover insects and diseases (and estimate their incidence) before it is too late to manage them. In scouting, typically 2% of the plants should be observed. Over time, you will become familiar with which insects like which plants and where to look for them. For example, whiteflies “like” the third set of leaves down on tomato plants.

Sticky cards are a well-accepted and inexpensive monitoring tool. Yellow cards attract most insect pests, including whiteflies and aphids, while blue cards attract thrips. Attach these cards to posts or strings with clothespins. Write the date on the card so it serves as a record of pest activity. Each card can be used for an entire month. For the first week, remove the protective paper from one half of one side of the card. The next week, place clear plastic wrap over the used section and remove the protective cover from another half of the card. The next week, continue on the back of the sticky card. At the end of the four-week period, the card provides a snapshot of weekly changes in the populations of certain pests.

In addition to scouting and sticky cards, there are other monitoring practices. Index plants attract specific pests. For example, to determine if thrips are present, use New Guinea Impatiens, a plant they favour. Plants like these can also function as a trap crop that will be destroyed in order to reduce the specific insects. Exercise caution when using this approach. Early in our greenhouse experience, we grew Impatiens transplants for sale in part of a tomato greenhouse. This was a big mistake, as we invited every thrips in the county to infest our tomatoes.

Pest Control Options

Sometimes an insect pest population exceeds the level at which beneficial insects can provide adequate or timely control. Faced with this situation, I might turn to a biorational insecticide, such as a fatty acid like Safer's Soap. A soap application can knock down localized outbreaks of certain pests (e.g., aphids and whitefly), allowing beneficial populations to gain an advantage.

A drawback of this strategy is the potential harm to beneficial insects populations, for even these soaps have a lethal effect on some beneficials. Restrict the use of botanical pesticides such as rotenone and pyrethrum. Though natural, these pesticides can devastate beneficial insects as well.

Beneficial insects can be purchased to help bring particular pests under control. It is absolutely critical to introduce beneficial insects before the pest population can no longer be controlled by beneficials. Therefore regular monitoring is an essential component of any biological control program.

In my climate and growing conditions, I have introduced parasitic wasps such as *Aphidius colemani* to control aphids and *Encarsia formosa* to control whitefly. Beneficial insect suppliers can help you determine what

species of parasitoid or predator will be most appropriate and effective for your situation. These suppliers provide basic directions on how to use them and often will help with troubleshooting as it is in their interest for you to be successful with your beneficial introductions. (See "Beneficial Insects" on page 69.)

Provide Food and Habitat for Beneficials

Growing in the soil (as opposed to hydroponically) allows many beneficial insects to complete their life cycles and hence respond to pest pressures. For example, *Amblyseius cucumeris*, a predator mite that relishes thrips, needs the soil for part of its life cycle. Additionally, undisturbed soil will encourage ground and rove beetles, generalist insect predators.

Some beneficials cannot fly. These beneficials are easily stranded on a plant "island" after they have eaten all the pests within their reach. When the canopy of plants inside a high tunnel touches, it provides a concourse for wingless beneficials such as predatory mites and midge larvae. This allows them to walk between plants so they can access and attack their pest prey. If your plants don't touch, you need a different beneficial.

Feed beneficial insects. One study documented a 600% increase in beneficial insects where they were fed. One nectar substitute is 3 to 6 ounces of powdered sugar dissolved in a gallon of water. A pollen substitute is a half-pound nutritional yeast dissolved in water. Spray these solutions every week to 10 days when you see pests. When using these nectar and pollen substitutes, exercise caution about foliar diseases.

Insectary Crops

We establish insectary crops for food and habitat. These are plants that flower rapidly and are good nectar sources, providing high-energy food

for beneficial insects. Excellent insectary plants include dill, cilantro, and others in the *Umbelliferae* family; yarrow; sea holly; and crimson clover. In a 30' x 96' hoop house, we often plant 10 to 12 square feet of permanent insectary plants throughout the high tunnel.

"Banker plants" are host plants grown to rear pest species that are not harmful to the cash crop. Banker plants can be grown in the high tunnel. The pseudo-pests raised on the banker plants attract and increase the population of beneficial insects that can control the "real" pests on cash crops. A classic example is using barley or other small grains to raise grain-specific aphids. These aphids, in turn, attract beneficial insects which can control populations of other types of "pest" aphids within the tunnel.

Cherish Your Spiders

Spiders consume twice their body weight every day. While spiders are indiscriminate eaters, investigators have found that at least 80% of their diet consists of pest insects. (See "*LeSar and Unzicker*" article referenced on page 74.) Spiders eat aphids, leafhoppers, whiteflies, and cucumber beetles, as well as many other pests, and their pheromones also scare off a lot of insects.

Habitat is important to spider survival. They need a hiding place during the day and in the winter, though they may overwinter in the soil. Easy-to-make spider condos consist four or five 6" long bamboo sections bundled together. To make a section, cut the bamboo so that it includes a node near one end. It should look like an upside down test tube or a pipe with a cork in it at the top. Wrap four or five of these together and place them near problem pest areas as needed. These can be suspended a couple inches off the ground attached to the inner cover support structure.