

Use of Herbicides as Harvesting Aids for Field-grown Caladiums

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Abstract. One pot study and 2 field experiments were conducted to evaluate the use of ethephon, acifluorfen, endothall, dinoseb, glyphosate, oxyfluorfen, and paraquat as harvesting aids (removal of root and shoot tissue) in caladium (*Caladium* × *hortulanum* Birdsey) tuber production. Of these 7 compounds, paraquat and oxyfluorfen showed the most potential with 2 applications at 15-day intervals reducing 'Canadium' and 'Freida Hemple' caladium root weight as much as 51% and shoot weight up to 90%. No residual effects were observed for these herbicide treatments when tubers were subsequently forced in a greenhouse. Chemical names used: (2-chloroethyl)phosphonic acid (ethephon); [2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoate (acifluorfen) (7-oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid (endothall); 2-(1-methylpropyl)-4,6-cinitrophenol (dinoseb); N-(phosphonomethyl)glycine (glyphosate); 2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene (oxyfluorfen); (1,1-dimethyl-4,4'-bipyridinium ion (paraquat).

Caladium tubers must undergo a dormant period before they initiate new growth and can be used for production of pot plants (2). For early spring forcing, growers need to harvest as early in the fall as possible after tubers have reached the desired size. In years when caladiums have not received enough cold to promote loss of root and shoot tissue, which clog harvesting machines, growers often remove the shoot tissue with a tractor-driven rotary mower. When fields are too wet to support this equipment, a caladium grower must wait for drier conditions. Often field conditions are such that lightweight pesticide sprayers could enter the field long before a heavy tractor-mower. If one were available, growers would readily accept a chemical spray-based alternative to remove or reduce shoot and root tissue.

Herbicides have been used in other crops as defoliant or harvesting aids with some success (4, 5); however, their use in caladiums has been researched very little and always from the standpoint of weed control (1, 3). This paper reports research conducted to determine if herbicides or other growth regulators could be used as harvest aids in field grown caladiums.

Two-cm² 'Candidum' tuber "chips" were planted 14 July 1983 in 10-cm pots containing artificial media composed of 2 peat : 1 sand : 1 vermiculite (by volume) with 4.5 kg dolomite, 2.3 kg hydrated lime, and 2.7 kg of slow-release fertilizer (14%N-6.1%P-11.6%K) added to each 76 liters of media. Pots were placed in full sun and were hand watered one or more times per day, as needed.

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Uniform plants were selected and treatments were assigned to single-pot experimental units arranged in a randomized complete block design, replicated 8 times.

Treatments (Table 1) were applied 15 Sept. 1983 with a CO₂ back pack sprayer equipped with a 2-nozzle boom fitted with 11,004 flat fan nozzles and operated at 1.5 kg/cm² and 4.8 km/hr, delivering 249 liter/ha of spray material. Tubers were dug 5 Oct. and the percentage of dead roots was estimated. Data were transformed by the arcsin transformation and analyzed by analysis of variance with means ranked by Duncan's new multiple range test at the 5% level of significance.

All chemicals increased the percentage of dead roots (Table 1). Glyphosate killed the tubers and was deleted from subsequent tests. Foliar applications of paraquat and oxyfluorfen killed a greater percentage of roots than application of ethephon, endothall, and dinoseb. An arbitrary value of 50% or more dead roots was used to select the 4 most promising treatments for further evaluation: oxyfluorfen, paraquat, acifluorfen, and ethephon.

In a 2nd experiment, tuber chips (2 cm diameter) of 'Candidum' and 'Freida Hemple' caladiums were planted 19 May 1983 12 cm apart in 2 rows spaced 30 cm apart on 76-cm wide, 18-cm high raised beds covered with white polyethylene film mulch. The Eau Gallie fine sand soil (pH 6.4, 1% organic matter) had been fumigated with 392 kg/ha of a mixture (67%) and 33% by volume, respectively) of methyl bromide and chloropicrin 3 weeks prior to planting, at which time controlled release fertilizer (8 to 9 month formulation of 18%N-2.6%P-10%K) was applied to provide 336 kg/ha N. Supplemental water was supplied continuously by seepage irrigation. Treatments applied 4 and 10 Oct. included an untreated

Table 1. Effect of chemical treatment on roots of 'Candidum' caladium grown in pots. Bradenton, Fla., 5 Oct. 1983.

