Chapter 19

Weed Science

Learning Objectives
1. Explain the difference between a weed and a plant out of place
2. Explain how weeds are generally classified
3. Name and briefly describe different weed control methods
4. Explain the difference between a selective and non-selective herbicide
5. Describe the differences between the way contact and residual herbicide work
Weeds compete with native plants, ornamentals and crops for water, nutrients and sunlight. In fact, weeds reduce agricultural crop yields by 12% causing $36 billion dollars in revenue losses annually. Over $7 billion is spent annually for herbicides and other management practices. In addition to direct economic impacts for growers, certain weeds can also impact mankind in other more direct ways such as serving as hosts for viral, fungal or insect pests; interfering with infrastructure; interfering with recreation; and causing harmful rashes to humans.

**What is a Weed?**

There are many definitions used to describe weeds. Basically all weed definitions are generated based on three distinct characteristics of a plant:

- **Location:** Is the plant growing outside of its normal habitat?
- **Growth habit:** What is the plant’s rate of spread and competitive attributes in relation to other plants in the area?
- **Interference:** What impact does the plant have on people who manage the land where it resides?

The above being said, a weed is in the “eye of the beholder,” unless the government mandates action against a particular plant because of its competitive properties or its nature of interference. This has been done with Executive order No. 13,112. This order established the classification and the control of the introduction of “invasive species” or “alien invaders.”

In addition to the designation of some plants as invasive weeds by the Federal govern-

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**Negative Impacts of Weeds**

**Serve as a host for viral, fungal or insect pests**

- Black nightshade (*Solanum nigrum*) serves as an alternate host for potato late blight (*Phytophthora infestans*).
- Insect pests are generally more prevalent in areas where weeds are not controlled; it is well documented that black cutworm moths (*Agrotis ipsilon* Hufnagel), are attracted to over-wintering weeds like annual bluegrass (*Poa annual*), yellow rocket (*Capsella bursa-pastoris*) and curly dock (*Rumex crispus*).

**Interfere with transportation or infrastructure**

- The tree-of-heaven (*Ailanthus altissima*) can actually grow through cracks in asphalt or concrete.

**Interfere with aesthetics and recreation**

- Kudzu (*Pueraria montana*) grows aggressively and often outcompetes trees by growing over them; robbing them of much needed sunlight.

**Poison human, livestock or pets**

- The compound urushiol exuded by poison ivy (*Toxicodendron radicans*) is famous for its ability to cause contact dermatitis in sensitive people.
- Jimsonweed (*Datura stramonium*) seeds contain high levels of the anesthetic atropine that can cause death if ingested.
Weed Control

ment, some municipalities have taken weed control to a whole new level. For example, a new California civil code (801.5) allows for the removal or trimming of any tree blocking any “Solar Easement” (area where sunlight travels through to reach solar collectors) regardless of whether the tree was there first. In short, any plant may be considered a weed; it just depends on where it grows and what it impedes.

Weed Classifications

Weeds are generally classified as a broadleaf, for example (i.e. wild carrot, chickweed, dandelion, etc.), a grass (i.e. johnsongrass, crabgrass, goosegrass, etc.) or a sedge (i.e. yellow or purple nutsedge, kyllinga spp.). Broadleaf weeds are also referred as dicots (dicotyledons) because they initially produce two leaves (cotyledons) following germination. Grass weeds are often referred to as monocots (monocotyledons) because they only produce one leaf at germination. Sedges can look very similar to grasses, but can be distinguished by their glossy leaf texture and their triangular shaped stems.

Weeds can also be further classified by their life cycle. Annual weeds (i.e. crabgrass, chickweed) reproduce from seeds and complete their life cycle within one year. Biennial weeds (i.e. wild carrot, curly dock, etc.) reproduce from seeds and complete their life cycle in two years. Perennial weeds (i.e. yellow nutsedge, dandelion, johnsongrass, Canada thistle, etc.) can continue to reproduce over an indeterminate number of years by producing specialized aboveground or underground reproductive structures (i.e. rhizomes, tubers, stolons, etc.).

