*Proc. Fla. State Hort. Soc. 98:*107-110. 1985.

CHEMICAL WEED CONTROL IN CALADIUMS GROWN IN ORGANIC SOIL[1]

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Additional index words: herbicide, *Caladium* X *hortulanum*, phytotoxicity.

Abstract. **Twelve herbicides were evaluatd for weed control and phytotoxicity in field grown *Caladium* X *hortulanum* Birdsey cv. Candidum during 1982. Subsequent research indicated oryzalin (Surflan) (3,5-dinitro-N,N- dipropylsulfanilamide) provided good weed control without yield reduction for caladiums grown in mineral soil. In 1984, pre and postemergence applications of 3.0 and 6.0 lb./acre alachlor (Lasso) (2-chloro-2′,6′-diethyl-N-(methoxymethyl)acetanilide), 2.0 and 4.0 lb./acre simazine (Princep) (2-chloro-4,6-bis(ethylamino)-s-triazine), and 1.5 and 3.0 lb./acre oryzalin were evaluated for weed control and crop phytotoxicity in 'Pink Beauty' caladiums grown in organic soil on a commercial farm. Plant vigor was greater with 1.5 lb./acre oryzalin than where 6.0 lb./acre alachlor or both rates of simazine were applied. Only oryzalin (both rates) provided acceptable control of purslane. Late season control of pigweed was obtained with 6.0 lb./acre alachlor and both rates of oryzalin. Control of barnyard grass was good to excellent with all herbicides. Highest tuber yield was obtained with 1.5 lb./acre oryzalin, which was higher than the yield observed in plots treated with 4.0 lb./acre simazine, but was not significantly different from the yields obtained in plots treated with alachlor, 3.0 lb./acre oryzalin or 2.0 lb./acre simazine.**

Weed control is a constant problem during the 6- to 8-month production period for caladium tubers and is estimated to be the greatest single cost factor involved in their production (3). Growers rely on herbicides, principally alachlor, and hand weeding, since cultivation often injures the shallow root system.

Little research has been conducted on chemical weed control in field-grown caladiums. Scudder (3) determined that atrazine (Aatrex) (2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine), CDAA (Randox) (N-N-diallyl-2-chloroacetamide), CDEC (Vegedex) (2-chloroallyl diethyldithiocarbamate) and simazine provided satisfactory weed control without seriously reducing caladium tuber yields. CDEC an CDAA are no longer manufactured, while atrazine can be used only preemergence or in the spike leaf stage and at times results in crop injury. Weed control has been erratic with simazine and occasionally is injurious to caladiums. Alachlor has never been evaluated properly for weed contról in caladiums grown on muck, even though growers currently use it with mixed results. Recent research indicated multiple applications of alachlor, oxyfluorfen (Goal) (2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene), and simazine were injurious to caladiums grown in mineral soil; whereas, oryzalin provided excellent weed control without crop injury (1).

Two field experiments were conducted to evaluate herbicides for weed control and caladium phytotoxicity, including yield effects. The first was a general screening experiment on mineral soil at the Gulf Coast Research and Education Center in 1982. The second was conducted on muck (organic) soil on a commercial farm near Lake Placid in 1984 and was an evaluation of the best herbicides from the previous experiment on mineral soils.

