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WEED CONTROL IN CELERY WITH CDAA AND CDEC

J. R. ORSENIGO[1]

Weed control has been a major expense in celery production on Florida's organic soils. The long crop duration and growing season, embracing a wide climatic range, influence the diversity and severity of the weed problem. Weeds affect crop yield and quality and may increase harvesting costs. Also, weeds may serve as hosts for diseases and insects and complicate control programs by interfering with proper pesticide applications.

Mechanical tillage of level, friable organic soils is effective and economical in the row middles but difficult within the plant row. Row weeding has required some mechanical equipment, hand "scratching," hand weeding and mineral spirits. These transitory measures may be expensive and are partially and temporarily effective. New weed seedlings may emerge unrestricted after each mechanical operation. Preemergence herbicides, which provide initial and residual control of weed seed and small seedlings, minimize annual weed problems when applied after celery transplanting.

Chemical weed control investigations in celery at the Everglades Experiment Station date from 1954. Initial trials conducted and reported by Guzman (1, 2, 3) demonstrated the potential advantages obtainable with pre-emergence herbicides. CDAA[2] and CDEC[3] were better and more reliable herbicides than CIPC[4] in most pretransplanting applications. Herbicidal treatment tended to decrease yield of larger plant sizes (with a corresponding increase in small sizes) as compared with conventional controls. In subsequent trials, yield differences were slight and nonsignificant among pre- and post-transplanting herbicidal treatments. Guzman preferred herbicide application between celery transplanting and the customary overhead irrigation to "water-in" the seedlings. The best weed control was afforded by CDAA, CDEC and (CDEC + CIPC); treated celery did not differ from controls in yield or quality. The pro and con of several timing methods are presented later in the discussion.

The evaluation[5] of experimental herbicidal chemicals is a continuing process. More than 40 individual chemicals were assessed specifically for their utility in celery weed control programs, and over 100 other chemicals were evaluated with carrot and parsley as *Umbelliferous* test crops in periodic "primary" (initial) evaluations (4,5). The most promising chemicals were evaluated in "secondary" trials which narrowed the selection process further on the basis of crop and weed response. Superior chemicals were then evaluated in "tertiary" trials for their most desirable management in commercial celery production.

CDAA and CDEC, efficient herbicides in early trials, were selected for comparison with other promising chemicals in "secondary" evaluations and, finally, in advanced "tertiary" trials. The performance of CDAA and CDEC in the latter evaluations is reported here.

MATERIALS AND METHODS

Rate and time of application: All application rates are in terms of active ingredient per sprayed acre. Herbicides were applied in 20 to 40 gpa water carrier. With the exception of one trial, herbicides were applied before weed seedling emergence and as soon after the transplanting irrigation as practical.

Application equipment: Single- and multi- row secondary evaluation plots were applied with a compressed air experimental hand-carried plot sprayer. Larger, multi-row tertiary evaluation plots were made as simulated commercial applications with an experimental tractor herbicide sprayer. Sprays were applied as semi-directed applications which did not avoid wetting all celery foliage. Granular formulations were applied broadcast with a Noble "Chemi-caster."

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[1]Associate Horticulturist, University of Florida, Everglades Experiment Station, Belle Glade, Florida.

[2]CDAA, 2-chloro-N,N-diallyacetamide, "Randox"

[3]CDEC, 2-chloroallyl diethyldithiocarbamate, "Vegadex"

[4]CIPC, isopropyl N-(3-chlorophenyl) carbamate, "Chloro IPC"

[5]Orsenigo, J. R. 1958 et seq. University of Florida, Everglades Station Mimeo Reports: 59-5, 59-6, 59-12, 60-7, 62-1, 63-1.

Soil type and location: All trials were conducted on Everglades or Okeelanta peaty muck at the Everglades Experiment Station or with cooperating growers.

Experimental design: Randomized complete block designs were installed in all trials. Data were analyzed by analysis of variance procedures, and single degree of freedom comparisons were made when appropriate.

Response data: Celery plant tolerance and weed control were evaluated visually on a numerical scale which was converted to percentage values for this report.

