EVALUATION OF SEVERAL SELECTIVE POSTEMERGENCE GRASS HERBICIDES FOR USE IN ANNUAL FLOWER AND GROUNDCOVER PLANTINGS

by

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B. S., Kansas State University, 1981

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1985

Approved by:

Major Professor

ACKNOWLEDGEMENTS

The author wishes to express her sincere appreciation to Dr. D. L. Hensley for his encouragement, assistance, guidance, and never ending sense of humor throughout this study. Appreciation is also extended to Dr. Charles Long and Dr. Loren Moshier for their assistance and serving on the advisory committee.

Acknowledgement is made to the following: Mr. Paul Ritty of Dow Chemical Company and Mr. Bob Munson of ICI Americas, Inc. for providing chemicals, technical information, and financial support; to BASF Wyandotte Corporation for providing chemical and technical information; to Mr. George B. Park, Jr. of Park Seed Co. and Mr. George Ball of Ball Seed Co. for providing seeds.

The author wishes to express appreciation to Mr. Jerry Pence and Mr. Mark Furry for technical assistance during this investigation. Last, but not least, a special thanks to my husband, Ron, for always being there with support and encouragement.

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LITERATURE REVIEW

INTRODUCTION

Many nurserymen and landscapers utilize preemergence herbicides to control weed growth in landscape and nursery plantings. Chemical weed control is often inadequate due to improper chemical applications, volatilization, or poor weather conditions during or following treatment. There is also a wide variation in tolerances of ornamentals to various preemergence chemicals. Additional weed control, usually in the form of hand labor, is necessary to overcome these problems and maintain acceptable weed control. Some directed sprays of non-selective, postemergence herbicides, such as paraquat and glyphosate, are commonly used in some situations.

Paraquat is effective on young seedling annuals, especially grasses, but older annuals, biennials, and perennials tend to resprout and require further treatment (Bing, 1984). Glyphosate effectively controls most perennial weeds and grasses (Hensley and Carpenter, 1983; Bingham, 1984). Both chemicals will injure the foliage of many desirable ornamental plants, therefore, must be used with caution in tree plantings and are rarely used in annual flower and groundcover plantings.

Weed control in annual and perennial flower beds and groundcover plantings has been a laborious and expensive problem for landscape maintenance personnel. Not only do weeds present an unsightly appearance to an otherwise attractive landscape, but they compete for available nutrients, light, space, moisture and harbor insects and diseases (Williams, 1981).

Weeds have been traditionally controlled by handweeding and cultivation. Although, effective, these methods are expensive in terms of capital and time. As labor costs escalate, it becomes more important to incorporate other control methods into a weed control program.

Williams (1981) considered weeds a problem during establishment and maintenance of groundcover and bedding plants. Miller et al. (1981) recommended that soil in specialized planting areas may be fumigated with methyl bromide or metham (sodium N-methyldithiocarbamate). This will eliminate most annual and perennial weed seeds. Use of a mulch and/or a preemergence herbicide applied after planting can effectively control weeds. A 5.0-7.5 cm layer of organic mulch will not only suppress weed growth but will also reduce the volatility of many herbicides, and thus extend the weed control period (Fretz, 1980).

Several herbicides are labelled for weed control in annual and perennial flower beds and groundcover plantings. Some discrepancy exists concerning which herbicide(s) will provide the best control and with the least damage to desirable plants. Many researchers have investigated the subject of crop tolerance with varying degrees of success.

Fretz (1976) evaluated the performance of several preemergence herbicides applied post-transplant to 15 annual bedding plants. Acceptable broadleaf weed control was attained by alachlor, diphenamid, and napropamide and grass control by chloramben, alachlor, diphenamid, napropamide, butralin, and trifluralin. EPTC and DCPA provided neither acceptable broadleaf nor grass weed control.

Evaluations made two months after chloramben (4.5 kg/ha) was applied to bedding plants revealed that mild to severe phytotoxicity occurred in nine of the 15 treated species. Alachlor injured salvia (Salvia splendens F. Wellow cv.

St. John's Fire) but appeared safe for all other species. Celosia (Celosia argentea L. cv. Golden Torch) was moderately injured by diphenamid (6.7 kg/ha) while napropamide caused foliar chlorosis and leaf burn on dianthus (Dianthus chinensis L. cv. Rainbow Pink), celosia, and salvia. EPTC, DCPA, butralin, and trifluralin caused slight to moderate injury on several of the species evaluated.

Bing (1982) conducted a similar study utilizing chloropropham, diphenamid, trifluralin, napropamide, and DCPA on newly planted annual flowers. Diphenamid and napropamide proved to be very effective in the control of broadleaf and grass weed species six weeks after application. Each herbicide was responsible for some damage on at least one of the nine species.

Haramaki and Kuhn (1983) evaluated eight popular annual flowers utilizing the same chemicals as Bing (1982), except trifluralin with similar results.

Bing (1983) applied the herbicides chloropropham, diphenamid, chloramben, oryzalin, trifluralin and napropamide to twelve annual bedding plants. Ratings seven weeks later indicated the best weed control was achieved by napropamide and oryzalin. Chloramben appeared to be toxic to several species while oryzalin damaged only alyssum (Lobularia maritima L.) and salvia.

POSTEMERGENCE GRASS HERBICIDES

In 1983, weed control entered a new era with the introduction of selective, postemergence grass herbicides. The first materials of this type were fluazifop-butyl, marketed as Fusilade by ICI Americas, Inc., Wilmington, DE and sethoxydim marketed, as Poast by BASF Wyandotte Corporation, Parsippany, NJ. Dow Chemical Company, Midland, MI plans to introduce haloxyfop-methyl, recently given the trade name Verdict, into the market in the near future.

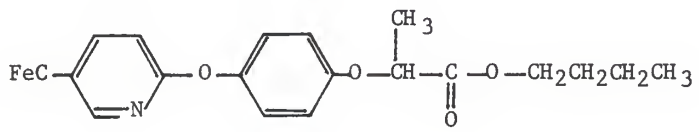
The herbicides are rapidly absorbed by the leaves, usually within one hour of application. Following application, they are translocated acropetally and basipetally. The first injury symptom is termination of growth and later, the death and decay of inner whorls of grass. Under good growing conditions, initial symptoms appear in five to seven days but generally two to three weeks are required for death of the grass.

These chemicals are intended to control annual and perennial grasses, however, species and size, application rate and environmental conditions can influence whether the underground parts of perennial grasses are completely killed (Kuhns, 1983).

Fluazifop-butyl

Fluazifop-butyl (Fusilade) is labelled for postemergence control of annual and perennial grasses in ornamental crops, but, the label is divided into over-the-top and directed applications. Fluazifop-butyl, ((+)-butyl 2-(4-((5-(trifluoromethyl)-2-pyridinyl) oxy) phenoxy) propanoate), controls perennial grasses including rhizome Johnsongrass (Sorghum halepense (L.) Pers.), quackgrass (Agropyron repens (L.) Beauvois), and Bermudagrass (Cynodon dactylon L.) generally with two applications at a maximum of 1.1 kg/ha. Many annual grasses are susceptible to fluazifop-butyl at 0.28 and 0.56 kg/ha.

