Postemergence Weed Control with Combinations of Herbicides in Different Sugarbeet Planting Periods

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The mild climate of California permits the planting of sugarbeets from late August through June. The same climatic conditions that favor sugarbeet culture also stimulate the germintion and growth of many broadleaf weeds and grasses. The challenges and methods of weed control vary widely with the time of planting. Consequently, no single herbicide or application method provides season-long control for any of the major planting periods. Therefore, growers need to carefully select fields and adopt weed control programs to provide economic and effective weed control for their individual growing conditions.

Postemergence weed control has been widely accepted since the development of phenmedipham (Betanal) and desmedipham (Betanex) (3, 11, 12, 14). These two herbicides control a wide range of broadleaf weed species, but they are not effective on grasses (4, 5, 7, 12, 15). The advantages of a postemergence herbicide are numerous. The most obvious is that weed problems can be identified before the herbicide is applied. This permits the selection of the most effective herbicide, or combination of herbicides to control specific weed problems (13). Postemergence applications also require less energy and time than preplant incorporated treatments (6, 8).

Since grasses and broadleaf species usually emerge at the same time, it would be desirable to have an effective grass herbicide which could be combined with Betanal and/or Betanex.

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The search for an effective grass herbicide has been an ongoing goal for a number of years, starting with dalapon [Dowpon (2)] and propham (Chemhoe) and continuing with diclofop-methyl (Hoelon), ethofumesate (Nortron) and several promising compounds (8, 9, 12).

Three new herbicides have recently been made available for evaluation as potential grass killers (10). They are BAS-9052 (Poast), RO-13-8895 and KK80. After its evaluation in several trials where it appeared promising, KK80 was withdrawn by its developer.

The purpose of these studies was to compare the effectiveness of several herbicides applied singly, or in combination with Betanal plus Betanex for control of barnyardgrass (*Echinochloa crusgalli* L.), as well as mixed populations of broadleaf weeds and grasses. A series of 10 experiments, conducted over a two-year period, are summarized in this report.

MATERIALS AND METHODS

The herbicides were applied with a CO_2 constant pressure backpack sprayer. Each trial was replicated three or four times. Individual plots were two rows wide and 30 or 40 feet long. Row spacings were single-row beds, spaced 30 inches apart, or two rows on 40-inch beds spaced 14 inches apart. The herbicides were applied broadcast or in 12-inch bands in 35 to 50 gallons of water per acre. At time of treatment, sugarbeets ranged from the 2- to 6-leaf stage of growth. In one trial, sugarbeets had 8 to 10 leaves. Barnyardgrass was the principle weed, however, volunteer cereals and other annual grasses were present in some trials. Broadleaf weeds varied from common winter annual species, such as black mustard (*Brassica nigra* L., Koch), shepherd's purse (*Capsella bursa pastoris* L., Medic) and fiddleneck (*Amsinckia intermedia* F&M) and summer annuals such as lambsquarters (*Chenopodium* sp.), pigweeds (*Amaranth* sp.), and purslane (*Portulaca oleracea* L.).

Seven herbicides were evaluated for grass control alone and in combinations with Betanal plus Betanex.

Adjuvants X-77 or pace (paraffin base petroleum oil 83%, polyal fatty acid esters of polyethoxylated derivatives 15%) were added, except when the grass herbicides were combined with Betanal or Betanex.

Appropriate weed control and sugarbeet injury evaluations were made. Beet injury ratings were based on a 0-10 scale, with "0" indicating no injury, and 10 complete kill. Weed control ratings were visual estimates expressed as percent control. Treatments and rates are given in the table that summarize the results. The results from each experiment are summarized in a table bearing the same number.

Experiment 1 was established on March 12, 1979 on sugarbeets in the 2-4 leaf stage and infested with 2-4 inch tall barnyardgrass. The temperature was 65 F.

Experiment 2 was established on March 30, 1979 in a field infested with barnyardgrass, johnsongrass *(Sorghum halepense* L.) and redroot pigweed *(Amaranthus retroflexus* L.). Grasses were less than 1.5 inches high with sugarbeets in the early 2-leaf stage.

