Preplant Weed Control on Sugar Beets[1]

E. F. SULLIVAN, R. R. WOOD, R. L. ABRAMS, AND S. G. WALTER[2]

Received for publication July 1, 1964

Introduction

Today, with the uncertainty of availability of hand labor, researchers need to devise effective systems of chemical weeding on sugar beets. For, the ultimate, complete spring mechanization, remains dependent on the development of chemical controls that permit planting to stand in a weed-free environment without hand labor and cultivation. Therefore, the systematic screening of available herbicides is an important contribution toward the realization of this goal.

The preemergence herbicides disodium 3,6-endoxohexahydrophthalic acid (endothall) and trichloroacetic acid (TCA) have given variable results in surface irrigated regions although satisfactory weed controls are obtained under humid climates and natural rainfall conditions (2,3,6,8,9)[3]. Lately, preplant applications of ethyl *N*, *N*-di-*n*-propylthiolcarbamate (EPTC), *n*-propyl ethyl-n-butylthiolcarbamate (PEBC) and 2,3-dichloroallyl diisopropylthiolcarbamate (DATC) have shown effective control of certain weed species but ineffective control of kochia in irrigated regions (1,3,7,8,9). Research in Colorado and Montana has shown that the combination, PEBC + DATC, is more effective in the control of wild oat, *Avena fatua*, and lambsquarters, *Chenopodium album*, while controlling pigweed, *Amaranthus retroflexus*, and foxtail, *Setaria* spp., than PEBC applied alone (8).

The objectives of this study were to determine further (A) the weed control effectiveness of new herbicides and (B) to evaluate the relative effectiveness of herbicide combinations in an attempt to increase the spectrum of weed control on sugar beets.

Materials and Methods

The spring experiments were conducted at 6 locations, namely: Windsor and Sterling, Colorado; Mitchell and Bayard, Nebraska; Lovell, Wyoming; and Billings, Montana. These trials were initiated on March 27 through April 20 in the spring and on June 13 and July 17 in the summer. The number of treatments per trial ranged from 12 to 24 and the number of treatments at each location ranged from 24 to 66 among locations

[1] Contribution from The Great Western Sugar Company, Agricultural Experiment Station, Longmont, Colorado.

[2] Agronomist, Manager, and Assistant Agronomists, respectively.

[3] Numbers in parentheses refer to literature cited.

and dates. These treatments were arranged in randomized complete blocks with 2 to 3 replicates. The single herbicides evaluated in this report are shown in Table 1.

Table 1.—Single herbicides evaluated under preplant conditions in the spring and summer, 1963.

Code name	Chemical name
CP32179	2-bromo-6't-butyl-o-acetotoluidide
DATC	2,3-dichloroallyl diisopropylthiolcarbamate
EPTC	Ethyl *N*, *N*-di-*n*-propylthiocarbamate
Pyrazon	1-phenyl-4-amino-5-chloro-pyridazone-6
PEBC	*n*-propyl ethyl-n-butylthiolcarbamate
R1910	ethyl diisobutylthiolcarbamate
R4572	ethyl-1-hexamethyleneimenecarbothiolate
TD282	dimethyltridecylamine-3,6-endoxyhexahydrophthalic acid

The herbicides were applied preplant at planting time as sprays incorporated to a depth of 1½ to 2 inches. The power-driven incorporator which was used tilled an area 6 inches in width, and the tilled soil was compacted with a press wheel. A variable dosage sprayer, operating at 40 psi, 2.2 mph ground speed, and equipped with Delavan ES-4 nozzle tips, was used. The sprayer gave a half-dosage distance of 25 feet. Spray output under constant rate conditions measured 14.3 gpa. The initial rates of active ingredient varied, depending on the chemical, and these rates ranged from 4 to 16 pounds per acre. The plot size was 44 inches by 125 feet, with the herbicides applied in 7-inch bands on two rows spaced 22 inches apart. The commercial monogerm sugar beet seed used, with variety location dependent, germinated from 80 to 85%. The seed was planted at the rate of 6 seeds per foot at the 1-inch soil depth. Soil textures among locations included sandy loam, silty clay loam, and clay loam, and these soils were of high fertility.

The experiments were conducted under natural precipitation conditions supplemented with surface irrigation water. Surface irrigation was used to establish beets and weeds at 3 locations in the spring and on July 17 at Windsor. At other locations, precipitation was sufficient to maintain the plots without supplemental water until plant counts were made. When the herbicides were applied, soil temperatures at the 2-inch depth averaged 56°F in the spring and 79°F in the summer. The spring soil temperature ranged from 44 to 64°F, while the temperature range at application in the summer was from 72 to 86°F. Wind conditions were calm to moderately windy.