Weed Definitions

- “A plant out of place….”- Dr. William James Beal, Professor Michigan State University
- “Plants that are competitive, persistent and pernicious. They interfere with human activities and as a result, are undesirable.” – In “Applied Weed Science” by M.A. Ross and C.A. Lembi
- “Plants whose virtues have not yet been discovered”- unknown
- “A plant that is not valued where it is growing and is usually of vigorous growth; especially one that tends to overgrow or choke out more desirable plants”-Merriam-Webster’s dictionary

These structures make perennial weeds very difficult to control.

It is extremely important to properly identify your weed issues because the optimal control measures may vary depending on the species present.

Identifying the weed is the most important step in determining its control. Visit The University of Tennessee Turf Weed ID Guide online to find pictures of the weeds listed in Table 1. The online guide is updated regularly and its web address is listed in the resources at the end of this chapter.
Figure 3. Smooth Crabgrass is a Monocot or Grass Weed

A. Individual Plant

B. Crabgrass established in turfgrass

Figure 4. White Clover is a Dicot or Broadleaf Weed

Table 1. The Most Common Garden Weeds in Tennessee

<table>
<thead>
<tr>
<th>Type</th>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadleaf weeds</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Redroot pigweed</td>
<td>Amaranthus retroflexus</td>
</tr>
<tr>
<td></td>
<td>Common lambsquarters</td>
<td>Chenopodium album</td>
</tr>
<tr>
<td></td>
<td>Common ragweed</td>
<td>Ambrosia artemisiifolia</td>
</tr>
<tr>
<td></td>
<td>Carpetweed</td>
<td>Mollugo verticillata</td>
</tr>
<tr>
<td></td>
<td>Common purslane</td>
<td>Portulaca oleracea</td>
</tr>
<tr>
<td></td>
<td>Hairy bittercress</td>
<td>Cardamine hirsuta</td>
</tr>
<tr>
<td></td>
<td>Purple deadnettle</td>
<td>Lamium purpureum</td>
</tr>
<tr>
<td></td>
<td>Henbit</td>
<td>Lamium amplexicaule</td>
</tr>
<tr>
<td></td>
<td>Common chickweed</td>
<td>Stellaria media</td>
</tr>
<tr>
<td></td>
<td>Jimsonweed</td>
<td>Datura stramonium</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Type</th>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadleaf weeds</td>
<td>Morningglory species</td>
<td>Ipomoea spp.</td>
</tr>
<tr>
<td></td>
<td>Yellow woodsorrel</td>
<td>Oxalis stricta</td>
</tr>
<tr>
<td></td>
<td>Prostrate spurge</td>
<td>Euphorbia humistrata</td>
</tr>
<tr>
<td></td>
<td>Hairy galinsoga</td>
<td>Galinsoga ciliata</td>
</tr>
<tr>
<td></td>
<td>Buttercup species</td>
<td>Ranunculus spp.</td>
</tr>
<tr>
<td></td>
<td>Dandelion</td>
<td>Taraxacum officinale</td>
</tr>
<tr>
<td>Grasses and sedges</td>
<td>Large crabgrass</td>
<td>Digitaria sanguinalis</td>
</tr>
<tr>
<td></td>
<td>Bermudagrass</td>
<td>Cynodon dactylon</td>
</tr>
<tr>
<td></td>
<td>Goosegrass</td>
<td>Eleusine indica</td>
</tr>
<tr>
<td></td>
<td>Barnyardgrass</td>
<td>Echinochloa crus-galli</td>
</tr>
<tr>
<td></td>
<td>Annual bluegrass</td>
<td>Poa annua</td>
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<tr>
<td></td>
<td>Dallisgrass</td>
<td>Paspalum dilatatum</td>
</tr>
<tr>
<td></td>
<td>Foxtail species</td>
<td>Setaria spp.</td>
</tr>
<tr>
<td></td>
<td>Johnsongrass</td>
<td>Sorghum halepense</td>
</tr>
<tr>
<td></td>
<td>Yellow nutsedge</td>
<td>Cyperus esculentus</td>
</tr>
</tbody>
</table>