Fluazifop-butyl is marketed as an emulsifiable concentrate. Fluazifop, the parent acid, has a structural formula of:

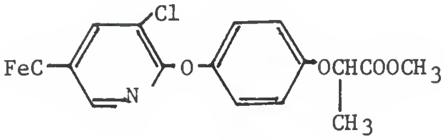


The herbicide has an acute oral LD 50 of 4830 mg/kg of body weight for male rats while for female rats the LD 50 is 4350 mg/kg. The acute dermal LD 50 to rabbits is greater than 2000 mg/kg of body weight. Fusilade is of low toxicity to birds and invertebrates, however, it is moderately toxic to fish. The LC 50 at 96 hours for rainbow trout (Salmo gairdneri) was 1.6 ppm. Although, the available data does not suggest possible significant hazards from use of this chemical, the toxicological properties have not been fully determined.

Fluazifop-butyl is expected to be safe for most broadleaved crops; however, slight stunting of plants, speckling of leaves and chlorsis of leaf margins may occur on some crops at rates of 1.1 kg/ha or higher. Fluazifop-butyl remains active in the soil for short periods of time when applied at rates of 0.6 to 1.1 kg/ha. Susceptible crops such as corn, sorghum, and small grains, may be injured when sown up to three months or less after soil treatment. Biological activity persists longer in light, sandy soils.

Haloxyfop-methyl

Haloxyfop-methyl (Verdict) is still experimental in nature, but appears to be selective to grasses and tolerant to many broadleaf crops. Haloxyfop-methyl (methyl 2- (4-((3-chloro-5-(trifluoromethyl)-2-pyridinyl) oxy) phenoxy) propanoate), is formulated as an emulsiable concentrate. The parent acid, haloxyfop, has the structural formula of:

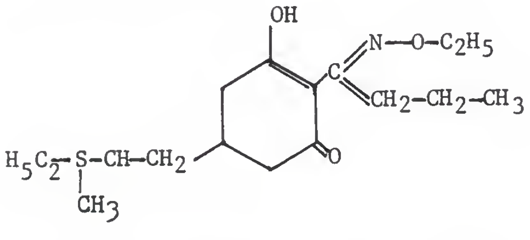


Male rats exhibited an acute oral LD 50 of 2398 mg/kg while the LD 50 of female rats was 2179 mg/kg. It exhibits a low toxicity to birds and is moderately toxic to fish and aquatic invertebrates. The LC 50 at 96 hours for rainbow trout is 0.4 ppm. Haloxyfop-methyl is also a moderate skin and eye irritant.

Haloxyfop-methyl degrades to its parent acid, haloxyfop, in 24 hours. Haloxyfop has been determined to have a half-life of 27 to 100 days, generally averaging 55 days, in a variety of soil types. This residual soil activity is usually sufficient to provide control of later germinating grasses, but, this is dependent upon dosage, weed competition, and soil and environmental conditions (Schober, 1983).

Sethoxydim

Sethoxydim, (Poast) 2-(1-ethoxyimino) butyl)-5-(2-(ethylthio)propyl)-3-hydroxy-2-cyclohexen-1-one, is formulated as a 20% emulsifiable concentrate. This herbicide has exhibited excellent selectivity in numerous broadleaf agronomic crops, vegetables, and ornamentals. The chemical structure of sethoxydim, a cyclohexane compound is:



The acute oral LD 50 of sethoxydim to rats is 2676 - 3125 mg/kg. Low toxicity has been demonstrated with rodents, rabbits, birds, fish, aquatic invertebrates and pollinating insects. Acute toxicity data indicate that user hazards to the applicator are not serious by any route of exposure.

The persistence of sethoxydim in the soil is very short, therefore, preemergence grass control is not efficacious. Most annual grasses can be controlled with rates consisting of 0.1 to 0.6 kg/ha but perennial grasses require rates ranging from 0.6 to 1.1 kg/ha, with two applications usually necessary (McAvoy, 1980).

POSTEMERGENCE GRASS CONTROL

Agronomic Crops

These chemicals were initially labelled for use on soybeans (*Glycine max* (L.) Merr.) and cotton (*Gossypium hirsutum* L.) but are commonly used on other broadleaf agronomic crops, such as afalfa (*Medicago sativa* (L.)) and tobacco (*Nicotiana tobacum* L.). Several researchers have reported excellent control of annual and perennial grasses in soybeans (Horng and Illnicki, 1982; Lange et al., 1982; Wilson and Hines, 1983; Warren, 1983) and cotton (Warren, 1983). Early and late postemergence treatments with these chemicals have been suggested for control of barnyardgrass (*Echinochloa crusgalli* (Roxb)) in alfalfa (Himmelstein and Peters, 1983).

Swisher and Corbin (1982) reported tolerance of soybeans to sethoxydim was due to the plant's ability to degrade the herbicide to a non-toxic metabolite. Crop tolerance was affected by stage of growth, environmental conditions, and, to some extent, varietal sensitivity (Hartzler and Foy, 1983).

Seven cultivars of soybeans, treated with sethoxydim (3.36 kg/ha) at the first trifoliate leaf stage, displayed "bronzing" effect on exposed leaves two days following application, but no injury was apparent on the growing points or newly expanded leaves. Within one week, necrotic lesions appeared on the unifoliate leaves, and some defoliation occurred. A 1.1 kg/ha rate caused minor "bronzing" effect on exposed leaves, but little necrosis occurred. No differences in tolerance were apparent between cultivars tested.

Hartzler and Foy (1983) indicated that time of application did not significantly affect the soybean response to rates less than 2.24 kg/ha. However, plants were significantly more tolerant to the highest herbicide rate when treated at the third-trifoliate leaf stage.

Ornamental Plants

Little or no phytotoxic reaction exhibited by many broadleaf agronomic crops suggests these chemicals would be safe for use on ornamental plant materials. Extensive evaluations are needed on landscape plants, however, due to limited labelling of ornamental crops on these products.

Grewe and Williams (1981) applied sethoxydim to four container grown woody plants with no phytotoxicity. Applications of fluazifop-butyl and sethoxydim to first year seed beds of European alder (Alnus glutinosa (L.) Gaertn.), black locust (Robinia pseudoacacia L.), Canada hemlock (Tsuga canadensis (L.) Carriere.), Colorado spruce (Picea pungens Engelm.), white pine (Pinus strobis Siebold and Zucc.) and fraser fir (Abies fraseri (Pursh) Poir.) resulted in excellent grass control with little injury to the seedlings (Kuhns et al., 1983). Ahrens (1983) reported similar results using some of the same species.

Severe tip burn occurred on California privet (Ligustrum ovalifolium Hassk.) when sprayed with sethoxydim (1.1 kg/ha). Injury was less severe at 0.6 kg/ha but some tip burn was still evident (Bing, 1983). No injury was apparant from equivalent rates of fluazifop-butyl and haloxyfop-methyl. Bing (1983) reported that injury occurred to 'Golden Bells' forsythia (Forsythia x intermedia Zab) which conflicts with Ahrens (1983), who reported sethoxydim and fluazifop-butyl (0.3 to 1.7 kg/ha) occasionally caused tip distortion and growth reduction of actively growing forsythia (Forsythia sp.).