Experiment 3 compared Poast and KK80 with Hoelon in a trial established on June 8, 1979. The principle weeds present were purslane and barnyardgrass. Temperature was 95 F at 2 p.m. when the herbicides were applied. Beets were mostly in the 4-leaf stage with weeds ranging from 2 to 4 inches high and under moisture stress.

Experiment 4 was established on May 31, 1979 in a field severely infested with barnyardgrass ranging in size from 3 to 12 inches tall with beets in the 8-10 leaf stage. The experiment was replicated 4 times and carried to harvest.

The remaining experiments were conducted between March and July of 1980 and were designed primarily to evaluate Poast and RO-13-8895 singly and in combination with Betanal and Betanex.

Experiment 5 was established on March 7 on a winter planted field having a variety of broadleaf and grassy weeds such as: sand spurry *(Spergularia ruba* L.), pineapple weed *(Matricaria matricarioides)* knotweed *(Polygonum*

aviculare L.), clover *(Trifolium* sp.), wild oats *(Avena fatua* L.), rabbitsfoot grass *(Polypogon monspeliensis* L., Desf.), prickly lettuce *(Latuca scariola* L.). Sugarbeets were in the 6-leaf stage with weeds ranging from newly emerged to approximately the size of the beets.

Experiment 6 was established in the early afternoon of June 12 when the temperature was 76 F. The beets had 2-4 leaves. Nortron, Poast, and RO-13-8895 were applied in combination with equal amounts of Betanal plus Betanex.

Experiment 7 established June 27, contained combination treatments and sequential applications. Two rates of Poast and RO-13-8895 were applied singly and in combination with Betanal plus Betanex. After a delay of five days, Betanal plus Betanex were applied sequentially to the areas treated with grass herbicides. Poast and RO-13-8895 were superimposed on the Betanal plus Betanex treatments.

Experiment 8 was established on June 12 when the sugarbeets were in the 4-leaf stage. Barnyardgrass was growing vigorously and equal in height with the beets. Two rates of Poast and RO-13-8895 were applied in the late afternoon when the temperature was 76 F.

Experiments 9 and 10 were established on the same planting of sugarbeets, but at two stages of growth. Experiment 9 was initiated on June 20 when sugarbeets were in the 2-4 leaf stage, and the barnyardgrass and redroot pigweed were 1 to 3 inches tall. Five days later in an adjacent area, an additional trial was conducted. Temperatures ranged from 80-85 F on the afternoons when each experiment was initiated.

OBSERVATIONS AND RESULTS

Experiment 1. Barnyardgrass was not adequately controlled with either Dowpon or Hoelon (Table 1). Combination of Hoelon plus Betanal or Betanex provided 85 to 88% barnyardgrass control 14 days after application.

Experiment 2. Excellent control of young barnyardgrass and johnsongrass resulted three weeks after applying HOE 29152, Hoelon or Hoelon plus Betanex (Table 2). Dowpon plus Betanex and Nortron provided less effective grass control and produced

Table 1. The effect of several postemergence treatments for control of early season Barnyardgrass (Experiment 1).

Treatment	Rate Lb ai/A	Evaluated 3/30 Beet Injury	Evaluated 3/30 Barnyardgrass Control %	Evaluated 4/7 Beet Injury	Evaluated 4/7 Barnyardgrass Control %
Hoelon[a]	1.0	1.8	30	1.8	50
Hoelon[a]	2.0	2.8	45	2.3	45
Dowpon[a]	2.0	2.0	32	2.8	40
Hoelon + Betanal	1.0 + 1.0	2.8	93	2.3	88
Hoelon + Betanex	1.0 + 1.0	2.3	88	1.3	85
Untreated		1.3	10	1.0	10

a - X-77 at .5% of spray volume was added. Established: 3/23/79. Temp 65 F.

more initial injury to sugarbeets These two experiments confirm results from earlier trials that neither Nortron nor Dowpon effectively control barnyardgrass (2, 5, 9). Hoelon did not control barnyardgrass beyond the 2-leaf stage of growth.

Table 2. A comparison of several postemergence treatments for control of newly emerged Barnyardgrass and Johnsongrass (Experiment 2).

