research in which a wide range of species responded to the chemical with an increase in axillary shoot development (2). For example, in this earlier work 'Elsie Lee' azalea treated with 80 ppm of ASC-66952 formed seven times as many flower buds per plant as a result of increased branching than did non-sprayed control plants. Neither azalea cultivar in this current experiment was affected by ASC-66952 rates up to 200 ppm. Differences in response may relate to cultivar differences, to 'Elsie Lee' not being pruned two weeks after treatment (2), to use of different adjuvants, or to environmental or nutritional status of tested plants (3). Although most plant species did not respond to ASC-66952 application in this study, results with 'Harbour Dwarf' nandina are encouraging. Increased numbers of axillary and aerial rhizomic shoots represent an important source of propagation material for the grower from a cultivar that does not readily branch or form aerial rhizomic shoots during production.

(*Ed. note:* This paper reports the results of research only, and does not imply registration of a pesticide under amended FIFRA. Before using the product mentioned in this research paper, be certain of its registration by appropriate state and/or federal authorities.)

Literature Cited

1. Arzee, T., H. Langenauer, and J. Gressel. 1977. Effects of dikegulac, a new growth regulator on apical growth and development of three Compositae. Bot. Gaz. 138:18–28.

2. Crosby, K.E., H.S. Ku, L.E. Limpel and L.J. Powers. 1989. Modification of branching using a new PGR, R-50629. Proc. Plant Growth Reg. Soc. Amer. 16:192–199.

3. Gregory, F.C. and J.R. Veale. !957. A reassessment of the problem of apical dominance. Symp. Soc. Exp. Biol. 11:1–20.

4. Gwaltney, T. 1983. Propagation of dwarf nandina cultivars. Proc. Intern. Plant Prop. Soc. 33:624–628.

5. Keever, G.J., W.J. Foster, and J.C. Stephenson. 1990. Paclobutrazol inhibits growth of woody landscape plants. J. Environ. Hort. 8:41–47.

6. Lewnes, M.A. and B.C. Moser. 1976. Growth regulator effects on apical dominance of English ivy. HortScience 11:484–485.

7. Phillips, I.D.J. 1975. Apical dominance. Annu. Rev. Plant Physiol. 26:341–367.

8. Ryan, G.F. 1985. Branching of *Photinia × fraseri* in response to growth regulators and fertilizer. J. Environ. Hort. 3:15–18.

9. Sachs, T. and K.V. Thimann. 1967. The role of auxins and cytokinins in the release of buds from dominance. Amer. J. Bot. 54:136–144.

10. Wright, R.D. 1976. 6-benzylaminopurine promotes axillary shoots in *Ilex crenata* Thunb. HortScience 11:43–44.

Nontarget Losses of Granular Herbicide Applied to Container-grown Landscape Plants[1]

Wayne C. Porter and Richard L. Parish[2]

Hammond Research Station and Biological and Agricultural Engineering Department
Louisiana Agricultural Experiment Station
Louisiana State University Agricultural Center
21549 Old Covington Highway
Hammond, LA 70403

Abstract

Nontarget losses of granular material applied over widely spaced containers were reduced from 87% with a broadcast rotary applicator to 72-86% with a drop-type spreader and to 48-75% with a drop spreader modified to band apply the material. Plant species and container spacing configuration had a significant effect on material loss. With a drop spreader, losses ranged from a low of 10% with pot-to-pot spaced juniper to 86% with liriope on 30-cm centers. With a pot-to-pot hexagonal configuration, the losses varied from 10.2% with juniper to 19.9% with liriope. With a pot-to-pot square configuration, the losses varied from 15.1% with azalea to 31% with liriope. There were no significant differences in loss with the wide-spaced configuration with respect to plant species.

Index Words: herbicide application, weed control, granular herbicides, container-grown.

Species used in this study: liriope [*Liriope Muscari* (Decne.) L.H. Bailey]; prostrate juniper (*Juniperus horizontalis* Moench); dwarf lilyturf [*Ophiopogon japonicus* (Thunb.) Ker-Gawl.]; azalea (*Rhododendron × 'Carror'*); dwarf gardenia (*Gardenia jasminoides* Ellis).

