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Weed Control in Container Crops

A Guide to Effective Weed Management through Preventive Measures

J. Altland

Weeds compete with commercial crops for nutrients, water, and light. Competition from weeds is particularly important in container crops due to the crops' limited root volume. Weeds also harbor insects, disease organisms, and vertebrate pests (Figure 1). Marketable nursery crops must be free of weed, insect, and pathogen pests.

Effective weed management involves a combination of sound sanitary and cultural practices along with proper use of preemergence herbicides. This publication is separated into three sections:

- ➤ Using sanitary and cultural practices to minimize weed populations
- ➤ Selecting the most appropriate preemergence herbicides
- ➤ Timing of herbicide applications

Sanitary and cultural practices

Sanitation

Weed control in container production must be preventive. In field production, where crops are planted directly in soil, weeds often can be efficiently controlled after they germinate with directed sprays of herbicides or mechanical cultivation. In container crops, where directed sprays are not feasible, there are few alternatives to costly hand-weeding to remove weed infestations. Thus, a successful container weed management program should *prevent* weed germination.

Figure 1.—Annual sowthistle (Sonchus oleraceus)*, shown above, is a weed typically found in and around nursery crops. It can serve as a host for aphids.*

The first step to effective weed management is sanitation. A common characteristic of weeds is their ability to produce prolific numbers of seed. Practices that minimize the number of weed seeds in the production system will improve weed control. The more weed seed allowed to contaminate containers, the higher the probability that weeds will germinate in areas where the herbicide barrier has been weakened (see page 6).

The following are some sanitation practices that should be considered for reducing weed seed numbers in containers.

James Altland, Extension agent, North Willamette Research and Extension Center, Oregon State University.

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Figure 2.—Weeds (bittercress is shown above) can germinate in small piles of debris spilled on weed fabrics.

Weed control under containers

Containers should be placed on covered ground, using either gravel, plastic, or woven weed-fabric to cover the ground surface. Weeds under the covered area usually are suppressed. However, weed seeds often germinate in debris on top of the surface cover, and their roots penetrate down through the cover.

Figure 3.—Eclipta often infest containers through drain holes, and their roots aggressively compete with crops for nutrients and water.

Weed control and sanitation under and around containers is almost as important as weed control in the containers. Weeds growing between containers are an immediate source of weed seeds. Bittercress (*Cardamine hirsuta*) and oxalis (*Oxalis* spp.) growing in debris spilled on weed fabric can propel seeds several feet, rapidly infesting nearby containers (Figure 2). Other weeds, such as eclipta (*Eclipta alba*), can establish in drainage holes and compete for water and nutrients (Figure 3).

When beds are empty between crop cycles, remove or chemically control existing weeds. Install fresh stone or new weed fabric if necessary, and sweep the area to remove all debris. Herbicides can be applied directly on the stone or weed fabric. Products containing prodiamine are an excellent choice for this application due to the herbicide's low solubility (0.013 ppm). Current products containing prodiamine (Table 1) are labeled for this use, and research has shown they provide weed control in gravel beds for up to 8 months (Briggs et al., 1998). Other preemergence herbicides also are suitable for this application, but use only those with low solubility (less than 1 ppm).

Weed control in noncrop areas

Eliminating weeds in noncrop areas such as roadways, drainage ditches, between hoop houses, etc., will drastically reduce production of weed seeds and improve weed control (Figure 4, page 4). This can be accomplished with regular mowing to prevent weeds from setting seed.

Mechanical removal such as hoeing or plowing can be used, although these methods make the area susceptible to soil erosion. Herbicides provide effective control. Postemergence herbicides can be used to eliminate existing weeds, and preemergence herbicides can be used to prevent regrowth. Maintaining weed-free noncrop areas is probably the easiest and most effective sanitary practice for reducing weed seeds in containers.

Table 1. Preemergence herbicides commonly used in nursery production.