Treatment	Rate Lb ai/A	Evaluated 4/7 Beet Injury	Evaluated 4/7 Grass Control	Evaluated 4/20 Beet Injury	Evaluated 4/20 Grass Control
HOE 29152[a]	1.0	3.0	90	2.0	100
Hoelon[a]	1.0	1.8	67	1.5	88
Nortron[a]	1.0	2.0	28	2.2	32
Dowpon + Betanex	2.0 + .65	5.0	72	3.2	62
Hoelon + Betanex	1.0 + .65	2.0	85	2.2	95
Untreated		2.0	18	1.0	10

a - X-77 at .5% of spray volume was added. Established: 3/30/79. Temp. 65 F.

Experiment 3. Barnyardgrass control was excellent with Poast and the higher rate of KK80 (Table 3). Hoelon provided ineffective control of the larger grasses. Treatments containing Betanex were phytotoxic to sugarbeets under the moisture and temperature stress condition existing when the herbicides were applied. Control of purslane, however, was satisfactory, and the surviving sugarbeets recovered rapidly although severe loss of stand occurred.

Table 3. Beet injury and weed control as influenced by postemergence applications of several herbicides and combinations (Experiment 3).

Treatment	Lb ai/A	Evaluated 6/12			Evaluated 6/25			
		Beet Injury	Barnyard Grass Control %	Purslane Control %	Beet Injury	Barnyard Grass Control %	Purslane Control %	Beet Stand Loss %
Poast[a]	1.0	2.5	82	15	1.0	100	48	0
Poast[a]	0.5	2.2	82	0	1.0	100	35	0
KK80[a]	2.0	3.8	80	18	1.5	100	55	5
KK80[a]	1.0	3.0	70	15	1.0	88	48	0
Hoelon[a]	1.5	5.0	50	8	2.5	48	60	10
Hoelon + Betanex	1.5 0.65	8.3	63	100	8.3	53	97	70
Poast + Betanex	0.5 0.65	6.8	88	100	4.5	82	88	40
Untreated		2.2	0	0	1.0	10	42	0

a - X-77 at 0.5% of spray volume was added. Established: 6/8/79. Temp. 95 F.

Experiment 4. Outstanding barnyardgrass control resulted from single applications of Poast at 1 and 2 lb ai/A applied on well established barnyardgrass (Table 4). Excellent control was maintained through August probably because the dense mat of dead grass and sugarbeet foliage inhibited additional barnyardgrass seed germination. The results from this experiment are noteworthy because a hand crew was removed from the section of the field containing the plot because the cost of control was exceeding the expected value of the crop. The yields suggest that a single application of Poast could have saved the severely infested portions of the field from abandonment.

Table 4. The influence of postemergence chemical control of Barnyardgrass on sugarbeet yields (Experiment 4).

			Evaluated		Yield Data		
Treatment	Lb ai/A	Beet Injury	7/3 Grass Control %	8/12 Grass Control %	Gross Sugar T/A	Root Yield T/A	Sucrose %
Poast[a]	1.0	1.2	92	85	2.87	19.9	14.4
Poast[a]	2.0	1.2	98	95	2.17	16.2	14.9
HOE 29152[a]	2.0	1.2	45	30	1.93	13.9	13.9
Untreated		5.5[b]	19	0	0.44	3.0	14.4

a - X-77 added at 0.5% of spray volume. Established 5/31/79.

b - Vigor reduced by grass competition.

Experiment 5. Excellent weed control was achieved with combinations of Betanal plus Betanex with Poast or KK80 (Table 5). The three-way combination of Betanal plus Dowpon and H273 resulted in poor weed control and greater sugarbeet injury.

Experiment 6. The relationship between temperature and sugarbeet injury with herbicide combinations involving Betanal and Betanex was again demonstrated (Table 6). Very little injury and rapid sugarbeet recovery was obtained without stand loss in Experiments 1, 2, and 5, but severe injury resulted at the higher temperatures encountered in Experiments 3 and 6. This confirms earlier work with Betanal and Betanex combinations leading to the practice of delaying applications until afternoon in order to minimize crop damage

Table 5. Effect of Postemergence herbicides on weed control and beet injury (Experiment 5).

