Effect of Postemergence Applications of Herbicides On Sugarbeet Development and Weed Control In Central California

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The San Joaquin Valley of California is an important sugarbeet producing area where beets are planted from late October through March. Winter annual broadleaf weeds and grasses including volunteer barley are serious problems in the fall and winter planted fields. In addition to the winter annual weeds, summer annuals are abundant in the spring-planted fields.

S-propyl butylethylthio-carbamate (pebulate) and more recently N-ethyl-N-cyclohexythiolcarbamate (R-2063) are being used as preplant soil incorporated herbicides. The ineffectiveness of the thiocarbamate herbicides on *Brassica* species is well known. Their performance in cold, moist soils, during the winter months, is poorer than in warm, dry soils.

In February and March planted fields, the performance of pebulate or R-2063 in controlling the summer annual weeds is much more effective.

7-oxabicyclo [2.2.1] heptane - 2,3 - dicarboxylic acid (endothal) and trichloroacetic acid (TCA) successfully used in other sugarbeet growing areas are not effective in central California where furrow irrigation is used after planting to establish a stand.

The introduction of 5 amino-4-chloro-2-phenyl-3 (2H - pyridazinone (pyrazon) created considerable interest in central California. Trials were conducted (1, 2)[2] using pyrazon alone and in combination with pebulate and TCA. Pyrazon incorporated prior to planting or at planting caused stand reductions ranging from 10 - 30%.

Pyrazon was successfully used in Canada in 1966 (3) for postemergence weed control in sugarbeets. Recently postemergence trials were conducted by the authors in central California, Kings and Fresno Counties, using pyrazon alone and in combination with 2,2-dichloropropionic acid (dalapon) and an adjuvant containing alkylaryl-polyoxyethylene glycols, free fatty acids and isopropanol (X-77). Excellent control of broadleaf weeds and grasses was obtained (4).

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[2] Numbers in parentheses refer to literature cited.

Two time series studies were conducted to evaluate the effectiveness of pyrazon, pyrazon plus dalapon and adjuvant mixtures in controlling winter and summer annual weeds. Tolerance of sugarbeets to postemergence application of these herbicides was also evaluated. This report presents a summary of these studies.

Methods and Materials

Early Spring Series. A trial area was selected in a commercial beet field planted on 30 inch beds January 18, 1967 on Chino loam soil.

The first series of treatments was applied March 1, when the beets were in the dicotyledon stage of growth. Treatment schedule, weeds present and the stage of weed and beet growth, are summarized in Table 1.

Table 1.—Schedule of postemergence applied herbicides in early spring time series studies.

Date of herbicide application	Stage of beet growth	Stage of weed growth	Weeds present
March 1	Dicot	Cotyledon to 1st leaf	Fiddleneck (*Amsinckia Douglasiana*)
March 9	2 True lvs.	2-4 True lvs.	Black Mustard (*Brassica nigra* (L.) Koch) Shepherds Purse (*Capsella Bursapastoris* (L.) Medic) London Rocket (*Sisymbrium Irio* (L.))
March 20	4-6 True lvs.	4-8 True lvs.	Knotweed (*Polygonum Aviculare* L. *prostrate*) Red Maids (*Calandrinia caulescens*)
April 13	8-10 True lvs.	12-14" Tall. Some in bloom.	Wild Oats (*Avena fatua* L.) Rabbitfootgrass (*Polypogon monspeliensis* (L.) Desf)

Each plot consisted of two rows 20 ft long replicated three times, in a randomized block design. The herbicides were applied in 850 cc water per plot with a CO_2 pressure sprayer equipped with two 8002 nozzle tips and operating at 30 psi.

The herbicides used were pyrazon 2 and 4 lb/A, pyrazon at 2 plus dalapon at 2 lb/A and pyrazon at 4 plus dalapon at 2 lb/A; all as active ingredient. An adjuvant (X-77) at ½% of spray volume was added to all treatments.

Subsequent treatments scheduled for weekly application had to be modified because of inclement weather.

