SOME EFFECTS OF PRE-AND POST-EMERGENT HERBICIDE APPLICATION TO GARDEN FLOWERS

by

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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

1969

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INTRODUCTION

The value of attractive flowers to the landscape is well known. Few residences are without at least a meager planting of flowers in the grounds area during the growing season. Parks and other public areas are greatly enhanced by well kept beds of flowering plants.

However, the time and effort required to weed flower beds is a major complaint of flower growers. Close plant spacing of flowers required for mass effect makes hand weeding difficult. The frequent watering required provides ideal conditions for weed seed germination. Weeds compete with flower growth as well as being unsightly. Control of weeds by cultivation destroys many shallow roots of flowering plants and dries surface soil.

Weed control is necessary for the success of commercial flower production. Kansas has approximately 327 commercial greenhouse flower growers. Weed control in bench and pot plants depends on the initial heat pasteurization of the soil or plant growing mediums prior to planting. Often, heavy work schedules or other conditions force this practice to be omitted. Many other growers lack facilities for heat pasteurization. Hand weeding or chemicals must then be employed.

Bedding plant production in Kansas is presently quite lucrative, but many professional and amateur producers lack heat pasteurization equipment. Because of the high value of the crop per unit of area, herbicide use has been extremely cautious.

Grounds managers of tax-supported parks and public areas frequently experience difficulty in justifying large expenditures for hand control of weeds in flower beds. Labor for weeding flowers is more costly than for other ornamental plantings.

Crabgrass (Digitaria spp.) is frequently the most prevalent and competitive weed in garden soils. Foxtail (Setaria spp.), barnyard grass (Echinochloa crusgalli), chickweed (Stellaria media), henbit (Lamium amplexicaule), lambsquarter (Chenopodium album), pigweed (Amaranthus spp.) and others also become a problem in Kansas gardens.

The value of herbicides for controlling weeds in agronomic and horticultural crops is well known. No herbicides at the present time are being produced specifically for flowers. Herbicide manufacturers are confining their efforts to crops representing larger acreage. Understandably, herbicide research in greenhouses and flower gardens has lagged behind that for economically more important crops. The need is nevertheless apparent for information pertaining to herbicide use for floricultural crops. Many herbicides presently on the market should be screened to determine their possible use for flowers.

Herbicides used by amateur and professional flower growers should have the following characteristics: (1) ease of application (2) safe to humans and animals (3) non-phytotoxic to desirable plants (4) wide weed control spectrum and (5) economical.

Considering the limited research on chemical weed control for flowers under Kansas conditions, testing of herbicides on flowers was begun at Kansas State University in 1966. Ten herbicides showing promise for use on ornamentals and other horticultural crops were selected for the research in this thesis. All rates of herbicide application are expressed in pounds active ingredient per acre (a.i.a.).

REVIEW OF LITERATURE

Alban (2) reported the use of pre-emergent contact sprays with no residual effect, appeared very promising on direct-seeded annuals, biennials and perennial ornamental plants. He found surface soil moisture must be controlled for best results with pre-emergent contact herbicides.

Evidence of differences in the tolerance of annual flower species to herbicidal treatment was noted by Adamson and Crossley (1). This necessitates both care in selection and application of the herbicide, and in grouping of flower species according to their herbicidal tolerances. The preplanting soil incorporation method of herbicidal application is well adapted to provide weed control for annual flowers, since it can readily become a part of the planting bed preparation. Orr (30) believes early or preventative weed control to be better than later control.

Schuldt et. al. (32) indicated Dacthal showed particular promise for crabgrass control in annual flowers. Dacthal is a selective pre-emergent herbicide and is most effective when used post-transplant according to Gouin (13). Good control for almost 3 months was achieved on most annual grasses and broadleaf weeds. Dacthal is safe for most ornamental plants including annuals. For maximum weed control, Dacthal should be applied immediately after transplanting and again in late summer or early fall. It may be sprayed directly on the plants without injury. Dacthal is most effective when applied to the surface of the soil and left undisturbed. Byrne and Lert (4) applied Dacthal to asters and chrysanthemums 4 to 6 weeks after transplanting at 8-12 lbs. a.i.a. with good results. Higher rates caused no injury to the transplants. Satisfactory results using Dacthal as a post-transplant application were also reported by Dana and Newman (6) and Haramaki (15, 17, 18). Davis (8) found Dacthal to be safe on strawflowers.

Carpenter and Daniel (5) applied Dacthal 75 W.P. at the rate of 8 & 16 lbs. to garden trials and 8 lbs. a.i.a. to greenhouse trials of 47 different species of annual flowers. Most species were not affected, but a significant reduction in germination occurred in the case of celosia, chrysanthemum, delphenium, Dianthus, and sweetwilliam. Danielson and Klingman (7) stated many germinating weeds including annual grasses can be controlled with Dacthal.

DiDario (9) observed minor stunting of Dacthal treated ajuga, field carnation, germander, lavender, speedwell and viola. This, however, was not apparent at the end of the season. In another experiment (10) slight injury to post-plant treated ajuga and Dianthus was noted. Susceptible direct sown annuals were poppy, canterbury bells, larkspur, cockscomb and Virginia stock. Haramaki and Meahl (18) found Salvia splendens slightly susceptible to Dacthal at 16 lbs. Kozlowski (27, 28) reported Dacthal did not affect the germination of red pine seedlings.

Waters (34) found no adverse affect on chrysanthemum flower yields treated pre- or post-plant with 12-15 lbs. of Dacthal. Acceptable weed control in garden chrysanthemums treated with granular Dacthal 16 lbs. was reported by Widmer et. al. (37)

Gouin (13) reported diphenamid, a selective pre-emergent herbicide, to be most effective when used as a post-transplant application. Application should be made two to three days after transplanting, but before the weed seeds begin germination. One application is sufficient to control weeds for 4 to 5 months under most conditions. Diphenamid is most effective when it is applied by either shallow cultivation or light irrigation. Rate of application varies from 4 to 6 pounds a.i.a. depending on the soil type.

Dunham (11) found diphenamid to be safe and effective for petunia, ageratum, marigold and scarlet sage. Adamson and Crossley (1) reported good weed control in annuals with soil-incorporated diphenamid at rates of 4 to 8 lbs. Growth of snapdragon, phlox and marigold were retarded by the 4 lb. rate. At the 8 lb. rate, ageratum, alyssum, geranium, heliotrope and lobelia also were adversely affected. Petunia, on the other hand, showed a trend toward a more vigorous growth.

