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This publication includes lecture notes of papers presented at the 2000 New Jersey Turfgrass Expo. Publication of these lectures pro-

vides a readily available source of information covering a wide range of topics and includes technical and popular presentations of importance to the turfgrass industry.

This proceedings also includes research papers that contain original research findings and reviews of selected subjects in turfgrass science. These papers are presented primarily to facilitate the timely dissemination of original turfgrass research for use by the turfgrass industry.

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WEED MANAGEMENT IN ORNAMENTAL PLANTINGS

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Supplemental hand weeding of ornamental landscape beds is often a laborious process and can account for the majority of expenses involved in long-term maintenance of ornamental landscape beds. The development of a weed management program prior to planting, followed by implementation of that plan following planting can go a long way to help minimize the expenses.

Developing a weed management program involves site assessment, defining the type of ornamental planting, consideration of weed management options when selecting ornamental species for the site, preparation of the site prior to planting, and finally, installation of the planting and implementation of the weed management plan.

SITE ASSESSMENT

A site assessment of cultural factors to determine the suitability of ornamental species for the site is an excellent time to begin the development of a weed management program. Landscapers will generally take soil samples to determine pH and nutrient analysis, note drainage and shading patterns, and identify potential long-term maintenance problems such as heavy traffic areas. At this time, landscapers should also note the presence of any weed species on the site, paying particular attention to perennial weeds. Some perennial weeds such as yellow nutsedge, mugwort, Canada thistle, bindweed, bamboo, and Japanese knotweed are difficult, if not impossible, to control once the site is planted.

Also, inspect surrounding areas (especially in the turf) for weeds that may encroach such as ground ivy, wild violet, bermudagrass, and quackgrass.

DEFINE THE TYPE OF PLANTING

The ornamental species selected for the site will, to a large extent, dictate the weed management options available once the site is established.

Woody Tree and Shrub Beds

A planting of woody tree and shrub beds allows the maximum amount of weed management options. Since these plantings are open and easy to work around, removal of weeds manually is less laborious and least damaging to the planting. Spot treatments of non-selective herbicides, such as Roundup, without injury to the planting is also a possibility. Annual weeds may be controlled with the use of landscape fabrics, and mulches. The widest range of preemergence and postemergence herbicides are available for use in woody tree and shrub bed plantings.

Woody Ground Cover Beds

As woody ground cover beds spread, most weeds should eventually be shaded out and excluded from the planting; however, weed control within the first few years of establishment may be required. Spot treatments of non-selective

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herbicides without injury to desired plants may be difficult, so every effort should be made to control perennial weeds prior to planting. If ground covers are expected to root and spread out, landscape fabrics are not an option. Mulches may be utilized to suppress annual weeds and a wide range of preemergence and postemergence herbicides may be safely used.

Herbaceous Perennial Beds

Closed plantings of herbaceous perennials may eventually shade out annual weeds, but weed control at establishment is critical. It is very important to control perennial weeds prior to planting since it may be difficult to make spot treatments of non-selective herbicides. Landscape fabrics may be used in clump type plantings but are not an option around spreading species. Mulches may be used and there are a limited number of preemergence herbicides available. Perennial grasses may be controlled in most herbaceous perennials with postemergence herbicides such as Fusilade II.

Annual Flower Beds

Planning a weed management program for annual flower beds is similar to herbaceous perennial beds, except that even less preemergence herbicide options are available and the use of landscape fabrics is not economical due to the short-term nature of the planting. Perennial weeds can be suppressed between plantings with non-selective herbicides.

Mixed Plantings of Woody and Herbaceous Plants

Development of a weed management program is more complex because few herbicides are safe to use on a wide range of ornamental species; however, different areas of the bed could receive different herbicide treatments. It is very important to control perennial weeds prior to planting since it may be difficult to make spot treatments of non-selective herbicides. Landscape fabrics may or may not be useful depending on the nature of the planting.

ORNAMENTAL SPECIES SELECTION AND WEED MANAGEMENT OPTIONS

Ornamental species selection is generally determined by the landscape design, their suitability for the site, and desired aesthetics. The landscaper should strive, however, to select species that are compatible with weed management options that are available. Selection of weed management options will depend upon weed species present, ornamental species selection, planting design, economics, and personal choice.

