Herbicide Levels in Nursery Containment Pond Water and Sediments[1]

N. D. Camper[2], T. Whitwell[3], R. J. Keese[4] and M. B. Riley[5]
Departments of Plant Pathology and Physiology, and Horticulture
Clemson University, Clemson, SC 29634-0377.

Abstract

Herbicide movement from broadcast granular applications via runoff waters into containment ponds was monitored over a two-year period. The nursery site was approximately 20 ha (50 A) and contained all runoff waters and recycled it for irrigation. Levels of pendimethalin, oryzalin and oxyfluorfen applied as either OH-2 or Rout herbicides were determined in containment pond water and sediment. Herbicides were extracted by a solid-phase column method and analyzed by HPLC with confirmation by GC-MS. Generally, low herbicide levels (highest level detected was 0.013 μg/ml in water and 12 μg/g in sediment) were detected compared to quantities applied [12 to 50 kg (26 to 110 lb) ai per year]. Results showed that herbicide levels did not accumulate in containment ponds following repeated applications and there was no correlation of herbicide levels detected with amount or timing of herbicide applications.

Index words: OH-2, Rout, container production.

Herbicides used in this study: OH-2 (oxyfluorfen), 2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene, plus (pendimethalin), N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzamine; Rout (oxyfluorfen) plus (oryzalin), 3,5-dinitro-N,N-dipropylsulfanilamide.

Significance to the Nursery Industry

This study provides evidence that herbicides from OH-2 and Rout formulations do not accumulate in containment pond water or sediment with repeated applications. The potential movement of herbicides from the nursery site thus posing an environmental problem is remote when runoff water is collected in containment ponds.

Introduction

Herbicides are used extensively in containerized nurseries and are generally applied either as broadcast sprays or granules (4). As much as 80% of the herbicide from broadcast applications does not reach the targeted container, but falls on the bed cover (6). Herbicide applications are usually followed by overhead irrigation and the granules or spray residues can be carried in runoff water to drainage ditches and containment ponds. Simazine and metolachlor were detected in nursery runoff following broadcast spray, granular broadcast and pot applications (10). Broadcast sprays resulted in the greatest amount of herbicide movement followed by broadcast granular and the per pot application. Nutrient and pesticides in runoff water from forestry container nurseries amounted to 60 to 80% of the total applied (3). An additional source of herbicide comes from leaching which is facilitated by the porosity of the potting media (4). Leaching of oxyfluorfen from potting media was reduced when the media contained peat (7). Studies have shown that herbicides reaching the bed cover do move into runoff water and could accumulate in containment ponds.

[1]Received for publication July 29, 1993; in revised form October 12, 1993. Technical contribution No. 3436 of the S.C. Agric. Expt. Stn., Clemson University. Supported in part by grants from the Horticultural Research Institute, 1250 I Street, N.W., Suite 500, Washington, DC 20005, Scotts Chemical Company, Grace-Sierra Chemcial Company and the S.C. Agricultural Experiment Station Ornamental Horticulture Competitive Grant Program. Appreciation is extended to Gilbert's Nursery for their assistance and cooperation.

[2]Professor of Plant Pathology and Physiology

[3]Professor of Horticulture

[4]Agricultural Science Associate II

[5]Assistant Professor, Plant Pathology and Physiology

Movement of herbicide residues resulting from broadcast applications via runoff waters into containment ponds is a concern for nursery operations. These herbicides could be phytotoxic when runoff water is used in irrigation, and pose adverse environmental impacts. Herbicide formulations most frequently used in nursery applications are OH-2 (pendimethalin and oxyfluorfen); Rout (oryzalin and oxyfluorfen); and Ronstar (oxadiazon). Oryzalin, oxyfluorfen and pendimethalin were detected in nursery containment pond water and sediment in South Carolina (8). Keese et al. (9) detected maximum levels of oryzalin, pendimethalin and oxyfluorfen within 15 minutes after beginning irrigation. They also showed that bedcover composition was a significant factor in herbicide movement after application and irrigation. However, there is little documentation of herbicide movement from container nursery operations via runoff water into containment ponds. The objectives of this study were to determine the levels of pendimethalin, oryzalin and oxyfluorfen in containment pond water and sediment with repeated applications.

