Circular 678

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Container Nursery Weed Control[1]

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Weed control in container-grown ornamental crops is one of the most important cultural concerns. Weeds are plants growing where they are not wanted. A plant can be a weed in one situation, and a desirable plant in other situations. Weeds compete with crop plants for space, water, light and nutrients. For example, one crabgrass plant in a one-gallon container can reduce the growth of an *Ilex crenata* 'Convexa' liner by 60 percent. However, even if weeds did not reduce growth, a container plant with weeds is a less marketable product than a weed-free product. Weeds can also harbor insects and diseases.

Although the predominant weed species change from season to season in Florida, the amount of pressure from these pest plants remains consistently high. This publication provides information relative to weed control principles, common weed plants, integrated weed control programs, and herbicide characteristics, availability and use.

COMMON WEEDS IN FLORIDA NURSERIES

Weeds can be categorized as broadleaves, grasses or sedges. They may be further distinguished by the length of their life cycle.

Broadleaf Weeds

Broadleaf weeds are a highly variable group of plants but most have net-like veins in their leaves and many have showy flowers. They are easy to separate from grasses due to their generally different leaf structure and habits of growth. Some examples of broadleaf weeds are burning nettle, cocklebur, common chickweed, creeping beggarweed, creeping charlie, cudweed, eclipta, Florida pusley or purslane, Florida beggarweed, henbit, pennywort or dollarweed, and spurges.

Grass Weeds

True grasses have hollow, rounded stems, and nodes (joints) that are closed and hard. The leaf blades have parallel veins, are much longer than they are wide, and alternate on each side of the stem. Some examples are goosegrass, crabgrass, crowfootgrass, sandbur, annual bluegrass, torpedograss and vaseygrass.

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Sedges

Sedges are an important group of 'grass-like' weeds; however, they are not true grasses and are characterized by a solid, triangular-shaped stem with leaves extending in three directions. There are annual sedges (often called water grasses), and the predominant and difficult-to-control perennial sedges. Of the latter group, yellow nutsedge has a yellowish green seedhead and reproduces by seed, rhizomes and tubers. The rhizomes radiate from the plant with a single bulb or tuber, the end of which may produce new plants. Purple nutsedge is usually smaller than yellow nutsedge, has reddish purple seedheads, and produces a series of bulbs on radiating rhizomes called 'tuber chains.'

The classification of weeds based on the length of their life cycle may not be obvious on visual inspection but will have a great impact on the selection and/or success of control procedures. The life cycle characteristics should become an automatic association as specific weeds and weed types are learned. The three basic life cycles of weed plants are annual, biennial, and perennial.

Annual Weeds

Annual weeds, as the name implies, complete their life cycle within one year. They germinate from seed, grow, flower, produce seed and die in 12 months or less. There are annual grasses, sedges and broadleaf weeds. In addition, annuals may be further categorized as (a) winter or cool season annuals, and (b) summer or warm season annuals, based on when the weeds germinate and flourish. Weeds such as crabgrass and spotted spurge are typical of summer annuals. These weeds sprout in the spring and thrive in the summer and early fall. Henbit, common chickweed, and annual bluegrass are typical winter annuals. Cool season weeds like these sprout in the fall and thrive during the winter and early spring.

Biennial Weeds

Compared to annual weeds, biennial weeds are few in number. These weeds have a 2-year life cycle. They germinate from seed in the fall and develop large root systems and a compact cluster of leaves during the first year. In the second year they flower, produce seed, and die. Examples of biennial weeds are Carolina falsedandelion, wild carrot, bull thistle, and some cudweed species.

Perennial Weeds

Weeds that live more than 2 years are perennials. They reproduce by vegetative parts such as tubers, bulbs, rhizomes (underground stems) or stolons (above-ground stems). In addition, many (like long-stalked phyllanthus) also produce seed. During the winter season most are dormant and many lose their above-ground foliage and stems. In the spring they initiate growth from food reserves in their root systems. Torpedograss, nutsedge, and various vines are members of this group of weeds. Florida betony is a perennial weed that, under a subtropical climate, initiates its growth in the fall, grows during the winter months and goes dormant during the heat of the summer.

Perennial weeds may be further divided into groups based on the type of root system and reproductive process.

- **Simple perennials** reproduce by seeds but root pieces distributed by cultivation or other mechanical means will produce new plants. Florida betony and some trees and shrubs are characteristic of this group.

- **Bulbous perennials** reproduce by seed and above- or below-ground bulbs. Yellow nutsedge and wild onions have their bulbs below ground while wild garlic has an above-ground bulb.