Mulches

Organic (tree bark or plant hulls) and inorganic (crushed rock) mulches are available. Mulches suppress annual weeds by excluding light, which is required for weed seed germination. To effectively suppress weeds, mulches should be about 4 inches thick and replenished periodically. If organic mulches are applied too thick or begin to decompose, they stay wet between rains and allow weed seeds to germinate on top of the mulch. Used alone, mulches will rarely provide 100% control of annual weeds and will not control perennial weeds.

Landscape Fabrics

Landscape fabrics or geotextiles are useful tools for weed control in long-term ornamental plantings such as woody ornamental beds, trees, and shrubs. They should not be used in areas planted to ground covers which are expected to spread. Landscape fabrics are recommended instead of black plastic because they are porous and allow for movement of water and gases through the fabric. There are two types of landscape fabrics, woven and non-woven (also referred to as spun-bonded). For weed control, fabrics that are darker in color will generally work best. On flat surfaces, spun-bonded fabrics with a minimal amount of open space should be used, but on sloping areas it may be best to use woven fabrics since they tend to hold mulch in place better. The most critical factor in maintaining

long-term weed control is to keep landscape fabrics covered with a shallow layer of mulch (1 to 2 inches) so they are not degraded by sunlight. If exposed to sunlight, landscape fabrics can quickly degrade and become ineffective within a year. Landscape fabrics will not provide long-term control of perennial weeds, especially yellow nutsedge. If annual weeds germinate in the mulch layer above the fabric they should be quickly removed to prevent their roots from penetrating the fabric.

Herbicides

A variety of preemergence and postemergence herbicides are labeled for use in ornamental planting beds. Preemergence herbicides are applied after planting but before weeds germinate, while postemergence herbicides are applied to the foliage of actively growing weeds. Some postemergence herbicides are non-selective and can only be used for spot treatments (no herbicide contact with the foliage of desired plants), while others can be safely used directly (commonly referred to as 'over the top' applications) on a number of ornamental species. Refer to the appendix on specific comments on herbicide use in ornamental plantings.

Site Preparation Prior to Planting

Every effort should be made to try to control perennial weeds prior to planting, especially if the type of ornamental planting will exclude the use of spot treatments of non-selective herbicides. Repeated cultivation will help reduce the populations of annual weeds, but will do little to control perennials. The easiest method for controlling perennial weeds is to apply an herbicide containing glyphosate (Roundup). Since this is the one chance to make a blanket application of Roundup to the entire bed, we suggest using at least 2 quarts per acre, or 3 or 4 ounces per gallon, of spray solution. Late summer/fall applications of Roundup will control perennials much better than spring/early summer applications. There are still a few weeds that Roundup will not effectively control such as yellow nutsedge and field horsetail (*Equisetum*). Fumiga-

tion of the landscape bed is also an option, but it is a complicated operation and should be contracted to a professional.

Installation and Implementation of the Weed Management Plan

After taking the trouble (and expense) to prepare a landscape bed as free of weeds as possible, do not ruin your efforts by introducing weeds from nursery stock and mulches. While it is nearly impossible to obtain nursery stock completely free of annual weed seeds, carefully inspect soil balls of field grown nursery stock as well as containers. Look for signs of yellow nutsedge tubers, mugwort rhizomes, etc. Inspect mulch for signs of these weeds also. If landscape fabrics are to be used, take the time to install them carefully, and apply herbicides in a timely manner with the greatest precision possible.

APPENDIX: HERBICIDES FOR USE IN ORNAMENTAL PLANTINGS

Before using any herbicide, read the label carefully to insure it is safe to use on all of the ornamental species in the landscape bed. The use of many herbicides listed below may be limited to only a few ornamental species. No herbicide is safe to use on all ornamental species.

The herbicides listed below are sold under a variety of trade names, formulations, and combinations. In some cases, there may be several different manufacturers and distributors marketing the same herbicide. Therefore, the list of trade names may be incomplete and no application rates are provided. Consult a current herbicide label for recommended use rates.

Principles of Preemergence Herbicides

1. In most cases, preemergence herbicides must be applied prior to weed emergence for effective control. Most preemergence herbicides will not control established perennial weeds. To obtain weed control year round, preemergence herbicides should be

applied in early spring to control summer annual weeds and again in late summer/early fall to control winter annual weeds.