Harvest data: These data included number and length of petioles, and number, weight and size distribution of fresh-trimmed, marketable plants ("stalks"). Marketable plants conformed to "U.S. Extra No. 1" grade standards. Number of petioles and length of the two outermost petioles per plant were obtained from 15 plants taken at random within the harvest sample. Plants harvested from each plot were separated into size classes of 2 to 8 dozen stalks per Howard crate and "calculated crates per acre" yields were determined on this basis.

Quality evaluation: The exterior quality was evaluated by plant measurements and yield data. No objective examination was made of interior quality. Plants were observed for appearance and were tasted for off-flavor by the author at each harvest.

Residue sampling: Samples for residue analysis were submitted to cooperating chemicals companies as required for their development and registration programs.

Experimental Results

Comparison of herbicides and irrigation timing: Emerald celery was transplanted in the spring in single-row plots 25 feet long with four replications for each irrigation timing. Herbicides applied before the post-transplanting irrigation were slightly more effective than the same chemicals applied after the irrigation. Irrigation timing did not affect celery tolerance to the herbicides; CDEC was among the chemicals to which celery was most tolerant. CDAA was the most effective grass herbicide under both irrigation conditions, but herbicides other than CDAA or CDEC were most effective against broadleaf weeds.

Evaluation of herbicide and application rate: Three-row plots 30 feet long were installed in three replications after transplanting and irrigating Utah 52-70H celery in the fall crop. Harvest samples comprised 81 feet of row per plot. CDAA and CDEC did not differ significantly from EPTC,[6] propazine[7] or the control in weed control, celery tolerance, number of petioles per plant or yield as measured by number or weight of marketable plants per plot or calculated crates per acre (Table 1). An average reduction in petiole length (1.5 cm or about ⅝ inch) between all

[6]EPTC, ethyl N,N-di-n-propylthiolcarbamate, "Eptam 6E"

[7]propazine, 2-chloro-4,6-bis(isopropylamino)-s-triazine

Table 1. Average response of 52-70 H celery to herbicides applied after setting for pre-emergence weed control.

Herbicide treatment	Number petioles	Length petioles	Plants per plot	Weight per plot	Calculated crates/A.
Handweeded control	9.7	27.2 cm	135	181 lb	922
CDEC, 4 lb/A.	9.0	24.5	132	181	885
6 lb/A.	10.0	26.0	127	179	899
CDAA, 4 lb/A.	10.0	26.3	135	193	981
EPTC, 4 lb/A.	9.3	25.7	134	177	954
6 lb/A.	10.0	25.7	132	194	965
Propazine, 4 lb/A.	9.2	26.0	129	175	896
6 lb/A.	9.7	25.8	126	189	897

Table 2A. Average response of 52-70H celery to CDAA, CDEC and CDAA + CDEC applied after transplanting for pre-emergence weed control.

Herbicide treatment	Number petioles	Length petioles	Plants per plot	Weight per plot
Handweeded control	9.7	27.7 cm	122	178 lb
CDAA, 4 lb/A.	9.6	29.0	122	174
5 lb/A.	9.7	27.4	122	172
6 lb/A.	9.4	28.4	122	167
CDEC, 4 lb/A.	10.1	28.4	119	170
5 lb/A.	9.7	29.5	122	178
6 lb/A.	9.5	30.0	126	179
CDAA, 2 + CDEC, 2 lb/A.	9.1	29.5	121	167
CDAA, 3 + CDEC, 3 lb/A.	10.1	27.7	124	178
CDAA, 2 + CDEC, 3 lb/A.	9.5	29.7	120	174
CDAA, 3 + CDEC, 2 lb/A.	9.4	29.7	125	172

Table 2B. Distribution of marketable plants into size classes and relative crates per acre yield following pre-emergence herbicide treatment.

Herbicide treatment	Distribution of marketable plants[1/]						Calculated crates/A
	2 dz	2-1/2 dz	3 dz	4 dz	6 dz	8 dz	
Handweeded control	4%	18%	31%	33%	10%	4%	733
CDAA, 4 lb/A.	1	17	39	28	11	4	738
5 lb/A.	2	13	40	31	11	3	714
6 lb/A.	0	16	35	30	12	7	693
CDEC, 4 lb/A.	3	19	32	31	10	5	710
5 lb/A.	0	11	40	36	10	3	711
6 lb/A.	5	21	33	27	10	4	777
CDAA, 2+CDEC, 2 lb/A.	0	11	40	30	14	5	695
CDAA, 3 + CDEC, 3 lb/A.	0	17	40	29	10	4	750
CDAA, 2 + CDEC, 3 lb/A.	1	18	39	26	10	6	745
CDAA, 3 + CDEC, 2 lb/A.	1	11	38	34	13	3	730

1/ Based on commercial pack sizes reported to nearest whole percent.

treatments and the control was highly significant; the treatments, however, did not differ significantly among themselves. Herbicide application rate did not significantly affect herbicide performance or crop response.