Herbicide	Active ingredient	Chemical family	Solubility (ppm)	Formulation	Weed control strengths
Gallery	isoxaben	benzamide	1.0	spray	broadleafs
Goal	oxyfluorfen	diphenyl ether	0.1	spray	broadleafs
Princep	simazine	triazine	6.2	spray	broadleafs
Devrinol	napropamide	acetamide	73.0	spray or granular	grasses
Lasso	alachlor	chloroacetamide	242.0	spray	grasses, sedges
Pennant	metolachlor	chloroacetamide	530.0	spray	sedges, grasses
Kerb	pronamide	chloroacetamide	15.0	spray	winter annuals
Casoron	dichlobenil	nitrile	21.0	granular	broadleafs
Surflan	oryzalin	dinitroaniline	2.5	spray	grasses
Treflan	trifluralin	dinitroaniline	0.7	granular	grasses
Pendulum, Corral	pendimethalin	dinitroaniline	0.3	spray or granular	grasses
Regal Kade, Factor, Barricade	prodiamine	dinitroaniline	0.013	spray or granular	grasses
Ronstar	oxadiazon	oxadiazole	0.7	spray or granular	grasses
Rout	oxyfluorfen oryzalin	diphenyl ether dinitroaniline	0.1 2.5	granular	grasses and broadleafs
Snapshot	isoxaben trifluralin	benzamide dinitroaniline	1.0 0.7	granular	grasses and broadleafs
XL 2G	benefin oryzalin	dinitroaniline dinitroaniline	0.1 2.5	granular	grasses and broadleafs
OH2	oxyfluorfen pendimethalin	diphenyl ether dinitroaniline	0.1 0.3	granular	grasses and broadleafs
Pre Pair	napropamide oxadiazon	acetamide oxadiazole	73.0 0.7	granular	grasses and broadleafs
Regal O-O	oxyfluorfen oxadiazon	diphenyl ether oxadiazole	0.1 0.7	granular	grasses and broadleafs

Weed control on bark piles

Keep bark piles weed-free. Not only will weeds growing on bark piles generate seeds that can be blown into containers, but they also deposit seed and/or vegetative propagules (tubers from nutsedge (*Cyperus* spp.), rhizomes from oxalis, etc.) directly into the media that will be used for potting (Figure 5, page 4). When bark piles are kept weed-free, they generally are not a source of weed seeds (Cross and Skroch, 1992).

Steam pasteurization, solarization, composting, and fumigation are some treatments that will kill seed and other propagules in bark piles. These treatments are too expensive to be used

Figure 4.—Weeds in noncrop areas, such as those shown here growing next to containers, disseminate large numbers of seed, making weed control efforts less effective.

regularly in most nursery operations. Simple sanitation will avoid the need for treatment.

Clean pots

Use of clean or new pots for propagation and/or potting will also reduce the number of weeds in containers. A common characteristic of container weeds is their small seed size. Seeds cling to the side of containers along with other debris. Research has demonstrated that by simply washing propagation pots with pressurized water, the number of germinated weeds can be reduced up to six-fold (Bachman and Whitwell, 1995). The same study showed that when dirty pots were used, weeds (bittercress) germinated around the edges of the pots, compared to few or no weeds when new or cleaned pots were used.

Figure 5.—Weeds growing in bark piles add seeds and vegetative propagules to the bark, resulting in greater weed numbers in containers.

Wind breaks

Even if weeds are effectively controlled throughout your nursery, it might be impossible to affect weed control on neighboring property. Yet seed from neighbors likely will blow into your containers (Figure 6, page 5). Use of a wind break, such as a tall, weed-free hedgerow or fence, to minimize the amount of seed entering the nursery will improve weed control (Figure 7, page 5). The hedgerow or fence need not be permanent. One nursery lined a side of its property (bordering a weedy lot) with large 15-gallon plant material (mostly trees and large shrubs). This solution works doubly well by providing additional production area and by blocking weed seed from entering the nursery.

Start with weed-free liners

Use of weed-free liners is critical, especially when dealing with weeds that have extensive root systems such as oxalis, liverworts (rhizoids instead of roots), and pearlwort (*Sagina procumbens*). Because roots from these plants can generate new plants, thorough hand-weeding to remove shoots and roots is necessary. A single escaped weed can generate new plantlets at an alarming rate. One bittercress plant (Figure 8, page 6) can produce up to 5,000 seeds in just 5 weeks (Bachman and Whitwell, 1995).