### Table 2. The Most Common Turf Weeds in Tennessee

<table>
<thead>
<tr>
<th>Type</th>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadleaf weeds</td>
<td>Common purslane</td>
<td>Portulaca oleracea</td>
</tr>
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<td></td>
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<td></td>
<td>Common chickweed</td>
<td>Stellaria media</td>
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<td>Oxalis stricta</td>
</tr>
<tr>
<td></td>
<td>Prostrate spurge</td>
<td>Euphorbia humistrata</td>
</tr>
<tr>
<td></td>
<td>Dandelion</td>
<td>Taraxacum officinale</td>
</tr>
<tr>
<td></td>
<td>White clover</td>
<td>Trifolium repens</td>
</tr>
<tr>
<td></td>
<td>Broadleaf plantain</td>
<td>Plantago major</td>
</tr>
<tr>
<td></td>
<td>Buckhorn plantain</td>
<td>Plantago lanceolata</td>
</tr>
<tr>
<td></td>
<td>Ground ivy</td>
<td>Glechoma hederacea</td>
</tr>
<tr>
<td></td>
<td>Prostrate knotweed</td>
<td>Polygonum aviculare</td>
</tr>
<tr>
<td></td>
<td>Virginia buttonweed</td>
<td>Diodia virginiana</td>
</tr>
<tr>
<td></td>
<td>Wild violet</td>
<td>Viola papilionacea</td>
</tr>
<tr>
<td>Grasses and sedges</td>
<td>Large crabgrass</td>
<td>Digitaria sanguinalis</td>
</tr>
<tr>
<td></td>
<td>Smooth crabgrass</td>
<td>Digitaria ischaemum</td>
</tr>
<tr>
<td></td>
<td>Bermudagrass</td>
<td>Cynodon dactylon</td>
</tr>
<tr>
<td></td>
<td>Goosegrass</td>
<td>Eleusine indica</td>
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</table>
Weed Control Measures

There are several effective ways to control weeds; however many of the techniques outlined below are not stand-alone methods for long-term weed control. Effective long-term weed control programs include multiple weed control techniques. Following are some of the most common and effective weed control techniques.

Sanitation

Sanitation is the act of inspecting plant materials, soil or seeds before introducing them to a garden or landscape area. This technique aids in the prevention of introducing seeds or other reproductive structures of undesired plant species to the garden or ornamental beds. In addition, sanitation may include sterilizing soils or other growing media to destroy the viability of weed seeds.

Sanitation techniques may be effective in preventing the introduction of several weed species, however it is extremely difficult to identify, remove and/or destroy all reproductive structures of all weed species. As a result, sanitation should be considered a necessary step in reducing the risk of introducing the most aggressive and persistent weed species. Therefore, teach clients to inspect the soil, seeds and roots for weeds and weed reproductive structures before transplanting any potted plant. If weeds or their reproductive structures are found, they should be carefully removed by hand or by rinsing them gently with running water. Reproductive structures should be rinsed off away from bedding areas and lawns, where they could possibly germinate.

Cultivation

Cultivation is the practice of mechanically disturbing the soil in order to uproot weeds. Uprooting weeds allows them to desiccate in the sunlight. In gardens and ornamental beds, cultivation is often done with a hoe or a rotary tiller. In turf, cultivation is done with either a solid or hollow tine aerator. Often, cultivation in turf usually improves soil conditions impeding internal drainage, which can subsequently discourage some weed species that prefer compacted, poorly drained soils (goosegrass, sedges, etc.) Cultivation may be done prior to planting, selectively between rows of crops or around ornamental plants. In general, cultivation is highly effective in controlling most annual weeds. However, it may aide in the spread of perennial weeds by breaking-up and spreading smaller fragments of the underground reproductive structures. Therefore, the life cycle of the weeds should be determined before any control measures are implemented.

Mulching

Mulching is the act of smothering or preventing light from reaching the weeds. If a weed does not receive light, then plant photosynthesis and growth are inhibited. Mulches are most often differentiated by whether they are organic or inorganic. Organic mulches include materials like grass clippings, manure, straw, ground tree bark, sawdust, wood chips, rice/peanut hulls, compost, leaves/pine needles and newspapers. A 2 to 4-inch layer of organic mulch prevents many annual weeds from becoming established. Organic mulches provide additional benefits other than weed control.