Treatment	Rate (kg/ha)	Dead roots (%)
Untreated check	---	0 e ^z
Ethephon ^y	2.24	57 cd
Acifluorfen ^x	0.56	70 bc
Paraquat ^y	1.12	78 b
Oxyfluorfen ^y	1.12	84 ab
Endothall ^y	0.84	39 d
Dinoseb ^x	1.68	42 d
Glyphosate	0.84	96 a

^zMean separation within columns by Duncan's multiple range test, 5% level.

^ySpray preparation included 1% (v/v) crop oil concentrate.

^xSpray preparation included 0.25% (v/v) nonionic surfactant.

check, 2.24 kg/ha ethephon, 1.12 kg/ha paraquat, 0.56 kg/ha acifluorfen, and 1.12 kg/ha oxyfluorfen. Applications of ethephon, paraquat, and oxyfluorfen included 1% (v/v) crop oil concentrate, whereas 0.25% (v/v) of nonionic surfactant was included with applications of acifluorfen. Twelve plant plots were arranged in a randomized complete block design with 4 replications. Tubers were dug and weights of roots and shoots adhering to the tubers were recorded 15 Nov. 1983.

'Candidum' shoot weights were less where plants were treated with paraquat, acifluorfen or oxyfluorfen, whereas paraquat and oxyfluorfen decreased root weights to 50% of that of the check treatment (Table 2). All chemical treatments reduced shoot weights of 'Freida Hemple' caladiums (Table 2). Oxyfluorfen was the only treatment to reduce significantly root weight of 'Freida Hemple'. Overall, paraquat and oxyfluorfen caused the loss of the most tissue and, as a result, were chosen for continued evaluation.

In a 3rd experiment, 'Candidum' and 'Freida Hemple' tuber chips were planted 8 May 1984 as described in Expt. 2. Treatments included a nonmowed check, a mowed

Table 2. Effect of chemical treatment on weight of root and shoot tissue of 'Candidum' and 'Freida Hemple' caladiums. Bradenton, Fla., 15 Nov. 1983.

Treatment	Rate (kg/ha)	Wt (g)/plot	
		Roots	Shoots
<i>Candidum</i>			
Untreated check	---	454 a ^z	2938 a
Ethephon ^y	2.24	367 ab	2281 a
Paraquat ^y	1.12	229 b	724 b
Acifluorfen ^x	0.56	336 ab	589 b
Oxyfluorfen ^y	1.12	226 b	347 b
<i>Freida Hemple</i>			
Untreated check	---	334 a	1931 a
Ethephon ^y	2.24	213 ab	909 b
Paraquat ^y	1.12	152 ab	139 c
Acifluorfen ^x	0.56	199 ab	253 bc
Oxyfluorfen ^y	1.12	98 b	93 c

^zMean separation within columns within cultivar by Duncan's multiple range test, 5% level.

^yApplied twice with 1% (v/v) crop oil concentrate.

^xApplied twice with 0.25% (v/v) nonionic surfactant.

Table 3. Effect of chemical and cultural treatments on reduction of root and shoot tissue for use as a harvesting aid in 'Candidum' and 'Freida Hemple' caladium tuber production. Bradenton, Fla., 13-14 Nov. 1984.

Treatment	Rate (kg/ha)	No. dug/plot		Tuber weight (g/plot)	Weight (g)/plant	
		Plants	Tubers		Roots	Shoots
<i>Candidum</i>						
Nonmowed check	---	14 a ^w	15 a	2304 a	34 a	140 a
Mowed check ^z	---	12 a	14 a	1650 b	26 ab	44 b
FHA-check ^y	---	12 a	15 a	1778 ab	33 a	140 a
Oxyfluorfen ^x	1.12	13 a	14 a	2159 ab	27 ab	44 b
Paraquat ^t	1.12	12 a	14 a	1924 ab	18 b	53 b
<i>Freida Hemple</i>						
Nonmowed check	---	14 a	18 a	1497 a	17 ab	75 a
Mowed check ^z	---	13 a	16 a	1349 a	13 bc	18 b
FHA-check ^y	---	14 a	16 a	1293 a	21 a	78 a
Oxyfluorfen ^x	1.12	13 a	15 a	1076 a	10 c	8 b
Paraquat ^t	1.12	14 a	18 a	1237 a	10 c	14 b

^wMowed twice: 17 Oct. and 1 Nov. 1984.

^zDug 17 Oct. 1984 at the time of first herbicide application.

^yApplied 17 Oct. and 1 Nov. 1984 in combination with 1% (v/v) crop oil concentrate.