Cultural practices

Research currently being conducted at Oregon State University (OSU) is demonstrating how fertilizer placement affects weed establishment. Growers typically apply fertilizers by either topdressing (applying fertilizer to the container surface after potting), incorporation (mixing fertilizer with bark prior to potting), or dibbling (placing fertilizer directly under the plant root ball while potting). By dibbling fertilizers, nutrients are not available at the container surface. Thus, weeds often fail to germinate, and those that germinate grow poorly. Control of common groundsel (*Senecio vulgaris*), oxalis (*Oxalis corniculata*), and prostrate spurge (*Chamaesyce prostrata*, syn. *Euphorbia prostrata*) is greatly improved by dibbling fertilizers compared to topdressing or incorporating. Research has demonstrated that most crops grow as well and nitrogen leaching often is reduced by dibbling fertilizers compared to topdressing or incorporating (Meadows and Fuller, 1984). If dibbling is not an option, incorporating reduces weed growth compared to topdressing.

Other OSU research has evaluated the influence of cultural practices on liverwort (*Marchantia polymorpha*) control (Svenson, 1998; Svenson et al., 2001). Liverworts thrive in moist environments with high levels of available nitrogen and phosphorus (Figure 9, page 6). Thus, any practice that allows the container surface to dry quickly, or removes nitrogen and phosphorus from the container surface, results in improved liverwort control. Cultural practices that reduce liverwort infestations include increased air circulation, use of a mulch, use of coarse container media (container surface dries more quickly), and dibbling or incorporating fertilizer instead of topdressing. Herbicides such as Ronstar (oxadiazon) and oryzalin alone failed to provide adequate liverwort control in OSU research. It was concluded that a combination of herbicides and cultural practices was necessary for liverwort control.

Figure 6.—Seeds of some weeds, such as the common groundsel shown above, have an attached white pappus that aids in wind dispersal. These and similar weed seeds often are blown in from nearby properties.

Herbicide use

For instructions on safe herbicide use, consult your local Extension agent, or refer to the *Oregon Pesticide Applicator Manual: A Guide to the Safe Use and Handling of Pesticides* (EM 8532).

Figure 7.—Use of permanent or temporary hedges around the perimeter of the nursery will prevent weed seeds from blowing in.

Maintaining a chemical barrier

Sanitation is the first step in effective weed control; proper herbicide use is the second. Herbicides form a chemical barrier over the container surface.

Figure 8.—Bittercress produce seed at an alarming rate. One bittercress plant can produce up to 5,000 seeds in just 5 weeks.

Though each herbicide controls weeds differently, preemergence herbicides provide control at the point where germinating seeds emerge through the chemical barrier (Figure 10, page 7).

If the chemical barrier is incomplete, there will be a gap where weed seed can successfully germinate and grow. Several common practices can disrupt the chemical barrier, including but not limited to the following: poking holes in the barrier with fingers or hands while moving containers, dropping containers, and container blow-over. All of these activities should be minimized to prevent disruption of the chemical barrier. Instruction and explanation of this concept to the work crew is necessary, as they typically are responsible for moving and working around the containers.

Figure 9.— Liverworts infesting these containers thrive on high nutrient levels, moist soil, high humidity, and shade.

Pulling uncontrolled weeds also creates gaps in the chemical barrier. Weeds should be pulled before they go to seed. However, soon after removing weeds from an area, apply an herbicide to create a complete chemical barrier and prevent germination of more weeds.

Sufficient and uniform herbicide application

To create an effective chemical barrier over the container surface, always apply herbicides at the rate specified on the label. If rates are too low, the chemical barrier may not be sufficient to prevent weed growth. If rates are too high, the herbicide may cause crop injury. Also, it is important to apply herbicides uniformly. When herbicides are not applied uniformly, weeds will emerge in areas with insufficient herbicide. Use properly calibrated equipment that is functioning correctly. Pay careful attention to equipment calibration and application uniformity, and take steps to ensure that proper herbicide rates are applied.

Even with correct application, however, flaws in equipment engineering may result in nonuniform applications. It has been documented that even with trained staff using properly calibrated equipment, the actual amount of applied herbicide may vary throughout the treated area from 0.5 to 2.2 times the intended rate (Darden and Neal, 1999). Collection pans placed throughout the application area can be used to measure uniformity of application and identify regions with weak herbicide barriers. This method is similar to using rain gauges to measure irrigation uniformity.