Periodic weed control and beet injury ratings were made. Following the April 24 evaluations, the check plots and the April 13 treated series were hand weeded and the beets in all plots were hand thinned.

The plots, with the exception of the April 13 treated series, were harvested September 13. Samples were taken from each plot for sucrose determinations.

Summer Series. To evaluate the effectiveness of pyrazon plus dalapon, 3-chlorohexyl-5,6-trimethyleneuracil (lenacil) and R-11914 on summer annual weeds a time series study was conducted June and July of 1967.

The sugarbeets were planted June 1, 1967 in dry soils. The field was furrow irrigated June 6 to obtain a stand.

Soil type, plot size and methods of herbicide application were the same as described in the early spring series. Pigweed (*Amaranthus retroflexus* L. and *A. graecizans* L.) were planted in the trial area.

Treatment schedule, stage of beet and weed growth, temperature at time of treatment and weed population in the trial area are summarized in Table 2.

Table 2.—Schedule of postemergence applied herbicides in early summer time series studies.

Date of herbicide application	Stage of growth			Temperature at time of treatment	Weeds present
	Sugarbeets	Broadleaf weeds	Grasses		
June 22	Dicot	2 leaves	1-2 leaves	86°F	Pigweeds (*amaranthus retroflexus* L. and *A. graecizans* L.)
June 29	2 True lvs.	4-8 leaves	4 leaves	101°F	Lambsquarter (*Chenopidium album* L.) Goosefoot (*Chenopidium murale* L.)
July 5	4 True lvs.	3-9" 9-12 leaves	6 leaves	83°F	Barnyardgrass (*Echinochloa crusgalli* (L.) Beauc)

The pyrazon 4 lb/A plus dalapon 2 lb/A combination that gave the most effective control in the early spring series along with pyrazon plus lenacil, R-11914 and the combination of R-11914 plus dalapon were the herbicides used in the summer series. Following the July 25 evaluations, the trial was terminated.

Results and Discussion

Winter Annual Weed Control. Pyrazon at 4 lb/A with ½% adjuvant effectively controlled most of the winter annual broadleaf weeds infesting the trial area when sprayed in the seedling stage of growth. The addition of dalapon enhanced the effectiveness of pyrazon on broadleaf weeds. Dalapon was essential for controlling the winter annual grasses.

The effectiveness of weed control was somewhat enhanced by increasing the rate of dalapon to 4 lbs/A, but beet injury was also more severe as shown in Table 3.

Examination of Tables 3, 4, and 5 clearly demonstrates that the effectiveness of weed control was reduced as the weeds became older. It was important to note that even though the weed control was less effective when the weeds were sprayed in the more mature stages of growth, they were severely retarded and more readily removed by cultivation than the untreated areas. This may be an important consideration in commercial fields.

The weeds in the April 13 treated plots were large and with the exception of black mustard and London rocket they were not effectively controlled with any of the treatments, therefore, a summary of the April 13 series is omitted from this report.

Sugar Beet Injury. Sugarbeets in the dicotyledon and later stages of development tolerated pyrazon plus dalapon treatments but retardation in the growth and slight injury to the sugarbeets was evident in all plots.

Injury symptoms were expressed as thickening and slightly wrinkled appearance of the leaf blades. Marginal necrosis was evident, especially in plots where higher rates of pyrazon and pyrazon plus dalapon were used. The retardation in the growth of beets was shortlived as clearly indicated in Tables 3, 4 and 5.

Table 3.—Effect of postemergence foliar applied herbicides on weed control and sugarbeets in a spring time series[1].