Redbud (Cercis canadensis L.) was damaged by sethoxydim (1.1 kg/ha) and 'Hexe' azalea (Rhododendron x 'Hexe') by fluazifop-butyl (1.1 kg/ha) 14 days after application. All plants, with the exception of 'Hexe' azalea, were of salable quality 70 days after treatment (Gilliam et al., 1984).

'Hinocrimson' azalea (Rhododendron x 'Hinocrimson') showed necrosis and chlorosis six days following treatment of 1.0 kg/ha of sethoxydim and fluazifop-butyl (Ahrens, 1983; Frank and Beste, 1983). Fluazifop-butyl (0.25 kg/ha) caused significant damage to the azaleas for 33 days thereafter, while 0.5 and 1.0 kg/ha caused significant injury for 82 days.

Bing and Macksel (1984) evaluated the tolerance of 27 azalea cultivars to a single treatment of fluazifop-butyl and sethoxydim (0.6 kg/ha). 'Hershey Red' (Rhododendron x 'Hershey Red') showed only minor damage on very young leaves from both treatments while considerable foliage burn was apparent on 'Hinocrimson' and 'Hinodegeri' (Rhododendron x 'Hinodegeri') as a result of the fluazifop-butyl treatment. All cultivars recovered from the injury by producing new growth.

Sethoxydim did not injure any of 34 different woody plants, however, fluzaifop-butyl injured 'Rosebud' azalea (Rhododendron x 'Rosebud') and 'Mother's Day' azalea (Rhododendron x 'Mother's Day') (Kuhns et al., 1983).

Irregular and inconsistent damage of azaleas based on varietal differences has identified a need for extensive tolerance testing among plant species. This irregularity has also occurred in junipers (Juniperus spp. L.). Several studies which have shown various juniper species to be quite tolerant to these chemicals (Ahrens, 1983; Bing, 1983; Coffman et al., 1984; Gilliam et al., 1984; and Kuhns et al., 1984). Nevertheless, severe damage to 'Bar Harbor' juniper

(Juniperus horizontalis Moench) resulted from fluazifop-butyl applied at 0.56 and 2.2 kg/ha (Rice et al., 1985). Three other junipers included in this study exhibited no damage when exposed to identical treatments. Smith and Treaster (1984), reported severe injury to compact pfitzer juniper (Juniperus chinensis L.) when treated with sethoxydim and fluazifop-butyl (2.2 kg/ha). Foliar color changed from blue to green with some needle browning and shoot tip dieback. Similar results were also reported from sethoxydim at these rates. The sensitivity of these few junipers indicate that higher rates may be damaging to blue colored junipers and points out the importance of cultivar evaluations.

Rice et al. (1985) evaluated the phytotoxicity of fluazifop-butyl to 23 species of groundcovers. Bellflower (Campanula garganica Ten.) was the only test species which exhibited damage six weeks after an application of 0.27 and 0.56 kg/ha. Slight injury was observed on Sprengeri fern (Asparagus densiflorus Regel.), carpetbugle (Ajuga reptans L.), (Carpobrotus edulis (L.) L. Bolus.), and C. garganica at the 1.12 kg/ha rate. Higher rates (2.24 kg/ha) resulted in unacceptable injury to C. edulis but no increase in affect was found on asparagus fern, carpetbugle, and bellflower. Lantana (Lantana camara L.) was slightly injured at 2.24 kg/ha. All injured plants except C. edulis grew out of the symptoms by 18 weeks after application. Crownvetch (Coronilla varia L.), periwinkle (Vinca minor L.), Japanese spurge (Pachysandra terminalis Sieb. and Zucc.), and English ivy (Hedera helix L.) were tolerant to Poast (0.6 and 1.1 kg/ha) (Coffman et al., 1984). Fluazifop-butyl and sethoxydim (2.2 kg/ha) caused severe damage to 'Coronation Gold' fernleaf yarrow (Achillea filipendulina Lam.), McKana giant columbine (Aquilegia x hybrida Sims.), and shasta daisy (Chrysanthemum x superbum Bergmans x J. Ingram) (Smith and Treaster, 1984). Plants treated with fluazifop-butyl showed no apparent damage.

No phytotoxic reaction was evident when Bing and Macksel (1984) evaluated five gladiolus cultivars (*Gladiolus x hortulanus* L. H. Bailey) treated with fluazifop-butyl, sethoxydim, and haloxyfop-methyl (0.6 and 1.1 kg/ha). Begonia (*Begonia spp.* L.), impatiens (*Impatiens balsimina* L.), petunia (*Petunia x hybrida* Hort. Vilm.-Andr.), and geranium (*Pelargonium x hortorum* L. H. Bailey) were tolerant to 1.7 kg/ha of sethoxydim (Grewe and Williams, 1981).

CHAPTER II

GREENHOUSE SCREENING TRIAL EVALUATING POSTEMERGENCE GRASS HERBICIDES FOR USE ON FLOWERS AND GROUNDCOVERS

INTRODUCTION

Fluazifop-butyl and sethoxydim have limited labelling for ornamental plants, especially for herbaceous flowering annuals and perennial groundcovers. Several researchers have reported variation in species tolerance among herbaceous ornamentals and groundcovers (Bing, 1984; Coffman et al., 1984; Smith and Treaster, 1984; Rice et al., 1985).

MATERIALS AND METHODS

Fifteen species of annual flowers (Table II-1) and two groundcover species commonly grown in Kansas were selected for evaluation in a greenhouse screening trial from January, 1984 to October, 1984. Annual flowers were seeded in a peat-lite mix and placed under mist for germination.

All seedlings were transplanted at the two true leaf stage into bedding plant com-packs (17 cm x 13.3 cm x 5.9 cm) filled with a media comprised of two parts sphagnum peat, one part sandy loam soil, and one part horticultural perlite, by volume. Four seedlings were transplanted into each com-pack to represent one replication.

The groundcovers evaluated in this study were purchased as rooted cuttings and transplanted into com-packs utilizing the same system as for

Table II:1 Species and cultivars of annual bedding plants and groundcovers utilized in screening trial for postemergence selective grass herbicides.

Botanical Name	Common Name
Ageratum houstonianum Mill. 'Blue Puffs'	Ageratum, Floss Flower
Ajuga reptans L. 'Bronze Beauty'	Ajuga, Bugleweed
Antirrhinum majus L. 'Floral Carpet Mix'	Snapdragon
Calendula officinalis L. 'Fiesta Gitana'	Calendula, Pot Marigold
Catharanthus roseus G. Don 'Little Bright Eye'	Annual Periwinkle
Celosia cristata L. 'Geisha Mixed'	Cockscomb
Coleus x hybridus Voss. 'Wizard Mix'	Coleus
Lobularia maritima (L.) Desv. 'New Carpet of Snow'	Sweet Alyssum
Lobularia maritima (L.) Desv. 'Wonderland'	Sweet Alyssum
Lonicera japonica Thunb. 'Halliana'	Halls Honeysuckle
Pelargonium x hortorum L. H. Bailey 'Showgirl'	Geranium
Petunia x hybrida Hort. Vilm.-Andr. 'Viva'	Common Garden Petunia
Salvia farinacea Benth. 'Victoria'	Blue Salvia
Salvia splendens F. Sellow ex Roem. & Schult. 'Red Hot Sally'	Salvia
Senecio cineraria DC.	Dusty Miller
Tagetes sp. L. '	Marigold
'Bonanza Harmony'	
'Bonanza Orange'	
'Boy O' Boy'	
'Janie Bright Yellow'	
'Queen Mix'	
'Red Cherry'	
'Red Marietta'	
Zinnia elegans Jacq. 'Sombrero'	Common Zinnia

bedding plants. Two cuttings were planted in each com-pack and two com-packs (four plants) represented one replication.