Significance to the Nursery Industry

Application of herbicides formulated on granular carriers is a common practice in container nurseries. Depending on container arrangement and plant species, a high percentage of the material applied may not be retained in the containers–particularly when the material is applied with a broadcast rotary spreader. The material loss represents a significant unproductive cost to the nurseryman and can also contribute to surface or groundwater pollution. This research demonstrated the increased efficiency of application possible with a drop-type spreader. The differences in application efficiency among different plant species are also reported.

Introduction

Container production of landscape plants is a major industry in the United States. Controlling weeds in the containers requires the use of herbicides. In many cases, herbicides are

[1]Received for publication February 26, 1993; in revised form May 10, 1993. Approved for publication by the Director of the Louisiana Agricultural Experiment Station as manuscript number 93-68-7069.

[2]Associate Professor and Professor, respectively.

applied in a granular formulation. In Alabama, growers make an average of three applications per year (2). Rotary broadcast spreaders are frequently used to apply the granular herbicides, and losses from such applications can be very significant. Gilliam *et al.* (1) documented losses ranging from 23–30% with closely spaced containers, to 79–80% with containers spaced 30 cm (12 in) on center. Their research was conducted by sprinkling a measured amount of granules directly over the plants; additional losses occurring due to the tapering pattern and end-of-bed effects common with typical rotary broadcast spreaders were not measured.

Several approaches to the problem of nontarget herbicide losses have been suggested. Verma (5) developed slow-release herbicide tablets for individual containers, thus eliminating application losses. Parish *et al.* (4) developed a precision metering system that could be mounted on a potting machine to apply a discrete charge of granular material to the container potting media. This system placed granular material in the media, not on the surface as is needed for effective herbicide activity. Parish *et al.* (3) built an applicator that straddled container beds and applied discrete charges of granular material to individual pots in multiples across the container beds. The applicator was originally designed to make a dibble hole for the plants and then place the granules in the hole, but the machine could easily be modified to apply granules to the surface of planted containers. Labor efficiency with the container bed applicator was less than with broadcast application.

Objectives of the current study were: (1) to quantify the granular material losses from rotary broadcast application to several plant species, taking pattern feathering into account, (2) to compare those losses with the losses in three container configurations with a drop-type broadcast applicator, and (3) to evaluate the potential improvement in application efficiency possible with a drop-type spreader modified to apply a band of granular material.

Materials and Methods

Attapulgite clay granules (Florex LVM 20/40 from Floridin, Quincy, FL), a base material for granular pesticide formulations, were used for this experiment. The granules had a nominal sieve size of –20+40. Blank granules were used to avoid any operator toxicity or environmental problems that might have arisen from the use of active herbicide granules.

Five species of ornamental plants were used for this study; azalea (two growing seasons old) and liriope, prostrate juniper, dwarf lilyturf, and dwarf gardenia (one growing season old). These species represent a wide range of canopy openness. Heights and widths of plants are as follows: azalea, 25 cm (9.8 in) by 30.8 cm (12.1 in); gardenia, 24.5 cm (9.6 in) by 43.8 cm (17.2 in); dwarf lilyturf, 13 cm (5.1 in); liriope, 8.5 cm (3.3 in); and juniper, (9.5 cm (12.2 in). All of the plants were in #1 nursery containers that were 16.5 cm (6.5 in) in outside diameter and 16.2 cm (6.375 in) high.

Three container configurations (Fig. 1) were evaluated:

Configuration 1. Containers were placed pot-to-pot in a hexagonal pattern with a straight line of containers in the direction of spreader travel.

Configuration 2. Containers were placed pot-to-pot in a square pattern.