^tMean separation within columns by Duncan's multiple range test, 5% level.

check, a check where the tubers were dug at the time of the first herbicide application (FHA-check), and foliar applications of 1.12 kg/ha of either oxyfluorfen or paraquat. Treatments were assigned to 14 plant plots (per cultivar) arranged in a randomized complete block design with 4 replications. Herbicide treatments were applied to caladium foliage 17 Oct. and 1 Nov. 1984, as described in Expt. 1. Tubers in the FHA-check were dug 17 Oct., whereas foliage of plants in the mowed check was hand pruned 5 cm above the soil at each application date. Tubers were dug, counted, and weighed 13 and 14 Nov. 1984. Adhering roots and shoots were trimmed from the tubers, weighed separately, and their weights expressed on a per plant basis to compensate for missing plants in some plots.

None of the treatments significantly affected the number of plants or tubers dug of either cultivar in 1984 (Table 3). Weight of 'Candidum' tubers was decreased by remov-

ing the shoot growth (mowed check), presumably due to loss of storage materials as plants initiated new growth after clipping. 'Freida Hemple' plants did not initiate new growth after clipping, and there were no differences among treatments for tuber weight. Two applications of paraquat reduced 'Candidum' root weight 47% compared to the nonmowed check but did not reduce weight any more than mowing or application of oxyfluorfen. Shoot weight was reduced equally by mowing and application of paraquat and oxyfluorfen, with over 60% of the foliage lost. Mowing 'Freida Hemple' plants did not have a significant effect on root weight. Applications of paraquat and oxyfluorfen to 'Freida Hemple' reduced adherent root weights 41%, but did not provide results different from those obtained with mowing. Paraquat, oxyfluorfen, and mowing removed undesired foliage with equal effectiveness (greater than 76% reduction).

Tubers from the 3rd experiment were stored

Table 4. Residual effects of chemical and cultural treatments on growth of dormant caladium tubers when subsequently forced in a greenhouse. Bradenton, Fla., 1985.

Treatment	Rate (kg/ha)	No./days to sprout	No. of leaves	Shoot fresh wt (g)
<i>Candidum</i>				
Nonmowed check	---	41 a	9 b	30 b
Mowed check ^z	---	43 a	6 b	22 b
FHA-check ^y	---	36 a	14 a	57 a
Oxyfluorfen ^x	1.12	45 a	6 b	23 b
Paraquat ^t	1.12	42 a	8 b	30 b
<i>Freida Hemple</i>				
Nonmowed check	---	41 a	12 a	27 a
Mowed check ^z	---	40 a	16 a	29 a
FHA-check ^y	---	34 b	16 a	30 a
Oxyfluorfen ^x	1.12	43 a	12 a	24 a
Paraquat ^t	1.12	41 a	13 a	25 a

^wMowed twice: 17 Oct. and 1 Nov. 1984.

^zDug 17 Oct. 1984 at the time of first herbicide application.

^yApplied 17 Oct. and 1 Nov. 1984 in combination with 1% (v/v) crop oil concentrate.

^tMean separation within columns by Duncan's multiple range test, 5% level.

at a temperature of 16°C for 9 weeks beginning immediately after harvest to overcome dormancy. Tubers were placed in 10-cm pots in the same medium as used in Expt. 1 and forced in a fan-pad cooled glass greenhouse with minimum night temperatures of 16° and maximum day temperatures of 32° to determine if the herbicide treatments had adverse residual effects on tubers. Pots were observed daily, and the number of days required for the first leaf to sprout and fully expand was recorded. After 56 days, the number of shoots per tuber and shoot fresh weight were recorded and data were analyzed.

Results of the greenhouse tuber forcing study indicated there were no residual effects from the herbicide treatments (Table 4). The number of days required for sprout initiation was not affected with 'Candidum' tubers, whereas tubers of 'Freida Hemple', which were dug early (FHA-check), sprouted faster than those from any of the other treatments, presumably because their dormancy requirement had been satisfied for a long period of time as a result of the early harvest date (2). 'Candidum' tubers from the FHA-check produced more leaves and a greater foliage weight than tubers obtained from the other treatments, again presumably related to satisfying the dormancy requirement. No differences were observed for the number of leaves or shoot weight produced by 'Freida Hemple' tubers for any treatments.

Although mowing reduces the weight of roots and shoots attached to 'Candidum' and 'Freida Hemple' caladium tubers, it requires movement of heavy equipment into fields that may be too wet for support. Foliar applications of paraquat and oxyfluorfen to caladium plants can be achieved with light-weight application equipment and will remove as much root and shoot tissue from tubers as will mowing without adverse residual effects on caladiums produced from treated tubers. In addition, the propensity for regrowth is not as great with paraquat or oxyfluorfen as it is with mowing; therefore, tuber weights (yield) would be less likely to be decreased due to subsequent regrowth.

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