- **Creeping perennials** which produce seed but also produce rhizomes or stolons. Bermudagrass, torpedograss, and purple nutsedge produce these specialized stems (rhizomes and stolons) that act as food storage organs and can initiate growth at each node (joint) along the stem.

Perennial weeds are the most difficult to control because of their great reproductive potential and persistence.

Proper identification of target weeds is necessary before effective control measures can be selected. More information regarding identification of weeds can be obtained from county Extension offices.

WEED CONTROL PRINCIPLES

Seed can be distributed by people, animals, birds, wind and/or water, and are the most important weed source in Florida nurseries. Weed root pieces must

be moved mechanically to the container by contaminated media, containers or liners.

Preventative weed control is the objective of any program because control of established weeds in containers is limited primarily to hand labor. Effective prevention requires proper emphasis be placed on nursery sanitation. Since seeds are the main weed source, reduction in weed seed number in the production area should be a high priority. Although some weed seeds are wind-blown for several miles, most only move a short distance. Thus, elimination of seed-bearing weeds adjacent to production areas will reduce the weed seed population. Weeds that do develop in containers should not be allowed to flower and set seed before they are removed. Weed seed can also be distributed to containers through irrigation water, especially if a surface water source is used. Elimination of seed producing weeds near surface waters can reduce this problem. Irrigation system filters can remove many weed seeds before they reach the containers. Container media may contain weed seed or vegetative propagules. Contamination can occur before media components are prepared and during mixing or storage. Native peat may contain viable seed or propagules even though it was dug from bogs 20 or 30 feet deep. Media should not be prepared or stored in areas with high weed populations.

Rooted cuttings and seedlings transplanted from propagation beds or containers can transfer weed problems from the propagation area to production areas. Therefore, it is essential that preventative weed control start with the propagation phase of production. If liners or seedlings are purchased, care must be taken to ensure that only high quality weed-free plants are brought into the production system.

It has been estimated that controlling weeds with only hand labor would cost in excess of $6000 per acre per year. This could account for up to 30 percent of total production costs, without considering growth reduction due to weed competition between weedings. Although some hand removal of escape weeds may be necessary, preventative weed control with herbicides may account for as little as 3 percent of the total production costs. Weed control for container nurseries must start with clean production areas that are kept clean through an integrated preventative program.

WEED CONTROL METHODS

Weed control can be accomplished by physical or chemical means or by a combination of the two. Mechanical weed control can consist of cultivation or mowing of surrounding areas, use of ground covers on production beds and hand weeding. Chemical weed control consists of preemergence and postemergence herbicides.

Physical Controls

Weeds in nonproduction areas can be controlled by cultivation, chemicals or competition from groundcovers, such as turfgrass. Cultivation is expensive and predisposes the soil to erosion by wind and water. Cultivation within the container production areas is impractical. Turfgrasses are tough competitors for weeds if proper, yet low maintenance schedules are followed. Turfgrass selection should be based on seed production characteristics, tolerance of traffic, and nutrition, light and irrigation requirements.

Mulches in container production areas are used to stabilize production bed surfaces and prevent weed growth. Black plastic is by far the most common ground cover. Although some weeds can penetrate the plastic, most will not. Care should be taken to minimize the number and size of holes made in the plastic since each hole represents a site for weed establishment. Chemical pretreatment under the plastic has proven to be helpful and will be discussed in more detail in the next section. Some woven plastic fabrics provide a barrier to weed growth by reducing light but allow water penetration. Plastic materials will last from 1 to 4 years in full sun production areas but ultraviolet light inhibitors are required for plastic ground covers to last more than one year. Some plastic ground covers may last for more than 8 years in shaded production areas. Gravel placed over black plastic film may be used, but it is expensive and provides a place where weed seeds can germinate and become established. Organic ground covers or mulches such as pine bark, sawdust or cypress shavings break down rapidly, provide a good environment for weed seed germination and may be
moved easily by wind and water.

Organic mulches can also be placed on the surface of container media to provide short term weed control. Inorganic mulches, such as plastic and fiberglass discs, have been evaluated by researchers,

but due to economic considerations and reduction in air exchange with the media, the use of such mulches has been limited.

Chemical Controls

Chemical weed control with herbicides has reduced greatly the cost of weed control in Florida nurseries. Annual herbicide costs may be one-tenth that of hand labor for weeding. Herbicides are a group of chemical compounds that control plant growth and development by interrupting some metabolic pathway or by contact action. Plant response to these chemicals depends largely on concentration of the chemical applied. For example, 2,4–D can effectively control broadleaf weeds but at lower concentrations this chemical exhibits growth-regulating properties by stimulating rooting of cuttings in certain cases.