Bingham and Kates (3) reported diphenamid to be successfully used on ageratum, aster, chrysanthemum, dahlia, marigold, peony, petunia, phlox, snapdragon, tulip and zinnia. Haramaki and Atmore (17) obtained good weed control with diphenamid in petunias.

Heather and Majestic daisies tolerated diphenamid at 10 lbs. according to Davis (8). Haramaki et. al. (22) found diphenamid at 16 lb. to be a satisfactory postplant treatment on zinnia. Schubert and Fortney (31) reported diphenamid at 6 lb. caused no injury when applied to the foliage of geranium. At 5 lb. preplant treatment was toxic to rooted chrysanthemums according to Waters (35). Tests by Widmer et. al. (37) found unacceptable weed control in garden chrysanthemums with diphenamid at 5 lbs.

Adamson and Crossley (1) found no phytoxicity to any flower species treated with bensulide, and it provided adequate weed control for one year. Bensulide appeared safe for strawflowers according to Davis (8). Seventy-two percent control of crabgrass at 15 lbs. was reported by Dana and Newman (6). Bensulide prevents crabgrass and foxtail invasion according to Danielson and Klingman (7).

Haubein and Hansen (23) found terbutol to be effective against germinating crabgrass seeds and seedlings. Uptake was limited to the roots. Foliar application caused little or no injury to crops studied. Dana and Newman (6) obtained 94% control of crabgrass with 10 lbs. granular terbutol.

Linuron gave outstanding weed control in gladiolus flowering stock according to Welker (36). Waters (33) found linuron phytotoxic to gladiolus cormels at 1 lb. a.i.a. pre-emergent. Leiber (29) used linuron successfully on dahlia, geranium, gladiolus, iberis, sedum and salvia. Rosa sp. and anemone were tolerant to linuron in Iven's (24) experiments.

Terbacil and DuPont 733 at 2 lbs. pre-emergent caused delayed kill of gladiolus foliage according to Welker (36). Waters (34) reported damage to third-year roses at rates of 4 lbs. in a fine sandy soil using these two herbicides. Trials by Davis (8) showed the uracils to be toxic at 1 lb. to three varieties of daisies.

Dana and Newman (6) reported 61% crabgrass control using siduron. They found this level of control was not satisfactory under their conditions.

Chrysanthemum morifolium tolerated DMPA (Zytron) granular at 10 lbs. in tests by Waters (35). Gill and Lyon (12) found DMPA controlled crabgrass and broad-leaf weeds at the rate of 10 lbs. post-emergent. DMPA prevents infestations of crabgrass and foxtail in flowerbeds according to Danielson and Klingman (7). Twelve pounds DMPA gave 85% crabgrass control in the granular form in tests by Dana and Newman (6).

Nitralin at the rate of 4 lbs. applied to the foliage, did not cause appreciable reduction in early flowering, total flowers produced, or total weight of tops of geranium plants according to Schubert and Fortney (31). Excellent weed control was obtained from June 23rd through October. Haramaki et. al. (22) found nitralin at 1 to 4 lbs. combined satisfactory weed control with minimum crop injury 9 weeks after transplanting.

MATERIALS AND METHODS

This investigation was carried out in four phases: (1) A pre-emergent herbicide application to the soil after sowing seeds, (2) A pre-emergent herbicide application to banded seedlings after transplanting to flats in the greenhouse, (3) A post-emergent herbicide application to banded flowers after transplanting to the garden and (4) pre-emergent herbicide application to banded flowers previously transplanted to the garden.

Herbicides selected for the study were bensulide, DCPA, diphenamid, DMPA, D. P. 733, linuron, nitralin, siduron, terbacil and terbutol. The same chemicals, concentration, form and rate (table 1) were used for all four phases of the study. The rates listed in table 1 were applied as single applications in each treatment.

Flower species used for the various phases of the study are listed in tables 2, 3 and 4. No plants were reused for other parts of the study.

All treatments were replicated and randomized. Data were collected from each replicate and analyzed statistically at the Kansas State University Statistical Laboratory using a two way analysis of variance. Three untreated control replicates were used in each part of the study. Routine cultural practices for each plant were followed for the duration of the study.

Effect of Pre-Emergent Herbicides on Flower Seed Germination

Many flower growers sow seeds directly in the garden where they are to be grown. Soil temperatures sufficiently warm for flower seed germination also are favorable for the germination of many weed seeds. Removal of weeds

Table 1. Herbicides used in all phases of study and their form and rate of application.

Common Name	Trade Name	Chemical Name	Active Ingredient Per Acre (lbs.)	Form
Bensulide	Betasan	N-(2-mercaptoethyl) benzenesulfonamide S-(O,O-diisopropyl phosphorodithioate)	15	7% G.
DCPA	Dacthal	Dimethyl 2,3,5,6-tetrachloroterephthalate	10	75% W.P.
Diphenamid	Enide	N,N-dimethyl-2,2-diphenylacetamide	4	50% W.P.
DMPA	Zytron	O-(2,4-dichlorophenyl) O-methyl-isopropylphosphoramidothioate	12	4.4% W.P.
Du Pont 733		5-Bromo-3-tert-butyl-methyluracil	2	80% W.P.
Linuron	Lorox	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea	1	50% W.P.
Nitralin	Planavin	4-(methylsulfonyl) 2,6-dinitro-N,N-dipropylaniline	2	75% W.P.
Siduron	Tupersan	1-(2-methylcyclohexyl)-3-phenylurea	12	50% W.P.
Terbacil	Sinbar	3-tert-butyl-5-chloro-6-methyluracil	1	80% W.P.
Terbutol	Azak	2,6-di-tert-butyl-p-tolyl-methylcarbamate	12	80% W.P.

germinating with or before flower seeds is undesirable because of the danger of disturbing germinating seeds or seedlings. Therefore, it is desirable to have herbicides that can be applied at sowing to prevent competition from weeds, yet allow flower seeds to germinate and grow normally.

The investigation of the effect of herbicides on the seed germination of 15 garden flowers (table 2) was conducted during 1966 in the floriculture greenhouses at Kansas State University. Thirty-three new wooden flats 22 by 15½ inches were lined with one layer of newspaper and filled to a depth of 2½ inches with an unpasteurized silt loam soil sifted through a ½ inch screen.