Treatment	Rate Lb ai/A	Evaluated 3/14 Beet Injury	Evaluated 3/14 Barnyard Grass Control %	Evaluated 3/14 Broadleaf Control %	Evaluated 3/24 Beet Injury	Evaluated 3/24 Barnyard Grass Control %	Evaluated 3/24 Broadleaf Control %
Betanel + Betanex + Poast	0.75 + 0.75 + 0.5	1.3	73	73	0.3	96	91
Betanal + Betanex + Poast	0.75 + 0.75 + 1.0	1.3	77	77	0.3	100	90
Betanal + Betanex + KK80	0.75 + 0.75 + 1.0	1.3	73	70	0.6	95	88
Betanal + Betanex + KK80	0.75 + 0.75 + 2.0	2.0	73	73	1.1	96	90
Betanal + H273 + Dowpon	1.0 + 0.75 + 2.0	2.7	53	70	1.1	60	70
Untreated		0.3	0	0	0	0	0

Established: 3/7/80. Temp. 65 F.

(1, 8, 9). The treatments were applied between 1 and 2 p.m. with temperatures in the mid-seventies and the sugarbeets were in the their 2-4 leaf stage. Excellent weed control was obtained, but it resulted in severe reduction in beet stand

The relationship between the size of beet and weeds for effective control is critical. Broadleaf weeds, especially pigweeds and purslane, rapidly develop beyond the stage when effective control can be obtained with Betanal plus Betanex.

Limited experience with Poast or RO-1308895 indicates that vigorous growing grasses, espsecially barnyardgrass, can be effectively controlled at a later growth stage. These observations suggested that sequential applications may be desirable, or necessary under some circumstances.

Experiment 7. In the sequential application of the herbicides, the best overall weed control was achieved when Betanal plus Betanex preceeded the grass herbicide application (Table 7). Treatment with Poast and RO-1308895 at 0.5 lb ai/A resulted in excellent barnyard grass control. When the grass herbicides were combined with Betanal plus Betanex, excellent broadleaf control was obtained; however, initial beet injury and stand loss occurred. The least beet injury occurred when the grass herbicide preceeded the Betanal plus Betanex application. Barnyardgrass control was somewhat less satisfacatory than when Betanal plus Betanex preceeded the grass herbicide applications.

Sugarbeet recovery was rapid following all herbicide applications, however, further work is necessary to explain the apparent differences between Poast and RO-13-8895 when they are applied in combination with Betanal plus Betanex. The results did confirm the initial premise that the broadleaf application should preceed the grass herbicides in sequential treatments. This procedure should result in maximum weed control with minimum beet injury.

Experiment 8. Excellent barnyardgrass control was obtained with both Poast and RO-13-8895 (Table 8). Although

Table 6. Effect of postemergence herbicides on weed control and sugarbeet injury (Experiment 6).

Treatment	Rate Lb ai/A	Evaluated 6/20			Evaluated 6/25		
		Beet Injury	Barnyard Grass Control %	Broadleaf Control %	Beet Injury	Grass Control %	Beet Stand Loss %
Betanal + Betanex + Poast	0.65 + 0.65 + 0.25	5.6	96	100	+ 0	98	78
Betanal + Betanex + Poast	0.65 + 0.65 + 0.50	5.6	96	96	4.0	96	63
Betanal + Betanex + Poast	0.65 + 0.65 + 1.0	6.3	100	100	5 3	100	73
Betanal + Betanex RO-13-8895	0.65 + 0.65 + 0.5	6.6	100	96	3.3	96	82
Betanal + Betanex + RO-13-8895	0.65 + 0.65 + 1.0	7.6	100	100	5.0	100	87
Betanal + Betanex + Nortron	0.65 + 0.65 + 2.0	6.3	100	90	5.0	86	70
Nortron + X-77	2.0 + 0.5%	3.3	76	26	1.6	50	4
Untreated		1.0	56	0	0	0	2

Established: 6/12/80. Temp. 76 F.

Table 7. Effect of sequential applications of postemergence herbicides on weed control and beet injury (Experiment 7).