Weed seedings were made, at a shallow depth prior to application of the herbicides, to insure the presence of weeds in the test areas. The experimental weed seed and synthetic weed stands

contained pigweed, *Amaranthus retroflexus;* kochia, *Kochia scoparia;* and Setaria millet, *Setaria italica,* among other species. At some locations, volunteer lambsquarters, *Chenopodium album;* green foxtail, *Setaria viridis;* yellow foxtail, *Setaria glauca;* and barnyardgrass, *Echinochloa crusgalli,* were present in minor percentages while volunteer black nightshade, *Solanum nigrum,* presented major infestations. The ratio of broadleaved weeds to grasses in the untreated controls, as determined by plant counts, ranged from 73:27 to 51:49 among trials. Weed population densities in the check plots ranged from 26 to 100 weeds per square foot and sugar beets had emerged densities ranging from 1.3 to 3.7 plants per linear foot of row.

Weed and beet seedling counts were taken, within a wire rectangle which measured 4 by 36 inches, as a measure of treatment effectiveness. The counts were made at a place in each row estimated to have the greatest weed control with the least injury to seedling beets, and the place was recorded as optimum. Border effects were eliminated by placing the quadrate at equidistant intervals to each side of the beet row. In addition, a retardation estimate was made on beets. These observations were made from May 16 to May 28, on July 1 and 2 and on August 13 for the spring, June 13, and July 17 experiments, respectively. The optimum data were recorded and calculated as the percentages of the untreated control of single or total species. In this study, the average weed control percentages of herbicides showing less than 60% control remain unreported except standard chemicals. While, emerged weed seedling densities of less than 2 per square foot in the untreated checks were composited and reported as the percentage control of other broadleaved weeds.

No attempt was made to adapt statistics to the analysis of variable dosage results.

Results and Discussion

Spring results

The average weed control percentages ranged from 50 to 75 when preplant herbicides were applied in the spring (Table 2).

Specific comparisons showed that the thiolcarbamates, R1910 and EPTC, gave promising control of pigweed and foxtail but insignificant control of kochia which had been shown earlier (8). Likewise (8), in the absence of wild oats, the standard herbicide, PEBC + DATC, gave 14 points more broadleaved weed control than the percentage control produced by PEBC applied alone (Table 2).

Table 2.—Average effects of various preplant herbicides at the optimum response, spring experiments at 6 locations. Treated March 27 through April 20.

Herbicide[3]	% of Check		Percent of Control[4]					
	Beet Stunting	Beet Stand	Pig-weed	Kochia	Other Brdlv.	All Brdlv.	Fox-tail	Average
TD282 (12)	13	103	70	77	72	69	81	75
R1910 (15)	19	109	92	48	69	69	88	74
Pyrazon + CP32179 (13), 3:1	16	93	87	57	64	71	83	73
Pyrazon + EPTC (13), 3:1	17	102	86	42	65	66	88	70
Pyrazon (11)	11	104	83	69	79	75	46	69
PEBC + DATC (27), 2:1	18	102	77	39	81	65	75	68
EPTC (16)	15	99	79	40	72	64	79	67
R4572 (16)	21	92	79	51	65	67	73	67
CP32179 (19)	11	101	85	40	51	61	86	65
Pyrazon + CP32179 (10) 1:1	18	99	71	41	59	54	91	65
Pyrazon + DATC (11), 3:1	9	104	70	48	73	62	64	64
PEBC (39)	12	97	60	29	57	44	71	54
PEBC + EPTC (26), 4:1	13	106	60	27	52	45	63	50

[3] Number of observations shown in parenthesis followed by combination ratio of active.
[4] Weed densities in the untreated controls averaged: pigweed, 14.5; kochia, 10.5; other broadleaved weeds 5.9; and foxtail, 18.4 per sq ft. The emerged beet seedlings averaged 3.7 per linear ft of row. Data for foxtail from 4 locations only, all broadleaves omitted from total species control or average.

The data gave evidence that the herbicides evaluated had three average intensities of effectiveness, namely, 74, 67 and 52% control (Table 2). Therefore, computations showed that the average difference between the standard treatment, PEBC + DATC, and the 74% control group, was 6 percentage points among 6 locations (Table 2). While, the difference between the medium group of 67% control and the higher group averaged 7 percentage points. The lowest control group averaged 52% which was 21 and 14 percentage points less than the average of the high and medium groups, respectively (Table 2).