Fifteen rows per flat were pressed in the soil 1/8 inch deep with a marking stake, making the rows 15 inches long and spaced approximately 1½ inches. Fifty seeds of each of 15 flower species were sown April 3, 1966, per flat. Each treatment had 3 replicates which were randomized on the greenhouse bench. Three untreated flats were left as a check. Wettable powders were applied with a bulb syringe equipped with a perforated nozzle immediately after sowing, using 8 ounces of water per flat as a carrier. An equal amount of water was applied to granular herbicide treatments immediately after application. All flats, except the one being treated, were covered with film plastic during herbicide application to prevent contamination from drift. Soils were sufficiently moist after treatment that they were not irrigated until the following day.

The soil was kept constantly moist by surface watering with a watering rose until seedlings emerged. Flats were covered with cheese cloth to maintain humidity and prevent the soil surface from drying between waterings.

Seedling numbers were recorded from each replicate and analyzed statistically at the Kansas State University Statistical Laboratory. Where

Table 2. Garden flowers which were used for the pre-emergent herbicide application to the soil after sowing seeds.

COMMON NAME	FAMILY	GENUS	SPECIES
Ageratum	Compositae	Ageratum	houstonianum
Canterbury bells	Campanulaceae	Campanula	medium
Carnation	Caryophyllaceae	Dianthus	caryophyllus
China aster	Compositae	Callistephus	chinensis
Cockscomb	Amaranthaceae	Celosia	argentea
Hollyhock	Malvaceae	Althaea	rosea
Marigold	Compositae	Tagetes	patula
Pentstemon	Scrophulariacea	Penstemon	gloxinoides
Petunia	Solanaceae	Petunia	hybrida
Portulaca	Portulaceae	Portulaca	grandiflora
Salvia	Labiatae	Salvia	splendens
Snapdragon	Scrophulariaceae	Antirrhinum	majus
Sweetwilliam	Caryophyllacea	Dianthus	barbatus
Rudbeckia	Compositae	Rudbeckia	hirta
Zinnia	Compositae	Zinnia	elegans

observable differences in plant heights occurred, in the case of hollyhock, marigold and zinnia, measurements were made and analyzed statistically.

Since the close seed spacing would not allow adequate development of plants to maturity, all seedlings were discarded after four weeks.

Post-Transplant Herbicidal Application to Banded Seedlings

Bedding plant producers commonly transplant seedlings from the germination medium to 2¼ inch peat pots, plant bands or plastic pots for later sale. The transplanting medium is frequently not pasteurized because of a lack of facilities, labor, or the grower does not feel it necessary. Resulting weed growth can reflect an attitude of slovenness by the grower. Newly transplanted seedlings are in a tender stage of growth which could be susceptible to herbicide injury.

In the second phase of this study, seeds of 18 flower species (table 3) were germinated in 6 inch clay pots. Seedlings were transplanted, when they attained their second set of true leaves, into flats containing 2½ inch square asphalt impregnated cardboard bands filled with 2 parts unpasteurized silt loam soil and 1 part sphagnum peat. Each standard flat contained 54 banded plants -- 6 plants for each of 9 species. Three flats were used as replicates for statistical analysis. All were randomized in the greenhouse bench. A total of 36 flats containing 1,944 individual plants were required for this phase of the study.

Herbicidal applications were delayed until four days after seedling transplanting to allow the plants to regain turgidity and root establishment. A bulb syringe was used for applications of the solutions of the wettable powder herbicides. Granular herbicides were applied by hand and irrigated

Table 3. Garden flowers which were used for the pre-emergent herbicide application to banded seedlings after transplanting to flats in the greenhouse.

COMMON NAME	FAMILY	GENUS	SPECIES
Ageratum	Compositae	Ageratum	houstonianum
Alyssum	Cruciferae	Alyssum	saxatile
Aubrietia	Cruciferae	Aubretia	deltoidea
Candytuft	Cruciferae	Iberis	gibraltarica
Carnation	Caryophyllacea	Dianthus	caryophyllus
Cerastium	Caryophyllaceae	Cerastium	tomentosum
China aster	Compositae	Callistephus	chinensis
Cockscomb	Amaranthaceae	Celosia	argentea
Cosmos	Compositae	Cosmos	bipinnatus
Flax	Linaceae	Linum	perenne
Lupine	Leguminosae	Lupinus	polyphyllus
Marigold	Compositae	Tagetes	patula
Petunia	Solanaceae	Petunia	hybrida
Rudbeckia	Compositae	Rudbeckia	hirta
Salvia	Labiatae	Salvia	splendens
Snapdragon	Scrophulariaceae	Antirrhinum	majus
Sweetrocket	Cruciferae	Hesperis	matronalis
Sweetwilliam	Caryophyllaceae	Dianthus	barbatus

immediately after application. Foliar contact with herbicides was avoided. Seedlings were syringed immediately after herbicide application.

Plant injury, death and height measurement were recorded from each replicate and all data were analyzed statistically.

Post-transplant, Post-emergent Herbicide Application to Banded Flowers Transplanted to the Garden

The average flower grower often neglects weed control until they become a menace. The question then often arises if a chemical weed killer can be applied to eliminate the growing weeds without damaging the flowers.

Ten flower species (table 4) were planted in the garden on May 25, 1966. The banded plants were in a stage of growth normally marketed by bedding plant producers for spring sales to the home gardener. The soil had been prepared with a rotary cultivator followed by a hand raking. Plant bands were removed immediately prior to planting.

Ten plants of each species (table 4) were used for each of the three randomized replicates. Plants were spaced 12 inches within the row with rows 2 feet apart making 20 square feet per plot. Three check plots were similarly planted. A barrier of 1 foot surrounded each plot.

Each plot was overseeded with ½ oz. of crabgrass (Digitaria sanguinalis) seeds. Herbicide application was delayed two weeks after transplanting to evaluate post-emergent effect of the herbicides on crabgrass. Each herbicide was applied to three randomized plots. Three randomized check plots were left untreated. A knapsack sprayer equipped with an agitator was used to apply wettable powder herbicides. Two quarts of water as a carrier for wettable powder herbicides was applied at 20 lbs. p.s.i. to each plot. A lawn seeder was used to apply granular herbicides. Air temperature at application time

Table 4. Garden flowers which were used for pre- and post-emergent herbicide application to banded flowers after transplanting to the garden.

COMMON NAME	FAMILY	GENUS	SPECIES
Ageratum	Compositae	Ageratum	houstonianum
Calendula	Compositae	Calendula	officinalis
Cockscomb	Amaranthaceae	Celosia	argentea
Hollyhock	Malvaceae	Althaea	rosea
Madagascar-Periwinkle	Aprocynaceae	Lochnera	rosea
Marigold	Compositae	Tagetes	patula
Petunia	Solanaceae	Petunia	hybrida
Snapdragon	Scrophulariaceae	Antirrhinum	majus
Sweetalyssum	Cruciferae	Lobularia	maritima
Zinnia	Compositae	Zinnia	elegans

was 80 degrees F. with no noticable wind. Herbicides were kept off the foliage as much as possible. Flower foliage was syringed immediately after treatment.