In summary, the most effective weed management is provided by using sanitation to reduce weed seed numbers in your production system, while maintaining an effective chemical herbicide barrier to prevent growth of the few seeds that elude sanitation efforts. If herbicide use is over-emphasized while neglecting sanitation, increased numbers of weed seeds will find a place to germinate where the chemical barrier has been weakened. On the other hand, if sanitation is made a priority while herbicide applications are neglected or implemented improperly, the few weed seeds that are present will emerge and quickly generate more seeds.

Selecting preemergence herbicides

Preemergence herbicides are applied before weed emergence to prevent weed growth, in contrast to postemergence herbicides, which kill weeds after they have emerged and are actively growing. Base your selection of herbicides primarily on three criteria: the crop to which the herbicide will be applied, weed species to be controlled, and herbicide solubility. Other considerations include the importance of rotating herbicide chemistry and the choice of granular versus spray-applied herbicides.

Crop tolerance to herbicides

Selecting an herbicide based on the crop being grown is critical. Every herbicide label describes how the product should be used and to which plants it can be applied (Figure 11). The plant list is a compilation of plants to which the herbicide has been applied safely in experimental tests. Every effort is made by chemical manufacturers to ensure that plants listed on labels can be treated safely. However, not every environmental or cultural situation can be predicted or accounted for when testing products. Therefore, prior to using a new herbicide, or using a familiar herbicide on a new crop, conduct a small trial to ensure the plant and herbicide are compatible under conditions specific to your production system (regardless of whether the plant is listed on the label).

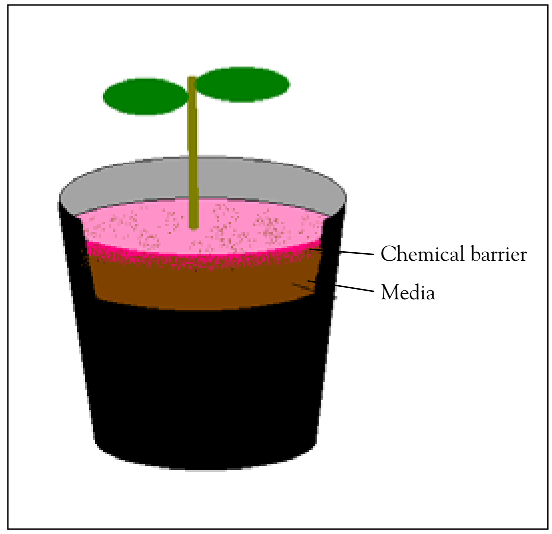

Figure 10.—Herbicides form a chemical barrier over the container surface. As weeds germinate within the chemical barrier, they either are killed or are inhibited from growing.

Some labels specify whether the product can be applied to container crops, field crops, or both. Most labels specify which *species* can be treated; some list the *genus* only. The issue is further complicated for nurseries because the horticulture industry frequently introduces new cultivars, species, and even genera. In Oregon, more than 2,000 species, and many more varieties or cultivars, are grown commercially. For crops not listed on the label, some manufacturers allow you to conduct trials on a small number of plants to determine for yourself whether the herbicide is safe. While this clause is helpful to nursery growers, in Oregon you still must obtain an experimental use permit by the Oregon Department of Agriculture (ODA).

Figure 11.—Every herbicide has a label that describes how the product should be used and to which crops it can be applied. Read each label carefully prior to use.

Dinitroaniline herbicides

There is some concern over using products containing dinitroaniline (DNA) herbicides at potting. This class of chemicals (see Table 1) includes trifluralin, prodiamine, pendimethalin, benefin, and oryzalin. DNA herbicides are root-inhibiting chemicals used in many herbicide products. While most crops are tolerant of DNAs regardless of when they are applied, some crops are sensitive at potting (azaleas, herbaceous perennials, and some ornamental grasses, for example) and are subject to lodging, poor root development, and stunting. Use products that do not contain a DNA if previous experience or prior knowledge does not provide you with information on crop safety at planting.

Weed susceptibility to herbicide types

Every herbicide has both active and inert ingredients. The active ingredient is the chemical component that actually provides weed control. The inert ingredient is a carrier (for granular herbicides) or a substance to facilitate herbicide solubility or coverage (for spray herbicides).