		Weed control[2]				Beet injury[2]					
	Lb/A	Dates evaluated				Dates evaluated				Clean beet	Sugar
Herbicide	ai	3/9	3/20	4/6	4/24	3/9	3/20	4/6	4/24	yield T/A	percent
Pyrazon	2	5.3	5.6	6.0	5.6	1.0	1.0	1.0	1.0	24	10.1
X-77	.5%										
Pyrazon	4	6.6	8.6	8.0	7.3	1.0	1.0	0.6	0	22	12.0
X-77	.5%										
Pyrazon	2										
Dalapon	2	6.3	8.3	6.6	6.0	1.0	1.0	0.6	0	27	10.6
X-77	.5%										
Pyrazon	4										
Dalapon	2	8.3	9.0	9.0	9.0	1.0	2.0	1.0	0	26	10.3
X-77	.5%										
Pyrazon	4										
Dalapon	4	9.0	9.0	9.0	9.0	2.0	3.6	3.0	1.0	25	11.4
X-77	.5%										
Untreated		0	0	0	0	0	0	0	0	23	11.6

[1] Stage of Growth: Beets—Dicot stage
Weeds—Cotyledon to first true leaf

[2] Weed control and injury ratings based on a scale of 0-10: 0 = no control, or no injury, 10 = perfect control, or severe injury.

Table 4.—Effect of postemergence foliar applied herbicides on weed control and sugarbeets in a spring time series[1].

Herbicides	Lb/A ai	Weed control[2] Dates evaluated 3/20	4/6	4/24	Beet injury[2] Dates evaluated 3/20	4/6	4/24	Clean beet yield T/A	Sugar percent
Pyrazon	2	3.6	4.6	4.0	0	.6	0	34	10.4
X-77	.5%								
Pyrazon	4	6.3	7.0	6.3	.6	2.0	1.0	34	9.7
X-77	.5%								
Pyrazon	2								
Dalapon	2	6.3	5.6	4.0	0	1.3	1.0	41	11.0
X-77	.5%								
Pyrazon	4								
Dalapon	2	8.0	8.0	8.0	1.0	3.0	1.0	36	10.3
X-77	.5%								
Pyrazon	8	7.3	7.6	7.0	0	2.3	2.0	38	10.1
X-77	.5%								
Pyrazon	16	8.5	9.0	8.3	3.0	4.5	3.0	38	10.3
X-77	.5%								
Pyrazon	32	9.0	9.0	9.0	5.0	3.0	3.0	36	9.6
X-77	.5%								
Untreated	—	0	0	0	0	0	0	32	10.8

[1] Stage of Growth: Beets—2 true leaves
Weeds—2 to 4 true leaves

[2] Weed control injury based on a scale of 0 - 10: 0 = no control, or no injury. 10 = perfect control, or severe injury.

Table 5.—Effect of postemergence foliar applied herbicides on weed control and sugarbeets in a spring time series[1].

Herbicide	Lb/A ai	Weed control[2] Dates evaluated 4/6	4/24	Beet injury[2] Dates evaluated 4/6	4/24	Yield Clean beet T/A	Sugar percent
Pyrazon	2	5.0	4.6	1.6	0	34	9.6
Tronic	.5%						
Pyrazon	4	7.0	7.0	2.0	0	34	11.0
X-77	.5%						
Pyrazon	2						
Dalapon	2	5.3	5.0	2.0	0	34	10.4
X-77	.5%						
Pyrazon	4						
Dalapon	1	7.0	7.0	2.0	1.0	35	10.0
X-77	.5%						
Pyrazon	4						
Dalapon	2	7.3	7.0	2.0	1.0	34	11.3
X-77	.5%						
Untreated		0	0	.6	0	34	11.3

[1] Stage of Growth: Beets—4 to 6 true leaves
Weeds—4 to 8 true leaves

[2] Weed control and injury ratings based on a scale of 0 - 10: 0 = no control, or no injury. 10 = perfect control, or severe injury.

Effect on Sugarbeet Yield and Quality. The retardation of sugarbeet development was neglegible 30 days after treatment

and no visual evidence of injury was detectable 90 days following treatment even in plots treated with 32 lb/A of pyrazon.

Yield data were obtained by harvesting the plots with a mechanical digger. Samples for sucrose percentage determinations were drawn from each plot and analyzed by Spreckels Sugar Company. No significant differences in yield and sucrose percentage among treatments were obtained as shown in Tables 3, 4 and 5.