2. In general, granular formulations of preemergence herbicides are preferred for a more uniform application and to minimize the risk of injury to ornamental plants.
3. Following application, preemergence herbicides must be activated with 1 to 2 inches of rainfall or irrigation to be fully effective.
4. Many preemergence herbicides are more effective and last longer if placed under organic mulch (except Goal and Ronstar). Rout, OH2, and Regal O-O contain Goal. This will be noted in the individual descriptions of each herbicide.
5. It is preferable to apply preemergence herbicides to new transplants after the soil is settled around the roots by irrigation or rainfall and there are no cracks in the soil leading to the roots of ornamentals.
6. Apply granular products to dry foliage. Granules that stick to plants may cause injury. Do not apply granular herbicides to herbaceous plants with whorls of leaves that channel granules to the growing point at their base.
7. It is best to avoid the use of any preemergence herbicides for at least one year if the landscape bed is to be replanted. If planting new ornamental species into a landscape bed treated within the previous year with herbicides, the risk of injury can be minimized by planting only those species listed as safe on the herbicide label.

Descriptions of Preemergence Herbicides

The following herbicides are used primarily for annual grass control:

Common name: bensulide

Trade names: Betasan, Lescosan, Betamec, Pre-San, and others

Bensulide is labeled for use in a variety of trees, shrubs, and groundcovers. A few herbaceous perennials and bulbs are also listed. Sprayable and granular formulations are available. Bensulide will provide season long

control of many annual grasses. Control of broadleaf weeds is minimal and perennials will not be controlled. Performs best if applied under the mulch.

Common name: dithiopyr

Trade name: Dimension

Dithiopyr is labeled for **directed spray applications only** (no spray contact with ornamental species) in a wide range of trees, shrubs, ground covers, and herbaceous perennials. Sprayable and granular formulations are available. Effective for control of annual grasses and a good number of broadleaf weeds including chickweed, spurge, marehail, and bittercress. Perennial weeds will not be controlled. Since it can only be utilized as a directed spray this herbicide cannot be placed under the mulch.

Common name: metolachlor

Trade name: Pennant

Metolachlor is labeled for use in a wide range of trees, shrubs, and ground covers. Only a liquid formulation for spraying is available. Production of the granular formulation has been discontinued but may soon be available again. Effective for control of annual grasses and controls yellow nutsedge if applied early in the spring. To minimize the risk of injury to ornamental species, irrigate after application to wash spray from treated foliage. Cool season turfgrass can be injured by metolachlor. Take steps to avoid runoff of Pennant. Can be applied under or on top of the mulch.

Common name: napropamide

Trade name: Devrinol

Napropamide is labeled for use in a wide range of trees, shrubs, and ground covers. It may also be used in a selected number of flowers. Sprayable and granular formulations are available. Effective for control of annual grasses and a few select broadleaf weeds. Perennial weeds will not be con-

trolled. Performs best if applied under the mulch.

Common name: oryzalin
Trade name: Surflan

Oryzalin is labeled for use in a wide range of trees, shrubs, ground covers, herbaceous perennials, flowers, and bulbs. If used alone, only a sprayable formulation is available, but oryzalin is sold in combination with other products in granular formulations. If using the sprayable formulation, avoid spray contact with plants forming newly emerging buds. Effective for control of annual grasses and a good number of broadleaf weeds including chickweed, spurge, common groundsel, and bittercress. Perennial weeds will not be controlled. Performs best if applied under the mulch.

Common name: pendemethalin
Trade names: Pendulum, Corral, Pre-M, Stomp, and many others

Pendemethalin is labeled for use in a wide range of trees, shrubs, ground covers, herbaceous perennials, flowers, and bulbs. Sprayable and granular formulations are available. The widest range of ornamentals species labeled are for the granular formulations. Effective for control of annual grasses and selected broadleaf weeds including chickweed and spurge. Perennial weeds will not be controlled. Performs best if applied under the mulch.

Common name: prodiamine
Trade names: Factor, Barricade

Prodiamine is labeled for use in a wide range of trees, shrubs, ground covers, herbaceous perennials, and some flowers and bulbs. Sprayable formulations are available but granulars are only available on fertilizer. Provides season long control of annual grasses and selected broadleaf weeds including chickweed and spurge. Perennial weeds will

not be controlled. Performs best if applied under the mulch.