Evaluation of application rate of CDAA, CDEC and their combination: Four replications of five-row plots 90 feet long were applied in a fall crop of Utah 52-70H celery one day after transplanting. Harvest samples contained 81 feet of row. CDAA and CDEC combination treatment ratios of 3.2, 1:1, and 2:3 (totalling 5 lb/A) were more effective in weed control, especially of annual grasses, than 5 lb/A of either herbicide applied alone. There was no significant response to increasing application rates. Compared to the control, the chemical treatments did not significantly influence number or length of petioles per plant nor number or weight of marketable plants per plot (Table 2A). Yield in calculated crates per acre did not differ significantly among the treatments, but size distribution of the marketable plants was variable (Table 2B).

Comparison of single and repeat applications of CDAA and CDEC: This experiment was installed in a spring crop of Utah 52-70 celery. There were five replications of five-row plots 70 feet long; sub-plots for repeat sprays were five rows 35 feet long. Harvest samples comprised 40 feet of row per sub-plot. Initial applications were made following the transplanting irrigation; repeat applications were made either three or four weeks later. Some treatments received only the initial application; others were cultivated for three or four weeks and then sprayed with herbicides; and some treatments received both the initial spray plus a repeat application three or four weeks later.

Repeat applications were highly significantly more effective than single applications after transplanting in control of annual weeds. Single applications following three or four weeks' cultivation were as effective as repeat applications. Repeat applications at three weeks provided significantly better weed control than at four weeks after initial treatment. CDAA was superior to CDEC in control of all weeks (Table 3A).

The timing interval between initial and repeat treatment did not significantly influence plant response; petiole length was reduced slightly but not significantly (0.35 cm or 0.14 inch) at the three-week as compared with the four-week interval. Neither chemical treatment or timing interval significantly affected petiole number, outer petiole length or yield as measured by number or weight of marketable plants per plot. Size distribution of marketable plants was not uniform among the treatments, but calculated crates per acre yield did not differ significantly. CDAA treatments tended to yield slightly less than CDEC. Since three-week and four-week data did not differ significantly, their values are combined in Table 3B.

The first comparison of granular and spray applied CDAA, CDEC and (CDAA + CDEC): Liquid sprays and dry granules of CDAA, CDEC and (CDAA + CDEC) were applied two days after fall transplanting of Utah 52-70 celery. There were four replications of five-row plots 90 feet long; 50 feet of row were harvested per plot. No additional weed control treatment was applied during the crop. There were no observable differences in crop response or herbicidal efficacy. Annual grass and broadleaf weed control ranged from 95 to 99 percent. Yield under chemical herbicides was superior to the control. Size distribution of marketable plants was variable; spray treatments yielded significantly more crates per acre than granular treatments. Differences between CDAA, CDEC and (CDAA + CDEC) were not significant (Table 4A).

A second comparison of granular and spray applied CDAA, CDEC and (CDAA + CDEC): This experiment compared liquid sprays and dry granules of CDAA, CDEC and (CDAA + CDEC) when applied as a second or repeat application two weeks after a broadcast post-transplanting spray application of CDAA + CDEC (3 + 2 lb/A). The treatments were applied to fall-crop Utah 52-70 celery in four replications with five-row plots 90 feet long; the harvest sample was 50 feet of row per plot. The repeat application had no visible effect on crop growth and effectively controlled (95-99 percent) all annual weeds except *Sesbania* sp. (*probably macrocarpa*), which volunteered from a preceding cover crop. Marketable plant distribution into pack sizes was not uniform among the treatments, and differences in calculated crates per acre yield were not significant (Table 4B).