Materials and Methods

Experiment 1. Twenty 'Candidum' caladium tuber chips (1-inch diameter) were planted 6 inches apart in 2 rows spaced 1 ft apart. Five ft out of each 9-ft plot were planted. The plots were situated on 6 inches tall, 30 inches wide raised beds at a 4.5-ft row spacing. The EauGallie fine sand soil with a pH of 6.2 and 0.7% organic matter content was fumigated with ethylene dibromide prior to planting. Caladium tuber chips were planted 20 May 1982. Herbicide treatments (Table 1) were applied twice to plots arranged in a randomized complete block design and replicated 4 times. In both experiments, herbicides were applied with a CO_2 back pack sprayer equipped with four 11004 flat fan nozzles operated at a pressure of 29 psi and a speed of 3 mph delivering 26.6 gal/acre. The initial application was made preemergence or preplant incorporated on 20 May, while the second was postemergence over the top on 1 Sept., with the exception of fluazifop-butyl (Fusilade) (butyl 2-[4-[(5-(trifluoromethyl)-2-pyridinyl)oxy]phenoxy] propanoate); sethoxydim (Poast) (2-[1-(-ethoxyiminol)butyl]-5-[2-ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one); acifluorfen (Blazer) (sodium 5-[2-chloro-4-(trifluoro-methyl)phenoxy]-2-nitrobenzoate); and bentazon (Basagran) (3-isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one2,2-dioxide), which initially were applied postemergence 9 June 1982. Applications of these postemergence herbicides included the appropriate recommended adjuvant and rate for each herbicide. Fluazifop-butyl was applied September 1 to all plots, except those treated with sethoxydim (another grass controlling herbicide), in an effort to control emerged grasses. Fertility consisted of an application of 112, 16, and 62 lb./acre of N, P, and K, respectively, from a slow release fertilizer (Osmocote), at planting and a sidedressing of 100, 44, and 83 lb./acre of N, P, and K on 24 Sept. Water was supplied by seepage irrigation. The hoed check was weeded weekly.

Caladium plant vigor was evaluated twice (1 July and 28 Sept. 1982) using a pretransformed 0 to 1 rating scale

[1]Florida Agricultural Experiment Station Journal Series No. 6851.
The Authors wish to thank the Richardson family and Bear Hollow Bulbs, Lake Placid, FL for providing the crop used in this research.

Table 1. Effect of herbicide treatments on plant vigor, plant survival, and tuber production by 'Candidum' caladium on a per plot basis. Bradenton, *FL. 1982.*

Treatment[z]	Rate (lb. a.i./ acre)	Method of initial applica-tion	Vigor rating[y]		Number of surviving plants	Tuber production						
						Weight (lb.)	Total no. dug	Average number per size grade				
			1 July	28 Sept.				3	2	1	Jumbo	Mammoth
Weedy check	—	—	6.8 bcd[x]	4.2 g	9 c	0.3 f	10 f	7 ab	3 e	0 c	0 c	0 b
Hoed check	—	—	8.4 ab	8.5 abc	19 a	1.6 b-e	21 a	5 b	7 a-d	8 ab	0 c	0 b
Simazine	3.0	pre[w]	8.4 ab	9.4 a	18 a	2.9 a	19 abc	2 b	5 b-e	9 ab	3 a	0 b
Diuron	1.0	pre	8.9 a	9.4 a	18 a	2.3 ab	20 ab	3 b	5 b-e	10 a	0 c	0 a
Oxyfluorfen	1.0	pre	9.0 a	8.8 a	18 a	2.2 abc	17 a-d	4 b	6 b-e	4 bc	2 ab	0 a
Alachlor	2.0	pre	8.8 a	8.6 ab	19 a	1.9 a-d	20 ab	5 b	6 b-e	8 ab	1 bc	0 b
Ethofumesate	1.5	pre	8.0 abc	6.9 de	15 ab	0.7 ef	15 b-f	6 ab	7 a-d	2 c	0 c	0 b
Napropamide	2.0	pre	7.9 abc	7.9 a-d	15 ab	0.8 ef	15 b-f	5 ab	7 abc	2 c	0 c	0 b
Fluazifop-butyl	0.25	post	5.0 e	6.8 de	15 ab	0.6 ef	13 c-f	10 a	5 b-e	1 c	0 c	0 b
Sethoxydim	0.25	post	6.2 de	5.0 fg	10 bc	0.5 ef	10 f	5 b	4 de	1 c	0 c	0 b
Metribuzin	0.25	ppi	8.5 a	9.1 a	19 a	1.5 b-e	19 ab	4 b	8 ab	7 ab	0 c	0 b
Oryzalin	1.0	pre	8.1 ab	7.1 b-e	15 ab	1.2 c-f	16 a-e	4 b	10 a	2 c	0 c	0 b
Acifluorfen	0.25	post	6.5 cde	7.0 cde	12 bc	0.9 def	13 def	4 b	7 a-d	2 c	0 c	0 b
Bentazon	0.75	post	8.1 ab	5.9 ef	12 bc	0.6 ef	11 ef	5 b	4 cde	2 c	0 c	0 b

