Assessment of Herbicide Benefits in Sugarbeets (*Beta vulgaris*)*

Stephen D. Miller and K. James Fornstrom
Box 3354, Laramie, Wyoming 82071

ABSTRACT

Sequential or complementary herbicide applications were particularly effective for providing season-long weed control in sugarbeets (95 to 98%). The benefit of herbicides over the hand weeded check ranged from a low of $19/A with layby treatments to a high of $147/A with complementary preplant incorporated/postemergence applications of cycloate plus ethofumesate followed by postemergence applications of desmedipham plus phenmedipham. The benefit of preplant incorporated herbicides over the handweeded check exceeded $120/A whether applied alone or as a complementary treatment. This data suggests that under heavy weed pressure preplant incorporated herbicide treatments are essential to minimize weed control costs in sugarbeets.

Regression analysis of hoeing time as a function of weed population indicated that 2.8 hr/A/trip was required to walk a sugarbeet field without weeds and that an additional 0.3 hr/A/trip was required for every 1000 weeds/A. This information should provide growers and laborers some basis for price negotiations.

Additional Key Words: Herbicides, weeds, hand labor

Sugarbeets are grown annually on approximately 50,000 acres in Wyoming. Weeds are a major problem in growing sugarbeets. Weeds that emerge within 8 weeks after planting or within 4 weeks after the two-leaf stage of sugarbeets are the most

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damaging (2,3,6,7). In addition broadleaf weeds are generally considered more competitive than grasses (1,2,9). For example one green foxtail (*Setaria viridis* (L.) Beauv.) per sugarbeet plant reduced yield by 26% in Wyoming compared to 70% for one redroot pigweed (*Amaranthus retroflexus* L.) (1).

Sugarbeet producers presently use a combination of chemical, mechanical and manual weed control methods. In Wyoming, herbicides are applied to over 70% of the sugarbeets prior to planting, 35% sprayed postemergence and over 6% treated after thinning (5). Sugarbeets also are cultivated one to three times during the season and weed escapes controlled by one to three hand hoeings.

Sequential or complementary applications of herbicides have proven to be particularly effective in sugarbeets and have provided season-long control of many annual weeds (4,7,8). However, herbicide injury and herbicide cost may limit a grower's herbicide options. The objective of this study was to determine labor requirements necessary to remove weeds after treatment with different levels of herbicide input and to determine the most economical combination of herbicides and hand labor to optimize sugarbeet returns.

MATERIALS AND METHODS

Field experiments were conducted at two locations in 1985 and one location in 1986 near Torrington, WY. The soils were a Bayard loamy sand (coarse, mixed mesic Torriorthentic Haplustoll – 77% sand, 11% silt and 12% clay) with 1.2% organic matter and pH 6.8 at the cooperator site in 1985 and a Bayard fine sandy loam (coarse, loamy mixed mesic Torriorthentic Haplustoll – 71% sand, 17% silt and 12% clay) with 1.3% organic matter and pH 7.3 at the experiment station site in 1985 and 1986.

Weeds included redroot pigweed, common lambsquarters (*Chenopodium album* L.), wild buckwheat (*Polygonum convolvulus* L.), hairy nightshade (*Solanum sarrachoides* Sendtner), common sunflower (*Helianthus annuus* L.) and green foxtail. The predominant weed was green foxtail.

Sugarbeets (Holly Hybrid 30) were planted between April 15 and 17 in 1985 and April 15 in 1986 in 30-inch rows at a depth of 1 to 1.25 inch and rate of three seeds/ft of row. Plots were four rows wide and 65 ft long. The plots were sprinkler irrigated at the experiment station site and furrow irrigated at the cooperator site. The experimental design was a randomized complete block with a split plot arrangement. Treatments were replicated four times at the cooperator site, and six times at the experiment station site in 1985 and four times in 1986.