Table 2. The Most Common Turf Weeds in Tennessee

<table>
<thead>
<tr>
<th>Type</th>
<th>Common Name</th>
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</tr>
<tr>
<td></td>
<td>Foxtail species</td>
<td>Setaria spp.</td>
</tr>
<tr>
<td></td>
<td>Nimblewill</td>
<td>Muhlenbergia shreberi</td>
</tr>
<tr>
<td></td>
<td>Wild garlic</td>
<td>Allium vineale</td>
</tr>
<tr>
<td></td>
<td>Yellow nutsedge</td>
<td>Cyperus esculentus</td>
</tr>
<tr>
<td></td>
<td>Green kyllinga</td>
<td>Kyllinga brevifolia</td>
</tr>
<tr>
<td></td>
<td>False green kyllinga</td>
<td>Kyllinga gracillima</td>
</tr>
</tbody>
</table>
Managing Perennial Weeds

When managing perennial weeds with cultivation it is important to follow a few important rules:

- Attempt to remove as much of the perennial root structure as possible from the soil.
- Minimize the spread of these perennial structures to other parts of your garden or ornamental beds.
- Perennial weeds should be emerged approximately 1 to 2 weeks before initiating any type of cultivation; continue similar cultivation intervals until the weed is effectively removed from the area. If the problem does not improve then treatment with a systemic herbicide may be necessary for optimal control.

including the addition of organic material to soils and the prevention of a rapid loss of soil moisture. However, organic mulches are less effective at inhibiting the growth of perennial weeds that are able to push through these barriers with the energy they have stored in their underground reproductive structures. In addition, organic mulches may also harbor insect or disease pests that may create unforeseen issues in the garden or ornamental beds.

Inorganic mulches include plastic films (polypropylene), woven fabrics, shredded rubber and other materials not derived from living matter. Plastic films and woven fabrics are highly effective in controlling both annual and perennial weeds with the exception of certain perennials like yellow and purple nutsedge that are able to penetrate most types of mulch. Woven fabrics have the added bonus of allowing water to permeate their surface, which enhances the ability of the user to maintain even watering when compared with the impermeable surface of plastic films. However, woven fabrics may allow certain weeds to germinate on their surface, which is not an issue with plastic films. The use of herbicides impregnated on or applied in conjunction with woven fabrics will improve weed control.

Soil Solarization

Soil solarization is the process of killing pests by covering soil with a clear plastic mulch. This clear plastic (polypropylene) mulch allows sunlight through while trapping heat between the plastic and the upper crust of the soil. This practice can increase soil temperatures to over 120 degrees F, which can destroy weed seeds and certain plant pathogens in the upper 2 to 3 inches of soil. This technique is generally most effective in areas south of Tennessee because in these areas, there are fewer differences in daytime and nighttime temperatures, which increases the lethality of this heating process.

Soil Covered in Clear Plastic for Solarization in a Vegetable Garden at UT Gardens in Jackson, TN.

Soil Solarization

In Tennessee several steps should be followed to maximize the effectiveness of soil solarization. Here are a few tips for you to get the most out of this technique:

- This technique is really only effective if the clear plastic (at least 2 mil thick) is left in place for at least 1 month.
- Two layers of clear plastic should be used spaced 3 inches apart by bricks, cinder blocks or lumber. The use of two layers of plastic will trap warm air and will minimize the cooling effects of low nighttime temperatures. Always bury the edges and ends of the plastic into the soil to trap as much heat as possible.
- Wash clear plastic periodically (~once a week) as dirt and dust can minimize the amount of sunlight absorbed under the plastic.
- After the plastic is removed do not cultivate greater than 2 inches deep into the soil profile as this may bring viable weed seeds back to the soil surface where they can germinate.
Row Spacing
Row spacing is one of the most overlooked methods for reducing weed competition, especially in crops. In general, most vegetable crops should be spaced approximately 1 to 8 feet apart, depending on the plant. Planting crops closer together will decrease the amount of time for the plants to shade over the bare soil in between the rows. This covering of the bare soil by the crops is referred to as canopy closure and is a very effective means of reducing the competitive nature of germinated weeds by reducing the amount of sunlight they receive for photosynthesis. The bottom-line: never space vegetable crops further apart than is recommended.