[z]Initial applications were made as indicated with a subsequent application over the top of the crop on 1 Sept. 1982. Additionally, an application of 0.25 lb. a.i./acre fluazifop-butyl was made 1 Sept. to all herbicide treated plots, except those treated with sethoxydim.
[y]Vigor was evaluated using a pretransformed 0 to 10 rating scale were 0 indicated all plants were dead and 10 represented no injury, optimum growth.
[x]Mean separation within columns by Duncan's new multiple range test, 5% level.
[w]Pre = preemergence, post = postemergence, and ppi = preplant incorporated.

(2), where 0 indicates all plants were dead and 10 represents no phytotoxicity, optimum growth. Weed control was evaluated 3 times (1 July, and 28 Sept. 1982 and 14 Jan. 1983) using a similar pretransformed rating scale where 0 indicates no control and 10 represents complete control. Predominant grass weeds were crabgrass (*Digitaria ciliaris* (Retz.) Koel.) and goosegrass (*Eleusine indica* (L.) Gaertn.), whereas the major broadleaf weeds were pigweed (*Amaranthus viridis* L.), eclipta (*Eclipta alba* (L.) Hassk.), hedyotis (*Hedyotis corymbosa* L.) and dove weed (*Murdania nudiflora* (L.) Brenan). At harvest (14 Jan. 1983), the number of surviving plants were counted. Tubers then were dug, dried for 2 weeks, counted, weighed, and graded with the number per size grade recorded.

Experiment 2. Three applications of each herbicide treatment were applied to 12-ft long x 6-ft wide plots arranged in a randomized complete block design with 4 replications. Each plot contained 4 rows of 'Pink Beauty' caladiums spaced 1 ft apart with plants spaced an average of 6 inches apart within the row. Treatments were a chemical check (grower's standard best management practice) of 3 lb. a.i./acre alachlor, 6 lb. a.i./acre alachlor, 2 or 4 lb. a.i./acre simazine, or 1.5 or 3 lb. a.i./acre oryzalin. Adjacent to the test bed (4 rows) on 1 side was a 4-row bed treated with the grower's standard of 3 lb. a.i./acre alachlor, while on the other side was an untreated area which was used for evaluation of weed control efficacy. The soil was a nonfumigated muck (Histosol) typical of the production area, and irrigation was provided by volume gun as needed. Fertilization and application of pesticides other than herbicides consisted of the standard grower practices. All herbicide applications were made over the top of the crop. Treatments were applied 3 times at intervals corresponding to the grower's practices on 20 June, 16 Aug., and 14 Sept. 1984.

Initial crop vigor was evaluated using the previously described rating scale. Three subsequent vigor evaluations (relative vigor) were made by 3 people, including the grower, and constitute comparisons with the adjacent grower's standard row expressed as percentage of the alachlor standard. This procedure was used to compensate for natural variation in plant growth across the field and to provide a more realistic assessment of crop vigor. Weed control was evaluated 3 times as previously described. The major grass weed in the test area was barnyard grass (*Echinochloa crus-galli* (L.) Beauv.) and predominant broadleaf weeds were pigweed (*Amaranthus lividus* L.) and purslane (*Portulaca oleracea* L.). Tubers were dug and trimmed of adhering roots with a commercial harvester and weighed, ungraded on 27 Nov. 1984.

Results and Discussion

Experiment 1. Caladium plant vigor was acceptable (rating greater than 7.5) with 1 application of each herbicide treatment (1 July), except fluazifop-butyl, sethoxydim, and acifluorfen (Table 1). Low vigor ratings associated with fluazifop-butyl and sethoxydim were due to broadleaf weed competition and not phytotoxicity. Acifluorfen was phytotoxic and produced marginal burn on the foliage. Two applications of ethofumesate (Nortron) (2-ethoxy-2.3-dihydro-3,3-dimethyl-5-benzofuranyl methanesulfonate), oryzalin, acifluorfen, and bentazon reduced caladium plant vigor compared to simazine, diuron (Karmex) (3-(3,4-dichlorophenyl)-1,1-dimethylurea), oxyfluorfen, and metribuzin (Sencor) (4-amino-6-tert-butyl-3-(methylthio)-as-triazin-5(4H)-one when evaluated 28 Sept. Vigor was also reduced where plants were treated with fluazifop-butyl and sethoxydim; however, this again was felt to be due to broadleaf weed competition.