All plants were grown in the greenhouse at a 24° C day temperature and a 13 to 15° C night temperature. A complete, soluble fertilizer diluted at a ratio of 1:100 was used to irrigate plants as required during the work week. Leaching of the plants during weekend waterings was necessary to avoid soluble salt buildup. Insect populations were monitered and controlled as necessary.

When all plants were sufficiently established, the com-packs were randomly selected for nine treatment groups (Table II-2). At this stage, the annual flowers generally had eight to ten true leaves and the groundcovers were in an active stage of growth.

Plants were removed from the greenhouse before herbicide application, then grouped in the assigned treatments and labelled. All treatments were applied with a CO_2 backpack sprayer at a pressure of 2.1 kg/sq cm delivering a volume of 227 l/ha. Following treatment, all solutions were allowed to dry on the leaves before moving the plants back into the greenhouse.

Visual quality ratings were based on a scale of one to 10, with one representing a dead plant and 10 a perfect plant. A rating of seven or below was considered undesirable for landscape use. Visual quality evaluations were recorded at two, four, seven, 10, and 14 days following treatment. After the final evaluation period, all plants were cut at the soil line and dried in a forced air oven at 35° C for 96 hours before weighing. All data were statistically analyzed.

Table II-2: Treatment groups and corresponding rates utilized in the greenhouse screening trial.

Treatment	Rate
Sethoxydim 1x	0.31 kg ai/ha
Sethoxydim 2x	0.62 kg ai/ha
Fluazifop-butyl 1x	0.28 kg ai/ha
Fluazifop-butyl 2x	0.56 kg ai/ha
Haloxyfop-methyl 1x	0.14 kg ai/ha
Haloxyfop-methyl 2x	0.28 kg ai/ha
Crop Oil Control	2.35 l/ha
X-77 (Surfactant)	0.25% (v:v)
Control	No treatment

RESULTS AND DISCUSSION

No adverse effects were exhibited as a result of any herbicide application on the majority of annual flowers and groundcovers tested (Table II-3). No significant differences among visual quality ratings (F-test) were detected between treatments. Fluazifop-butyl, haloxyfop-methyl, and sethoxydim all appeared safe for use at normal rates on these plants. Three species of annual flowers, annual periwinkle (Catharanthus roseus 'Little Bright Eye'), cockscomb (Celosia cristata 'Geisha Mixed'), and geranium (Pelargonium x hortorum 'Showgirl') were damaged by one or more of the various herbicide treatments (Table II-4).

Annual periwinkle was damaged by sethoxydim (0.31 and 0.62 kg/ha). Phytotoxicity symptoms included extreme chlorosis and malformation of the terminal and speckling and marginal burn of the leaves. Tender new growth appeared to be damaged to the greatest extent. Symptoms became evident within seven days after application and progressed. Little to no damage was evident from other treatments (Table II-4). At harvest, the periwinkle were not of acceptable quality for use in the landscape.

Application of fluazifop-butyl (0.28 and 0.56 kg/ha) and haloxyfop-methyl (0.14 and 0.28 kg/ha) produced significantly more damage on celosia than all other treatments (Table II-4). Although the visual quality ratings numerically fall within the acceptable range for landscape use, they are somewhat deceptive. Extreme chlorosis of the leaf margins was evident within seven days of treatment. When plants were harvested at 14 days, the damage had progressed; however, if given enough time, plant growth would likely reduce the amount of observable damage. This suggests that these materials might be used

Table II-3: Annual flowers and groundcovers not injured by applications of three postemergence grass herbicides.

Botanical Name	Common Name
Ageratum houstonianum 'Blue Puffs'	Ageratum
Ajuga reptans 'Bronze Beauty'	Ajuga, Carpetbugle
Antirrhinum majus 'Floral Carpet Mix'	Snapdragon
Calendula officinalis 'Fiesta Gitana'	Pot Marigold
Coleus x hybridus 'Wizard Mix'	Coleus
Lobularia maritima 'New Carpet of Snow' 'Wonderland'	Sweet Alyssum
Lonicera japonica 'Halliana'	Hall's Honeysuckle
Petunia x hybrida 'Viva'	Petunia
Portulaca grandiflora 'Wildfire Mix'	Rose Moss
Salvia farinacea 'Victoria'	Blue Salvia
Salvia splendens 'Red Hot Sally'	Salvia
Senecio cineraria	Dusty Miller
Tagetes sp. 'Queen Mix' 'Boy O' Boy' 'Janie Bright Yellow' 'Bonanza Orange' 'Bonanza Harmony' 'Red Marietta' 'Red Cherry'	Marigold
Zinnia elegans 'Sombrero'	Zinnia

Table II-4: Mean visual quality ratings of annual flowers injured following application of one or more postemergent grass herbicides.

	Visual Quality Ratings					
	Periwinkle		Geranium		Celosia	
Herbicide Treatment	7 day	14 day	7 day	14 day	7 day	14 day
Control	9.3a[z]	9.5a	10.0a	10.0a	9.5a	9.7b
Crop Oil 2.35 l/ha	9.7a	9.7a	10.0a	10.0a	9.3b	9.7b
X-77 Surfactant 0.25% (v:v)	--	--	10.0a	10.0a	9.3b	9.5b
Sethoxydim 0.31 kg/ha	8.3b	7.5c	9.7b	10.0a	9.5a	10.0a
Sethoxydim 0.62 kg/ha	7.3c	6.2d	9.5c	9.5b	9.2b	9.5b
Fluazifop-butyl 0.28 kg/ha	9.3a	9.7a	8.0d	7.3c	9.0c	8.5c
Fluazifop-butyl 0.56 kg/ha	9.5a	9.5a	8.0d	7.0d	8.5c	7.6d
Haloxyfop-methyl 0.14 kg/ha	9.5a	9.2a	8.0d	3.2e	8.5c	7.8d
Haloxyfop-methyl 0.28 kg/ha	9.5a	9.0b	7.3e	1.0f	8.5c	7.5e

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

if some plant damage was acceptable for a period of time. Sethoxydim, however, produced no phytotoxicity on celosia.