Summer Annual Weed Control. In the spring time series studies and in other trials conducted by the authors, it was demonstrated that the most effective control of annual broadleaf weeds and grasses can be obtained with the combination of 4 lb of pyrazon plus 2 lb dalapon per acre. Therefore, in the summer time series study, this was the only pyrazon dalapon combination included.

It was demonstrated in this series that pyrazon plus dalapon was less effective on barnyardgrass and pigweed once they were beyond the seedling stage of growth. This was also observed in other trials conducted by the authors at several locations in the central valley.

Lambsquarter was effectively controlled in the 4 - 6 leaf stage of development, but pigweeds became more tolerant to the herbicides once beyond the two true leaf stage of growth. It was noted that once the lateral buds at the base of the leaf petiole began to enlarge, the weeds became more tolerant to the herbicides.

Barnyardgrass was effectively controlled only when treated in the 1 to 1½ leaf stage of growth and growing vigorously. When treated later than the 1½ leaf stage of growth or if the seedlings were stressed for moisture, effective control was not obtained.

Sugarbeet injury was more pronounced in the summer series. The beet injury and retardation in the growth was shortlived, three weeks, even though the beets were treated in the dicot stage of growth when the temperature was 86° F. The injury was much more severe when the herbicide application was made when the temperature was 101°F even though the beets were older, as shown in Tables 6 and 7.

The beet injury was again less severe following the July 5 treatment when the temperature was 83°F as shown in Table 8.

Lenacil in combination with pyrazon did not enhance the control of the barnyardgrass at rates used. R-11914 had good herbicidal activity on broadleaf weeds, but it was weak on grasses and the tolerance of beets to this herbicide was narrow.

Table 6.—Effect of postemergence foliar applied herbicides on sugarbeet development and weed control in a summer time series[1].

		Weed control and beet injury evaluations[2] Dates of evaluation								
	Lb/A	Broadleaf weeds			Grasses			Beet injury		
Herbicides[3]	ai	7/5	7/13	7/25	7/5	7/13	7/25	7/5	7/13	7/25
Pyrazon	4	8.3	9.0	8.0	1.3	1.0	1.0	2.3	.7	0
Dalapon	2									
Pyrazon	1	7.3	8.0	7.0	.6	4.0	2.0	3.3	.7	0
Lenacil	1									
Pyrazon	2	8.3	8.0	7.0	3.0	4.0	2.0	3.3	2.0	1.0
Lenacil	2									
R-11914	1	9.3	9.0	8.0	2.6	1.0	0	4.6	3.0	3.0
R-11914	2	7.6	9.0	9.0	.6	1.0	0	6.6	4.0	4.0
R-11914	1	8.0	8.0	8.0	2.0	2.0	1.0	4.3	3.0	3.0
Dalapon	2									
Untreated	—	0	0	0	0	0	0	0	0	0

[1] Stage of Growth: Beets—Dicot
Weeds—Grasses 1 to 2 leaves
Pigweeds 2 leaves

[2] Weed control and beet injury ratings based on a scale of 0 - 10: 0 = no control, or no injury. 10 = perfect control, or severe injury.

[3] An adjuvant (X-77) at ½% of spray volume was added to all treatments.

Table 7.—Effect of postemergence foliar applied herbicides on sugarbeet development and weed control in a summer time series[1].

		Weed control and beet injury evaluations[2] Dates of evaluation								
	Lb/A	Broadleaf weeds			Grasses			Beet injury		
Herbicides[3]	ai	7/5	7/13	7/25	7/5	7/13	7/25	7/5	7/13	7/25
Pyrazon	4	9.6	9.0	8.0	4.3	3.0	2.6	8.0	8.0	7.6
Dalapon	2									
Pyrazon	1	7.6	6.0	5.0	4.0	2.0	2.0	6.3	5.0	5.0
Lenacil	1									
Pyrazon	2	9.0	8.0	7.3	3.0	4.0	3.0	7.3	5.0	5.0
Lenacil	2									
R-11914	1	9.6	9.0	9.0	4.0	2.0	2.0	8.6	7.0	7.0
R-11914	2	10.0	10.0	10.0	2.0	3.0	2.6	9.6	9.0	9.0
R-11914	1	10.0	9.0	9.0	3.3	2.0	2.0	9.6	9.0	9.0
Dalapon	2									
Untreated	—	0	0	0	0	0	0	0	0	0

[1] Stage of Growth: Beets—2 true leaves
Weeds—Grasses 4 leaves
Pigweeds 4 - 8 leaves

[2] Weed control and beet injury ratings based on a scale of 0 - 10: 0 = no control, or no injury. 10 = perfect control, or severe injury.