No single preemergence herbicide provides complete control of all weed species. Herbicides are generally effective on *either* broadleaf weeds *or* grasses.

The following herbicides are effective in controlling emerging broadleaf weeds but provide poor control of most grasses: Goal (oxyfluorfen), Gallery (isoxaben), and Princep (simazine).

Herbicides that are effective at controlling emerging grasses and *some* small-seeded broadleaf weeds (but not all broadleaf weeds) include: Surflan (oryzalin), Pendulum (pendimethalin), and Factor, RegalKade, or Barricade (prodiamine).

Ronstar (oxadiazon) does not fall neatly into either category. It controls many broadleafs and grasses, but when used alone, it fails to control some weeds, most notably common chickweed (*Stellaria media*) and pearlwort.

When a single chemical is used, poor weed control may result due to infestation of uncontrolled species. Table 1 lists the types of weeds controlled by preemergence herbicides used in nursery production.

The herbicides mentioned above that are effective against grasses and small-seeded broadleafs are among the most effective herbicides for containers. This is because many weeds prevalent in container crops are "small-seeded" broadleafs. Bittercress, oxalis, pearlwort, and phyllanthus (*Phyllanthus tenellus*) are small-seeded broadleafs. Nonetheless, using an herbicide combination that contains an active ingredient effective against broadleafs and one effective against grasses provides better control of common container weeds than any single herbicide alone.

Selecting a granular herbicide based on prevalent weed species is easy because most of these products are formulated to provide broad-spectrum weed control. That is, they contain an active ingredient for controlling grass weeds and one for controlling broadleafs. For example, Snapshot TG contains the active ingredients trifluralin and isoxaben. If using granular preemergence herbicides, it is a good idea to use those that contain two active ingredients, one for controlling grasses and one for controlling broadleafs.

Granular herbicides are loaded onto a dry carrier. The carrier is the inert ingredient used to make application easier. For example, Ronstar 2G contains 2 percent of the active ingredient oxadiazon and 98 percent inert material. Inert carriers can be clay particles, crushed corn cobs, a recycled paper product called biodac, or granular fertilizers.

Spray-applied preemergence herbicides are sold with just one active ingredient. Currently, they cannot be purchased as combination products. Herbicide manufacturers do not supply combination spray-applied preemergence herbicides for nursery crops because blends can be made simply by adding multiple herbicides to a spray tank. A common question, however, is "which herbicides can be tank-mixed together?" In terms of chemical compatibility, herbicide labels either provide this information or explain a simple procedure for testing compatibility (mixing the products in a small jar to observe the reaction). In terms of effectiveness, mixing a chemical from each of the two groups previously mentioned generally provides excellent control, superior to either product applied alone.

The active ingredient for every herbicide is listed near the top of the label or on the front of the bag/container. Check the active ingredients to make sure the product you use provides control of the weeds prevalent in your nursery. Table 1 lists commonly used herbicides, their active ingredients, and the weed groups best controlled by each product.

Solubility of preemergence herbicides

Herbicide solubility is a measure of how readily an herbicide goes into solution. Herbicides with high solubility are more likely to go into solution. Herbicides in solution can have negative consequences on plant growth and weed control.

Preemergence herbicides are applied to the container surface, where they form a chemical barrier. As weed seeds germinate, the roots or shoots grow through the chemical barrier, where they contact and/or absorb the herbicide. Because container production utilizes high volumes of water applied daily, herbicides with a high solubility are likely to go into solution and be flushed away from the container surface. If herbicides are moved away from the container surface, the chemical barrier will be weakened. Herbicides that are flushed through the media also may contact crop roots and cause injury.

Herbicides for container production should have a solubility of less than 3 ppm. (Table 1 lists the solubility of each active ingredient in common preemergence herbicide products.) Use herbicides with higher solubility only when specific circumstances require it. For example, metolachlor has a very high solubility, but is currently the only herbicide that provides effective preemergence control of nutsedge (or nutgrass, *Cyperus* spp.). Use metolachlor when this weed is of concern (providing the crop being grown is on the label).

Rotating herbicide chemistry

Rotating herbicides is accomplished by using herbicides from different chemical families in successive applications. Rotate herbicides as often as possible, at least once per growing season. Table 1 lists the chemical families of herbicides commonly used in nursery production. With granular herbicides that contain two active ingredients, at least one of the actives should be from a different chemical family than those in the previously applied herbicide.