Cycloate (S-ethyl cyclohexylethylcarbamothioate), ethofumesate (±-2-ethoxy-2, 3-dihydro-3, 3-dimethyl-5 – benzofuranyl methanesulfonate), cycloate plus ethofumesate, and ethofumesate plus diethatyl (N-(chloroacetyl)-N-(2,6-diethylphenyl)glycine) were applied preplant with a tractor-mounted sprayer delivering 40 gpa at 25 psi (7 inch band) and incorporated with a PTO driven rotary incorporator. A 50:50 mixture of desmedipham (ethyl[3-[[(phenylamino)carbonyl]oxy]phenyl]carbamate) plus phenmedipham (3-[(methoxycarbonyl) amino] phenyl (3-methylphenyl) carbamate) was applied postemergence with a tractor mounted sprayer using two nozzles per row and delivering 40 gpa at 26 psi (7 inch band) to 4-to 6-leaf sugarbeets and 1-to 2-inch weeds. A mixture of EPTC (S-ethyl dipropylcarbamothioate) plus trifluralin (2,6-dintro-N,N-dipropyl -4-(trifluromethyl) benzenamine) was applied broadcast at layby with a tractor mounted sprayer delivering 20 gpa at 29 psi and incorporated immediately with a Danish S-tine cultivator at 1.5 to 2 inches.

Evaluations included sugarbeet and weed populations, hoeing times and sugarbeet yields. Sugarbeet and weed populations were determined by counting two areas 3 inches wide by 10 ft long in each replication about 14 days after desmedipham plus phenmedipham application. After plant counts were made, the plots were hand hoed with times recorded. A second timed hoeing was performed on the plots later in the season (approximately the first week of July). Sugarbeet final stand and yield were determined by hand harvesting 10 ft of row in each replication. Sugar percentage and tare were determined by Holly Sugar Corporation. All plots were essentially weed-free at harvest.

For economic comparisons, cycloate, ethofumesate, diethatyl, desmedipham plus phenmedipham, EPTC and trifluralin were valued at \$6.85, \$31.50, \$9.35, \$50.00, \$3.47, and \$5.10/lb of active ingredient. Hand labor was charged at \$4.00/hr. The application of preplant herbicides was assumed to add \$4/A to the cost of the planting operation; the application of postemergence herbicides was assumed to be a separate operation which would cost \$4/A; and the application of layby herbicides assumed to add \$3/A to the cost of a cultivation. These were prevailing prices at Torrington, WY in November 1987. Herbicide rates and costs at the cooperator site in 1985 and the experiment station site in 1985 and 1986 are presented in Table 1.

RESULTS AND DISCUSSION

Since herbicide treatments were performed similarly at the three locations, the data presented are combined over locations. Data were subjected to analysis of variance and means separated at the 0.05 level of probability using FLSD.

Table 1. Herbicide rates and costs at the cooperator site in 1985 and the experiment station site in 1985 and 1986.

Herbicide	Rate: Cooperator 1985	Rate: Experiment Stn. 1985 and 1986	Cost: Cooperator 1985	Cost: Experiment Stn. 1985 and 1986
	(lb/A)		($/A)	
cycloate	2.0	3.0	3	5
ethofumesate	1.5	2.5	11	18
cycloate + ethofumesate	0.75 + 0.75	1.5 + 1.5	7	13
ethofumesate + diethatyl	1.0 + 1.0	2.0 + 2.0	10	19
desmedipham + phenmedipham	0.375 + 0.375	0.375 + 0.375	9	9
trifluralin + EPTC	0.5 + 0.75	0.5 + 1.5	5	8

The sugarbeets were planted to stand and no thinning was performed on any plot. Sugarbeet stands were considered adequate with all treatments (Table 2). Sugarbeet yield and percentage sucrose were the same whether weeds were controlled only by hand weeding or by a combination of herbicide and hand weeding (Table 2). Thus in the following discussion all weed control systems were compared on the basis of weed control, hoeing time and total control costs.

Table 2. Sugarbeet response to various herbicide combinations averaged over three locations.

Treatment	Sugarbeets stand	Sugarbeets sucrose	Sugarbeets yield
	(1000 pl/A)	(%)	(T/A)
cycloate (cycl)	27	13.9	26.6
cycl/desmedipham + phenmedipham (post)	28	13.7	26.4
cycl/trifluralin + EPTC (layby)	28	13.9	26.4
cycl/post/layby	26	13.9	26.3
ethofumesate (etho)	26	13.9	27.0
etho/post	27	14.0	26.5
etho/layby	26	13.8	26.2
etho/post/layby	27	13.8	26.8
cycl + etho	28	14.0	27.5
cycl + etho/post	27	14.0	27.3
cycl + etho/layby	26	13.8	26.9
cycl + etho/post/layby	27	13.9	27.1
etho + diethatyl (diet)	26	13.8	26.1
etho + diet/post	26	13.7	25.6
etho + diet/layby	28	14.1	27.7
etho + diet/post/layby	30	13.7	27.8
post	29	14.1	27.6
layby	27	13.9	27.6
post/layby	26	14.1	26.6
hand weeded	25	14.2	26.6
$LSD_{(0.05)}$	NS	NS	NS