Flame Cultivation
Flame cultivation, with a propane-powered flamer, is gaining acceptance for weed control, especially among organic producers. Flame cultivation has demonstrated safe and effective weed control in both row and vegetable crops. Flaming rates around 70 kg of propane/ha have provided broad-spectrum broadleaf weed control. However, the size of weeds at application as well as the cuticle size has impacted the level of weed control observed with flame cultivation. Larger weeds and larger cuticle sizes are generally harder to control. When used properly, flame cultivation has performed better than certain pesticides, especially when multiple flame cultivations were made to a specific area. A single orifice flamer can be purchased at most home and garden centers for under $100 and could be a nice investment for someone interested in evaluating this technique for themselves.

Mowing
Mowing is quite simply the process of killing or impairing plant growth by cutting. Often times when we hear the word mow, we think about mowing our lawn. However, mowing can include equipment other than lawn mowers and can include plants other than turfgrass. Any time a hedge is pruned with clippers, a brush or tall grass is cleared with a scythe or machete or a tree is cut down with a chainsaw, a type of mowing is being performed.

Mowing is an extremely effective way of controlling erect growing, annual broadleaf weeds. However, prostrate growing broadleaf weeds (i.e. dandelion, prostrate knotweed and spotted spurge) can often escape the cutting blades of a lawn mower by growing laterally across the soil surface. Additionally, the top-growth of perennial broadleaf weeds and brush/tree species may be effectively removed by mowing, but re-growth from rich reserves in their perennial root structures often occurs. Finally, grass and sedge weeds are suppressed and rarely controlled completely by mowing techniques.

Hand Weeding
Hand weeding is the oldest and one of the most effective methods of weed control. Annual grasses, broadleaf and sedge weeds are all controlled by this method. To successfully control a perennial weed through hand weeding, the entire underground reproductive system must be removed. Hand weeding is especially effective in controlling weeds next to plants where hoeing or other forms of cultivation would cause excessive damage. When hand-weeding, appropriate gloves should always be worn, as several plants have developed defense mechanisms that can create severe harm to humans.

Herbicides
Herbicides are commonly used to control weeds. They can be classified by the mode of action; the site of action; the timing of application; if they are selective or non-selective; if they are systemic, contact or residual; or if they are organic.

Controlling Weeds with Flame Cultivation

Tips for controlling weeds with a single orifice propane-powered flamer:

▪ Target applications to weeds around 2 to 3 inches in height.
▪ Do not linger for multiple seconds on individual weeds but move briskly over top of weeds with the flamer. The flame can very quickly boil the water in each plant causing rapid tissue necrosis.
▪ Plan to flame secondary flushes of weeds or re-growth of grasses or perennial broadleaf weeds approximately 2 to 4 weeks after your initial application.
▪ Avoid contact the foliage of crops with any part of the flame.
Mode and Site of Action
Herbicides are chemicals that kill or suppress the growth of plants. There are over 300 chemicals that are used as herbicides throughout the world. Often herbicides are classified by their mode or site of action. An herbicide's mode of action describes the herbicides activity on a specific physiological process in plants (e.g. glyphosate prevents the formation of aromatic amino acids in plants). While an herbicide's site of action describes the specific biochemical target interfered with by the herbicide (e.g. glyphosate inhibits the enzyme 5-enol-pyruvyl-shikimate-3-phosphate synthase or EPSP synthase). In general, the mode of action is known for most commercial herbicides; however the site of action is not always known.

Timing of Application
Gardeners need to apply herbicides at the proper timing in order to get optimal weed control while minimizing any negative potential plant response. Herbicides can be grouped by their timing of application. Most often these are known as pre-emergence or post-emergence herbicides. Pre-emergence applications are made prior to the emergence of the weeds and/or the plants of interest. In contrast, post-emergence applications are made following the emergence of weeds and/or the plants of interest. Other herbicide application timings include pre-plant, post-directed and spot spray. Pre-plant herbicide applications are made prior to planting the plants of interest and, in general, are made to “burndown” existing weed vegetation prior to planting.

- Post-directed applications are made directed to the base of fruit trees, ornamental plants or vegetable crops in a way to prevent or minimize contact of the spray solution on the foliage.
- Spot spray treatments are often made with a set amount of herbicide dissolved in a spray solution that is applied to the foliage of small, intermittent patches of weeds in a field.