Materials and Methods

The nursery chosen for this study was a container production nursery located in the Piedmont region of South Carolina, which has several containment ponds and all open beds are on sloped terrains. Runoff water is channeled through gravel drainage ditches into a series of containment ponds. Ponds receive runoff from one or more beds. One pond serves as a central reservoir for irrigation. The site covers approximately 20 ha (ca 50 A). Granular applications of Rout and OH-2 were applied to bed areas for weed control, and followed by overhead irrigation. Herbicide application and irrigation were managed by the nursery operators. Water and sediment samples were collected monthly from February 1992 to January 1993. Duplicate samples were collected and analyzed for each sampling date and at each sampling site. Herbicide application data was provided by the nursery operators. Water samples were collected at specific sites in each of four ponds from the top 15 to 30 cm (6 to 8 in) depth. Sediment samples were collected directly from

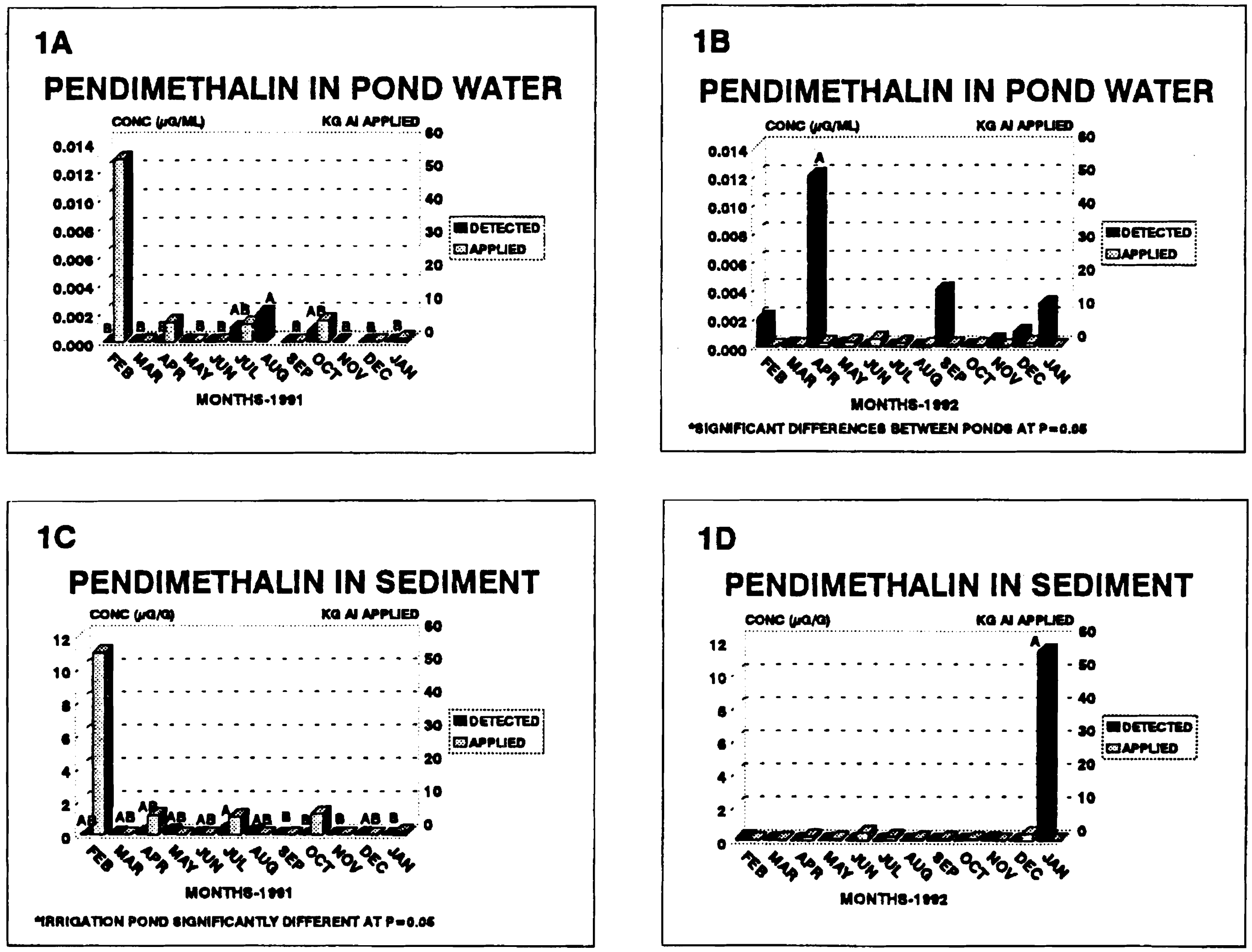

Fig. 1. Pendimethalin detected in containment pond water (mg/ml) during 1991 (A) and 1992 (B) and in sediment (mg/g) (1991; C and 1992; D). The total amount of formulated material applied (kg ai) was supplied by the nursery operators. Bars with different letters are significantly different at P > 0.05 (amount of herbicide detected only).

shallow areas (30 to 50 cm (8 to 15 in)) or with an Eckman Dredge from deeper portions (ca 25 m (15 ft)) of the ponds. Samples were collected in silanized glass jars, transported to the laboratory on ice and refrigerated at 4°C (43°F) until processed.