Common name: trifluralin
Trade name: Treflan

Trifluralin is labeled for use in a wide range of trees, shrubs, ground covers, herbaceous perennials, flowers, and bulbs. Sprayable and granular formulations are available. Effective for control of annual grasses and a few broadleaf weeds including chickweed. Perennial weeds will not be controlled. Performs best if applied under the mulch.

The following herbicides are primarily used for broadleaf weed or broad spectrum weed control:

Common name: dichlobenil
Trade names: Casoron, Barrier, and others

Dichlobenil is labeled for use in a limited number of trees, shrubs, and ground covers. Only granular formulations are available. Dichlobenil controls a broad range of annual grasses and broadleaf weeds. Dichlobenil will also control many established perennial weeds such as quackgrass, Canada thistle, and mugwort. Dichlobenil can only be applied from November 15 until February 15 when daytime air temperatures are below 45°F. Dichlobenil is volatile and if applied when air temperatures are higher, vapors can cause severe injury to ornamental plants. Avoid application of product to wet or dew laden foliage of ornamental plants. Allow at least 1 to 2 months following transplanting before using dichlobenil. Take steps to avoid runoff of dichlobenil onto cool season turf. Dichlobenil must be placed on top of the mulch.

Common name: isoxaben
Trade name: Gallery

Isoxaben is labeled for a wide range of trees, shrubs, ground covers, herbaceous peren-

nials, flowers, and bulbs. When used alone, only a sprayable formulation is available, but it is generally used as a combination product with trifluralin (Snapshot). Isoxaben controls a broad range of broadleaf weeds but will not control perennials. Performs best if applied under the mulch.

Common name: oxadiazon

Trade names: Ronstar and others

Oxadiazon is labeled for use in a number of trees, shrubs, and ground covers. Sprayable and granular formulations are available, but the widest range of ornamentals labeled are for the granular formulations. Granular combination products are available with prodiamine (RegalStar II) and oxyflourfen (Regal O-O). Oxadiazon controls a broad range of broadleaf weeds and several annual grasses. Avoid application of product to wet or dew laden foliage of ornamental plants. Oxadiazon requires light for weed control and products containing oxadiazon must be placed on top of the mulch.

Common name: oxyflourfen

Trade names: Goal, Rout, OH2

Oxyflourfen is labeled for use in a limited number of trees, shrubs, and ground covers. If used alone, only a sprayable formulation is available; however, combination products are available in granular formulations, which can be safely used on a much broader range of woody ornamentals. Rout is a combination of oxyflourfen and oryzalin, and OH2 is a combination of oxyflourfen and pendemethalin. Oxyflourfen controls a broad range of broadleaf weeds but will not control perennials. To minimize the risk of injury to ornamental plants, applications must be made while ornamental species are dormant in early spring or fall (no new flushes of growth). Avoid application of product to wet or dew laden foliage of ornamental plants.

Take steps to avoid runoff of products containing oxyflourfen onto cool season turf. Oxyflourfen requires light for weed control and products containing oxyflourfen must be placed on top of the mulch.

Principles of Postemergence Herbicides

1. Avoid spray contact with the foliage of ornamental plants, especially when using non-selective herbicides such as glyphosate (Roundup).
2. Apply postemergence herbicides to weeds that are actively growing and when there is good soil moisture. Weeds under drought stress or dormant due to cold weather will not be as effectively controlled.
3. Control of perennial weeds requires higher rates of application than control of annual weeds.
4. Injury symptoms from contact herbicides develop quickly (within 1 to 2 days) while injury symptoms from translocated herbicides may take 7 to 14 days to develop.
5. In some cases, a surfactant is required to improve herbicide absorption into the foliage of the weeds. Use a high quality surfactant with at least 80% active ingredients. Non-ionic surfactants should be added at a rate of 0.25% volume per volume of the spray solution (add 1/3 ounce of surfactant or 2 teaspoons per gallon of spray solution). Crop oil concentrates should be added at a rate of 1.0% volume per volume.
6. Avoid application of postemergence herbicides if rain is forecasted within the next few hours. Do not irrigate for at least 24 hours following herbicide application.
7. The following postemergence herbicides have minimal to no soil activity. Replanting may take place soon after application; however, halosulfuron and clopyralid have some soil activity. If possible, delay replanting herbaceous perennials and flowers into landscape beds previously treated with these herbicides.