Other considerations may include temperature and time of day for each specific chemical. Always consult the herbicide label for the best results.

Selective vs. Non-selective
Herbicides are also classified by whether their activity is considered selective or non-selective. A selective herbicide will control certain weeds but will not cause injury to a desired plant if the correct rate is applied. Most herbicides are sold for selective weed control. Certain plants are generally tolerant to these selective herbicides because they are able to compartmentalize, exude or metabolize the herbicide so that it is no longer a threat. Herbicides might also be selective based on the manner of application. For example, the herbicide trifluralin can be applied post-emergence over-the-top of watermelons without injuring this plant; however, if applied pre-emergence, then severe watermelon injury may occur. In contrast to selective herbicides, a non-selective herbicide will cause damage to most any plant material that it contacts. Glyphosate, paraquat, diquat, glufosinate, imazapyr and pelargonic acid are examples of herbicide active ingredients that are considered to be non-selective. These materials should be used with caution when spraying around desirable vegetation.

Systemic vs. Contact and Residual Herbicides
Herbicides can also be classified by how they enter the plant and how they behave once they come in contact with plant tissue or soil. Systemic herbicides are herbicides that enter plants and move freely in the xylem and/or phloem of the vascular system. In general,
Systemic herbicides are better at controlling larger weeds and perennial weeds because of this extensive movement in plants. This is especially true in perennial weeds where systemic herbicides are able to accumulate in toxic levels in the underground reproductive structures. Glyphosate and imazapyr are examples of commonly used systemic herbicides. In contrast, contact herbicides only control the portion of the plant that the spray solution covers. Diquat and pelargonic acid are common examples of commonly used contact herbicides.

Residual herbicides are herbicides that are able to enter plants through the roots or emerging shoots in the soil profile. Residual herbicides must be “activated” by shallow incorporation or with approximately 1/2 inch of rainfall or overhead irrigation. Residual herbicides create barriers that prevent germinating weed seedling’s survival. Contrary to popular belief, residual herbicides do not prevent seed germination, but prevent maturation of the weeds by inhibiting growth processes in these plants. Most contact herbicides are not residual herbicides, but some systemic herbicides actually do have residual activity in the soil (i.e. imazapyr). There are many residual herbicides that have little to no contact or systemic activity when applied to the foliage of weeds (i.e. trifluralin).

Organic

Finally, herbicides can be classified by whether they are registered for certified organic production or not. Several herbicides are available for organic production and many of these herbicides provide postemergence contact weed control. These contact organic herbicides include clove oil, vinegar, lime/lemon juice and cinnamon oil. Contrary to popular belief, there are chemicals associated with each of these products that actually cause the herbicidal activity. Clove oil and cinnamon oil contain the herbicidal chemical eugenol, while vinegar’s herbicidal agent is acetic acid. Citric acid is the herbicide in lemon and lime juice. Currently, the only residual herbicide for organic production is corn gluten meal. A combination of dipeptides present in corn gluten meal is the reason for its herbicidal activity.

Commonly Used Herbicides

Currently, there are only a few herbicides available for use in home gardens and ornamental beds. The reason for such limited options is that few herbicides can actually control a diversity of weeds while maintaining selectivity to a wide array of plants. Below is a list of most herbicides available for use in home gardens and/or ornamental beds. Before a gardener uses any of these products, they need to consult the product label for specific instructions for proper use in their area. Special attention needs to be paid to the formulation, use rate, mixing instructions and specific uses allowed for the specific product. The label is the law and herbicide products are regulated by both federal and state guidelines with special emphasis on safety to the herbicide applicator, the consumer of products treated with herbicides and the environment. By following the label exactly as directed, gardeners can safely combat weeds.

Pesticide Trade Names

Teach gardeners to never rely on trade names with any pesticide product. Companies change the ratios and the types of active ingredients they put in products often. Therefore, tell clients to always search for the proper product by the common name of active ingredient. Here are a few examples of where picking the trade name of a product may get someone in trouble.