Water samples were adjusted to pH 2.0 to 2.3, filtered (Whatman No. 5 filter paper) and extracted on C-18 solid phase columns (2). Herbicides were eluted with HPLC-grade acetone (2 µl). Samples were analyzed by high pressure liquid chromatography (HPLC) [Varian 5060 HPLC, C_{18} column (Rexchrom, 5 µ, 4.6 mm × 25 cm, Regis); UV detection at 206 nm; solvent gradient of 60:40 acetonitrile:water to 100% acetonitrile in 25 min]. Sediments were dried at 105°C (220°F) for a minimum of 4 hr, ground to a uniform powder and a portion (5 g) extracted by shaking for 2 hr in HPLC-grade methanol; samples were analyzed via HPLC as described. Retention times for oryzalin, oxyfluorfen and pendimethalin were 7.5, 19.2 and 21.4 min, respectively. Detection limits were 1 ppb in water and 0.1 ppm in sediment. Confirmation of oxyfluorfen and pendimethalin was obtained with a Hewlett-Packard 5890 GC coupled to a 5891A mass spectrometer detector (DB-5 column, 30 µ × 25 mm; initial temperature 150°C, with 5°C/min increase to 230°C; injector temperature of 250°C and transfer line at 300°C). Confirmation was obtained by electron impact ionization at 70 eV using single ion monitoring (252 ion). Oryzalin could not be confirmed by this method.

All sample results were analyzed statistically using ANOVA followed by pairwise t-tests.

Results and Discussion

Monthly sampling began in February 1991 and continued through January 1993. Pendimethalin was not detected in the pond water until July 1991, with the highest amounts detected in August (Fig. 1A). Less than 0.004 µg/ml was detected at any sampling time, whereas from 50 to 60 kg (110 to 132 lb) ai had been applied during the year. Significant levels were detected in April 1992 (Fig. 1B); however, very low levels were applied throughout the year. Low levels (0.3 µg/g or less) of pendimethalin were detected in the sediment in July 1991 (Fig. 1C); however, a higher level of pendimethalin was detected in January 1993 (Fig. 1D). Ad-