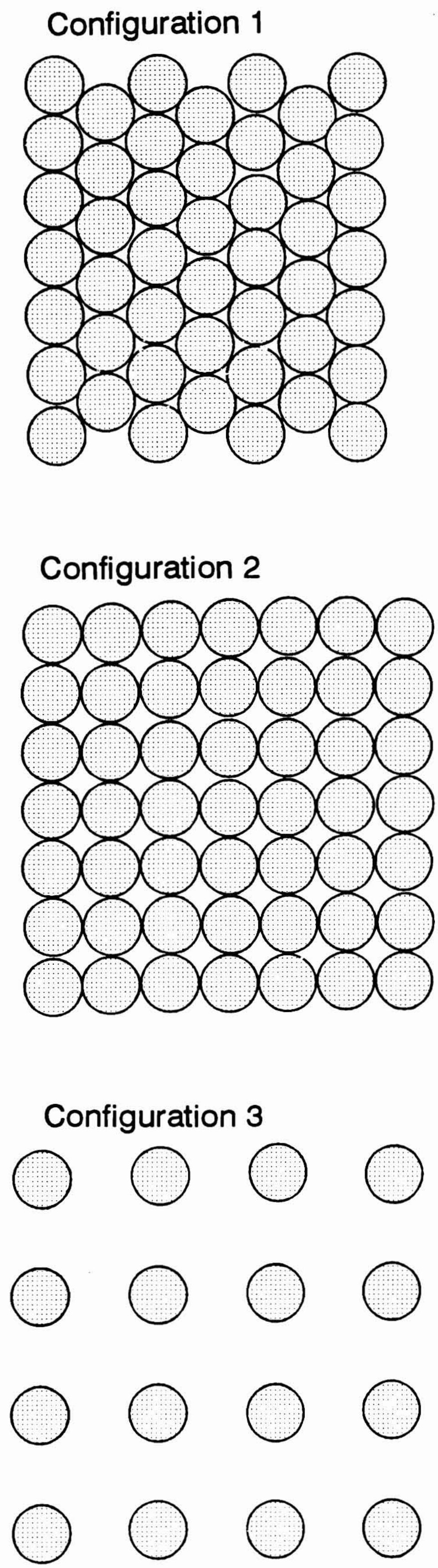

Fig. 1. Configurations of containers evaluated. Configuration 1: pot-to-pot hexagonal pattern; configuration 2: pot-to-pot square pattern; configuration 3: square pattern on 30.5 cm (12 in) centers.

Configuration 3. Containers were placed in a square pattern on 30.5 cm (12 in) centers in each direction.

The first part of the study determined the amount of material lost when a typical broadcast application was made using a hand-cranked rotary applicator[3]. Two plant species, azalea and dwarf lilyturf, were used, with only the "extreme" configurations being evaluated—configuration 1 for dwarf lilyturf and configuration 3 for azalea. Containers were arranged in beds about 1.8 m (6 ft) wide. Two strips of polyethylene film 1.2 m (4 ft) wide were placed under the containers, perpendicular to the bed and to the direction of spreader travel. A third strip of polyethylene film was laid down parallel to and between the first two strips, but without any plants or containers. Polyethylene film strips were long enough to catch the full width of the spreader patterns. Plant containers overlapped the polyethylene film strips in the direction of spreader travel. The spreader was operated down each side of the container area with the container-bed area to the left of the operator in each case and was angled in such a way that the spreader threw primarily to the left (the normal mode of operation for a spreader of this type in a container nursery application). This resulted in two complementary feathered patterns that approximate a uniform pattern when added together. Preliminary applications were made without plants to verify spreader patterns overlapped to provide a uniform pattern.

After applying the clay granules, the containers were removed and the clay granules on each polyethylene film strip were collected and weighed. Percentage of nontarget loss was determined by dividing the granule weight on the strip under the plants by the granule weight on the strip without plants. Polyethylene film strips without plants were used in calibration for each test run. Each test was replicated four times.