Herbicides may be selective or nonselective through chemical characteristics or rate adjustment. **Selective herbicides** kill some plants with little or no effect on other plants. **Nonselective herbicides** are toxic to most plants. Herbicide screening research identifies the selective rate range of these chemicals to find compounds that are not toxic to crop plants but that control many weed plants.

Some herbicides will kill only the plant tissue with which they come in contact, while others are absorbed by the plant and transported within the plant to other plant parts. Contact herbicides may kill the foliage of perennial plants but regrowth from the roots is likely. Translocated or systemic herbicides may affect the entire plant.

Preemergence herbicides prevent seedling emergence and development and are applied to the surface of weed-free container media and surrounding production areas when the crop foliage is dry. Most preemergent herbicides require overhead irrigation to activate the herbicide and/or incorporate it into the growing media. In containers, this is accomplished by applying ½ to 2 inches of water. The amount of irrigation, as well as the amount of time before the herbicide must be incorporated, varies with each herbicide so check the label for this information.

Postemergence herbicides are applied to existing weeds. They are most effective when the weeds are small and actively growing. These herbicides must remain on weed foliage one or more hours to be effective. Check the product label since the time varies with the herbicide. Most postemergent herbicides labeled for use in container crops are for control of grass weeds. These grass-control herbicides can be applied over-the-top to broadleaf ornamentals. In noncrop areas around the beds nonselective herbicides such as Roundup or Diquat can be used to control weeds.

Herbicides are formulated as wettable powders (W or WP), dry flowables (DF), water dispersible granules (WDG), solutions (L or S), granular (G) or emulsifiable concentrates (E or EC). If given the choice, select DF or WDG formulations over WP formulations because DFs and WDGs are safer for the applicator due to the reduced dust associated with these formulations. Granular herbicides are applied dry to crop areas. All other formulations are mixed with water and applied using a sprayer, or in some cases the irrigation system. Good agitation in the spray tank is necessary to provide uniform application rates. The amount of active ingredient in a herbicide formulation is presented as a number in front of the formulation designation (G, W, WP, DF, WDG, E, EC, L, S) on the label. For example, a 4 percent granular herbicide would be identified as a 4G material, with 4 pounds of active ingredient in 100 pounds of product. A 75 percent wettable powder (or dry flowable or water dispersible granule) is labeled as 75WP (or 75DF or 75WDG), which means that 3 of every 4 pounds of material in the bag is active ingredient. Liquid formulations are labeled as pounds of active ingredient per gallon of product. For example, a 2EC contains 2 pounds of active ingredient per gallon of product.

Selection of a herbicide should be based on the weeds to be controlled, the existing weed population, length of control desired and specific crop plants involved. The following herbicide descriptions should be helpful in choosing the proper material for a weed control program. Always follow the label instructions and restrictions. The following descriptions are not recommendations, but are intended as background information. The chemical name is listed first, followed by trade name(s) in parentheses. Trade names listed do not imply an endorsement of that particular product.

Preemergence Herbicides

Benefin plus oryzalin **(XL)** available only as a 2G, is the herbicide to use when you want a granular form of oryzalin (Surflan). The two active ingredients are in a 1:1 ratio. It will control most annual grasses

(including crabgrasses, foxtails, and goosegrass) as well as common chickweed and henbit. It is safe to use on a broad spectrum of ornamentals

DCPA **(Dacthal)** is available only as a 75W. It will control some annual grasses and broadleaves including crabgrass, foxtails, common chickweed, and Florida pusley.

Dichlobenil **(Casoron, Dyclomec, Norosac)** can be used as a pretreatment to container production beds before putting down black plastic or other physical barriers. Applications of 4 to 6 pounds of active ingredient per acre from the 10G formulation of this herbicide are appropriate for this purpose. It should not be used in containers because of its volatility and leachability.

Isoxaben **(Gallery)** is available as a 75DF. It is used for control of many broadleaf weeds including woodsorrel, spurges, bittercress, common and mouse-ear chickweed, and pennywort or dollarweed. It is safe to use on a wide variety of ornamentals.

Isoxaben plus oryzalin **(Snapshot DF)** contains 80% active ingredients, with 60% oryzalin (Surflan) and 20% isoxaben (Gallery). The combination of ingredients provides excellent control of most weeds found in container nurseries, including common chickweed, spurges, woodsorrel, and annual grasses. It is safe to use on a wide variety of ornamentals, and is a good choice for spurge or chickweed control.