Figure 12.—Consistent use of the same herbicide may result in a weed shift or weed resistance. Common groundsel, shown above, is resistant to triazine herbicides and has been reported to be resistant to dinitroaniline herbicides.

Failure to rotate herbicides may result in weed shifts (Figure 12). A weed shift occurs when constant use of a single herbicide results in gradual buildup of a weed species tolerant of that chemical. For example, constant use of Ronstar alone may result in a gradual buildup of common chickweed.

Also, herbicide resistance may occur if herbicides are not rotated. Resistance development is uncommon, but not impossible. It has been documented that common groundsel is triazine-resistant (Princep is a triazine herbicide) due to frequent use of this chemical class in agronomic crops. There have been undocumented reports of common groundsel developing resistance to dinitroaniline herbicides. This resistance could have serious implications in the nursery industry, because many of our herbicides are at least partly composed of dinitroanilines (including Rout, OH2, Snapshot, Surflan, Pendulum, Factor, Barricade, and Treflan).

Granular vs. spray-applied herbicides

Herbicides are available in either a granular or sprayable formulation. Some are available in both; for example, pendimethalin can be purchased as Corral (granular form) or Pendulum 65DG (sprayable form). Table 1 lists common herbicides and the formulations in which they are available.

Granular herbicides generally are safer for container production because they fall to the container surface without injuring crop foliage (assuming foliage is dry at the time of application). However, granular herbicides generally are more expensive than spray herbicides (especially shipping costs).

Because of lower costs, and in some cases a nursery's equipment and layout, growers may prefer to use spray herbicides. Some spray preemergence herbicides cause injury when applied to foliage, some do not. Through careful experimentation and record keeping, some nurseries have determined which crops can tolerate spray herbicides. Without this type of experience, use granular herbicides when treating container crops, as they generally are safer.

In conclusion, crop tolerance, weed species, and herbicide solubility should be considered first when choosing a herbicide. Other factors, such as price, availability, and time of year (see page 11) also may affect herbicide choice. Selecting the correct preemergence herbicide, in conjunction with using sound sanitation and cultural practices, will result in a more effective weed management program. As always, read and follow pesticide labels prior to application.

Timing preemergence herbicide applications

Timing of preemergence herbicide applications cannot be described in terms of calendar dates. Each nursery has its own schedule and procedures for potting, overwintering, pruning, etc. It is more appropriate to discuss herbicide timing relative to events such as potting and overwintering, which can be applied to any nursery regardless of its production schedule.

At a minimum, apply herbicides in the spring as plants are removed from overwintering (or soon after potting), and make another application prior to overwintering. One or two additional applications in the middle of the growing season may be necessary. Some growers have shown that, with proper sanitation and a little hand-weeding, only two applications each year are necessary. Most nurseries, however, routinely make three or four applications each year.

Apply herbicides prior to weed seed germination

The most important rule for herbicide application, the rule that trumps all others, is that preemergence herbicides must be applied prior to weed seed germination. Preemergence herbicides will not control weed plants present at the time of application (Figure 13). One notable exception is *spray-applied* Goal (oxyfluorfen), which will kill weeds less than 4 inches tall. However, it is limited to field use and some container-grown conifers.

Existing weeds in containers must be hand-weeded prior to herbicide application. Weed plants present at the time of herbicide application will continue to grow and produce seed, thus perpetuating the problem. Applying preemergence herbicides to containers where weeds are growing is a waste of the herbicide and labor needed to apply it (a costly mistake).

Herbicides at potting

Herbicides can and should be applied soon after potting. When potting liners or shifting plants into larger containers, allow two or three irrigation events to occur prior to applying an herbicide in order to settle the substrate (media). For best results, apply herbicides after recently potted crops have received approximately 1 inch of irrigation or precipitation. For some herbicides, you should wait 2 to 4 weeks prior to applying herbicides when potting *bareroot* plants into containers. (Check labels for specific instructions.)

Figure 13.—Preemergence herbicides will not control weeds present at the time of application. Even small weeds, such as the oxalis shown above, will continue to grow and generate new seed.