For the second objective of the study, a special laboratory fixture was built to facilitate the evaluation of the drop-type spreader. A wooden track about 0.6 m (2 ft) high and 4.9 m (16 ft) long was constructed over a wire mesh "table" on which the plants were placed. A sheet of polyethylene film 0.9 m (3 ft) long and wider than the bed of plants was placed under the wire mesh to collect nontarget granular losses. Plants were placed on the wire mesh in each of the three configurations. This was repeated for each species of plant. The number of plants used was extended beyond the test application and collection area in all directions.

A Gandy[4] drop-spreader was used. The ports on the spreader were 2.86 cm (1.125 in) apart resulting in discrete bands of granules being dropped. This problem was corrected with a steel deflector added under the ports at a 45° angle to vertical. The deflector caused the granules to spread and blend into a uniform band across the full 60.9 cm (24 in) spreader width.

A spreader forward speed of about 3.2 km/h (2 mile/h) was used. Since it was difficult to control spreader forward speed between runs, a set of four empty containers was placed under the test track just ahead of the plants. The material falling into those containers divided by the area of those containers represented the total application rate made by the spreader for each of the test runs. Thus, each test run had its own independent calibration. The amount of material falling onto the polyethylene film sheet under the plants could then be compared directly with the amount falling into the calibration containers to determine the percent of material not retained by the plants and containers for each individual test run. Each test was replicated four times. The delivery rate for this series of runs averaged 347 kg/ha (310 lb/A).

After the basic runs with empty containers and all species of plants at each of the three container configurations were completed, the spreader was modified to band the material over the 30-cm (12-in) spaced containers by closing off the unneeded delivery ports on the spreader with masking tape. Each test was replicated four times. The delivery rate for this series of tests averaged 116 kg/ha (104 lb/A).

Results and Discussion

With the dwarf lilyturf in a close hexagonal configuration (configuration 1), significantly more granular material was lost from the rotary broadcast application (37.2%) than with the drop-type broadcast spreader (12.9%) (Table 1). A rotary spreader does not restrict the distribution pattern to a discrete band, but allows the pattern to taper off gradually on each side of the pattern. In order to achieve a full application rate on the entire bed of containers, some material is necessarily thrown outside the bed. As indicated in Table 1, this loss (24.3%) increased the total loss significantly with closely spaced plants where the loss between plants was relatively small. With the azaleas on a wider spacing (configuration 3), the loss again was higher with the rotary spreader, but the difference (11.3%) was not statistically significant.

The actual nontarget losses were similar to the theoretical losses, but the plant species affected granular losses (Table 2). Granular material lost when applied to juniper was the lowest (10.2%) because the juniper canopy was low in stature and did not cover the surface of its container. Therefore, more of the granules reached the media surface and were retained in the container. Liriope exhibited increased material losses (19.9%), indicating that the smooth leaves covering the container surface deflected granules away to the ground.

Nontarget losses increased with configurations 2 and 3. As the containers were spaced farther apart, the losses increased since the containers covered a smaller percentage of the application area. Application efficiency was better with close-spaced plants. These results agree with research by Gilliam *et al* (1).

The improvement in application efficiency possible with a more controlled application pattern is shown in Table 3. For all plant species except dwarf lilyturf, nontarget losses were reduced by 15.6–23.9% with the banding spreader compared with the full-width drop spreader. Nontarget losses still occurred between containers in a line parallel to the direction of travel.

This study demonstrated the low application efficiency of rotary broadcast application on widely spaced plant containers. Nontarget losses were as high as 87% of the granular material applied. A close container spacing and a rotary

[3]Earthway Ev-N-Spred, Model 2700A, Earthway Prod., Inc., Bristol, IN 46507. Reference to brand names does not imply endorsement by the Louisiana Agricultural Experiment Station.

[4]Gandy drop-spreader model 24H12, Gandy Company, Owatonna, MN.

Table 1. Comparison of granular material losses[z] between a rotary-type broadcast spreader and a drop spreader.

		Broadcast rotary spreader		Drop spreader	
Species	Configuration[y]	Mean (%)	CV	Mean (%)	CV
Dwarf lilyturf	1	37.2*[x]	18.5	12.9*	6.3
Azalea	3	86.8	14.5	75.5	12.5

[z]Figures represent percentage of granular material not retained in containers.