Granular herbicides were not incorporated because of weed growth, but were watered in immediately. All plots received sprinkler irrigation as needed for the duration of the study.

Post-transplant, Pre-emergent Herbicidal Application to Banded Flowers Transplanted to the Garden

As suggested by Orr (30) early or preventative weed control is better than later control. Applying a herbicide before weed growth begins would provide a weed free period while the flowers are becoming established. Newly transplanted bedding plants, however, may also be in a stage susceptible to herbicidal injury. The object of this study was to evaluate pre-emergent weed control of the herbicides and their effect on flowers when applied shortly after transplanting.

The same flowers (table 4) were used as in the previous study. Banded plants were transplanted to the garden site on May 25, 1966. The plants were in a stage of growth similar to those marketed during spring sales by bedding plant producers. The soil had been previously prepared with a rotary cultivator followed by hand raking with a garden rake. Plant bands were removed immediately prior to transplanting the flowers into the soil.

After transplanting, the soil surface was releveled to eliminate footprints and soil disturbance resulting during the planting operation. Each 10' x 2' plot was then overseeded with ½ oz. of crabgrass seeds. Herbicide application was delayed 4 days to allow new transplants to become established.

Plot design and herbicide application were identical to those used in the previous study except granular herbicides were lightly incorporated with a garden rake.

Weed counts were taken four and eight weeks after over-seeding. Plant injury ratings were taken at this time. All data from each replicate were analyzed statistically using a two way analysis of variance.

EXPERIMENTAL RESULTS

Effect of Pre-Emergent Herbicides on Flower Seed Germination

The 15 flower species (table 2) used in this study represented 9 flower families. Flower plant emergence dates ranged from 4 days to 2 weeks after sowing (table 5). Results of the germination counts are summarized in table 6.

Germination of several flower species was increased by application of the herbicide treatments when compared to the check. Germination of zinnia was increased by the greatest number of herbicides. It was the only species showing increased germination when treated with bensulide, Du Pont 733, linuron and DMPA. Of the ten herbicides tested, none significantly reduced germination of zinnia seed.

Siduron produced the largest increase in marigold germination. However, this herbicide caused a large decrease in hollyhock seed germination.

Germination of carnation, petunia, portulaca, and rudbeckia was totally inhibited by Du Pont 733, linuron and terbacil. In addition, no germination occurred when ageratum, aster and canterbury bells were treated with Du Pont 733. Linuron inhibited germination of canterbury bells and terbacil inhibited sweetwilliam in addition to those previously mentioned.

DCPA significantly improved germination of ageratum, marigold and snapdragon. Reductions occurred in the case of aster, carnation, canterbury bells, cockscomb, portulaca, sweetwilliam and rudbeckia. This herbicide had no significant effect on the other seeds tested.

No significant germination increase resulted from herbicide applications on aster, canterbury bells, hollyhock, pentstemon, petunia, portulaca and salvia. Terbutol was the only herbicide significantly increasing germination of carnation. The most pronounced increase on cockscomb was produced by terbacil. Germination of pentstemon was reduced by all treatments except Du Pont 733 and DCPA. Sweetwilliam was the only case where an increase occurred when treated with nitralin.

All seedlings in herbicide treatments of Du Pont 733, linuron and terbacil were killed within 21 days after sowing the seeds.

Plant heights of hollyhock, marigold and zinnia were recorded (table 7) because of the observable differences in seedling growth occuring with treatment. Significant seedling growth reductions occurred for zinnias in treatments of DMPA, D.P. 733, linuron, siduron and terbacil. None of these herbicides significantly reduced germination of zinnia seed (table 6). No herbicide increased seedling growth for zinnia.

Marigold heights increased when treated with bensulide, DMPA and nitralin. A significant height reduction occurred in treatments of D. P. 733, siduron and terbacil. Siduron produced a significant increase in germination, but seedlings were stunted.

DMPA treated hollyhock seed showed the greatest plant height, however, the increase was not statistically significant. D. P. 733, linuron, nitralin, siduron, and terbacil produced a decrease in linear growth on hollyhock. Linuron was the only chemical of this group that did not reduce the initial germination of hollyhock.

Table 5. Dates of emergence and counting of seedlings from germination study.

(planting date 4-3-66)

SPECIES	EMERGENCE	COUNTS TAKEN
Ageratum	4- 8-66	4-11-66
Aster	4-11-66	4-15-66
Canterbury bells	4-12-66	4-17-66
Carnation	4-11-66	4-16-66
Cockscomb	4- 8-66	4-13-66
Hollyhock	4- 7-66	4- 9-66
Marigold	4- 7-66	4- 9-66
Pentstemon	4-17-66	4-21-66
Petunia	4-13-66	4-18-66
Portulaca	4- 8-66	4-12-66
Salvia	4-11-66	4-13-66
Snapdragon	4-12-66	4-16-66
Sweetwilliam	4-12-66	4-16-66
Rudbeckia	4- 8-66	4-10-66
Zinnia	4- 7-66	4- 9-66

Table 6. Mean germination percentage resulting from pre-emergent herbicidal application to the soil after sowing seeds.

	Bensulide	Check	DCPA	Diphenamid	DMPA	D.P. 733
Ageratum	19.0	15.0	23.0 a	5.0 b	4.6	00.0 b
Aster	18.0 b	28.0	17.0 b	13.0 b	6.3 b	00.0 b
C. bells	9.0	54.0	50.0 b	25.6 b	15.3 b	00.0 b
Carnation	9.0	14.0	7.1 b	11.6	18.0	00.0 b
Cockscomb	19.6 b	65.3	40.6 b	67.6	64.3	43.6 b
Hollyhock	76.0	82.3	80.6	84.0	84.3	74.3
Marigold	71.0	72.3	87.3 a	86.3	61.6	75.0
Pentstemon	4.0	17.3	10.6	3.6 b	1.3 b	18.0
Petunia	4.0	5.3	6.3	4.3	1.6 b	00.0 b
Portulaca	3.3	3.6	1.0 b	3.6	3.0	00.0 b
Salvia	47.3 b	87.6	83.3	70.3 b	41.6 b	5.3 b
Snapdragon	5.3 b	32.0	53.3 a	44.3 a	21.3 b	0.3 b
Sweetwilliam	5.6 b	15.3	4.0 b	18.6	00.0 b	0.3 b
Rudbeckia	44.0	45.6	30.6 b	44.0	40.0	00.0 b
Zinnia	93.6 a	85.6	89.6	84.3	97.3 a	96.0 a

a = Significant increase when compared to check at LSD .05
b = Significant decrease when compared to check at LSD .05