The experimental herbicides gave variable control responses among broadleaved weeds and between broadleaved and grassy weeds. For example, Pyrazon produced 75% control of all broadleaved weeds but ineffective control of foxtail which averaged 46%. The Europeans, Fisher (4) and L'hoste *et al.* (5), showed similar results from preemergence applications of Pyrazon. Conversely, control of foxtail from preplant applications of CP32179 and TD282 ranged from 86 to 81 percentage points while the broadleaved weed control from the two chemicals averaged 65% (Table 2). It is significant to note that TD282 gave the highest control of kochia which averaged 77%, while CP32179 gave 40% control of kochia and Pyrazon, 69%, at the time the observations were made (Table 2).

Although other factors may be responsible, the results showed that Pyrazon, TD282 and CP32179 gave 16 percentage points

more control of pigweed and kochia in coarse than in fine-textured soils when 2 locations for each soil class were compared (Table 3). Foxtail control from the application of chemicals other than CP32179 averaged 10 percentage points less on sandy loam than on clay loam soils. In particular, TD282 was effective in weed control when applied preplant on sandy loam soils.

Table 3.—Average effects of Pyrazon, TD282 and CP32179 at the optimum response, spring experiments at 2 locations each on coarse- and fine-textured soils.

	Percent of control[6]			
Herbicide[5]	Pigweed	Kochia	Foxtail	Average
	Sandy loam soils			
TD282 (4)	95	92	75	87
Pyrazon (4)	92	72	41	68
CP32179 (8)	94	46	87	76
Pyrazon + CP32179 (4) 3:1	99	59	70	76
	Clay loam soils			
TD282 (4)	73	77	86	79
Pyrazon (4)	79	56	51	62
CP32179 (5)	85	28	84	66
Pyrazon + CP32179 (5) 3:1	99	50	96	82

[5] Number of observations in parenthesis followed by combination ratio of active.
[6] Weed densities in the untreated controls averaged for coarse- and fine-textured soils, respectively: Pigweed, 14.3, 12.8; Kochia, 10.5, 10.6; and foxtail, 14.3 and 22.4 per sq ft.

Among the herbicide combinations, the data indicated that Pyrazon + CP32179 at the 3:1 ratio increased the spectrum of control when compared to the controls obtained with the single chemicals of the mixture (Table 2 and 3). For example, computations showed that the broadleaved weed and foxtail control for Pyrazon and CP32179 averaged 68 and 66%, respectively, while the average species control for the mixture was 71 and 83% (Table 2).

Seedling beet retardation from chemical applications ranged from 9 to 21% (Table 2). Stand reduction and crop retardation estimates exceeding 20 percentage points were considered limiting.

Summer results compared to spring

The average percentage control of weeds for the 8 most effective preplant treatments applied in the summer ranged from 87 to 93% (Table 4). The average of this group, 91%, and the percentage control for PEBC + DATC, were 9 percentage points higher than the control obtained from PEBC. The results showed that the difference in control between the highest (TD282) and the lowest (R4572) herbicide was 26 percentage points. This range difference was similar in magnitude to that observed for

Table 4.—Average effects of various preplant herbicides at the optimum response, summer experiments, Windsor, Colorado. Treated June 13 and July 17.

Herbicide[7]	Percent of Check		Percent Control[8]		
	Beet Stunting	Beet Stand	Pigweed	Foxtail	Average
TD282 (6)	9	128	90	96	93
CP32179 + TD282 (6) 1:1	11	138	91	95	93
CP32179 (6)	10	151	91	92	91
PEBC + DATC (6) 2:1	12	108	87	96	91
PEBC + EPTC (6) 4:1	8	127	89	93	91
Pyrazon + EPTC (6) 2:1	6	151	88	94	91
Pyrazon + TD282 (6) 1:1	7	136	92	88	90
Pyrazon (6)	1	133	99	75	87
PEBC (6)	10	114	79	86	82
R4572 (6)	18	92	47	87	67

[7] Number of observations shown in parenthesis followed by combination ratio of active. Each experiment contained 3 replicates.