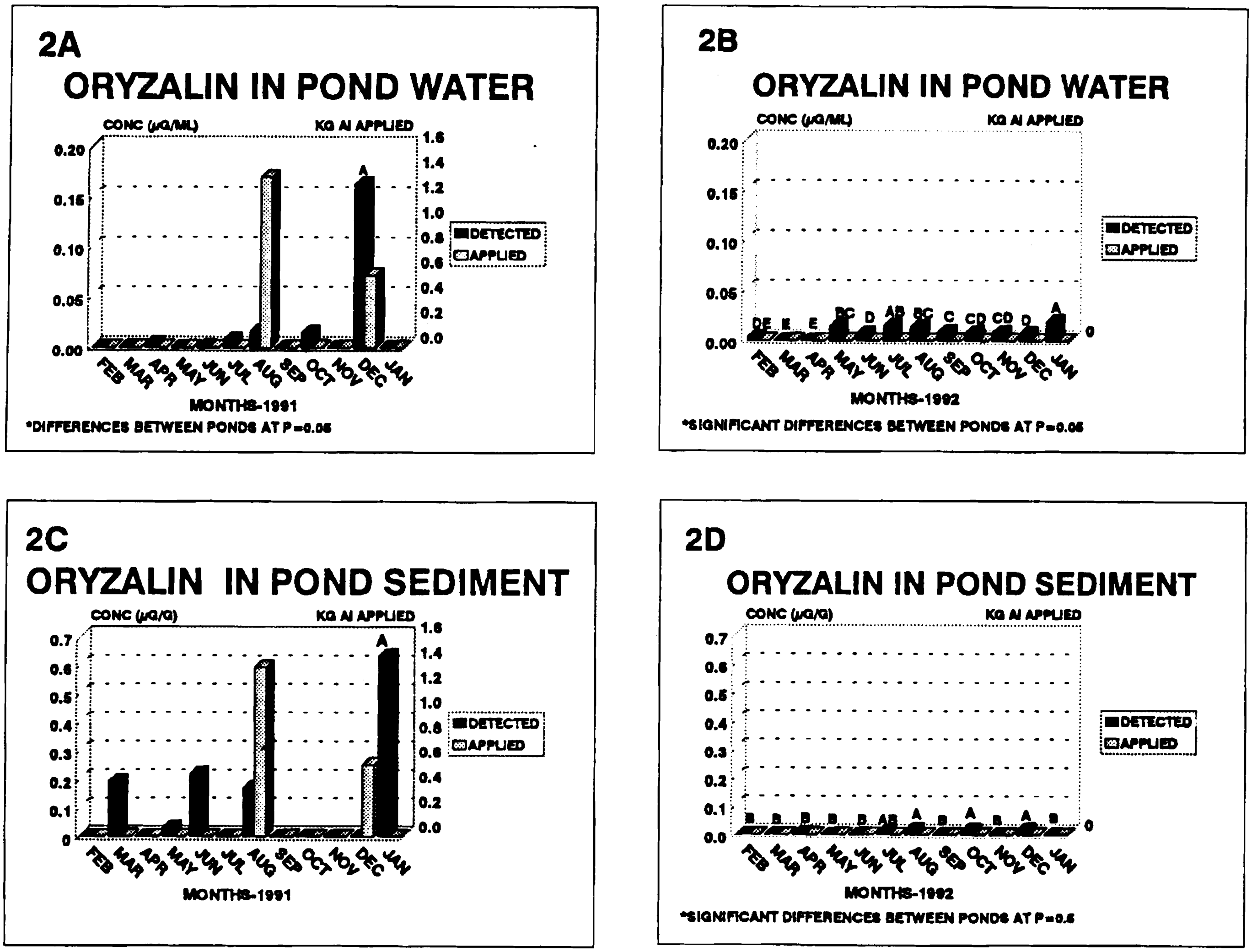

Fig. 2. Oryzalin in containment pond water (mg/ml) during 1991 (A) and 1992 (B) and sediment (mg/g) (1991; C and 1992; D). The total amount of formulated material applied is presented as kg ai. Bars with different letters are significantly different at P > 0.05 (amount of herbicide detected only).

sorption of pendimethalin to sediment as a function of time and repeated application may have contributed to the high level detected.

A second dinitroaniline, oryzalin, was detected in significant quantities in pond water in December 1991, with applications made only in August and December (Fig. 2A). No oryzalin was applied to the beds in 1992; however, low levels were detected throughout most of the year (Fig. 2B). This observation may be attributed to a slow release of material adsorbed to sediment particles as a function of time. No consistent pattern of oryzalin was detected in sediment during 1991; the highest level was detected in January 1992 (Fig. 2C). Again low levels were detected in the sediment throughout 1992, but they were 20 to 30 fold less than the levels detected in 1991 (Fig. 2D). It is possible that the low residue levels detected in 1992 came from applications of oryzalin (active ingredient of Surflan) for general weed control around the nursery site.