If herbicides are applied immediately after potting, before settling has occurred, macropores in the substrate may allow herbicides to channel and make contact with plant roots, thus causing injury or stunting. If herbicides are withheld for too long after potting, weed seed germination may occur.

Herbicide applications in early spring

Crops being removed from overwintering structures, held over from the previous growing season, require a preemergence herbicide application. Herbicides cannot be applied in covered structures (hoop houses, retractable roof structures, etc.). Either remove plants from the covered structure, or remove the covering from the structure prior to herbicide application. Hand-weed all containers prior to application. Preemergence herbicides are not effective against emerged weeds.

The best time to make this application is when plants are spaced pot-to-pot. Consider the following example, which compares herbicides applied to containers spaced pot-to-pot to those that have been spaced apart.

Example: Seventy-five thousand (75,000) 1-gallon shrubs (each pot is

6 inches wide) spaced pot-to-pot occupy roughly 0.4 acre, requiring 80 lb of herbicide (assuming a rate of 200 lb/acre). Spaced just 3 inches apart (assuming no aisle ways), the plants will occupy roughly 1 acre, requiring 200 lb of herbicide. By spacing the containers, the herbicide cost jumps 250 percent!

Now consider the environmental impact of applying herbicides to containers pot-to-pot versus those that are spaced. When the containers in this example are pot-to-pot, roughly 79 percent of the herbicide will fall into the containers while 21 percent falls *between* the containers and onto the ground, where it may be washed away with irrigation or rain. When spaced 3 inches apart, roughly 35 percent of the herbicide falls into the containers, while 65 percent falls *between* the containers (Figure 14)!

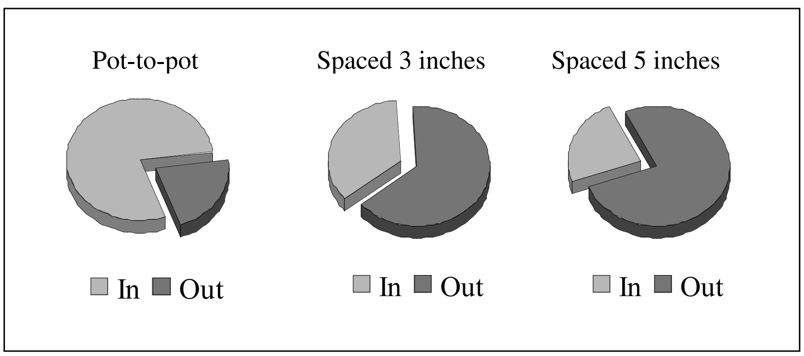

Figure 14.—Herbicides fall either in or out of (between) containers depending on the pots' spacing.

These numbers are based on calculations of the container surface area. Actual field measurements have been made that verify their accuracy (Gilliam et al., 1992), although the actual percentage of herbicide falling between containers varies based on plant height, canopy shape, etc. Nonetheless, it is clear that application of herbicides to containers prior to spacing makes sense both financially and environmentally.

Herbicide degradation and reapplication

Herbicides degrade over time. How long an herbicide persists depends on several factors, including light, temperature, and substrate moisture. Several processes are responsible for herbicide degradation, including photodegradation, chemical degradation, microbial degradation, leaching, and volatilization. Photodegradation occurs when ultraviolet (UV) light breaks chemical bonds of the herbicide's active ingredient. Secondary molecules resulting from the cleavage of the parent molecule generally are less effective in providing weed control.

Microbial degradation occurs when soil microorganisms use the herbicides as a food source. Virtually all pesticides are organic compounds made up mostly of carbon, hydrogen, nitrogen, and sulfur. These compounds are a food source for microorganisms. When the same chemical is applied repeatedly, microorganisms that preferentially feed on the chemical increase in number, consuming the chemical and thus reducing its efficacy and longevity of control. This factor is particularly important with preemergence herbicides, which are designed to have longevity in container media and soil.

Chemical degradation occurs when a nonbiological chemical reaction cleaves the herbicide's active ingredient into nonactive secondary molecules. The most common form of chemical degradation is hydrolysis (chemical cleavage through reaction with water).

Volatilization is the process by which chemicals go from a solid or liquid state into a gaseous state. If herbicides volatilize to a gas and are released into the atmosphere, they no longer provide weed control and may even cause injury to desirable crops. Of preemergence herbicides labeled for nursery crops, trifluralin is most subject to volatilization.