Geranium was, by far, the most sensitive plant evaluated in this study. Visual quality ratings for control plants and those treated with X-77 surfactant and crop oil, and sethoxydim (0.31 kg/ha) were excellent. Slight damage was observed when the higher rate of sethoxydim was used. Fluazifop-butyl (0.28 and 0.56 kg/ha) produced moderate damage which progressed to unacceptable levels for landscape use by harvest. Haloxyfop-methyl caused upward cupping of the leaves and marginal chlorosis within seven days. Necrotic areas and localized red pigmentation became more evident with time. Geraniums treated with haloxyfop (0.14 kg/ha) were unacceptable for landscape use and those treated with haloxyfop (0.28 kg/ha) were dead by the 14 day evaluation.

Damage sustained as a result of sethoxydim (0.62 kg/ha) treatment significantly limited growth of annual periwinkle as evidenced by its low mean dry weights (Table II-5). Sethoxydim (0.31 kg/ha) resulted in significantly less damage (Table II-4) and correspondingly increased dry weights. There were few differences in growth, with the exception of fluazifop-butyl (0.28 kg/ha), which significantly reduced dry weights although visual quality was excellent.

Haloxyfop-methyl (0.28 kg/ha) resulted in a significant reduction of growth by celosia (Table II-5). The resulting chlorosis likely decreased photosynthesis and therefore, plant growth. Dry weights of celosia were greatest when treated with crop oil and X-77 surfactant and remaining treatments reflected little statistical differences.

Dry weights of geraniums treated with crop oil were greater, although not statistically different, than all other treatments (Table II-5). Low dry weights exhibited by haloxyfop-methyl treated geraniums were consistent with the

Table II-5: Mean dry weights of annual flowers injured by one or more selective postemergence grass herbicides. Data were taken 14 days after application.

	Dry Weights (g)		
Herbicide Treatment	Periwinkle	Geranium	Celosia
Control	1.29abc[z]	0.58abc	1.16a
Crop Oil 2.35 L/ha	1.12bc	0.74a	1.17a
X-77 Surfactant 0.25% (v:v)	--	0.51abcd	1.07ab
Sethoxydim 0.31 kg/ha	1.01c	0.66ab	1.00ab
Sethoxydim 0.62kg/ha	0.73d	0.57abc	1.06ab
Fluazifop-butyl 0.28 kg/ha	1.02c	0.41bcd	1.01ab
Fluazifop-butyl 0.56 kg/ha	1.13abc	0.46abcd	0.90ab
Haloxyfop-methyl 0.14 kg/ha	1.17abc	0.30cd	0.72ab
Haloxyfop-methyl 0.28 kg/ha	1.37a	0.23d	0.63b

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

extreme damage resulting from these treatments. No substantial reductions in dry weights were evident among treatments.

CHAPTER III

FIELD EVALUATION OF POSTEMERGENCE HERBICIDES FOR USE ON FLOWERS AND GROUNDCOVERS

INTRODUCTION

Field evaluation of postemergence grass herbicides in flowering annuals and groundcovers has not been documented. This study will provide pertinent information useful to landscape maintenance personnel.

MATERIALS AND METHODS

Three annual flower and two groundcover species were evaluated in a field study utilizing information obtained from the preliminary greenhouse screening trials. The annual flower species included blue salvia (Salvia farinacea 'Victoria'), geranium (Pelargonium hortorum 'Ringo Scarlet'), and annual periwinkle (Catharanthus roseus 'Little Pinkie'). Hall's honeysuckle (Lonicera japonica 'Halliana') and carpetbugle (ajuga) (Ajuga reptans 'Bronze Beauty') were the groundcover species evaluated. The bedding plants were obtained from Kansas commercial growers and had six to eight true leaves at the time of planting. The containerized ajuga and dormant, rooted honeysuckle cuttings were obtained from commercial sources in Georgia.

The flower varieties and the honeysuckle cuttings were planted in a prepared field on June 2, 1984 utilizing a randomized complete block design. The ajuga cuttings were allowed to establish in the greenhouse before planting on June 16, 1984.

Prior to planting, fertilizer was applied at the rate of 454 g 10-8.8-8.3 fertilizer per 929 sq dec and tilled into the soil. A similar fertilizer application was made again on July 17, 1984. Irrigation was supplied at the rate of approximately 2.54 cm per week throughout the summer. Insect control was based on daily monitering of plants; however, insect populations were not sufficient to warrant control measures.

The primary weedy target species in this trial was large crabgrass (Digitaria sanguinalis (L.) Scop.). Although crabgrass was common to this area, crabgrass seed was sown on June 15, 1984 to insure an adequate population. Broadleaf weed species were eliminated by handweeding approximately every two weeks.

Herbicide treatments (Table III-1) were applied initially on July 17, 1984 and repeated on August 7, 1984. The herbicide solutions were applied at a pressure of 2.1 kg/cm from a CO_2 backpack sprayer. Herbicide solutions were applied in late afternoon during periods of minimal wind to avoid drift.

The plots were evaluated approximately every two weeks for crop phytotoxicity. Visual quality ratings utilized a scale of one to 10. A score of one represented a dead plant while a score of 10 indicated a perfect plant. Plants were classified as unacceptable for landscape use if given a rating of seven or below. Plants were rated on the percentage of total injury to the plant. Grass control was evaluated as a percentage of control. The same rating scale was utilized, whereby, 10 represented 100% grass control and one represented no grass control. All evaluations were continued until September 11, 1984.

At the conclusion of the study, three plants were randomly selected from each block to be weighed. Plants were cut at the soil line, placed in paper

Table III-1: Treatment groups and corresponding rates utilized in the field evaluation.

Treatment	Rate
Sethoxydim 1x	0.31 kg ai/ha
Sethoxydim 2x	0.62 kg ai/ha
Fluazifop-butyl 1x	0.27 kg ai/ha
Fluazifop-butyl 2x	0.56 kg ai/ha
Haloxyfop-methyl 1x	0.14 kg ai/ha
Haloxyfop-methyl 2x	0.28 kg ai/ha
Crop Oil Concentrate	2.35 l/ha
X-77 (Surfactant)	0.25% (v:v)
Control	No treatment

bags, and then dried in a walk-in forced air oven at 38° C for seven days before weighing. Analysis of variance and mean separation techniques were conducted on plant dry weights, visual quality ratings, and grass control ratings.

RESULTS AND DISCUSSION

Evaluations pertaining to Hall's honeysuckle cuttings were not made since it had only a 17% survival rate, therefore, were discontinued in the study. All other plants established readily and were actively growing at the initial treatment.

Plant tolerance was were evaluated on August 8 (21 days after herbicide application). Little damage was evident on ajuga and blue salvia. Geraniums, however, experienced moderate damage when treated with haloxyfop-methyl (0.14 and 0.28 kg/ha) (Table III-2). Initial injury symptoms were chlorosis and upward cupping of the leaves, similar to damage exhibited in the greenhouse trial. Visual quality was significantly reduced on untreated geraniums and on geraniums treated only with crop oil because of early grass competition. All remaining treatments produced excellent quality plants (Table III-2).

Sethoxydim (0.62 kg/ha) significantly injured periwinkle following the initial treatment. The most common symptoms were malformation of the terminal and chlorosis. Plant quality was reduced by treatments of haloxyfop-methyl (0.28 kg/ha), crop oil, and control plants. The latter were a result of weed competition. No significant injuries resulted from other treatments.