The diphenylether, oxyfluorfen, was never detected in high levels (< 0.01 µg/ml) in pond water throughout the 2-year sampling period (Fig. 3A and 3B). The highest levels were detected in October 1991 (< 0.005 µg/ml, Fig. 3A) and in April and June 1992 (0.009 µg/ml, Fig. 3B). Sediment concentrations were highest in December 1991 (2.75 µg/g, Fig. 3C) and April 1992 (> 3.0 µg/g, Fig. 3D). Compared to the amount of oxyfluorfen applied, levels detected were very low. Oxyfluorfen is strongly adsorbed to soil and not readily released or leached (5). This may explain the low levels detected in comparison to the levels of pendimethalin and oryzalin detected. A rigorous digestion of the sediments to release bound residues was not attempted in this study.

Correlations between application of the herbicides and levels detected were apparent at only two sampling times. A positive correlation can be noted between pendimethalin detected in sediment in January 1993 and the cumulative amount of herbicide applied during 1992 (Fig. 1D). Oxyfluorfen levels in the sediment were highest in December 1991 following fairly high applications in April, July and October (Fig. 3C). There were some differences in herbicide levels detected between ponds (Figs. 1B and 1C, 2B, and 3B). These differences may be attributed to application and drainage patterns within the nursery operations. Appli-