Discussion

CDAA and CDEC have been consistently effective post-transplanting herbicides in control of annual grass and broadleaf weeds in celery on organic soil. The superiority of these depends on celery tolerance and two conditions usually prevalent when celery is transplanted: absence of emerged weeds and high soil moisture. These

Table 3A. Average general weed control from single and repeat application of CDAA and CDEC.

Herbicidal treatment [2]		Percent weed control [1]		
		Interval [3]		
Original	Repeat	3-weeks	4-weeks	Overall
Handweed	Handweed	70	66	68
CDAA	None	--	--	66
Handweed	CDAA	100	88	94
CDAA	CDAA	100	88	94
CDEC	None	--	--	48
Handweed	CDEC	94	80	87
CDEC	CDEC	80	70	75
CDAA	CDEC	94	88	91
CDEC	CDAA	100	88	94

1/ Values are reported to the nearest whole percent.

2/ CDAA and CDEC were applied at 5 lb/A.

3/ Interval between original and repeat treatments.

Table 3B. Celery response to repeat applications of CDAA and CDEC. Values are averages of three- and four-week intervals between original and repeat application in 52-70 celery.

Herbicidal treatment [1]		Number	Length	Distribution of marketable plants [2]						Calculated
Original	Repeat	petioles	petioles	2 dz	2-1/2 dz	3 dz	4 dz	6 dz	8 dz	crates/A
Handweed	Handweed	12.4	25.0 cm	9%	33%	32%	18%	7%	1%	833
CDAA	None	11.9	25.5	6	33	32	22	6	1	834
Handweed	CDAA	11.9	25.5	13	34	30	18	5	0	844
CDAA	CDAA	12.1	25.1	14	25	29	23	7	2	826
CDEC	None	11.8	25.0	12	39	33	11	4	1	889
Handweed	CDEC	11.8	25.3	18	43	27	10	2	0	892
CDEC	CDEC	11.9	25.4	14	35	33	13	4	1	891
CDAA	CDEC	12.1	25.1	6	28	41	19	5	1	829
CDEC	CDAA	12.3	24.9	8	31	31	23	6	1	813

1/ CDAA and CDEC were applied at 5 lb/A./

2/ Based on commercial pack sized reported to nearest whole percent.

chemicals are "seedicides" basically effective against weed seed and small weed seedlings; their activity is enhanced by adequate soil moisture. As post-transplanting herbicides, CDAA and CDEC may be used in these ways in commercial celery production. 1) When applied prior to transplanting, CDAA and CDEC are effective from crop response and weed control viewpoints, but higher dosages may be necessary and the chemicals may be irritating to the transplanting crews. 2) When applied between transplanting and overhead irrigation, adequate soil moisture

Table 4A. Average size distribution and yield of marketable 52-70 celery after post-transplanting application of CDAA and CDEC granules and spray.

Herbicide treatment	Formulation	Distribution of marketable plants[1]						Calculated crates/A
		2 dz	2-1/2 dz	3 dz	4 dz	6 dz	8 dz	
Handweed	--	21%	29%	29%	14%	6%	1%	876
CDAA, 4 lb/A.	EC spray	33	26	29	11	1	0	986
	Granule	24	24	35	15	2	0	907
CDEC, 4 lb/A.	EC spray	37	22	24	12	3	2	946
	Granule	20	34	27	14	4	1	895
CDAA, 2 + CDEC, 2 lb/A.	EC Spray	38	27	25	6	3	1	975
	Granule	33	27	25	12	2	1	903
All CDAA		29	25	32	13	1	0	946
All CDEC		29	28	25	13	4	1	921
All CDAA + CDEC		35	27	25	9	3	1	939
All EC spray treatments		36	25	26	10	2	1	969
All granule treatments		26	28	29	13	3	1	902

1/ Based on commercial pack sizes reported to nearest whole percent.

is assured and foliar deposits of the herbicides are removed. However, this method may necessitate inefficient, stop-and-go operation of herbicide equipment. 3) In a third method, chemicals are applied after setting and irrigation. Usually soil moisture levels are favorable for several days after transplanting. This method is convenient and efficient but may be disadvantageous if inclement weather delays herbicide application until weed seedlings are established.