Early season grass control was reduced with metribuzin, oryzalin, acifluorfen, and bentazon compared to the hoed check and the other herbicides (Table 2). Fluazifop-butyl and sethoxydim did not control any broadleaf weeds and oryzalin and bentazon provided less control than the other herbicides or hoeing.

Midseason (28 Sept.) control of crabgrass, goosegrass, and eclipta was comparable to the hoed check with all her-

Table 2. Effect of herbicide treatments on weed control[z] in 'Candidum' caladiums. Bradenton, FL. 1982.

			1 July (1 application)		28 September (2 applications)[x]				14 January (2 applications)[x]	
Treatment[y]	Rate (lb. a.i./acre)	Method of initial application	Crabgrass and goosegrass	Broadleaf weeds	Crabgrass and goosegrass	Eclipta	Hedyotis	Dove weed	Crabgrass and goosegrass	Broadleaf weeds
Weedy check	—	—	0.0 d[w]	0.0 c	0.0 c	0.0 c	0.0 c	0.0 e	0.0 b	0.0 b
Hoed check	—	—	9.4 a	9.4 a	9.9 ab	10.0 a	10.0 a	10.0 a	10.0 a	10.0 a
Simazine	3.0	pre[v]	10.0 a	10.0 a	10.0 a	8.9 a	9.2 a	8.8 ab	0.0 b	0.0 b
Diuron	1.0	pre	9.6 a	10.0 a	9.7 ab	9.4 a	8.0 ab	1.5 de	0.0 b	0.0 b
Oxyfluorfen	1.0	pre	10.0 a	9.9 a	9.6 ab	9.6 a	9.4 a	1.8 de	0.0 b	0.0 b
Alachlor	2.0	pre	10.0 a	8.9 a	9.9 ab	9.1 a	9.2 a	8.8 ab	0.0 b	0.0 b
Ethofumesate	1.5	pre	9.4 a	8.9 a	10.0 a	8.6 a	1.8 c	3.6 cd	0.0 b	0.0 b
Napropamide	2.0	pre	9.9 a	10.0 a	9.9 ab	7.9 a	8.6 ab	3.5 cd	0.0 b	0.0 b
Fluazifop-butyl	0.25	post	9.5 a	0.0 c	10.0 a	1.5 c	0.0 c	0.0 e	0.0 b	0.0 b
Sethoxydim	0.25	post	9.8 a	0.0 c	10.0 a	3.5 b	0.0 c	0.0 e	0.0 b	0.0 b
Metribuzin	0.25	ppi	6.9 c	9.2 a	9.9 ab	9.2 a	6.0 b	3.2 cde	0.0 b	0.0 b
Oryzalin	1.0	pre	7.8 b	6.8 b	10.0 a	9.4 a	9.2 a	5.0 cd	0.0 b	0.0 b
Acifluorfen	0.25	post	0.0 d	9.9 a	9.8 ab	8.0 a	0.2 c	5.8 bc	0.0 b	0.0 b
Bentazon	0.75	post	0.0 d	7.2 b	9.2 b	9.8 a	3.0 c	8.9 ab	0.0 b	0.0 b

[z]Weed control was evaluated using a pretransformed 0 to 10 rating scale where 0 indicated no control and 10 represented complete control.
[y]Initial applications were made as indicated with a subsequent application over the top of the crop on 1 Sept. 1982. Additionally, an application of 0.25 lb. a.i./acre fluazifop-butyl was made 1 Sept. to all herbicide treated plots, except those treated with sethoxydim.
[x]Indicates 2 applications of indicated hericides plus one application of fluazifop-butyl as noted above.
[w]Mean separation within columns by Duncan's new multiple range test, 5% level.
[v]Pre = preemergence, post = postemergence, and ppi = preplant incorporated.