[8] Weed densities in the untreated controls averaged: Pigweed, 38.5; and foxtail, 27.2 per sq ft.

the spring applied herbicides (Tables 2 and 4). However, the effectiveness of the summer treatments, as measured by percentage control, was 15-20 percentage points higher than in the spring. Similarly, this increased effectiveness was reported for herbicides applied in the summer in 1962 (8). Apparently, these higher control percentages were affected by the summer soil temperatures which averaged 23°F higher than in spring, although the presence of kochia in the weed populations of spring and absence in the summer may have been a factor affecting the results.

Among herbicides and species, Pyrazon produced the least control of foxtail which averaged 75% (Table 4). The control of foxtail by the other herbicides was effective and ranged from 86 to 96%. Nevertheless, Pyrazon gave 29 percentage points more control of foxtail in the summer than in the spring although the control difference between seasons for pigweed was 16 percentage points (Table 2 and 4). The control of pigweed was effective for most herbicides, and this control ranged from 47% for R4572 to 99% for Pyrazon. The combinations, CP32179 + TD282 and Pyrazon + TD282 showed promise, these combinations averaged 93 and 90% control of pigweed plus foxtail, respectively.

Beet seedling injuries from the summer application of herbicides were slight with the exception of R4572 which averaged 18% stunting and 8% reduction in stand as it had in the spring (Tables 2 and 4). Computations showed that the average beet population of the experimentals applied in summer were 21

percentage points higher than those of PEBC and PEBC + DATC which averaged 111%. Stand differences among chemicals were undetected in the spring (Tables 2 and 4).

Summary

Several single herbicides and herbicide combinations were evaluated at 6 field locations to determine their preplant potential for chemical weeding on sugar beets.

The results showed that Pyrazon, TD282 and CP32179 were more effective in weed control than PEBC while PEBC + DATC was more effective than PEBC applied alone. The herbicide combinations Pyrazon + CP32179, Pyrazon + TD282 and CP32179 + TD282 among others gave effective control of certain broadleaved and grassy weeds without undue injury to sugar beet seedlings.

Specific comparisons showed that Pyrazon produced effective broad-leaved weed control, but the chemical was relatively ineffective in the control of grass, while, CP32179 and TD282 gave additional control of grass. TD282 effected superior and EPTC and PEBC gave inferior control of kochia.

The results indicated that CP32179, TD282 and Pyrazon were more effective on light than heavy textured soils.

Herbicides applied under summer conditions gave higher weed control percentages than the same herbicides applied in the spring.

Acknowledgement

The authors wish to express their appreciation on behalf of The Great Western Sugar Company to the following companies for furnishing the herbicides reported in this study: Amchem Products, Inc.; Monsanto Chemical Company; Pennsalt Chemicals Corporation; and Stauffer Chemical Company.

Literature Cited

(1) ALLEY, H. P., E. W. CHAMBERLAIN, C. F. BECKER, and G. L. COSTEL. 1961. Weed control in sugar beets. Wyoming Agr. Expt. Sta., Mimeo Circ. 159.

(2) ASCHEMAN, R. E., R. C. ZIELKE, and E. W. STROUBE. 1961. Herbicides in sugar beets. Res. Rpt. NCWCC 18: 69.

(3) ECKROTH, E. G., E. M. HOLST, and C. E. CORMANY. 1958. Chemical control of annual grasses in sugar beets in Montana, Wyoming, and Colorado. J. Am. Soc. Sugar Beet Technol. 10: 156-164.

(4) FISCHER, A. 1962. 1-phenyl-4-amino-5-chlor-pyridazon-6 (PCA) als ein neues Rüben-herbizid. Weed Res. 2: 177-184.

(5) L'HOSTE, J., H. D'ILLE, A. CASANOVA, and L. A. DURGEOT. 1963. Essais en plein champ de désherbage sélectif des betteraves por le chloro-amino-phenyl-pyridazone (PCA). Weed Res. 3: 52-65.

(6) NELSON, R. T. 1954. Grass control in sugar beet with the herbicides IPC, TCA and DCU. Proc. Am. Soc. Sugar Beet Technol. 8: 130-134.

(7) SEXSMITH, J. J. 1960. Chemical control of wild oats (Avena fatua L.) in sugar beets. J. Am. Soc. Sugar Beet Technol. 11: 268-278.

(8) SULILVAN, E. F., R. L. ABRAMS, and R. R. WOOD. 1963. Weed control in sugar beets by combinations of thiolcarbamate herbicides. Weeds. 11: 258-260.

(9) WICKS, G. A. 1962. Herbicides for control of broadleaf weeds in sugar beets. Res. Rpt. NCWCC 19: 93-94.