Table 6. continued

	Linuron	Nitralin	Siduron	Terbacil	Terbutol	LSD .05
Ageratum	1.3 b	18.0	14.0	1.0 b	18.3	7.1
Aster	0.3 b	31.0	7.0 b	1.0 b	20.6	8.3
C. bells	00.0 b	29.0 b	3.6 b	0.3 b	56.0	2.7
Carnation	00.0 b	12.6	6.3 b	00.0 b	24.3 a	5.2
Cockscomb	66.3	58.3	72.0	89.6 a	45.6 b	19.3
Hollyhock	84.3	72.3	66.6 b	75.3	77.0	10.6
Marigold	81.6	83.6	91.0 a	66.3	86.0	14.8
Pentstemon	0.6 b	0.6 b	2.3 b	0.6 b	6.6 b	8.1
Petunia	00.0 b	1.0 b	4.0	00.0 b	4.3	1.5
Portulaca	00.0 b	1.3 b	6.3 b	00.0	2.6	1.4
Salvia	64.0 b	44.3 b	63.0 b	52.6 b	74.6	15.8
Snapdragon	0.3 b	6.6 b	34.3	0.6 b	64.3 a	10.9
Sweetwilliam	0.3 b	21.3 a	2.0 b	00.0 b	5.6 b	3.6
Rudbeckia	00.0 b	40.0	32.3 b	00.0 b	55.3 a	10.2
Zinnia	94.6 a	87.6	90.3	91.3 a	83.6	5.4

a = Significant increase when compared to check at LSD .05
b = Significant decrease when compared to check at LSD .05

Table 7. Height comparison of three flower species 14 days after sowing seeds and herbicidal application.

(height measurements in cm.)

Herbicide	Hollyhock	Marigold	Zinnia
Bensulide	3.6	6.9 a	7.6
Check	3.2	5.3	7.5
DCPA	3.4	6.0	7.9
Diphenamid	3.9	4.5	7.7
DMPA	4.1	6.9 a	6.3 b
D.P. 733	1.7 b	1.4 b	3.5 b
Linuron	1.6 b	4.7	5.0 b
Nitralin	1.5 b	6.4 a	7.6
Siduron	1.8 b	2.6 b	2.9 b
Terbacil	1.5 b	1.0	3.2 b
Terbutol	3.6	5.9	7.6
LSD at .05	1.3	1.0	1.2

a = Significant increase when compared to check at LSD .05
b = Significant decrease when compared to check at LSD .05

Effect of Pre-emergent Herbicide Application to Banded Transplants

Eighteen species of banded seedlings were observed for plant height, plant injury and senescence after herbicide application. Results of plant height measurements 30 days after herbicide application are recorded on table 8.

D. P. 733 caused senescence of all plants by the time measurements were taken. Terbacil caused death in all species except lupine, however, this species was significantly reduced in height. The only species not killed by linuron were aster, cosmos and lupine. Growth of these three species was significantly reduced when compared to the check.

Bensulide was the only herbicide producing an increase in linear growth of ageratum and salvia. Terbutol caused an increase in growth of aubrietia. Bensulide, DCPA and terbutol were the only herbicides which did not significantly reduce the linear growth of any of the species tested. Applications of DMPA produced reductions only in the case of cockscomb and flax.

Linuron did not produce a significant effect on alyssum, aster, candytuft, carnation, lupine and salvia. All other species were stunted by this chemical. Nitralin reduced growth of 9 species, but did not affect the other 9 species.

Siduron caused reduced linear growth of ageratum, aubrietia, cockscomb, flax, lupine, marigold, petunia and rudbeckia. The other species were not affected.

Table 8. Mean linear growth 30 days after herbicidal applications to banded transplants.

(measurements in centimeters)

	Bensulide	Check	DCPA	Diphenamid	DMPA	D.P. 733
Ageratum	9.2 a	7.7	7.8	5.5 b	6.9	0.0 b
Alyssum	6.2	5.9	5.9	4.8	5.6	0.0 b
Aubrietia	10.2	10.0	10.0	2.7 b	8.8	0.0 b
Candytuft	3.1	3.6	3.5	2.2	3.5	0.0 b
Carnation	6.6	5.9	6.3	6.4	6.6	0.0 b
Cerastium	6.4	10.2	9.7	5.1 b	9.7	0.0 b
China aster	10.4	9.0	7.4	7.4	7.7	0.0 b
Cockscomb	13.6	14.9	11.8	6.5 b	6.5 b	0.0 b
Cosmos	15.3	15.5	15.4	10.6 b	13.1	0.0 b
Flax	13.4	15.9	11.7	6.2 b	6.2 b	0.0 b
Lupine	10.1	10.4	10.0	8.9	10.0	0.0 b
Marigold	17.5	15.4	15.7	5.7 b	14.1	0.0 b
Petunia	11.5	10.2	8.9	3.8 b	7.6	0.0 b
Rudbeckia	15.4	15.6	15.2	5.3 b	14.0	0.0 b
Salvia	11.0 a	7.9	7.9	5.9	8.2	0.0 b
Snapdragon	17.2	17.2	17.6	5.6 b	17.0	0.0 b
Sweet Rocket	17.7	17.4	17.8	12.3 b	17.0	0.0 b
Sweetwilliam	9.2	9.4	7.4	5.0 b	8.7	0.0 b

a = Significant increase when compared to check at LSD .05
b = Significant decrease when compared to check at LSD .05

Table 8. (continued)