Table 3. Effect of multiple applications of herbicide treatments on vigor[z] and tuber yield of 'Pink Beauty' caladium plants grown in muck soil on a commercial farm. Lake Placid, FL. 1984.

		1 application				
Treatment	Rate (lb. a.i./acre)	29 June	26 July	2 applications 12 Sept.	3 applications 10 Oct.	Weight/plot (lb.)
Alachlor	3.0	8.0 ab[y]	115 a	127 a	110 ab	8.9 ab
Alachlor	6.0	6.8 b	95 a	120 a	102 b	8.3 ab
Simazine	2.0	7.6 ab	98 a	100 a	102 b	8.8 ab
Simazine	4.0	7.9 ab	110 a	108 a	105 b	7.0 b
Oryzalin	1.5	8.7 a	110 a	127 a	135 a	12.4 a
Oryzalin	3.0	8.6 a	112 a	118 a	120 ab	10.6 ab

[z]Vigor was evaluated 29 June 1984 using a pretransformed 0 to 10 rating scale where 0 indicates all plants were dead and 10 represents no phytotoxicity. Subsequent evaluations were made by comparison with plants in an adjacent bed which was treated with the grower's standard, 3.0 lb. a.i./acre alachlor. Vigor is expressed as a % of this standard.
[y]Mean separation in columns by Duncan's multiple range test, 5% level.

bicide treatments (Table 2). Control of hedyotis was acceptable (rating greater than 7.5) with simazine, diuron, oxyfluorfen, alachlor, napropamide (Devrinol), and oryzalin; whereas, only simazine, alachlor, and bentazon controlled dove weed. By harvest, none of the herbicides controlled any of the grass or broadleaf weeds, indicating the need for more than 2 applications during the production season (Table 2).

When the tubers were dug, there were fewer plants in plots treated with sethoxydim, acifluorfen, or bentazon (Table 1). Tuber production (weight and total number) was greatest with simazine, diuron, oxyfluorfen, alachlor, metribuzin, and oryzalin. Most of the tubers produced in plots treated with oxyfluorfen, ethofumesate, napropamide, fluazifop-butyl, sethoxydim, metribuzin, oryzalin, acifluorfen, or bentazon were in the smaller size grades (numbers 3 and 2); whereas, application of simazine resulted in predominately number 1 and number 2 tubers. Diuron and alachlor were intermediate in size production with an approximate equal mix in the 2 size ranges.

Experiment 2. Early season (29 June) vigor was greater with both rates of oryzalin than with 6.0 lb. a.i./acre alachlor. However, 1 month later (26 July) there was no difference among the treatments when compared to the grower's standard of 3.0 lb. a.i./acre (Table 3). Two applications of each herbicide had no effect on relative vigor. After 3 applications, plants treated with 1.5 lb. a.i./acre oryzalin were more vigorous than those treated with 6.0 lb. a.i/acre alachlor or both rates of simazine.

All of the herbicide treatments provided acceptable season long control of barnyard grass with no differences among them (Table 4). Although one application of both rates of oryzalin, 6.0 lb. a.i./acre alachlor and 4.0 lb. a.i./acre simazine controlled purslane better than the low rate of alachlor or simazine with no significant differences among them, only the high rate of oryzalin and alachlor provided acceptable control. Two applications of oryzalin (both rates) provided better purslane control than any of the other treatments with only the high rate providing acceptable control. By harvest (after 3 applications) purslane control was acceptable with both rates of oryzalin and superior to the other treatments.

Pigweed control was poor and unacceptable with all herbicides until 3 applications had been made; however,

Table 4. Effect of multiple applications of herbicide treatments on weed control[z] in 'Pink Beauty' caladiums grown in muck soil on a commercial farm. Lake Placid, FL. 1984.