Weed populations in the experimental area averaged over 73,000 plants/A in the untreated check (Table 3). All herbicide treatments, except layby applications alone, reduced weed populations and hoeing times compared to the hand-weeded control. Complementary preplant incorporated plus postemergence treatments were generally more effective than preplant or postemergence treatments alone in reducing weed populations and hoeing times. For example, the complementary treatments reduced weed populations 95 to 98% compared to 77 to 93% for preplant and 41% for postemergence applications alone. Further, total hoeing times ranged from 6.6 to 10.2 hr/A for the complementary treatments compared to 8.7 to 17.8 hr/A for preplant and 30.0 hr/A for postemergence applications alone.

Table 3. Weed population and hoe-time with various herbicide combinations averaged over three locations.

Treatment	Weed stand	Hoe-time 1st	2nd	Total
	(1000 pl/A)			
cycloate (cycl)	17.3	10.5	7.3	17.8
cycl/desmedipham + phenmedipham (post)	3.8	4.9	5.3	10.2
cycl/trifluralin + EPTC (layby)	13.3	9.1	5.6	14.7
cycl/post/layby	1.8	4.8	3.4	8.2
ethofumesate (etho)	10.5	6.2	5.5	11.7
etho/post	3.4	4.0	3.7	7.7
etho/layby	12.6	7.5	4.6	12.1
etho/post/layby	4.1	4.4	3.1	7.5
cycl + etho	6.5	5.9	4.14	10.0
cycl + etho/post	1.7	3.7	2.9	6.6
cycl + etho/layby	5.2	5.1	2.7	7.8
cycl + etho/post/layby	0.9	3.3	2.5	5.8
etho + diethatyl (diet)	6.6	5.0	3.7	8.7
etho + diet/post	3.5	3.4	3.2	6.6
etho + diet/layby	6.5	5.6	3.2	8.8
etho + diet/post/layby	4.0	4.3	2.4	6.7
post	43.6	16.4	13.8	30.0
layby	71.7	29.9	13.2	43.1
post/layby	43.9	17.7	12.3	30.0
hand weeded	73.7	32.6	17.6	50.2
$LSD_{(0.05)}$	11.2	4.2	3.0	7.2

The effectiveness of preplant incorporated herbicides averaged over postemergence and layby treatments or postemergence and layby herbicides averaged over preplant incorporated treatments is shown in Table 4. Cycloate plus ethofumesate was more effective than either herbicide applied alone. Weed populations averaged 3,600 plants/A for the combination treatment compared to 9,100 and 7,700 plants/A for cycloate or ethofumesate alone. In addition, total hoeing time with the combination treatment was 7.6 hr/A compared to 12.7 and 9.7 hr/A for cycloate or ethofumesate alone. Weed control and hoeing times with ethofumesate plus diethatyl was similar to that obtained with cycloate plus ethofumesate (Table 4).

Table 4. Weed population and hoe-time with preplant incorporated, postemergence, and layby incorporated herbicides averaged over three locations.

Treatment	Weed stand	Hoe-time 1st	2nd	Total
	(1000 pl/A)	(hr/A)		
Preplant (averaged over post emergence and layby treatment)				
cycloate	9.1	7.3	5.4	12.7
ethofumesate	7.7	5.5	4.2	9.7
cycloate + ethofumesate	3.6	4.5	3.1	7.6
ethofumesate + diethatyl	5.2	4.6	3.1	7.7
none	58.2	24.2	14.1	38.3
$LSD_{(0.05)}$	3.3	1.1	0.7	1.8
Postemergence and/or layby (averaged over preplant treatment)				
desmedipham + phenmedipahm	11.2	6.4	5.8	12.2
trifluralin + EPTC	21.9	11.4	5.9	17.3
desmedipham + phenmedipham/ trifluralin + EPTC	10.9	6.9	4.7	11.6
none	22.9	12.1	7.6	19.7
$LSD_{(0.05)}$	2.7	0.9	0.7	1.6

Application of desmedipham plus phenmedipham postemergence alone or as a complementary treatment with trifluralin plus EPTC reduced weed populations over 50% and total hoeing time over 38% compared to when no postemergence or layby treatment was applied (Table 4). The layby treatment of trifluralin plus EPTC had very little effect on weed populations but reduced second and total hoeing time slightly (1.7 and 2.4 hr/A) compared to when no postemergence or layby herbicide was applied.