[3] An adjuvant (X-77) at ½% of spray volume was added to all treatments.

It was observed that pyrazon did not control *Salsola kali* L. (Russian thistle) and Trifolium spp. (clovers). It was also noted that R-11914 effectively controlled Russian thistle.

Table 8.—Effect of postemergence foliar applied herbicides on sugarbeet development and weed control in a summer time series[1].

Herbicides[3]	Lb/A ai	Weed control and beet injury evaluations[2] Dates of evaluation					
		Broadleaf weeds		Grasses		Beet injury	
		7/13	7/25	7/13	7/25	7/13	7/25
Pyrazon	4	6.0	5.0	4.0	2.0	3.0	2.0
Dalapon	2						
Pyrazon	1	2.0	0	0	0	2.0	1.0
Lenacil	1						
Pyrazon	2	3.0	2.0	1.0	0	3.0	2.0
Lenacil	2						
R-11914	1	3.0	1.0	1.0	0	3.0	2.0
R-11914	2	6.0	5.0	3.0	1.0	3.0	2.0
R-11914	1	7.0	6.0	3.0	1.0	4.0	3.0
Dalapon	2						
Untreated	—	0	0	0	0	0	0

[1] Stage of Growth: Beets—2 to 4 true leaves
Weeds—Grasses 6 leaves
Pigweeds 3 to 9 inches with 9 to 12 leaves

[2] Weed control and beet injury ratings based on a scale of 0 - 10: 0 = no control or no injury. 10 = perfect control or severe injury.

[3] An adjuvant (X-77) at ½% of spray volume was added to all treatments.

Conclusions

In central California, until very recently, winter annual broadleaf weeds have been the most difficult to control in winter and in early spring planted sugarbeet fields.

Pyrazon in combination with dalapon plus an adjuvant was the most promising chemical tool for the selective control of winter annual weeds in sugar beets.

From the numerous trials conducted in the central valley and in the two time series studies summarized in this report, the following conclusions can be drawn:

A. Winter annual weeds were more effectively controlled than the summer annuals with pyrazon plus dalapon.

B. Pyrazon at 4 lb/A with ½% adjuvant effectively controlled the mustard species.

C. Pyrazon at 4 lb/A plus dalapon at 2 lb/A with ½% adjuvant effectively controlled most of the winter annual grasses and broadleaf weeds commonly found in sugarbeet fields in central California.

D. The most effective control was obtained when the weeds were sprayed in the seedling stage of growth.

E. Sugarbeets tolerated pyrazon plus dalapon applications even in the cotyledon stage of growth.

F. Retardation in the growth of sugarbeets was evident, but shortlived.

G. As the rate of dalapon in combination with pyrazon was increased, the injury to the seedling sugarbeets was more severe.

H. To obtain summer annual weed control with pyrazon plus dalapon, the application of the herbicide relative to the weed growth was critical. Pigweed and barnyardgrass were the most difficult to control.

I. Pigweed beyond the 2-leaf stage, or when the axillary buds started growing, were not controlled satisfactorily.

J. To obtain good barnyardgrass control, the herbicides must be applied when the grass is in the 1 to 1½-leaf stage and growing vigorously. Grasses showing moisture stress at time of treatment, even in the seedling stage of development, were not killed.

K. Pyrazon plus dalapon and other herbicides, applied when the temperature was 101°F severely injured the beets and reduced the stand. The same herbicides applied when temperatures were in the 80's, did not cause severe injury.

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