		Barnyard grass			Purslane			Pigweed		
		Applications			Applications			Applications		
Treatment	Rate (lb. a.i./acre)	1	2	3	1	2	3	1	2	3
Alachlor	3.0	9.2 a[y]	9.2 a	9.1 a	3.4 b	2.0 c	0.0 c	5.2 ab	5.2 ab	6.8 b
Alachlor	6.0	10.0 a	10.0 a	10.0 a	7.9 a	6.3 b	4.1 b	7.4 a	7.4 a	8.1 a
Simazine	2.0	9.8 a	9.8 a	8.9 a	2.0 b	3.3 c	3.3 bc	2.8 c	2.8 c	3.0 c
Simazine	4.0	8.8 a	8.8 a	9.1 a	4.5 a	4.9 bc	4.6 b	3.8 bc	3.8 bc	3.9 c
Oryzalin	1.5	9.8 a	9.8 a	9.9 a	7.2 a	7.4 a	8.2 a	6.2 a	6.2 a	7.1 ab
Oryzalin	3.0	10.0 a	10.0 a	10.0 a	8.4 a	8.6 a	9.0 a	7.2 a	7.2 a	8.3 a

[z]Weed control was evaluated using a pretransformed 0 to 10 scale where 0 indicates no control and 10 represents complete control.
[y]Mean separation within columns by Duncan's multiple range test, 5% level.

after 1 and 2 applications, both rates of oryzalin and the high rate of alachlor were better than the other treatments (Table 4). Pigweed control was acceptable with 3 applications of 6.0 lb. a.i./acre alachlor and 3.0 lb. a.i./acre oryzalin, and was better than that obtained with either rate of simazine or the low rate of alachlor.

When tubers were harvested, highest yields (weight) were obtained with 1.5 lb. a.i./acre oryzalin, which was higher than the weight of tubers dug from plots treated with 4.0 lb. a.i./acre simazine, but not different from the other treatments (Table 3).

In these experiments and others (1), oryzalin consistently provided acceptable weed control with little or no caladium injury at rates which ranged from 1.5 lb. a.i./acre on mineral soils to 1.5 to 3.0 lb. a.i./acre oryzalin on muck soils.

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*Proc. Fla. State Hort. Soc. 98:*110-114. 1985.

TRICKLE IRRIGATION RATES FOR CHRYSANTHEMUM CUT FLOWER PRODUCTION

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Additional index words. Chrysanthemum x *morifolium,* drip irrigation.

Abstract. **The influence of trickle irrigation rates on *Chrysanthemum* x *morifolium* Ramat. cut flower yield and quality was evaluated over four seasons. The minimum amount of water to produce the greatest number of marketable stems of high quality was estimated to be from 0.96 to 1.1 cm/day. Culture or cultivars did not interact significantly with irrigation rate indicating a grower could irrigate with a single rate even though several cultivars with pinched or single stem culture were being grown simultaneously. However, seasonal water use would vary due to differences in the length of the cropping time dictated by the production method and cultivar flowering response time. A regression analysis utilizing data from 4 seasons was used to develop a prediction equation to estimate the loss of yield resulting from use of irrigation rates less than optimal.**

Florida Agricultural Experiment Stations Journal Series No. 6819. The authors express their appreciation to Yoder Brothers, Inc. for supplying the rooted chrysanthemum cuttings used in these experiments. This project was supported in part by a grant from the Southwest Florida Water Management District.

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The necessity to conserve water in Florida has resulted in increased interest and use of trickle irrigation systems. While trickle irrigation systems are known to conserve water compared to traditional furrow or overhead irrigation systems due to the efficiency of the delivery system (5, 8), information is scarce on the relationships of specific irrigation rates to the yield and quality of ornamental plants. Ponder and Kenworthy (15) reported that the diameter of *Fraximus americana* cv. Autumn Purple doubled with irrigation flow rates of 1.4 and 2.8 liters/hr compared with nursery grown liners with no supplemental irrigation, but no differences were observed between irrigation rates. Ponder et al. (16) also reported that increasing irrigation rates of 0, 25, 50, or 100% replacement of net evaporation from a Class A evaporation pan resulted in increased growth of field grown *Gardenia jasminoides* and *Ilex crenata,* but plants were similar when 25%-100% replacement rates were used. Koch and Holcomb (11) found that water use could be reduced by 30% with recycling in addition to that achieved with trickle irrigation for produc-