Total hoeing time as a function of weed population is shown in Figure 1. Based on linear regression analysis 5.6 hr/A were required to walk through a sugarbeet field twice when no weeds were present and an additional 0.6 hr/A required for every 1000 weeds/A ($r^2 = 0.93$). Thus a relatively light weed infestation of 4000 plants/A or 4 weeds per 20 ft of row could increase hoeing times 2.4 hr/A. The total hoeing time is made up of 2.7 hr/A walking time plus 0.4 hr/A per 1000 weeds/A ($r^2 = 0.89$) for the first hoeing and 2.9 hr/A plus 0.2 hr/A per 1000 weeds/A ($r^2 = 0.87$) for the second hoeing. Weed populations are based on counts made before the first hoeing. Thus the high correlation of times for the second hoeing indicates that these times are a function of escapes and/or residual weed control effects.

Weed control costs associated with the various herbicide treatments are presented in Table 5. All herbicide treatments reduced weed control costs compared to the hand weeded check. The benefit over the hand weeded check with the various herbicide treatments ranged from a low of $19/A with layby applications of trifluralin plus EPTC to a high of $147/A with complementary preplant incorporated applications of cycloate plus ethofumesate followed by postemergence applications of desmedipham plus phenmedipham. The benefit over the hand weeded check of preplant incorporated herbicides exceeded $120/A with or without complementary applications of postemergence and or layby treatments which suggests that under heavy weed pressure preplant incorporated herbicide treatments are extremely important in minimizing weed control costs.

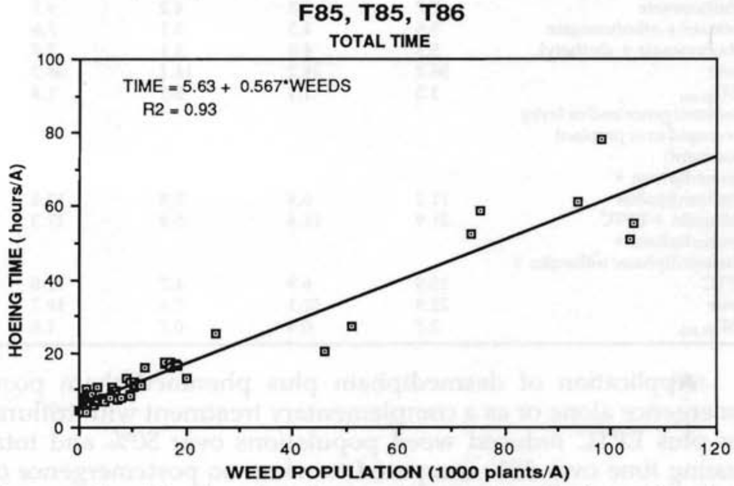

Figure 1. Total hoeing time (first and second hoeing) as a function of weed population.

Table 5. Weed control costs with various herbicide combinations averaged over three locations.

Treatment	Cost of weed control † hoeing	herbicide	total	Benefit over hand weeded
	($/A)			
cycloate (cycl)	71	8	79	122
cycl/desmedipham + phenmedipham (post)	41	21	62	139
cycl/trifluralin + EPTC (layby)	59	18	77	124
cycl/post/layby	33	31	64	137
ethofumesate (etho)	47	20	67	134
etho/post	31	33	64	137
etho/layby	48	30	78	123
etho/post/layby	30	43	73	128
cycl + etho	40	15	55	146
cycl + etho/post	26	28	54	147
cycl + etho/layby	31	25	56	145
cycl + etho/post/layby	23	38	61	140
etho + diethatyl (diet)	35	20	55	146
etho + diet/post	26	33	59	142
etho + diet/layby	35	30	65	136
etho + diet/post/layby	27	43	70	131
post	120	13	133	68
layby	172	10	182	19
post/layby	120	23	143	58
hand weeded	201	—	201	—

†Herbicide costs including application were considered as a constant for each treatment based on prevailing prices at Torrington, WY in November, 1987. Hoeing costs were based on a labor rate of $4/hr. LSD's for hoeing times are given in Table 3.

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