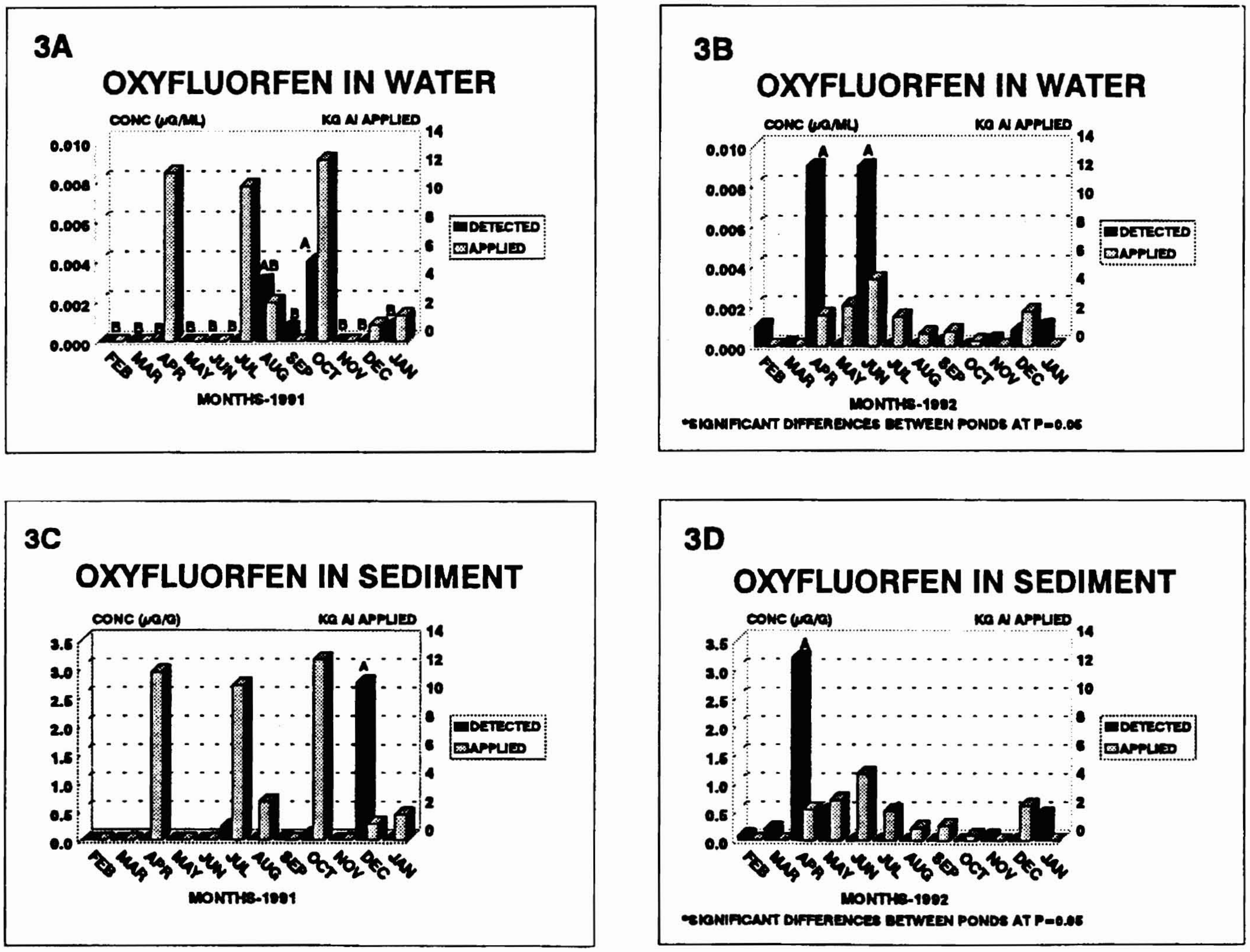

Fig. 3. Oxyfluorfen in containment pond water (mg/ml) during 1991 (A) and 1992 (B) and sediment (mg/g) (1991; C and 1992; D). The total amount of formulated material applied is presented as kg ai. Bars with different letters are significantly different at P > 0.05 (amount of herbicide detected only).

cation to a particular bed area and not others could result in detectable herbicide levels in that drainage pond and not others. Some of the bed areas drained into only one of the containment ponds.

Many factors can influence residue levels in pond water and sediment including chemical properties (e.g., water solubility), susceptibility to degradation (chemical, microbial, photo, etc.), timing of application in relation to rainfall or irrigation and adsorption to particulate or sediment particles. A previous study showed that rainfall had a significant effect on the dissipation of pendimethalin and oryzalin from soil and their presence in leachate (1, 11). Consideration of water solubility (oryzalin, 2.6 ppm; pendimethalin, 0.275 ppm; oxyfluorfen, 0.1 ppm) alone does not explain the herbicide level patterns detected. The data collected in this study show that herbicide levels do not accumulate in either water or sediment even though large quantities of the chemicals are applied on the nursery site. For these three herbicides, the potential off-site movement in the event of a "significant" rainfall occurrence and overflow of the containment ponds is quite low. The lack of herbicide buildup with continued herbicide use indicates that degradative reactions, either chemical or microbial, are occurring.

Literature Cited

1. Banks, P.A. and E.L. Robinson. 1984. The fate of oryzalin applied to straw-mulched and nonmulched soils. Weed Sci. 32:269–272.

2. Bogus, E.R., T.L. Watschke and R.O. Muma. 1990. Utilization of solid-phase, reverse-phase and ion-pair chromatography in the analysis of seven agrochemicals in water. J. Agric. Food Chem. 38:142–144.

3. Dumroese, R.K., D.S. Page-Dumroese and D.L. Wenny. 1991. Managing pesticide and fertilizer leaching and runoff in a container nursery. Proc. Intermountain Forest Nursery Assoc., USDA Forest Service, Gen. Techn. Rep. RM-211, pp 27–33.

4. Elmore, C.L. 1985. Ornamentals and Turf. *In* Principles of Weed Control in California, pp. 415–426. Thompson Publ., Fresno, CA.

5. Fadayomi, O. and G.F. Warren. 1977. Adsorption, desorption and leaching of nitrofen and oxyfluorfen. Weed Sci. 25:97–100.

6. Gilliam, C.H., W.J. Foster, J.L. Adrain and R.L. Shumack. 1992. Nontarget herbicide losses from application of granular Ronstar to container nurseries. J. Environ. Hort. 10:175–176.

7. Horowitz, M. and C.L. Elmore. 1991. Leaching of oxyfluorfen in container media. Weed Technol. 5:175–180.

8. Keese, R.J., T. Whitwell, N.D. Camper and M.B. Riley. 1992. Oryzalin, pendimethalin and oxyfluorfen levels in water and sediment from container nursery ponds. Proc. Southern Weed Sci. Soc. 45:141.

9. Keese, R.J., N.D. Camper, T. Whitwell, M.B. Riley and C. Wilson. 1993. Herbicide runoff from ornamental nurseries. J. Environ. Qual. (In press).