- Eagle is a trade name that has been used for a chlorpyrifos based insecticide and a myclobutanil based fungicide.
- Resolve is a trade name that has been used for a rimsulfuron based corn herbicide and an imazethapyr plus dicamba herbicide that would kill any corn variety not imidazolinone resistant.
- Milestone is a trade name that has been used for an azafenidin-based herbicide used for pre-emergence weed control in tree fruit, sugarcane and other specialty crops. It is now the trade name for a pasture herbicide that is not safe for use in most specialty crops.
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade Name</th>
<th>Description</th>
<th>Use Rate</th>
<th>Vegetable and Fruit Crops/Ornamentals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glyphosate</td>
<td>Roundup, other</td>
<td>Non-selective post-emergence systemic control of broadleaf, grass and sedge weeds; no soil residual activity</td>
<td>1 to 5 pints/acre or 1 to 10% solutions</td>
<td>Pre-plant applications allowed in most plants. Post-directed and spot spray treatments are allowed for certain crops/ornamentals as long as care is taken to avoid contact with any foliage or green tissue. Product labels should be consulted for more specific information.</td>
</tr>
<tr>
<td>Pelargonic acid</td>
<td>Scythe®, other</td>
<td>Non-selective post-emergence contact desiccation of several annual and perennial weeds; no soil residual activity</td>
<td>3 to 10% solution; spot spray</td>
<td>Post-directed and pre-plant applications in asparagus, artichoke, beet, carrot, parsnip, potato, radish, sweet potato/yam, turnip, rutabaga, garlic onion, leek, shallot, celery, cilantro, cress, endive, lettuce, parsley, rhubarb, spinach broccoli, brussels sprouts, cabbage, cauliflower, collards, kale, kohlrabi, greens (mustard and turnip), eggplant, okra, pepper (chili, bell, sweet), pimento, tomato, cucumber, gourd, muskmelon, cantaloupe, pumpkin squash and watermelon, apple, pear, apricot, cherry, nectarine, peach, plum, prune, blackberry, blueberry, dewberry, grape, strawberry and grape. All landscape trees, bedding plants, flowers and other ornamentals; avoid spraying on foliage or green bark. Avoid spray on foliage or green bark.</td>
</tr>
<tr>
<td>Diquat</td>
<td>Reward*, other</td>
<td>Non-selective post-emergence contact control of several broadleaf and grass weeds; no soil residual activity</td>
<td>1 to 2 pints per acre or 0.75 fluid ounce per gallon; spot spray</td>
<td>Post-directed and pre-plant applications in all landscape trees and ornamental gardens; avoid spraying on foliage or green bark</td>
</tr>
<tr>
<td>Clove oil active ingredient: eugenol</td>
<td>Matratec™</td>
<td>Organic herbicide that provides non-selective post-emergence contact desiccation of several broadleaf and grassy weeds; no soil residual activity</td>
<td>5 to 8% solution; spot spray</td>
<td>Post-directed and pre-plant applications in all fruit, nut and vegetable crops; avoid spraying on foliage or green bark</td>
</tr>
</tbody>
</table>
### Table 4. Pre-emergence Residual Herbicides

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade Name</th>
<th>Description</th>
<th>Use Rate</th>
<th>Vegetable and Fruit Crops/Ornamentals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trifluralin</td>
<td>Treflan™, other</td>
<td>Provides selective pre-emergence control of several grasses and certain broadleaf weeds. Residual activity is improved with immediate shallow incorporation (1-2 inches) with a rotary tiller or with at least ½ inch of overhead irrigation or rainfall.</td>
<td>1 to 2 pints/acre</td>
<td>Pre-plant incorporated applications in all dry/succulent beans and peas, lima beans, snap beans, celery, broccoli (transplants), brussel sprouts (transplants), cabbage (transplants), cauliflower (transplants), cucurbits (post-directed between the rows after the crops reach the three to four leaf stage), onions (dry bulbs only), potatoes, peanuts, pepper (transplants only), radish, sunflower, tomatoes, apricot, peach, plum and prune</td>
</tr>
<tr>
<td>DCPA</td>
<td>Dacthal®, other</td>
<td>Provides selective pre-emergence control of several grasses and certain broadleaf weeds. Residual activity of DCPA is improved with immediate shallow incorporation (1-2 inches) with a rotary tiller or with at least ½ inch of overhead irrigation or rainfall.</td>
<td>6 to 14 pints/acre or 4 to 5 fluid ounce/1 to 2 gallons; treats 1000 sq. feet</td>
<td>Pre-plant or pre-emergence weed control in broccoli, brussel sprouts, cabbage, cauliflower, all Brassica leafy vegetables, cantaloupe/honeydew/watermelons (not pre-emergence but 3 to 5 leaf; do not incorporate), onions, radish (from pre-emergence up to 3 leaf stage), sweet potato, strawberry, tomato/tomatillos/eggplant (4 to 6 weeks after transplanting or 4 to 6-inch tall seedling). Pre-emergence weed control in 117 woody and herbaceous nursery plants</td>
</tr>
<tr>
<td>Corn gluten meal</td>
<td>Preen® Organic Vegetable Garden Preventer, other</td>
<td>Organic herbicide that provides pre-emergence control of certain broadleaf and grass weeds. Residual activity is improved if corn gluten meal is raked in and immediately watered after application.</td>
<td>5 to 10 lbs/ 250 sq. feet if vegetables are 2 to 3 inches tall, but before weeds have emerged. Reapply every 4 to 6 weeks as needed.</td>
<td>All vegetable crops</td>
</tr>
</tbody>
</table>