A second application of all herbicide treatments were made on August 7, (21 days after the initial treatment). No significant damage was exhibited on ajuga or blue salvia when evaluations were made 18 days after the second

Table III-2: Mean visual quality ratings of annual flowers and groundcovers following applicaton of one or more postemergent grass herbicides.

	Visual Quality Ratings							
	Ajuga		Geranium		Periwinkle		Blue Salvia	
Herbicide Treatment	Aug 8	Aug 25	Aug 8	Aug 25	Aug 8	Aug 25	Aug 8	Aug 25
Handweeded Control	10.0a[z]	10.0a	10.0a	9.75a	10.0a	10.0a	10.0a	10.0a
Control	10.0a	5.63b	8.38bcd	7.13abc	8.5bc	7.0e	10.0a	8.88b
Crop Oil 2.35/ha	10.0a	5.88b	8.25bcd	7.38ab	8.5bc	6.75e	9.63a	9.00b
Sethoxydim 0.31 kg/ha	10.0a	9.88a	9.5ab	9.13a	8.3ab	8.88bc	10.0a	10.0a
Sethoxydim 0.62 kg/ha	9.88a	9.88a	9.25abc	8.5a	8.38c	7.26de	10.0a	10.0a
Fluazifop-butyl 0.28 kg/ha	10.0a	9.88a	9.63a	9.5a	10.0	9.88a	10.0a	9.88a
Fluazifop-butyl 0.56 kg/ha	9.88a	9.88a	9.75a	9.0a	9.75a	9.63ab	10.0a	10.0a
Haloxyfop-methyl 0.14 kg/ha	10.0a	10.0a	8.38bcd	5.38c	9.13abc	8.38cd	10.0a	10.0a
Haloxyfop-methyl 0.28 kg/ha	10.0a	9.75a	7.38d	4.5c	8.5bc	8.5bc	10.0a	10.0a

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

treatment. Visual quality of ajuga treated as crop oil control or control plants was significantly less due to grass competition. Visual quality of blue salvia, however, was not dramatically reduced by grass competition.

The quality of geraniums treated with sethoxydim (0.31 and 0.62 kg/ha), fluazifop-butyl (0.28 and 0.56 kg/ha), and handweeding was good to excellent (Table III-2). No significant difference in visual quality was determined between these treatments. Grass competition in the control and crop oil control plots resulted in stunted geraniums with poor quality blooms. Haloxyfop-methyl (0.14 and 0.28 kg/ha) produced dramatic injury on geraniums (Table III-2). These plants exhibited chlorosis, some red pigmentation of leaves, growth gradually slowed and necrotic lesions formed on the leaves. Geraniums treated with haloxyfop-methyl (0.28 kg/ha) slowly lost leaves and eventually died. These symptoms suggest geraniums are extremely sensitive to this herbicide.

Visual quality of periwinkle was not reduced by treatment with fluazifop-butyl (0.28 and 0.56 kg/ha) or handweeding (Table III-2). Slight to moderate injury was evident in haloxyfop-methyl (0.14 and 0.28 kg/ha) and sethoxydim (0.31 kg/ha) plots. The high rate of sethoxydim resulted in extreme chlorosis, marginal leaf burn and malformation of the tip and a reduction in flowering due to damage to flower buds (Table III-2). The periwinkles damaged by sethoxydim were within a numerically acceptable range for landscape use, however, would not have been considered for use in prime locations.

As a general rule, plant quality significantly decreased throughout the season. Repeated applications intensified any damage which the plants suffered. However, in order to maintain grass control two applications were necessary. No significant differences were evident in grass control between herbicide treatments, although, fluzaifop-butyl (0.28 kg/ha) and sethoxydim (0.31 kg/ha) had somewhat less control than other treatments (Table III-3). Of course, control and crop oil control plots had no control of grass throughout the season and seed heads and thick grass 46-61 cm in height were evident at the study's termination. Handweeding resulted in excellent quality plants but proved to be time consuming and repeated cultivation probably resulted in some root damage.

Dry weights of ajuga, geranium, and periwinkle were significantly less for control or crop oil control treatments (Table III-4). The uncontrolled grass resulted in stunted, chlorotic plants undesirable for landscape use. Poor quality blooms were evident in periwinkle and geranium. Blue salvia, however, did not experience significant reductions in dry weight, although, the control plants were somewhat smaller. The bushy habit and rapid growth of salvia allowed it to compete with the crabgrass (Table III-4).

Treatments of haloxyfop-methyl (0.14 and 0.28 kg/ha) and handweeding resulted in the highest dry weights of ajuga. Although no reductions in visual quality were evident, fluazifop-butyl (0.56 kg/ha) significantly decreased the dry weights of ajuga when compared to other chemical treatments (Table III-4).

No significant differences in geranium dry weights were detected between either rate of sethoxydim or fluazifop-butyl and handweeding. The extensive injury or in some cases, death of the plants, resulted in significantly lower dry weights as a result of treatment with haloxyfop-methyl (Table III-4).

Neither periwinkle or salvia experienced reductions in dry weight as a result of any chemical treatment (Table III-4).

Table III-3: Grass control ratings for treatments utilized in the field evaluation.

Herbicide Treatment	Grass Control Ratings
Sethoxydim 0.31 kg/ha	8.9a[z]
Sethoxydim 0.62 kg/ha	10.0a
Fluazifop-butyl 0.28 kg/ha	8.4a
Fluazifop-butyl 0.56 kg/ha	9.3a
haloxyfop-methyl 0.14 kg/ha	9.3a
Haloxyfop-methyl 0.28 kg/ha	9.4a
Weeded Control	10.0a
Crop Oil Control	0b
Control	0b

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

Table III-4: Mean dry weights of annual flowers and groundcovers injured by one or more selective postemergence grass herbicides.

	Dry Weights (g)			
Herbicide Treatment	Ajuga	Geranium	Periwinkle	Salvia
Handweeded control	22.23a[z]	60.13a	78.15a	79.07a
Control	4.15bc	16.63b	25.33b	60.87a
Crop Oil 2.35 l/ha	2.05c	8.75b	19.00b	64.92a
Sethoxydim 0.31 kg/ha	17.40a	66.98a	73.08a	115.80a
Sethoxydim 0.62 kg/ha	18.33a	73.23a	77.20a	81.50a
Fluazifop-butyl 0.28 kg/ha	14.58bc	63.85a	81.15a	88.90a
Fluazifop-butyl 0.56 kg/ha	16.55b	64.50a	71.00a	111.17a
Haloxyfop-methyl 0.14 kg/ha	20.35a	17.85b	80.83a	79.67a
Haloxyfop-methyl 0.28 kg/ha	23.75a	16.50b	76.50a	91.27a

[z]Mean separation by Tukey HSD (5% level). Means in columns followed the same letter are not significantly different.