Isoxaben plus trifluralin **(Snapshot TG)** is a 2.5G formulation that combines 0.5% isoxaben (Gallery) with 2% trifluralin (Treflan). This combination controls or suppresses a fairly broad range of grasses and broadleaves including common chickweed, spurges, woodsorrel, and annual grasses.

Metolachlor **(Pennant)** is available as a 7.8EC and 5G. It is primarily used for preemergent control of yellow nutsedge, although it will also provide some control of annual grasses (including crabgrass and foxtail) and broadleaf weeds (including pigweed, Florida pusley, and carpetweed). It is safe on a wide variety of ornamentals. Do not apply it more than two times per year.

Metolachlor plus simazine **(Derby)** is a 5G formulation containing both Pennant (metolachlor) and Princep (simazine) in a 4:1 ratio. This combination allows control of common chickweed, spotted spurge, annual grasses, and yellow nutsedge. It is primarily for use on woody ornamentals. Do not make more than two applications per year.

Napropamide **(Devrinol, Hurdle, Ornamental Herbicide 5G)** is available in 2G, 5G, and 50WP formulations. It is labeled for use on a wide range of container-grown ornamentals. It is effective for control of grasses but less effective on spurges and certain broadleaf weeds. Application of 4 to 6 pounds of active ingredient per acre should be repeated every 8 to 10 weeks.

Oryzalin **(Surflan)** is available as a liquid (4S), and will prevent emergence of most annual grasses and many broadleaf weeds (including common chickweed, Florida pusley, and pigweeds). Long-term use of this herbicide on the same crop is not recommended because of possible root inhibition. This nonvolatile herbicide can be applied in any season.

Oxadiazon **(Ronstar)** is available as a 2G or 50WP, and is labeled for a wide range of container-grown ornamentals. It controls most nursery weeds, but has limited effect on spurges and chickweed. It should not be broadcast on plants with rosettes (such as daylily or liriope), whorls or wet foliage. Applications of 2 to 4 pounds of active ingredient per acre can be repeated every 8 to 16 weeks.

Oxyfluorfen plus oryzalin **(Rout)** is a 3G formulation. The active ingredients are oxyfluorfen (Goal) and oryzalin (Surflan) in a 2:1 ratio. Rout is registered on a wide variety of ornamentals and gives preemergence control of a broad spectrum of weeds including spurges. Apply 3 pounds of active ingredient per acre every 3 months during the growing season. Avoid use of Rout on 'Hino-crimson' and 'Snow' azaleas, and crape myrtles.

Oxyfluorfen plus oxadiazon **(OO-Herbicide)** is a 3G formulation containing oxyfluorfen (Goal) and oxadiazon (Ronstar) in a 2:1 ratio. This combination can provide control of a broad spectrum of weeds on a wide range of crops. It should not be broadcast on wet foliage or plants with rosettes or whorls. It may be applied at 3 to 4 month intervals at a rate of 3 pounds of active ingredient per acre.

Oxyfluorfen plus pendimethalin **(Ornamental Herbicide II)** is also a 3G formulation. The two active ingredients, oxyfluorfen (Goal) and pendimethalin (Pendulum, Southern Weedgrass Control) in a 2:1 ratio, allow this product to control

a wide range of nursery weeds, and especially spurges. Applications of 3 pounds of combined active ingredient per acre can be repeated every 10 to 12 weeks. As with Ronstar, avoid broadcast application to plants with rosettes, whorls or wet foliage as injury may occur. Several azalea cultivars are also susceptible to injury.

Pendimethalin **(Pendulum, Southern Weedgrass Control)** is formulated as a 2.68G (SWC) and a 60WDG (Pendulum). It provides control of some annual grasses (including crabgrass, foxtail, and goosegrass) and broadleaf weeds (including prostrate spurge, common chickweed, and woodsorrel). It is labeled for use on a broad spectrum of ornamentals.

Prodiamine **(Factor)** is a 65WG formulation and is labeled for a fairly wide range of container-grown ornamentals. It controls a broad spectrum of weeds including spurges. Do not apply more than 1.5 pounds of active ingredient per acre per year.

Simazine **(Princep, Simazine, Sim-Trol)** is available as a 4G, 4L, 80W, and 90WDG. It controls several annual grasses (including crabgrass and foxtails) and broadleaf weeds (including common chickweed, Florida pusley, and pigweed). It is safe to use on junipers and several other woody plants, but do not apply it within one year after transplanting. It is applied in fall or spring, but only once per year except as directed for quackgrass control.

Trifluralin **(Treflan)** is marketed as 4EC and 5G formulations. This volatile herbicide controls most annual grasses and many broadleaf weeds at 1 to 4 pounds of active ingredient per acre and should be irrigated immediately after application. Trifluralin inhibits root growth, but remains where it is applied with minimal leaching.