Under unfavorable conditions, single applications of CDAA and CDEC at transplanting may not provide season-long weed control. Weed control can be extended, without affecting the crop, by a repeat application three or four weeks after the initial treatment. This application

Table 4B. Average size distribution and yield of marketable 52-70 celery when CDAA and CDEC granules and spray were applied as a second herbicide treatment two weeks after post-transplanting treatment (CDAA + CDEC combination spray).

Herbicide treatment	Formulation	Distribution of marketable plants[1]						Calculated crates/A.
		2 dz	2-1/2 dz	3 dz	4 dz	6 dz	8 dz	
Handweeded	--	13%	31%	36%	17%	2%	1%	947
CDAA, 4 lb/A.	EC spray	13	24	43	17	3	0	904
	Granules	13	26	41	17	3	0	940
CDEC, 4 lb/A.	EC spray	14	28	38	18	2	0	927
	Granules	11	29	41	17	2	0	987
CDAA, 2 + CDEC, 2 lb/A.	EC spray	7	29	46	16	2	0	930
	Granules	16	31	35	16	1	1	910
All CDAA		13	25	42	17	3	0	922
All CDEC		12	29	40	17	2	0	947
All CDAA + CDEC		11	30	41	16	2	0	920
All spray treatments		11	27	43	17	2	0	921
All granules treatments		13	29	39	17	2	0	939

1/ Based on commercial pack sizes reported to nearest whole percent.

should immediately follow the first fertilizer side-dressing, as a moist soil surface is provided by fertilizer incorporation. This treatment is desirable for its weed control effectiveness and its ease of scheduling in farm operations.

Usually, CDAA more effectively controls grass weeds and CDEC controls broadleaf weeds. General weed control may be obtained best by applying both herbicides as a tank mixture. Proportions are adjusted to provide control of the major weed pests. In fall celery, 5 to 6 lb/A. active ingredient (CDAA, CDEC or mixed) may be necessary to obtain satisfactory control of annual weeds. With cooler late fall and winter weather, the rate may be decreased to 4 lb/A. for efficient control. The rate may again be increased to control increasing weed populations when temperatures rise in the spring.

Granular formulations of these chemicals have been as effective herbicides as sprayable formulations.

CDAA and CDEC have not affected celery growth characteristics adversely. Applied alone, in combination or in repeat applications, there has been no significant effect on number or length of petioles on marketable plants. Cull plants were few in treated plots. Celery yields, as determined by number or weight of marketable plants, have been similar to handweeded and commercial controls. Crates per acre yields have not differed significantly among the herbicide treatments, but there has been variation in distribution of marketable plants among commercial size classes at a single harvest date. When present, size distribution and crates per acre differences appear to be equal to several days' delay in maturity.

Occasionally, celery leaf burn and slight plant stunting may follow use of CDAA and CDEC; these effects are temporary and usually are not apparent 2 or 3 weeks after application.

The herbicide treatments appeared to have no relationship to insect or disease prevalence in celery.

Summary

1. CDAA and CDEC were selected in evaluation trials as the most consistently effective post-transplanting, pre-emergence herbicides for celery on organic soil.
2. CDAA and CDEC applied alone or in combination at rates totalling 4, 5, or 6 lb/A. effectively controlled annual grass and broadleaf weeds without affecting celery plant characteristics or yield. The proportions of tank-mix combinations of these herbicides may be varied to suit the weed population.
3. Repeat applications of these herbicides prolonged effective weed control without affecting crop quality or yield. A method of applying repeat treatments is opportune and readily conforms to farm practice.
4. Granular and sprayable formulations of these herbicides had equal herbicidal effectiveness but may not have equal effect on the celery plant. In one of two trials, granular treatment plots yielded significantly fewer crates per acre.
5. A type program for using these chemicals in commercial production is:
   a. Transplant and irrigate celery seedlings.
   b. Apply herbicides as soon as possible. Use CDEC where broadleaf weeds are most common; use CDAA or both chemicals where grass or mixed weeds abound. A total application rate of 5 to 6 lb/A. is desirable for fall and spring while 4 lb/A. should suffice for winter celery.
   c. At 3 to 4 weeks after setting, work fertilizer side-dressing into soil and leave smooth moist surface.
   d. Immediately after fertilizer is worked in apply the repeat herbicide treatment if needed for effective weed control. CDEC or CDAA + CDEC would be most desirable at this time.

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