[y]Configuration: 1 = containers placed pot-to-pot in a hexagonal pattern; 3 = container placed in a square pattern on 30.5 cm (12 in) centers.

[x]Pairs of means followed by "*" are significantly different at the 0.05 level.

Table 3. Comparison of granular material losses[z] between a full-width drop spreader and a drop spreader modified to band the material. Five different plant species and empty containers were used. All plants are spaced in each direction on 30.5 cm (12 in) centers.

	Full-width drop spreader		Banding spreader	
Species	Mean (%)	CV	Mean (%)	CV
Empty containers	76.2*[y]	5.5	52.7*	2.0
Liriope	86.0*	8.4	70.2*	2.2
Juniper	72.1*	9.0	48.2*	7.9
Dwarf lilyturf	81.4	12.3	74.7	6.0
Azalea	75.5	12.5	59.9*	8.4
Gardenia	80.2*	2.9	60.2*	4.1

[z]Figures represent percentage of granular material not retained in container.

[y]Pairs of means followed by "*" are significantly different at the 0.05 level.

Table 2. Comparison of granular material losses[z] with five different plant species and empty containers using three container configurations.

	Configuration 1		Configuration 2		Configuration 3	
Species	Mean (%)	CV	Mean (%)	CV	Mean (%)	CV
Theoretical	9.3 a[y]	—	21.5 b	—	78.3 a	—
Empty cont.	12.3 b	3.6	27.7 c	7.2	76.2 a	5.5
Liriope	19.9 c	7.7	31.0 c	13.9	86.0 a	8.4
Juniper	10.2 a	11.7	20.1 b	16.6	72.1 a	9.0
Dwarf lilyturf	12.9 b	6.3	30.5 c	6.8	81.4 a	12,3
Azalea	10.5 a	7.8	15.1 a	10.7	75.5 a	12.5
Gardenia	13.4 b	12.9	21.4 b	23.2	79.4 a	2.9

[z]Figures represent percentage of granular material not retained in container.

[y]Means within the column followed by the same letter are not significantly different at the 0.05 level as determined by the Duncan's Multiple Range Test.

spreader reduced nontarget losses to 37%. Using a drop-type spreader reduced the losses somewhat with widely spaced containers to 72–86% and reduced nontarget losses with close container spacing to 10–20%. Modifying a drop spreader to apply discrete bands further reduced nontarget losses with the widely spaced containers to 48–75%.

Efficacy of granular application under typical nursery conditions is poor. This study demonstates that application efficiency can be significantly improved by using drop-type spreaders rather than rotary spreaders for granular application. Although a small, low clearance spreader was used for this test, large high-clearance spreaders with similar operating characteristics are commercially available in widths up to 3.7 m (12 ft). Using such a spreader in a broadcast mode for closely spaced containers and modifying it to band on widely-spaced containers would significantly improve the efficiency of granular herbicide application. This improvement in application efficiency would reduce costs to the nurseryman and would reduce environmental contamination from lost herbicide.

Literature Cited

1. Gilliam, C.H., D.C. Fare, and A. Beasley. 1992. Nontarget herbicide losses from application of granular Ronstar to container nurseries. J. Environ. Hort. 10:175–176.

2. Gilliam, C.H., W.J. Foster, J.L. Adrain, and R.L. Shumack. 1990. A survey of weed control costs and strategies in container production nurseries. J. Environ. Hort. 8:133–135.

3. Parish, R.L., P.P. Chaney, W.A. Meadows, and D.L. Fuller. 1988 A dibble fertilizer applicator for containers in nursery beds. J. Environ. Hort. 6:63–66.

4. Parish, R.L., R.J. Constantin, W.L. Brown, and D.W. Wells. 1986. Development of an automated fertilizer applicator for potting machines. J. Environ. Hort. 4:91–94.

5. Verma, B.P. 1978. Slow release herbicide tablets for container nursery. Trans. ASAE 21:1054–1059.