Postemergence Herbicides

Bentazon **(Basagran, Lescogran)** is available as a 4EC. It is a contact herbicide that is recommended for control of yellow nutsedge and some broadleaf weeds in liriope and English ivy only. In these crops, it can be applied as an over-the-top spray. You may notice minor chlorosis of 'Evergreen Giant' liriope one to two weeks after application. Two applications 7-10 days apart are required for yellow nutsedge control. A crop oil should be added to the spray for control of yellow nutsedge. Basagran will only kill the above-ground portion of weeds. Allow eight hours after application before overhead irrigation for maximum activity.

Diquat **(Diquat Herbicide H/A, Reward)** is a 2S formulation that kills all plant foliage on contact and has no residual activity in soil. Effects should be noticed within two to three days. The material is not translocated and regrowth of perennial weeds is likely. Diquat is applied as a directed spray; contact with green bark or suckers of some ornamental plants will cause injury. A nozzle shield will improve selective placement. Inclusion of a nonionic surfactant in the spray is recommended. Extreme precaution should be taken to prevent skin contact, inhalation of spray mist, soaking of absorbent clothing or eye contact.

Fluazifop **(Ornamec, Take-Away)**, ***sethoxydim*** **(Vantage)** and ***fenoxyprop*** **(Acclaim)** are all postemergence grass herbicides registered for over-the-top control of many annual and/or perennial grasses. Use a nonionic surfactant with Acclaim and Ornamec. No surfactant is necessary with Vantage (replaced Poast starting January, 1992) as it is already included in the product. While most broadleaf plants are tolerant, directed sprays must be used with certain species. Do not apply any of these products if rain is expected within an hour after application. No preemergence soil activity is expected.

Glufosinate-ammonium **(Finale)** is a nonselective contact herbicide with some systemic action. THis water-soluble liquid herbicide contains 1 pound of active ingredient per gallon and is applied on a spray-to-wet basis (prior to runoff) on green tissue of undesirable vegetation. Check label for rates depending on size and species of weed to be controlled.

Glyphosate **(Expedite Grass and Weed, Roundup)** are 4S formulations of a nonselective translocated, postemergence herbicide. For Roundup, rates of 1 to 4 pounds of active ingredient per acre in 20 to 50 gallons of water will kill most actively growing plants. Although Expedite Grass and Weed is more expensive, it comes premixed. Glyphosate is absorbed by green foliage, stems and branches and translocated throughout the plants. Six hours without rain is the recommended term for maximum absorption. Glyphosate requires 3 to 10 days or more to kill most plants and a repeat application may be required for plants with extensive underground storage organs like nutsedge and bermudagrass. Glyphosate is rapidly deactivated in most soils; therefore, a directed spray

around crop plants is effective and replant delays are not necessary.

Oxyfluorfen **(Goal)**, available as a 1.6E, provides early postemergence (weeds up to 4 inches tall) of several annual grasses (including crabgrass, goosegrass, and foxtail) and broadleaf weeds (including lambsquarters, pigweeds, henbit, and woodsorrel). It also gives preemergence control of those same grasses and broadleaf weeds, as well as many broadleaf weeds such as spotted and prostrate spurge. Goal is for use in conifers only, primarily junipers and arborvitae. Check the label for specific species.

Paraquat **(Gramoxone)** acts the same as diquat, but effects will probably be noted sooner than with diquat. Inclusion of a surfactant in the spray is recommended; however, do not use an anionic crop oil concentrate or surfactant as an insoluble precipitate may form. Gramoxone is a restricted use pesticide in Florida and extreme precaution should be taken to prevent skin contact, inhalation of spray mist, soaking of absorbent clothing or eye contact.

Pelargonic and related fatty acids **(Scythe)** is a nonselective, strictly contact herbicide whose effects can be observed within hours of applicaiton. Spray solution concentrations range from 5 to 10% and will kill the above-ground foliage and other nonwoody tissue of other plants.

Environmental Effects

Environmental conditions can change the activity of herbicides or alter plant response to these chemicals. The small volume to surface area of containers exposes the medium and root system of container-grown plants to wide temperature variations. Container plants grown outdoors may receive up to 160 inches of water annually and excessive irrigation may result in herbicide leaching.

Effective preemergence herbicides in containers must remain in the top surface of the medium and not move into the root zone. Many of these herbicides will inhibit root growth if leaching occurs. Media containing approximately 50% by volume pine bark seem to hold herbicides in the surface layer more effectively than peat and sand media components.