	Linuron	Nitralin	Siduron	Terbacil	Terbutol	LSD .05
Ageratum	0.0 b	5.8 b	5.6 b	0.0 b	8.9	1.4
Alyssum	0.0 b	5.6	5.0	0.0 b	6.2	1.2
Aubrietia	0.0 b	8.4	6.5 b	0.0 b	14.4 a	3.4
Candytuft	0.0 b	2.9	1.6	0.0 b	3.6	2.2
Carnation	0.0 b	5.1	7.0	0.0 b	6.3	1.3
Cerastium	0.0 b	8.1	6.5	0.0 b	9.4	4.0
China aster	5.0 b	7.6	5.9	0.0 b	9.1	3.1
Cockscomb	0.0 b	7.2 b	10.3 b	0.0 b	13.4	3.5
Cosmos	10.2 b	11.4 b	13.2	0.0 b	17.5	2.5
Flax	0.0 b	8.7 b	10.2 b	0.0 b	11.3	4.8
Lupine	5.2 b	4.9 b	5.8 b	1.7 b	9.9	1.6
Marigold	0.0 b	10.3 b	10.2 b	0.0 b	16.6	2.3
Petunia	0.0 b	6.2 b	7.4 b	0.0 b	10.8	2.6
Rudbeckia	0.0 b	9.9 b	10.2 b	0.0 b	14.9	4.8
Salvia	0.0 b	8.7	6.4	0.0 b	9.9	2.9
Snapdragon	0.0 b	15.7	20.3	0.0 b	19.9	3.1
Sweetrocket	0.0 b	12.8 b	15.8	0.0 b	18.3	3.4
Sweetwilliam	0.0 b	8.3	9.6	0.0 b	8.9	2.0

a = Significant increase when compared to check at LSD .05
b = Significant decrease when compared to check at LSD .05

Post-transplant, Post-emergent Herbicide Application to Banded Flowers Transplanted to the Garden

The average number of crabgrass and broadleaf weeds per square foot 4 and 8 weeks after post-emergent herbicide application are shown in table 9. Only D.P. 733, linuron and terbacil resulted in significant reduction in weed counts compared to the check at 4 or 8 weeks. The other herbicides did not significantly reduce crabgrass or broadleaf populations when applied after the weeds were established.

No visible injury to the flower species was observed in plots treated with bensulide, DCPA, DMPA and terbutol. Visual ratings of injury to the flower species are recorded in table 10.

D.P. 733 treatments resulted in extensive injury to all species. Cockscomb, marigold, petunia, sweet alyssum and zinnia were completely killed by this chemical. Linuron produced complete kill on cockscomb, sweet alyssum and zinnia. Cockscomb, marigold, petunia and sweet alyssum were killed by terbacil. Marigold was the only species completely killed by nitralin.

Siduron produced a slight injury to ageratum and snapdragon. Others were damaged more extensively.

Table 9. Mean crabgrass and broadleaf counts per square foot in garden trials four and eight weeks following post-emergent herbicide application.

	Crabgrass		Broadleaf	
	4 weeks	8 weeks	4 weeks	8 weeks
Bensulide	23.7	25.2	24.1	23.0
Check	24.0	26.5	26.8	30.2
DCPA	23.2	23.3	23.1	28.7
Diphenamid	20.1	19.8	25.5	24.2
DMPA	22.8	24.9	22.4	26.1
D.P. 733	5.4 a	1.1 a	6.1 a	2.6 a
Linuron	7.0 a	4.7 a	7.4 a	3.2 a
Nitralin	24.6	26.2	26.2	26.7
Siduron	21.7	23.6	25.3	24.9
Terbacil	6.0 a	2.1 a	5.1 a	2.3 a
Terbutol	22.3	23.2	22.8	23.6
LSD .05	6.8	7.2	5.9	7.5

a = Significiantly less than check at LSD .05

Table 10. Plant injury ratings in garden plots receiving post-emergent herbicide applications.

	Bensulide	Check	DCPA	Diphenamid	DMPA	D.P.733	Linuron	Nitralin	Siduron	Terbacil	Terbutol
Ageratum	0	0	0	3.5	0	3.0	3.1	4.6	0.5	3.2	0
Calendula	0	0	0	3.1	0	3.1	3.0	4.7	2.0	2.9	0
Cockscomb	0	0	0	2.5	0	5.0	5.0	3.9	2.1	5.0	0
Hollyhock	0	0	0	2.5	0	3.5	3.0	4.2	4.1	4.1	0
Madagascar Periwinkle	0	0	0	4.5	0	3.0	3.2	3.5	3.9	3.5	0
Marigold	0	0	0	4.2	0	5.0	2.5	5.0	4.9	5.0	0
Petunia	0	0	0	4.1	0	5.0	2.9	4.3	3.2	5.0	0
Snapdragon	0	0	0	4.3	0	3.0	4.3	4.1	0.5	3.4	0
Sweetalyssum	0	0	0	4.1	0	5.0	5.0	4.3	4.7	5.0	0
Zinnia	0	0	0	2.3	0	5.0	5.0	3.8	4.8	4.5	0

0 = no injury, 5 = complete kill

Post-transplant, Pre-emergent Herbicide Application to Banded Flowers Transplanted to the Garden

The average number of crabgrass and broadleaf weeds per square foot 4 and 8 weeks after herbicide application is found in table 11. All herbicides significantly reduced crabgrass counts at both 4 and 8 weeks when compared to the check. DCPA, DMPA, D.P. 733, linuron, terbacil and terbutol gave 100% control of crabgrass at four weeks. D.P. 733 was the only herbicide giving 100% control at the end of eight weeks.

Diphenamid, linuron and nitralin did not significantly reduce broadleaf weed counts at 4 weeks: D.P. 733, terbacil and terbutol treatments resulted in 100% control. Bensulide, DCPA, DMPA and siduron significantly reduced broadleaf weed populations, however, the degree of weed control was not considered adequate.

D.P. 733 and terbacil gave 100% control of broadleaf weeds at the end of eight weeks. DCPA, diphenamid and nitralin treatments did not result in adequate broadleaf weed control at eight weeks.

Plant injury ratings were taken four weeks after herbicide application. Results are recorded in table 12.

Bensulide, DCPA, DMPA and terbutol applications did not show visible injury when applied to the species previously transplanted to the garden. Diphenamid, D.P. 733, linuron, nitralin and terbacil extensively damaged all flower species. Siduron produced extensive damage to all species except ageratum and snapdragon.

Table 11. Mean crabgrass and broadleaf weed counts per square foot in garden trials four and eight weeks following pre-emergent herbicide application.

	Crabgrass		Broadleaf	
	4 weeks	8 weeks	4 weeks	8 weeks
Bensulide	1.3 a	3.1 a	3.0 a	10.1 a
Check	21.5	28.3	27.6	31.2
DCPA	0.0 a	4.3 a	4.2 a	12.1
Diphenamid	2.1 a	5.0 a	23.2	20.5
DMPA	0.0 a	2.7 a	2.0 a	6.0 a
D.P. 733	0.0 a	0.0 a	0.0 a	0.3 a
Linuron	0.0 a	1.3 a	12.9	8.6 a
Nitralin	1.3 a	5.0 a	10.5	13.1
Siduron	1.0 a	2.7 a	5.2 a	8.6 a
Terbacil	0.0 a	1.3 a	0.0 a	0.3 a
Terbutol	0.0 a	3.5 a	0.0 a	4.1 a
LSD .05	10.3	15.1	18.6	19.2

a = Significantly less than check at LSD .05

Table 12. Herbicide injury ratings to flowers in garden plots receiving pre-emergent herbicide applications.