Herbicide	Lb ai/A	Applied	Weed Control, Beet Injury and Beet Stand Evaluations						
			2 July 1980			15 July 1980			
			BYG Control %	Broadleaf Control %	Beet Injury	BYG Control %	Broadleaf Control %	Beet[a] Vigor	Stand Loss %
A Betanal	0.65	6/27	7	87	4.5	90	92	8.2	28
Betanex	0.65								
Poast	0.5	7/2							
Pace	1 Qt								
B Betanal	0.65	6/27	22	85	4.5	95	95	7.7	28
Betanex	0.65								
Poast	1.0	7/2							
Pace	1 Qt								
C Betanal	0.65	6/27	20	72	5.5	95	95	7.2	41
Betanex	0.65								
RO-138895	0.5	7/2							
Pace	1 Qt								
D Betanal	0.65	6/27	20	92	5.5	97	92	7.5	38
Betanex	0.65								
RO-138895	1.0	7/2							
Pace	1 Qt								
E Betanal	0.65								
Betanex	0.65	6/27	67	87	6.0	75	90	8.0	38
Poast	0.5								
F Betanal	0.65								
Betanex	0.65	6/27	70	95	7.2	90	92	7.2	54
Poast	1.0								

Table 7. Continued.

			Weed Control, Beet Injury and Beet Stand Evaluations						
			2 July 1980			15 July 1980			
Herbicide	Lb ai/A	Applied	BYG Control %	Broadleaf Control %	Beet Injury	BYG Control %	Broadleaf Control %	Beet[a] Vigor	Stand Loss %
G Betanal	0.65								
Betanex	0.65	6/27	37	65	4.0	47	90	8.2	31
RO-138895	0.5								
H Betanal	0.65								
Betanex	0.65	6/27	50	85	5.0	55	95	8.0	30
RO-138895	1.0								
J Poast	0.5	6/27							
Pace	1 Qt		32	0	1.2	77	97	8.0	31
Betanal	0.65	7/2							
Betanex	0.65								
K Poast	1.0	6/27							
Pace	1 Qt		42	0	1.7	92	90	7.5	28
Betanal	0.65	7/2							
Betanex	0.65								
L RO-138895	0.5	6/27							
X-77	½%		25	0	2.5	70	95	8.0	30
Betanal	0.65	7/2							
Betanex	0.65								
M RO-138895	1.0	6/27							
X-77	½%		40	0	3.2	10	90	7.7	25
Betanal	0.65	7/2							
Betanex	0.65								

N Untreated

a - Beet vigor indicates recovery from initial injury with 10 = complete recovery.

RO-13-8895 stunted sugarbeets more severely than did Poast; no significant stand loss occurred and complete recovery was obtained within 21 days after the applications.

Table 8. Effects of two experimental herbicides on barnyardgrass control and beet injury (Experiment 8).

Treatment	Rate Lb ai/A	Evaluated 6/20 Beet Injury	Barnyardgrass %
Poast + Pace	0.5 + 1 Qt	1.5	80
Poast + Pace	1.0 + 1 Qt	1.2	87
RO-13-8895 + Pace	1.0 + 1 Qt	4.5	88
RO-13-8895 + Pace	2.0 + 1 Qt	5.0	96
Untreated		0.5	7

Established: 6/12/80. Temp. 76 F.

Experiment 9. The data developed confirms earlier observations that Poast causes somewhat less beet injury than RO-13-8895 when the herbicides are applied singly (Table 9). Combinations of these two grass herbicides with Betanal plus Betanex resulted in more sugarbeet injury, but better weed control. More beet injury and poorer barnyardgrass control resulted when Hoelon or Nortron were combined with Betanal plus Betanex.

Experiment 10. Delaying the applications five days resulted in slightly less beet injury with no apparent loss in weed control. This trial included comparisons of two surfactants, X-77 and Pace, with RO-13-8895. Evaluations on July 2nd indicated that Pace was a safer adjuvant to use with this herbicide than X-77, however, without a surfactant, less effective grass control was obtained.

SUMMARY AND CONCLUSIONS

A number of postemergence weed control trials were conducted over a two-year period in the Central Valley of California. Several herbicides selected for their ability to control annual grasses were evaluated. All of the grass herbicides, except HOE 29152, were also tested in combination with Betanal and Betanex to study their effect on the sugarbeet as well as their effectiveness in controlling broadleaf weeds and grasses. It was demonstrated that:

Table 9. Effect of postemergence grass herbicides and combinations on weed control and beet injury (Experiment 9).