Wetting agents are applied to container media to facilitate thorough wetting of peat and pine bark particles. Since these materials decrease the surface tension of water and allow more rapid water dispersion, their effects on herbicide leaching through the depths of container media have been questioned. However, in a preliminary study three wetting agents did not increase leaching of trifluralin (Treflan) or oxadiazon (Ronstar) applied at recommended rates.

Enclosed structures such as greenhouses pose serious limitations for herbicide use. One must be concerned not only with phytotoxicity from direct contact from chemicals but also with the volatility of the chemicals in a partially closed system. Only four herbicides are labeled for use in greenhouses: **glyphosate** (Roundup), **diquat** (Diquat Herbicide H/A, Reward), **oryzalin** (Surflan A.S.). Be sure the fans are off when applying herbicides in greenhouses, and check the label for the re-entry interval.

HERBICIDE APPLICATION

Herbicides are usually applied in liquid or granular formulations. Most labeled preemergence herbicides for container production are granular formulations to ensure application to the medium surface with limited foliar contact and drift. It is essential that all preemergence herbicides be applied evenly over the target area. Most postemergence herbicides are liquid formulations to facilitate thorough weed coverage. General application procedures and guidelines for equipment calibration for granular and liquid herbicide formulations are presented below.

Granular Herbicide Application

The use of granular herbicides in the production of container ornamentals requires accurate application. A properly calibrated rotary or drop spreader is essential in achieving uniform coverage, but must be calibrated for each operator and each granular herbicide. A periodic recheck of the calibration is desirable since granule particle size, particle density, humidity, human variability and wind can affect the accuracy of application. In practical use, wind velocities of greater than 5 mph severely distort the uniformity of most applications and swath width.

The following is a general calibration method for granular applicators. Where specific instructions are stated by the manufacturer of either the granular herbicide spreader or the herbicide, follow those directions. Follow these steps, in order.

1. Mark out a test area of 200 square feet.

2. Weigh out enough herbicide so that there will be some left over after applying it to the test strip; place it in the applicator.

3. Apply the herbicide to the test strip.

4. Weigh the left-over herbicide in the applicator.

5. Calculate the amount used by subtracting the amount left over from what you started with.

6. Determine the approximate rate per acre by multiplying the amount used by 220. For the rate per 1000 ft^2, multiply the amount used by 5.

7. Adjust the equipment and repeat the test until the desired rate per acre (or per 1000 ft^2) is achieved.

   Note: This calibration procedure should be done for each spreader, spreader setting, and individual applying granular herbicides due to variations in equipment, walking speeds, and other factors.

A hand-held shaker can be utilized to apply granular herbicides to a small number of containers or to extremely large containers. This method may be useful for treating freshly potted plants while still on the trailer before they are spaced in the production area. This could save time and chemicals and ensure that preemergent herbicide applications were made before weed emergence. After the amount of surface area to be treated at one time has been determined, the recommended amount of herbicide can be placed in the shaker and applied uniformly to the area. Safety precautions should be followed rigidly.

Liquid Herbicide Application

Application of liquid formulations to large areas can be accomplished with either a continuous pump backpack sprayer or tractor-mounted sprayer. Regardless of the type of sprayer used to apply herbicides, the speed, pressure and nozzle height must be kept constant for accurate application. The backpack sprayer may require some modification so that it is better suited for herbicide application. A pressure gauge mounted on the tank side of the shutoff valve will allow continuous monitoring of the tank pressure, which must remain uniform. Optimum pressure control can be achieved by inserting a pressure regulator between the pressure gauge and nozzle. To prevent dripping after the shutoff valve is closed, use a quick, positive pressure shutoff valve or a strainer with a check valve. Nozzle clogging, a problem associated with the use of wettable powders (as well as DF and WDG formulations) can be reduced by inserting a 50 mesh in-line strainer and keeping the herbicide solution constantly agitated.

Listed below are general calibration procedures for continuous pump backpack sprayers and tractor-mounted sprayers.

Continuous Pump Backpack Sprayer Calibration

1. On dry ground or pavement, mark off an area equal to the desired band or broadcast width.

2. Partially fill the sprayer with water. Pump up the sprayer to the desired pressure.

3. Adjust the height of the nozzle (or boom if you are broadcast spraying) so as to achieve the desired band or broadcast width while spraying for a few seconds at a time on the dry areas within the marked area. Be sure to pump while spraying to maintain a uniform pressure.

   Nozzle height = _____ feet.

   *Example: **Band** — 4-ft band with nozzle height at 2 feet. **Broadcast** — 7-ft spray width with nozzle height at 3 feet.*

4. In an area with a terrain typical of that to be sprayed, mark off a distance of 100 feet.

5. Refill the sprayer with water. While pumping and spraying and with the nozzle at the desired height, record the number of seconds it takes to walk the calibration distance at a steady, comfortable pace.