	Bensulide	Check	DCPA	Diphenamid	DMPA	D.P.733	Linuron	Nitralin	Siduron	Terbacil	Terbutol
Ageratum	0	0	0	3.7	0	5.0	5.0	4.9	1.2	3.8	0
Calendula	0	0	0	3.4	0	5.0	5.0	4.8	2.3	3.2	0
Cockscomb	0	0	0.5	2.6	0.7	5.0	5.0	4.0	2.4	5.0	0
Hollyhock	0	0	0	2.7	0	5.0	5.0	4.3	4.6	4.6	0
Madagascar Periwinkle	0	0	0	4.6	0	5.0	5.0	3.9	4.1	3.7	0
Marigold	0	0	0	4.5	0	5.0	5.0	5.0	5.0	5.0	0
Petunia	0	0	0	4.2	0	5.0	5.0	4.5	3.6	5.0	0
Snapdragon	0	0	0	4.7	0	5.0	5.0	4.4	1.1	4.1	0
Sweetalyssum	0	0	0	4.3	0	5.0	5.0	4.5	4.9	5.0	0
Zinnia	0	0	0	2.6	0	5.0	5.0	3.9	4.9	4.8	0

0 = no injury, 5 = complete kill

DISCUSSION

The primary purpose of this study was to evaluate phytotoxicity of various herbicides to numerous flower species. The intent was to use as many of the common species as facilities would permit.

Since the effect of the herbicides tested on common weeds is generally known, weed control results were considered secondary. The rate of application of each herbicide most commonly applied on other horticultural crops was used in this study. Facilities did not permit testing several rates of application for each herbicide because of the large number of species included. Rather, it was desired to get a general indication of the effect of herbicides on the flower species and determine if their use for weed control was feasible.

It was evident from these results that a particular herbicide does not affect all flower species similarly. Differences in tolerance of annual flower species to herbicidal treatment was also reported by Adamson and Crossley (1). Since many flower beds contain a mixed population of species, the necessity for grouping flower species according to herbicidal tolerance when using chemical weed control can be seen.

The various herbicides tested exhibited a definite selectivity to germinating flower seeds. Some decreases in germination were expected, but in a few cases germination was increased. Increased germination resulting from herbicidal application has been reported by Carpenter and Daniel (5). It has been postulated that this is due to a fungicidal action of the herbicide in the soil. The author does not believe this to be the case. No individual herbicide in this study produced increases in germination of more than two species. If a herbicide increases germination because of fungicidal action, then a more general increased germination in most of the species would be expected. The reason for increased germination by herbicide action was not studied. Further study to determine if the seeds which were stimulated contain substances not contained in other seeds would be of merit.

Susceptibility of Canterbury Bells, cockscomb and Dianthus to Dacthal found in this study was also reported by several other workers (5, 10). A susceptibility of the family Caryophyllacae genus Dianthus to Dacthal was observed. No other common relationship was found of herbicidal action on the various species.

It would appear that herbicides have the least inhibitory effect on the germination of certain large seeds that germinate relatively fast. No herbicide significantly reduced germination of hollyhock, marigold or zinnia with exception of siduron treated hollyhock. These three species have relatively large seeds and germinated sooner than the others (table 5). Possibly, herbicides have more time to act on slower germinating seeds. Heavy seed coats may also inhibit initial herbicide action.

A herbicide's effect on seedling growth isn't necessarily the same as its effect on germination. Many flower species which had increased germination through herbicide treatment or were not affected showed inhibited seedling growth. This same effect was observed by Grover (14) on caragana. A possible explanation is that some herbicides don't inhibit germination but act on the root system of the seedling after a certain concentration is reached.

Several inconsistencies were found in plant heights between herbicidal applications to direct sown seeds and those applied to transplanted seedlings. The differences between planting mediums may be a factor. The transplanting mixture contained soil with a third peatmoss whereas the seeds were sown in a field soil. Possibly a difference in the leaching rate into the medium or the capacity of the medium to absorb herbicides occurred.

Although it was known that the herbicides used were recommended for pre-emergent application, their post-emergent effect was tested. Since many flower growers do not think about weed control until weeds occur, it was desired to observe if any degree of post-emergent weed control would be achieved. Only three chemicals produced any significant degree of post-emergent weed control, but extensive damage to the flowers occurred. A need is apparent for a study using post-emergent chemicals for established weeds in flower beds.

Host plant injury ratings generally were more severe from pre-emergent treatments than from post-emergent applications. Herbicide application was delayed two weeks in the post-emergent plots to allow crabgrass to become established. The lesser degree of damage was probably due to the extra growth attained during the two weeks. This delayed application may have allowed establishment of roots below the zone of herbicide concentration.

Bensulide, DCPA, DMPA and terbutol gave good pre-emergent crabgrass control while not damaging flower species. D. P. 733, linuron and terbacil gave good crabgrass control but damaged flowers extensively. Those not damaging flowers probably provide a phytotoxic layer at the soil surface to germinating weed seeds, but the herbicide doesn't leach into the root zone in sufficient quantity to injure the flower species.

Control of broadleaf weeds was generally less satisfactory than control of grassy weeds. The fact that most flowers and broadleaf weeds are dicots may provide difficulty in controlling broadleaf weeds in flowers.

Summary and Conclusions

Ten herbicides were screened for possible use by commercial and home flower growers. Four phases of study utilizing application times when herbicides might logically be applied were employed for this study. The same herbicides, rates and form were used for all phases.

The first study consisted of herbicides applied directly to the soil in which flower seeds had been sown. Since most pre-emergent herbicides prevent germination of weed seed or kill seedlings soon after germination, one might expect herbicides to have the same effect on flower seeds.

The herbicides exhibited some selectivity to certain flower species. In a few cases, germination was actually stimulated. In others, germination was not affected, reduced or totally inhibited. No general trend of herbicide action on flower species could be detected except for DCPA on the genus Dianthus. All herbicides reduced germination of at least a few species.

Germination counts did not prove to be the final analysis of herbicide action. In a plant height comparison of three species from the germination study, results were not consistent in all cases with germination results.

D. P. 733, linuron and terbacil increased germination of some species, but all species were killed after germination. Some of the other herbicides produced increases or decreases in plant height of species which did not have their germination affected.