10. Mahnken, G.E., W.A. Skroch and T.J. Sheets. 1992. Loss of simazine and metolachlor in surface water from a container ornamental production site. Weed Sci. Soc. Amer., Absts. 32:111.

11. Stahnke, G.K., P.J. Shea, D.R. Tupy, R.N. Stougaard and R.C. Shearman. 1991. Pendimethalin dissipation in Kentucky bluegrass turf. Weed Sci. 39:97–103.

Response of 'Prize' Azalea to Sumagic Applied at Several Stages of Shoot Apex Development[1]

Gary J. Keever and John W. Olive[2]
Department of Horticulture
Alabama Agricultural Experiment Station
Auburn University, Auburn, AL 36849

Abstract

'Prize' forcing azalea was treated with 15 or 30 ppm Sumagic at one of 4 stages of shoot apex development (stage 0 = vegetative; 1 = apex broadened; 2–3 = sepals and petals initiated; 4 = stamen initiated) in 2 experiments. Plants were taller and broader as the application was delayed; these parameters decreased with increasing Sumagic rate. Bypass shoot count decreased quadratically with increasing rate, and was not affected by stage of development (SOD) in one experiment but decreased when plants were treated at a later SOD in a second experiment. Time to flower increased and flower count decreased when plants were treated at a later SOD. Plants treated at SOD 0 flowered earlier with more blooms or at a similar time with a similar flower count to control plants.

Index words: growth retardant, growth regulator, pot crop, *Rhododendron*.

Growth regulator used in this study: Sumagic (uniconazole), (E)-1-(p-chlorophenyl)-4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol.

Species used in this study: 'Prize' azalea (*Rhododendron* x 'Prize').

Significance to the Nursery Industry

Results of these two experiments indicate the importance of applying Sumagic to 'Prize' forcing azalea when shoot apexes are at the appropriate stage of development. Application at SOD 0 (vegetative), 4-½ or 5-½ weeks after final pinch in experiments 2 and 1, respectively, resulted in compact plants that flowered earlier and more uniformly with more blooms than plants treated at a later SOD. Sumagic was effective not only in suppressing lateral shoot elongation and hastening flower bud initiation, but also in inhibiting bypass shoot development.

Introduction

Growth retardants (GRs) are applied to forcing azaleas primarily to restrict lateral shoot elongation, hasten flower bud initiation, and promote uniform flower development (2, 9) and secondarily to suppress bypass shoot development (4, 5, 10). Plant response to GRs is dependent upon time of application and other factors. It is recommended that uniconazole, a triazole GR labeled for forcing azaleas as Sumagic (Valent U.S.A., Walnut Creek, Calif.), be applied 4 to 6 weeks after final pinch. However, even when applied according to the label, the desired response may not always occur, due to cultivar differences or variation in light, temperature or cultural conditions. Kohl and Sciaroni (6) described 10 stages of shoot apex development in forcing azaleas, and Larson and Auman (8) later suggested that performing the various cultural practices based on stage of apex development would make allowances for cultivar, seasonal and climatic differences. The objective of this study was to evaluate vegetative and flowering responses of 'Prize' forcing azalea to Sumagic applied at several stages of shoot apex development (SOD).

Materials and Methods

'Prize' azaleas in 16.5 cm (6.5 in) azalea pots of sphagnum peat:softwood shavings (3:2 by vol) growth medium amended with 3.6 kg/m^3 (6 lb/yd^3) SREF 19N-1P-8.3K (19-3-10), 3.6 kg/m^3 (6 lb/yd^3) dolomitic limestone, and 0.4 kg/m^3 (0.75 lb/yd^3) Micromax micronutrient fertilizer were obtained from a commercial grower in November 1991. Plants were immediately placed in a glass greenhouse with 20°C day/18°C night (68°/64°F) minima, pruned for uniformity on December 2, and topdressed with 3 grams (0.5 tsp)/pot

[1]Received for publication July 26, 1993; in revised form October 22, 1993. Appreciation is extended to Blackwell Nurseries, Semmes, AL, for donation of plant material.

[2]Professor of Horticulture and Superintendent, Ornamental Horticulture Substation, Mobile, AL, respectively.