   Time to walk the calibration distance = _____ seconds.

   Example: Time to walk the 100 feet was 23 seconds.

6. Collect the spray output from one nozzle for the same number of seconds it took to travel the calibration distance. For a boom sprayer, repeat this step for each nozzle. Then calculate the average number of ounces collected per nozzle.

Band: Collected water = _____ ounces.

Example: Collected __35__ oz. of water from the nozzle over 23 seconds.

Boom: Average collected water = _____ ounces.

Example: Broadcast—Collected __12__ oz. from the 1st nozzle, __14__ oz. from the second, and __14__ oz. from the third nozzle. The average nozzle output = (12 + 14 + 14)/3 = __13.3__ oz.

7. Calculate the gallons per acre (GPA) as shown in Equation 1 and Equation 2:

Band (single nozzle)

$$GPA = \frac{(Ounces\ of\ water) \times 3.4^{*}}{Band\ width\ (feet)} \quad \textbf{(1)}$$

Example:

$$GPA = \frac{35\ oz. \times 3.4}{4\ feet} = 29.8$$

Broadcast (boom)

$$GPA = \frac{(Avg.\ oz.\ of\ water) \times (No.\ of\ nozzles) \times 3.4^{*}}{Broadcast\ width\ (feet)} \quad \textbf{(2)}$$

Example:

$$GPA = \frac{13.3\ oz. \times 3\ nozzles \times 3.4}{7\ feet} = 19.4$$

* See Appendix for how the **constant 3.4** is derived.

8. To obtain a different GPA, change the pressure, walking speed, and/or nozzle orifice size, and repeat the steps above.

9. Determine the amount of chemical to add to the tank by first determining the fraction of an acre that can be sprayed with one tankful. (See Equation 3.)

$$Fraction\ of\ an\ acre\ sprayed\ per\ tankful = \frac{Tank\ size}{GPA} \quad \textbf{(3)}$$

Example:

$$\frac{5\ gallon\ tank}{29.8\ GPA} = 0.17\ acres\ (7{,}405\ sq.ft.)$$

Then, multiply the application rate of the product per acre by the fraction of an acre covered by one tankful to obtain the amount of product per tankful of spray. (See Equation 4.)

Example:

$$(Fraction\ of\ an\ acre\ per\ tankful) \times (Application\ rate) = Amount\ of\ product\ per\ tankful \quad \textbf{(4)}$$

Example: Amount of product to add for one 5-gallon tankful of spray delivered at 29.8 GPA that would cover 0.17 acres when the herbicide should be applied at a rate of 4 pounds product per acre. (See Equation 5.)

$$Amt.\ product = 0.17\ A \times \frac{4\ lbs.\ (of\ product)}{A} \quad \textbf{(5)}$$

$$Amt.\ product = 0.68\ lbs. \times \frac{16\ oz.}{lb.} = 10.9\ oz.$$

Tractor-Mounted Sprayer

1. In an area with a terrain typical of that to be sprayed, mark off an area 330 feet long with two stakes. The sprayer will be calibrated over one round trip, that is, 660 feet.

2. Partially fill the spray tank with water.

3. Adjust the pressure regulator so as to achieve the desired pressure with the engine RPMs to be used during spraying. Shut off the sprayer. Note the RPMs and spray width.

RPMs = _____.
Spray width = _____ feet.

Example: Spray width = __20__ feet.

4. Fill the spray tank with water to full or some measurable point.

5. Select a safe speed to be used for spraying. Start the tractor about 30 feet from the first stake with the cut-off valve closed. Upon reaching the first stake, open the cut-off valve and start spraying. Note the gear that is used. Upon reaching the second stake, turn off the sprayer and turn the tractor around. Respray the area while maintaining the same pressure and speed used on the first pass.

Gear = _____.

6. Measure the amount of water (to the nearest quart) that it takes to refill the tank to the original level in Step 4. Be sure to refill the tank in the same spot as in Step 4 to avoid errors. This is the amount of water used over the 660-foot course.

   Amount of water used in 660 feet = _____.

   Example: Amount of water used in 660 feet = 15.25 gallons (that is, 15 gallons plus 1 quart).

   Calculate the gallons per acre as shown in Equation 6:

$$GPA = \frac{Gallons\ for\ tank\ refill \times 66^{*}}{Spray\ width\ (feet)} \quad \textbf{(6)}$$

Example:

$$GPA = \frac{15.25\ gallons \times 66^{*}}{20\ feet} = 50.3$$

   * See Appendix for how the **constant 66** is derived.