Non-Selective Herbicides

The following herbicides may be used for spot treatments (no contact with the foliage of ornamental plants):

Common name: diquat
Trade name: Reward

Diquat is a contact herbicide with rapid activity. Diquat will control most annual weeds and will burn back perennial weeds; however, perennial weeds will not be completely controlled. Add a non-ionic surfactant as specified by the label to improve activity. Diquat is rainfast within 1 to 2 hours after application.

Common name: glufosinate
Trade name: Finale

Glufosinate is a contact herbicide with rapid activity. Glufosinate will control most annual weeds and will burn back perennial weeds; however, perennial weeds will not be completely controlled. A surfactant is not required. Avoid spray contact with the bark of trees. Glufosinate is rainfast within 4 hours.

Common name: glyphosate
Trade names: Roundup Pro, Roundup Original, Rodeo, Accord, and others

Glyphosate is a translocated herbicide with slow activity. Glyphosate will control annual and perennial weeds. The best time to apply glyphosate for perennial weed control is in the late summer/early fall. Some formulations of glyphosate such as Roundup Pro require no surfactant while other formulations do. Check labels carefully. Avoid spray contact with the bark of trees. Glyphosate is rainfast in 6 to 8 hours depending on the formulation. Some weeds not controlled well by glyphosate are yellow nutsedge and field horsetail (*Equisetum*).

Common name: pelargonic acid
Trade name: Scythe

Pelargonic acid is a contact herbicide with rapid activity. Pelargonic acid will control most annual weeds and will burn back perennial weeds; however, perennial weeds will not be completely controlled. A surfactant is not required. Pelargonic acid is rainfast within 8 hours.

Postemergence Grass Herbicides

Common and trade names: fenoxypop (Acclaim Extra), clethodim (Envoy), fluazifop (Fusilade II, Ornamec), sethoxydim (Vantage)

These herbicides can be safely used in a wide range of trees, shrubs, ground covers, herbaceous perennials, flowers, and bulbs. Read the label for each individual herbicide carefully. These herbicides are specific for the control of annual and perennial grasses. These are translocated herbicides and injury symptoms will be slow to develop. For annual bluegrass control, clethodim herbicide is the most active. For perennial grass control, clethodim and fluazifop are recommended. Some herbicides require surfactant. These herbicides are rainfast within 1 to 2 hours.

Postemergence Broadleaf Weed Herbicides

Common name: bentazon
Trade name: Basagran

Bentazon is labeled for spot treatments (no spray contact with desired foliage) around all ornamental plants except sycamore and rhododendron. A limited number of trees, shrubs, and ground covers are tolerant of over the top applications. Bentazon is useful for the control of several broadleaf weeds and will suppress Canada thistle and yellow

nutsedge. Bentazon is a contact herbicide and only the above ground portion of Canada thistle and yellow nutsedge will be controlled. The addition of a crop oil concentrate will enhance activity. Bentazon is rain fast in 8 hours.

Common name: clopyralid
Trade name: Lontrel

Clopyralid is labeled for spot treatments (no spray contact with desired foliage) in landscape plantings of selected trees and woody ornamentals. Consult a current label for species that are tolerant. Some ornamental species are very sensitive to clopyralid and its use should be avoided in landscape plantings containing ornamentals in the legume family (acacia, locust, mesquite), nightshade family (potato vine), or composite family (daisies, sunflower). Clopyralid is useful

for control of clovers, goldenrod, thistles and suppression of mugwort. Clopyralid is a translocated herbicide and injury symptoms will be slow to develop. Clopyralid is rainfast in 8 hours.

Common name: halosulfuron
Trade name: Manage

Halosulfuron is widely used in turf to control yellow nutsedge; however, it is also labeled for control of yellow nutsedge in established woody ornamentals. For use as a spot treatment only. Do not allow spray to contact desired foliage. Halosulfuron is a translocated herbicide and injury symptoms will be slow to develop. Allow 3 months after transplanting woody ornamentals before using halosulfuron. For optimum activity allow nutsedge to grow to 6 to 8 inches and add surfactant. Halosulfuron is rainfast in 8 hours.