CHAPTER IV

SOIL BIOASSAY OF HALOXYFOP-METHYL

INTRODUCTION

The utilization of selective postemergence herbicides for grass control in ornamental plant materials, especially herbaceous plant material, appears promising. The fate of these herbicides in soil, however, has not been thoroughly studied. Preliminary research indicated that, when applied at equal rates, haloxyfop-methyl had greater soil activity than fluazifop-butyl or sethoxydim (Buhler and Burnside, 1984). Haloxyfop-methyl (0.5 kg/ha) and fluazifop-butyl (1.0 kg/ha) resulted in approximately 100% preemergence control of shattercane (Sorghum bicolor (L.) Moench) in soybeans after 80 days. Sethoxydim (0.8 kg/ha) resulted in 84% preemergence control of shattercane after 14 days, but only 43% after 80 days.

On sandy clay loam soils under semi-arid conditions, fluazifop-butyl was equal to haloxyfop-methyl and both were greater than sethoxydim for effective control of rhizome Johnsongrass (Sorghum halepense (L.) Pers.) 90 days following application. This trend remained consistent 14 months later (Abernathy, 1984).

Smith and Hsiao (1983) found soil activity and persistence was not a problem of sethoxydim. Fluazifop-butyl; however, has remained active in the soil for up to three months and longer in sandy soils (Anonymus, 1984). Schober (1983) reported that haloxyfop, the parent acid of haloxyfop-methyl, may remain at rates high enough to control later germinating grasses for 100 days. The fate of haloxyfop-methyl in different soils has not been documented.

MATERIALS AND METHODS

Root bioassays were used to determine the degree of adsorption by different soils utilizing modified techniques described by Hensley et al. (1978). Soils used in this experiment were a muck soil, a silt loam, and sodium saturated bentonite. Characteristics of the soils are given in Table IV-1.

The silt loam soil, muck soil, and bentonite clay were thoroughly mixed with white quartz sand. Both soils were added to 0, 1, 5, 10, and 20% total volume, however; the addition of bentonite clay was limited to 3% by volume due to mixing difficulties. The herbicide solutions (0, 0.25, 0.50, 1.0, 2.0, 5.0, 10.0, and 20.0 ppm) and soil and sand combinations were thoroughly mixed by hand. The mixture was placed in square petri dishes (100 x 100 x 15mm).

A hybrid variety of grain sorghum (Sorghum bicolor Moench 'PAG 4464') was used as the test plant. Seeds were germinated at 26°C for 24 hours prior to planting. Ten pre-germinated seeds were planted near the top of the dish. The dishes were sealed, placed in a holder at 20° from vertical and incubated in the dark at 26°C. Each treatment was replicated a minimum of four times and the experiment was repeated. After 8 hours, marks were made to indicated the extent of initial root growth. Forty-eight hours after planting, growth measurements were made from the 8 hour marks. Root growth inhibition by the herbicide treatment was expressed as a percent of the appropriate controls.

Table IV-1: Characteristics of soil types used in haloxyfop-methyl adsorption studies.

	O.M. (%)	Mechanical Analysis Sand (%)	Silt (%)	Clay (%)	pH
Silt loam soil	1.7	24.5	52.0	23.5	7.6
Muck soil	45.0	74.5	20.0	5.5	5.7

RESULTS AND DISCUSSION

Root growth of sorghum decreased as haloxyfop-methyl concentration in quartz sand increased (Tables IV-2, IV-3, IV-4). Haloxyfop-methyl concentrations of 0.25 ppm exhibited the greatest growth inhibition when mixed with 5% fine sandy loam soil as compared to the control (Table IV-2). This reaction is most likely explained by variation in the data. It should be noted that inhibition at this soil concentration varies significantly from all others at every herbicide concentration. Soil amendments of 10% and 20% showed no significant growth reductions, suggesting that the chemical was tied up to soil colloids at this low chemical concentration at least in the highest levels of soil.

Similar trends were exhibited in the 0.5 ppm herbicide concentration (Table IV-2). Once again, the herbicide appears to be inactivated, but to a lesser extent in the highest soil addition. Although, statistical differences do exist between treatment concentrations of 1.0 ppm and greater, there is marked inhibition at all chemical levels within all soil treatments (Table IV-2).

Haloxyfop-methyl at 0.25 ppm were significantly inactivated by the addition of muck soil, regardless of level, when compared to the quartz sand control (Table IV-3). Addition of 5% muck produced results which behaved differently than all other soil amendments, again likely due to data variations even though the study was repeated. No reduction of inhibition was exhibited with 5% muck at the 0.50 ppm concentration when compared to the quartz sand and 1% muck amendments (Table IV-3).

Growth increased at 1.0 ppm herbicide in the 10% and 20% muck amendments suggesting that some adsorption occurred. In addition, concentrations of 5.0 ppm and greater exhibit some statistical differences

Table IV-2: Inactivation of haloxyfopmethyl by a low organic matter mineral soil as determined by root bioassay.

Haloxyfop-methyl concentration	Inhibition of Root Growth				
	Quartz Sand	1% Soil	5% Soil	10% Soil	20% Soil
0.0 ppm	0.0a[z]	0.0a	0.0a	0.0a	0.0a
0.25 ppm	21.3c	14.5b	40.8d	0.0a	0.0a
0.50 ppm	23.3ab	42.0bc	59.8c	12.5a	13.5ab
1.0 ppm	57.8b	69.0c	79.8d	30.8a	66.3bc
2.0 ppm	69.3a	78.3b	85.8b	63.0a	74.3b
5.0 ppm	83.5ab	85.5ab	92.0b	56.3a	82.8ab
10.0 ppm	80.8ab	84.8b	95.8c	75.5a	86.5b
20.0 ppm	81.3ab	87.8a	93.3a	74.5a	85.5ab

[z]Mean separation by Tukey HSD (5% level). Means in rows followed by the same letter are not significantly different.

Table IV-3: Inactivation of haloxyfop-methyl by a high organic matter muck soil as determined by root bioassay.

Haloxyfop-methyl concentration	Inhibition of Root Growth				
	Quartz Sand	1% Muck	5% Muck	10% Muck	20% Muck
0.0 ppm	0.0a[z]	0.0a	0.0a	0.0a	0.0a
0.25 ppm	28.0b	4.0a	0.0a	11.8a	0.4a
0.50 ppm	23.3bc	34.5c	8.0a	20.0ab	17.0ab
1.00 ppm	57.8d	46.5c	36.3b	28.8a	20.3a
2.00 ppm	69.3c	73.5c	35.5a	47.0b	58.3b
5.00 ppm	84.5c	82.0bc	56.8a	76.5b	83.0c
10.00 ppm	80.8b	92.3d	71.5a	88.5cd	84.8bc
20.00 ppm	81.3a	88.8b	75.8a	89.0b	89.5b

[z]Mean separation by Tukey HSD (5% level). Means in rows followed by the same letter are not significantly different.

Table IV-4: Inactivation of haloxyfop-methyl by bentonite clay as determined by root bioassay.