7. To obtain a different GPA, change the pressure, tractor speed, and/or the nozzle orifice size, and repeat the steps above.

8. Determine the amount of chemical to add to the tank by first determining the fraction of an acre that can be sprayed with one tankful. (See Equation 7.)

$$Fraction\ of\ an\ acre\ sprayed\ per\ tankful = \frac{Tank\ size}{GPA} \quad \textbf{(7)}$$

Example:

$$\frac{50\ gallon\ tank}{50.3\ GPA} = 1\ acre$$

   Then, multiply the application rate of the product per acre by the fraction of an acre covered by one tankful to obtain the amount of product per tankful of spray. (See Equation 8.)

Example:

$$(Fraction\ of\ an\ acre\ per\ tankful) \times (Application\ rate) = Amount\ of\ product\ per\ tankful \quad \textbf{(8)}$$

   Example: Amount of product to add for one 50-gallon tankful of spray delivered at 50.3 GPA that would cover 1 acre when the herbicide should be applied at a rate of 4 pounds product per acre. (See Equation 9.)

$$Amt.\ product = 1\ A \times \frac{4\ lbs.\ product}{A} = 4\ lbs. \quad \textbf{(9)}$$

   Application of liquid herbicides to small areas can be accomplished with a continuous pump backpack sprayer or hand-held compression type sprayer. Calibration procedures like those described above are not necessary in this case. Just add the amount of herbicide needed to treat the area to enough water to uniformly spray the area at least two times. You may want to add a dye to the spray solution as an indicator of spray coverage. The dye should break down in the sun after three to four days.

APPENDIX

The Constant 3.4

This is to show the derivation of the constant 3.4 used in the various equations. (See Equation 10.)

Example:

$$GPA = \frac{(Ounces\ of\ water) \times \mathbf{3.4}}{Band\ width\ (feet)} \quad \textbf{(10)}$$

Given that we want to determine the sprayer delivery rate in GPA, and that there are 128 ounces per gallon and 43,560 square feet per acre, then:

The constant 3.4 is derived by dividing the amount of water collected from the nozzle in gallons (that is, the fraction of a gallon) by the area (in acres) covered during calibration, that is, the fraction of an acre. (See series of equations in Equation Box 11.)

$$Water\ collected\ (gallons) = \frac{Ounces\ collected}{128}$$

$$Area\ covered\ by\ spray\ (acres) = \frac{Width\ (ft) \times 100}{43{,}560}$$

$$GPA = \frac{\left(\frac{Ounces\ collected}{128}\right)}{\left(\frac{Width\ (ft) \times 100}{43{,}560}\right)}$$

$$GPA = \left(\frac{Ounces\ collected}{128}\right) \times \left(\frac{43{,}560}{Width\ (ft) \times 100}\right) \quad \textbf{(11)}$$

$$GPA = \frac{Ounces\ collected \times 43{,}560}{Width\ (ft.) \times 100 \times 128}$$

$$GPA = \frac{Ounces\ collected \times 43{,}560}{Width\ (ft.) \times 12{,}800}$$

$$GPA = \frac{Ounces\ collected \times 3.4}{Width\ (ft.)}$$

The Constant 66

This is to show the deriviation of the constant 66 used in the equation. (See Equation 12.)

Example:

$$GPA = \frac{Gallons\ for\ tank\ refill \times \mathbf{66}}{Spray\ width\ (ft)} \quad \textbf{(12)}$$

Given that we want to determine the sprayer delivery rate in GPA, and that there are 128 ounces per gallon and 43,560 square feet per acre, then:

The constant 66 is derived by dividing the amount of water, in gallons (to the nearest quart), that is used to refill the tank by the area (in acres) covered during calibration, that is, fraction of an acre. (See series of equations in Equation 13.)

$$Area\ covered\ by\ spray\ (in\ acres) = \frac{Width\ (ft) \times 660\ (ft)}{43{,}560\ \frac{ft^2}{acre}}$$

$$GPA = \frac{\left(\frac{Water\ refill\ (gallons/qt.)}{Width\ (ft) \times 660\ ft}\right)}{43{,}560\frac{ft^2}{acre}} \quad \textbf{(13)}$$

$$GPA = \left(\frac{Water\ refill}{1}\right) \times \left(\frac{43{,}560}{Width\ (ft) \times 660}\right)$$

$$GPA = \frac{Water\ refill \times 43{,}560}{Width\ (ft) \times 660}$$

$$GPA = \frac{Water\ refill \times 66}{Width\ (ft)}$$