### Table 5. Post-Emergence Selective Grass Herbicides

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade Name</th>
<th>Description</th>
<th>Use Rate</th>
<th>Vegetable and Fruit Crops/Ornamentals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sethoxydim</td>
<td>Poast®, other</td>
<td>Provides selective post-emergence control of several annual and perennial grass weeds; no soil residual activity</td>
<td>6 to 14 pints/acre or 4 to 5 fluid ounce/1 to 2 gallons; treats 1000 sq. feet</td>
<td>Post-emergence grass weed control in apricot, asparagus, beans (dry, succulent), beets, broccoli, brussel sprouts, cabbage, cauliflower, collards, garlic, kale, kohlrabi, leeks, mustard/rape greens, cantaloupe, cucumber, honeydew, musk melon, pumpkins, watermelons, onions, radish, sweet potato, carrot, cherries, strawberry, grape, peppers, celery, lettuce, rhubarb, groundcherry, tomato, tomatillos, eggplant, raspberry, blackberry, lettuce, endive, parsley, spinach, mint, nectarine, peach, peanut, potato, plum apples, pears, peas (dry, succulent), artichoke, yam and sunflower. Post-emergence grass weed control in deciduous trees and non-food crop areas</td>
</tr>
</tbody>
</table>

**Other post-emergence grass herbicides are available that contain the active ingredients clethodim, fluazifop, quinalofop and fenoxaprop. Product labels should be consulted to determine if these materials could be used in vegetable gardens or ornamental beds.**
Summary

Plants become weeds when they interfere with the goals of land and waterway managers. In order to properly control weeds, proper identification is essential. This will allow correct control measures to be chosen. The use of only one type of control measure will likely not satisfactorily control all weed issues. Therefore, creating programs that incorporate several of the techniques outlined above will offer the best chance of controlling weed issues. The most important thing to remember is to be aggressive and remove weeds before they go to seed because one old adage still remains true; “every year a weed goes to seed it is seven more years you fight that weed.” So clients need to be taught to identify the problem, assess their options and keep fighting those weeds.

Terms to Know

Contact Herbicides
Non-Selective Herbicide
Post-Directed
Post-emergence
Pre-emergence
Pre-Plant
Residual Herbicides
Sedge
Selective Herbicide
Site of Action
Spot Spray
Systemic Herbicides

Test Your Knowledge

1. What are the three classification characteristics to consider when determining whether or not a plant is a weed?
2. How are weeds generally classified and give an example of each type?
3. Name and briefly describe five (of the nine mentioned) weed control methods.
4. What is a selective herbicide?
5. What is the difference between the way contact herbicides and residual herbicides work?

Resources

Tennessee Exotic Pest Plant Council
tneppc.org
The University of Tennessee Turf Weed ID Guide
tennesseeturfgrassweeds.org
The Virginia Tech Weed ID Guide
http://www.ppws.vt.edu/weedindex.htm
The University of Missouri Weed ID Guide
http://weedid.missouri.edu/
The University of Tennessee Extension publications
utextension.tennessee.edu
Agrochemical Database
cdms.net