Herbicides are most prone to volatilization and photodegradation immediately after application, another reason why incorporation of the herbicide by irrigation is critical. Most preemergence herbicide labels recommend irrigation immediately after application with approximately 0.5 inch of water. Incorporation with irrigation will move the herbicide into the container; thus, little herbicide will be lost to volatilization and photodegradation, and an effective chemical barrier will improve weed control. Without incorporation of the preemergence herbicide, efficacy of the product and subsequent weed control will be reduced. (Note that labels on foliar-applied postemergence herbicides, in contrast, recommend a dry period after application to allow the herbicide to be absorbed by weed foliage.)

Over the course of the growing season, microbial and photodegradation are the primary means of herbicide degradation for the products most commonly used by container growers. Because of degradation, herbicides should be reapplied every 60 to 90 days if the plant canopy is not sufficient to exclude weed growth.

Application of preemergence herbicides prior to overwintering

If containers will be covered or set inside an enclosed structure for the winter, apply preemergence herbicides 2 to 4 weeks prior to covering (Figure 15). Check the label for specific recommendations. Again, all herbicides volatilize (turn to gas) at some level, and they are especially prone to volatilization soon after application. The major problem with using herbicides inside an enclosed structure is that the volatilized herbicides will injure plants by direct absorption of vapors or herbicide condensation on the foliage.

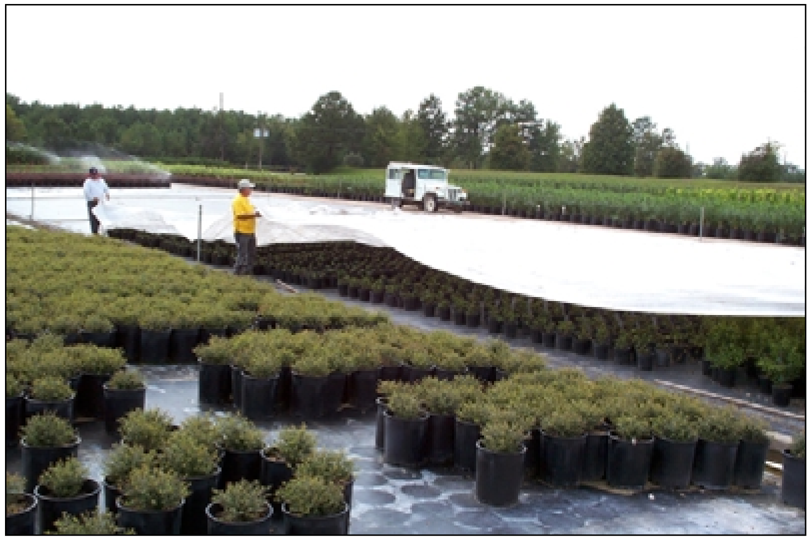

Figure 15.—Whether plants are placed in a permanent structure or under a plastic film, apply herbicides at least 2 to 4 weeks (check label) prior to covering with overwintering structures.

Weed growth while plants are overwintering can be devastating. Winter annuals such as bittercress, oxalis, fireweed (*Epilobium angustifolium*), and common groundsel can overwhelm a crop while overwintering unless an herbicide or some other form of weed control is used.

Conclusion

Herbicide timing is critical, both in terms of providing effective weed control and minimizing potential crop injury. Always check herbicide labels to make sure you are following manufacturer recommendations regarding application timing.

Weed control is most effective when herbicides are applied at the proper rate, the proper time, and used in conjunction with good sanitation.

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For more information

Oregon Pesticide Applicator Training Manual: A Guide to the Safe Use and Handling of Pesticides, EM 8532 (Oregon State University, Corvallis, reprinted 2003).

How Herbicides Work: Uptake, Translocation, and Mode of Action, EM 8785 (Oregon State University, Corvallis, 2001).

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Use herbicides safely!

- ➤ Wear protective clothing and safety devices as recommended on the label. Bathe or shower after each use.
- ➤ Read the herbicide label—even if you've used the product before. Follow closely the instructions on the label (and any other directions you have).
- ➤ Be cautious when you apply herbicides. Know your legal responsibility as a pesticide applicator. You may be liable for injury or damage resulting from herbicide use.

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