Conclusions drawn from this study are:

1. None of the herbicides tested could be applied at the time of seed sowing without regard to flower species.
2. Some of the herbicides can be safely applied to sown seeds of certain species.

3. Germination results do not provide the final analysis of herbicide action.

The second phase of study was an herbicide application to seedlings after they had been transplanted to bands. This study would have application for commercial bedding plant producers.

Need for discriminate herbicide use was again found. All species were killed by D. P. 733. Linuron and terbacil killed most species of the flower seedlings. Bensulide, DCPA and terbutol were found to be satisfactory on all species tested. DMPA was satisfactory on all species except cockscomb and flax. Other herbicides produced varying results.

Conclusions from this study are:

1. Bensulide, DCPA and terbutol can be safely used on transplants of the species tested.
2. D. P. 733, linuron and terbacil are unsatisfactory.
3. The other herbicides would have to be used very discriminately.

The third phase was a herbicide application to established weeds growing in flower beds. Only three herbicides resulted in post-emergent weed control. However, all three resulted in extensive damage to the flower species.

The conclusion from this study is that none of the herbicides tested are satisfactory for post emergent weed control.

The last phase of study was a herbicide application after transplanting flowers to the garden, but before weeds emerged. Significant crabgrass reduction was achieved by all herbicides except bensulide and diphenamid. Several herbicides also reduced broadleaf weed counts.

Bensulide, DCPA, DMPA and terbutol did not produce any visual injury on any flower species with the exception of a slight injury of DCPA and DMPA on cockscomb. Other chemicals resulted in excessive injury to flower species.

Conclusions from this study are that DCPA, DMPA and terbutol can control weeds when applied pre-emergent without excessive damage to flowers.

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ACKNOWLEDGMENT

The author wishes to express his sincere appreciation to his major professor, Dr. William J. Carpenter, Department of Horticulture and Forestry, for his counsel, guidance and encouragement throughout this investigation and during the preparation of this manuscript.

Sincere appreciation is also expressed to the other members of the advisory committee for their careful review and suggestions for preparing this manuscript: Dr. Ronald W. Campbell and Dr. Ray A. Keen, Department of Horticulture and Forestry and Dr. Raymond J. Agan, Department of Education.

The author also wishes to thank the cooperating chemical and seed companies for supplying products used in this study.

To my wife, Erma, I am especially grateful for her splendid cooperation in typing the final copy of this thesis.

PRE-AND POST-EMERGENT HERBICIDE APPLICATION TO GARDEN FLOWERS

by

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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture

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1969

The value of herbicides for controlling weeds in agronomic and horticultural crops is well known. Herbicide research in greenhouses and flower gardens, however, has lagged behind that for other crops. Because of the high value of the crop per unit of area, herbicide use has been extremely cautious. Chemical weed control will become increasingly important as the cost of labor increases and availibility decreases.

The purpose of this study was to investigate the feasibility of using herbicides for weed control in annual garden flowers. Ten herbicides which showed promise for use on other horticultural crops were evaluated. The primary objective was to determine their effect on the host plant, although the degree of weed control was also measured.

Four separate experiments were conducted in this study: (1) A pre-emergent herbicide application to the soil after sowing seeds, (2) A pre-emergent herbicide application to seedlings after transplanting to bands in the greenhouse, (3) A post-emergent herbicide application to flowers after transplanting to the garden and (4) A pre-emergent herbicide application to flowers after transplanting to the garden. Experiments 1 and 2 were conducted in the greenhouse.

Herbicides used in this study were: N-(2-mercaptoethyl) benzenesulfonamide S-(O,O-diisopropyl phosphorodithioate) (bensulide), Dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA), N,N-dimethyl-2,2-diphenylacetamide (diphenamid), O-(2,4-dichlorophenyl) O-methylisopropylphosphoramidothioate (DMPA), 5-Bromo-3-tert-butyl-methyluracil (Du Pont 733), 3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea (linuron), 4-(methylsulfonyl) 2,6-dinitro-N,N-dipropylaniline (nitralin), 1-(2-methylcyclohexyl)-3-phenylurea (siduron), 3-tert-butyl-5-chloro-6-methyluracil (terbacil) and 2,6-di-tert-butyl-p-tolyl-methylcarbamate (terbutol).

Flower species used were: Ageratum houstonianum, Althaea rosea, Alyssum saxatile, Antirrhinum majus, Aubretia deltoidea, Calendula officinalis, Callistephus chinensis, Campanula medium, Celosia argentea, Cerastium tomentosum, Cosmos bipinnatus, Dianthus barbatus, Dianthus caryophyllus, Hesperis matronalis, Iberis gibraltarica, Linum perenne, Lobularia maritima, Lochnera rosea, Lupinus polyphyllus, Penstemon gloxinoides, Petunia hybrida, Portulaca grandiflora, Rudbeckia hirta, Salvia splendens, Tagetes patula and Zinnia elegans.

Germination counts were recorded after herbicides were applied to the soil in which flower seeds had been sown. Herbicide applications showed increased, reduced, inhibited or no difference in germination counts. No definite trends were observed with the exception of a susceptibility of the family Caryophllacae genus Dianthus to DCPA. No single herbicide produced uniform effect on germination of all species.

Subsequent growth of all species treated with D.P. 733, linuron and terbacil was interrupted after germination results were recorded, and all plants senesced. Several other herbicides not reducing germination, later inhibited growth of the flower species.

Significant increases and decreases in plant height were found when herbicides were applied to banded transplants. The same three herbicides, D.P. 733, linuron and terbacil, killing all plants in the germination study, also killed all banded seedlings with exception of three species, Callistephus chinensis, Cosmos bipinnatus and Lupinus polyphyllus. Bensulide, DCPA and terbutol were found to be safe on all flower species tested. DMPA was toxic only to cockscomb and flax. This experiment has application to bedding plant producers lacking facilities for soil pasteurization.

None of the herbicides tested were found to be satisfactory for post-emergent application. The herbicides achieving a degree of post-emergent weed control were excessively phytotoxic to the flowering plants.

All herbicide treatments resulted in a significant degree of crabgrass control. Bensulide, DCPA, DMPA and terbutol produced no visible damage to the flower species. Others were excessively phytotoxic to the host plants.

These results indicate the use of herbicides is feasible for garden flowers. The importance of thorough testing is apparent. Further research on herbicides for post-emergent and broadleaf weed control is needed. Screening studies should continue to determine adaptability of other herbicides for use in garden flowers.