Haloxyfop-methyl concentration	Inhibition of Root Growth				
	Quartz Sand	0.5% Clay	1% Clay	2% Clay	3% Clay
0.0 ppm	0.0a[z]	0.0a	0.0a	0.0a	0.0a
0.25 ppm	28.0bc	37.5c	3.3a	18.5ab	0.0a
0.50 ppm	23.3bc	27.8c	7.0ab	16.0bc	0.0a
1.00 ppm	57.8c	56.5c	31.0b	47.5c	2.3a
2.00 ppm	69.3c	74.8c	58.0b	52.8b	35.3a
5.00 ppm	84.5c	88.3c	82.3bc	77.3ab	69.3a
10.00 ppm	80.8b	89.8c	85.8bc	88.3c	64.5a
20.00 ppm	81.3b	91.0c	89.8c	88.3c	78.8a

[z]Mean separation by Tukey HSD (5% level). Means in rows followed by the same letter are not significantly different.

among the data; however, these differences are nominal due to the marked reductions in root growth at these herbicide concentrations (Table IV-3).

Comparison of the soil activity of haloxyfop-methyl in a muck and sandy loam soils show some differences, particularly at the 10% and 20% level of each amendment. Less inhibition of root growth was evident in the higher levels of muck soil suggesting that haloxyfop-methyl is binding, to some degree, to organic matter.

Considerable variation in haloxyfop-methyl activity was apparent among the various clay amendments. There were no significant differences between the quartz sand control and 0.5% clay at 0.25 ppm; however, less inhibition of root growth was evident at all other clay amendment levels (Table IV-4). As the concentration of herbicide increased to 0.5 and 1.0 ppm, significant inactivation of haloxyfop-methyl occurred at 3% clay levels when compared to the sand and 0.5% clay. Root inhibition was statistically less at 3% clay than other treatment of all herbicide concentrations but concentrations of 2.0 ppm and greater, exhibited drastic growth reductions at all clay amendments (Table IV-4).

These studies indicate that haloxyfop-methyl remains largely active or loosely bound to clay particles and, to a lesser extent, to organic matter. Previous research by Abernathy (1984) indicated control of rhizome Johnsongrass was obtained 14 months later when using haloxyfop-methyl. In addition, haloxyfop, the parent acid of haloxyfop-methyl, may remain active in the soil up to 100 days (Schober, 1983). Some preemergent activity of haloxyfop-methyl was also reported by Schober (1983). These results indicate that repeated applications of this material may result in a chemical buildup detrimental to plants. Preliminary bioassay results indicated some reduction of cucumber root growth, as well as other graminaceae plants.

SUMMARY AND CONCLUSIONS

Greenhouse Study

Results of the greenhouse screening trials indicated twelve annual flower and two groundcover species were not injured following applications of sethoxydim (0.31 and 0.62 kg/ha), fluazifop-butyl (0.28 and 0.56 kg/ha), haloxyfop-methyl (0.14 and 0.28 kg/ha), crop oil (2.35 l/ha), and X-77 surfactant (0.25% v:v).

Three annual flowers, however, were extensively injured by one or more herbicides. Annual periwinkle (Catharanthus roseus (L.)) was severely injured when treated with sethoxydim but exhibited little, if any, phytotoxicity to fluazifop-butyl or haloxyfop-methyl. Celosia (Celosia cristata (L.)) exhibited injury following fluzaifop-butyl and haloxyfop-methyl treatments but sethoxydim caused no phytotoxic reactions. Geranium was the most sensitive species and was extensively damaged by haloxyfop-methyl treatments. Plants treated with the higher rate of haloxyfop died by the end of the evaluation period. Fluazifop-butyl treatments produced moderate damage within two weeks following application.

Dry weights of periwinkle were significantly reduced when treated with sethoxydim (0.62 kg/ha). Dry weights of celosia and geranium were significantly reduced by haloxyfop-methyl (0.28 kg/ha). Lower dry weights are likely due to decreased photosynthesis in damaged plants.

Field Study

The field evaluation of blue salvia (Salvia farinacea Benth. 'Victoria'), geranium (Pelargonium x hortorum L.H. Bailey 'Ringo Scarlet'), annual periwinkle (Catharanthus roseus G. Don 'Little Pinkie'), and ajuga (Ajuga reptans L. 'Bronze Beauty') showed trends similar to the greenhouse screening trials. Blue salvia and ajuga were not injured by any of the chemical treatments.

Geraniums were injured by haloxyfop-methyl (0.14 and 0.28 kg/ha). The higher rate of haloxyfop-methyl resulted in death of the geraniums. Periwinkle received slight to moderate damage when treated with haloxyfop-methyl (0.14 and 0.28 kg/ha) and sethoxydim (0.31 kg/ha). The high rate of sethoxydim caused more severe damage on periwinkle. No reduction in dry weight of periwinkle was evident as a result of any chemical treatment, however.

Ajuga, geranium, and periwinkle had significantly lower dry weights in the control and crop oil control plots due to grass competition. Dry weights of blue salvia were somewhat, but not significantly, lower due to the plants ability to compete with grass growth.

Soil Bioassay of Haloxyfop-methyl

Haloxyfop-methyl appears to remain largely active or loosely bound to clay particles or, to a lesser extent, to organic matter. This binding, however, occurs at herbicide levels of 1.0 ppm and less. Repeated applications may, therefore, result in detrimental affects to plants.

Conclusions

These postemergence grass herbicides show excellent promise for use in annual flower and groundcover plantings. Most species evaluated exhibited no phytotoxicity to the chemicals. Of the species which were injured, none were damaged by all three chemicals. These chemicals, therefore, should be utilized as excellent tools in a total weed care program. When designing groundcover or annual flower plantings, use species which are tolerant to the chemicals.

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EVALUATION OF SEVERAL SELECTIVE POSTEMERGENCE GRASS HERBICIDES FOR USE IN ANNUAL FLOWER AND GROUNDCOVER PLANTINGS

by

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B. S., Kansas State University, 1981

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1985

Fifteen species of annual flowers and two groundcovers commonly grown in Kansas were evaluated in a greenhouse screening trial. Treatments included sethoxydim (0.31 and 0.62 kg/ha), fluazifop-butyl (0.28 and 0.56 kg/ha), haloxyfop-methyl (0.14 and 0.28 kg/ha), crop oil (2.35 l/ha), X-77 surfactant (0.25% v:v) and a non-treated control. Plants were evaluated for phytotoxicity utilizing a visual quality rating scale of 1 to 10, with 10 being a perfect plant and 1 being a dead plant, and growth (dry weight).

A field study was conducted using three annual flower and two groundcover species. Crabgrass (*Digitaria sanguinalis* (L.)) was seeded to assure a weed population. All plants were sprayed on July 17, 1984 and again on August 7, 1984, utilizing the same treatments as the greenhouse trial. Plants were evaluated for phytotoxicity and dry weight.

Phytotoxicity was variable with species and chemical. However, in both studies, geranium (*Pelargonium x hortorum* L. H. Bailey) and celosia (*Celosia cristata* (L.)) exhibited extensive damage as a result of fluazifop-butyl and haloxyfop-methyl. Annual periwinkle (*Catharanthus roseus* (L.)) was injured by sethoxydim.

The soil activity of haloxyfop-methyl was examined utilizing a soil bioassay. Haloxyfop-methyl appears to remain largely active or loosely bound to clay particles or, to a lesser extent, to organic matter. This binding , however, occurs at herbicide levels of 1.0 ppm and less. These results indicate that repeated applications of this material might result in buildup which could be detrimental to desirable plants.