Herbicide	Rate Lb ai/A	Evaluated: June 25			Evaluated: July 2		
		Pigweed Control %	Barnyard Grass Control %	Beet Injury	Pigweed Control %	Barnyard Grass Control %	Beet Injury
Poast Pace	0.5 1 Qt	0	40	1.0	0	90	0
Poast Pace	1.0 1 Qt	0	56	2.0	0	100	0
RO-13-8895 Pace	0.5 1 Qt	0	46	2.6	20	96	0
RO-13-8895 Pace	1.0 1 Qt	0	50	4.0	13	100	0.6
Betanal Betanex Poast	0.65 0.65 .25	80	76	4.6	76	90	1.0
Betanal Betanex Poast	0.65 0.65 0.5	83	76	4.0	80	100	1.6
Betanal Betanex Poast	0.65 0.65 1.0	83	80	5.0	76	100	1.3
Betanal Betalal RO-13-8895	0.65 0.65 0.5	80	66	4.3	80	70	1.3

Table 9. Continued.

Herbicide	Rate Lb ai/A	Evaluated: June 25 Pigweed Control %	Barnyard Grass Control %	Beet Injury	Evaluated: July 2 Pigweed Control %	Barnyard Grass Control %	Beet Injury
Betanal	0.65						
Betanex	0.65	80	83	6.3	76	80	1.6
RO-13-8895	1.0						
Betanal	0.65						
Betanex	0.65	80	66	5.6	80	50	2.3
Hoelon	2.0						
Betanal	0.65						
Betanex	0.65	83	70	5.6	80	36	2.6
Nortron	2.0						
Untreated	---	0	0	0	0	0	0

Established: 6/20/80. Temp. 80 F.

Table 10. Effect of postemergence grass herbicides and combinations on beet injury and weed control (Experiment 10).

		Evaluated: 7/2	
		Beet Injury and Grass Control Evaluation	
Herbicide	Rate Lb ai/A	Beet Injury	Barnyardgrass Control %
Poast	0.0	0.6	46
Pace	1 Qt		
Poast	1.0	1.6	66
Pace	1 Qt		
RO-13-8895	0.5	0.6	10
RO-13-8895	0.5	3.6	50
X-77	½%		
RO-13-8895	0.5	1.6	43
Pace	1 Qt		
RO-13-8895	1.0	4.6	60
X-77	½%		
Betanal	0.65	2.6	70
Betanex	0.65		
Poast	0.5		
Betanal	0.65	3.0	70
Betanex	0.65		
Poast	1.0		
Betanal	0.65	3.6	53
Betanex	0.65		
RO-13-8895	0.5		
Betanal	0.65	4.0	46
Betanex	0.65		
RO-13-8895	1.0		
Betanal	0.65	6.0	43
Betanex	0.65		
Nortron	2.0		
Untreated	---	0	0

Established: 6/25/80. Temp. 85 F.

(1) Poast and RO-13-8895 are very effective postemergence grass herbicides. They controlled a wide spectrum of annual grasses, except annual bluegrass, with adequate sugarbeet safety. KK80 also exhibited effective grass control and selectivity on sugarbeets only slightly below that obtained with Poast and RO-13-8895. HOE 29152 provided less effective control than the other herbicides evaluated.

(2) Dowpon, Hoelon, and Nortron failed to control annual grasses as well as the new experimental herbicides. Hoelon was effective only against very young barnyardgrass.

(3) Poast and RO-13-8895 proved to be very effective when combined with Betanal and Betanex in controlling both grasses and broadleaf species.

(4) Betanal plus Betanex, and the grass herbicides applied sequentially, offer a possibility of minimizing sugarbeet symptoms to tolerable levels during periods of high temperatures.

(5) Poast and RO-13-8895 provided effective control of barnyardgrass when treatment was delayed past its seedling stage. Betanal and/or Betanex, however, are most effective on seedling broadleaf weeds. Therefore, the sequence of treatments would favor early applications of Betanal plus Betanex followed by the grass herbicide. More data is required before conditions which favor sequential applications and combinations can be precisely defined.

(6) Timing of all postemergence applications of herbicides whether they are used singly or in combination is critical with regard to sugarbeet safety and weed control efficiency. Crop injury is intensified during periods of high temperatures.

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