Postemergence Weed Control in Sugar Beets Under California Conditions

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Received for publication December 17, 1962

Annual weeds, particularly barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.) and junglerice (*Echinochloa colonum* (L.) Link.) are serious problems in the production of sugar beets in California. The problem continues after the sugar beets have been thinned and the sugar beet foliage has developed to the point that cultivation can no longer be practiced without severe damage to the sugar beet tops. This problem usually occurs from May to October in Central California and from September to March in Southern California.

Preemergence or preplant herbicides have met with considerable success in recent years, but those presently used may last only until the sugar beets are thinned; from this time on weeds must be controlled by cultivation or hand weeding (2)[5]. A number of herbicides has been investigated for use in controlling these late germinating weeds in established sugar beets. Dalapon (2,2-dichloropropionic acid) has been the most successful and most widely used (1, 3). It has been reported to kill annual grasses in sugar beet fields selectively. Although sugar beets do appear to be tolerant to dalapon under some California conditions, yield reductions generally occur when dalapon is applied directly to the foliage of the sugar beet. Some of the injury to sugar beets resulting from applications of dalapon can be avoided by using directed or shielded sprays (5).

Because of the injury generally resulting from applications of dalapon to sugar beets, even from shielded or directed sprays, trials were conducted to find a herbicide that would control these annual weeds when applied postemergence to both the weeds and the sugar beets.

Methods and Materials

Several experiments were conducted to compare the effect of four herbicides on sugar beets and annual weed control over a wide range of environmental conditions in California. A pre-

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liminary screening trial was established to evaluate several herbicides for selective postemergence use in sugar beets. The chemicals were applied as broadcast topical sprays to sugar beets growing in loamy soil. Application was made with a logarithmic dilution sprayer as indicated: sodium salt of dalapon 20 lb/acre to 1¼ lb/acre; disodium salt of endothal (3,6-endoxohexahydrophtalic acid) 24 lb/acre to 1¼ lb/acre; reciprocal combinations of dalapon and endothal (dalapon constant at 3 lb/acre with endothal decreasing from 20 lb/acre to 1¼ lb/acre: endothal constant at 5 lb/acre with dalapon decreasing from 12 lb/acre to ¾ lb/acre); barban (4-chloro-2-butynyl N-(3-chlorophenyl) carbamate) 4 lb/acre to ¼ lb/acre; and DPA (3,4-dichloropropionanilide) 12 lb/acre to ¾ lb/acre.

Some of these herbicides were further tested in small hand plots set up in a randomized block design; three one acre plots and two one-half acre plots were established using a commercial sprayer with shielded nozzles and a leaf-lifter. The materials used were diuron (3-(3,4-dichlorophenyl)-1,1-dimethylurea) at 2, 3, and 4 lb/acre in the small hand plots and 1.6, 2.4, and 3.2 lb/acre in the large one acre plots; IPC (isopropyl N-phenylcarbamate) at 3 and 6 lb/acre; dalapon (sodium salt) at 4 and 8 lb/acre; endothal (disodium salt) at 3 and 6 lb/acre; and a combination of endothal plus dalapon at 3 and 4 lb/acre, respectively. Applications made with the small hand sprayers included both directed and broadcast topical applications while the large commercially applied plots were all directed spray applications. All rates of herbicides are expressed as pounds active ingredient per acre.

Most of the applications were made in 50 gallons of water per acre when the sugar beets were approximately 12 inches tall. Weed growth varied from emerging plants to 12 inches tall. Soil types were predominantly clay loam with the exception of two trials established on a sandy soil. Care was used in the directed applications to avoid spraying the lower leaves of the sugar beet plants, but some of the older, lower leaves received some spray.

Results

Northern California

The initial hand plots in Northern California were established in an area expected to be severely infested with annual weeds, particularly barnyardgrass. The first application was made following a cultivation so the field was free of weeds. This application consisted of diuron and IPC. Following the application, the trial was thoroughly irrigated in order to activate the herbicides.

The beds were subbed completely across until the soil was saturated with moisture. The second application, consisting of endothal, dalapon, and the combination of endothal plus dalapon, was made when the predominant weed, barnyardgrass, had formed its secondary root system. No additional weed control treatments were given the plot area.

Treatments with corresponding yields and weed control for the trial conducted in Northern California are shown in Table 1. The yields and weed control for the plots treated with broadcast topical sprays are not reported here because of the severe injury that resulted from some treatments and the virtual failure of weed control with others. IPC was the only herbicide that did not cause visual stunting of the sugar beets. The combination of endothal plus dalapon showed only minor stunting at harvest time.

Table 1.—Sugar beet yields and percent weed control from directed postemergence herbicide applications in Northern California.

Herbicide	Lb/acre active ingredient	Roots tons/acre	% Weed control[1]	
			Broadleaved	Grass
Diuron	2	23	90	90
	4	17	99	99
IPC	3	16	0	40
	6	22	10	80
Dalapon	4	18	0	90
	8	15	20	95
Endothal	3	18	60	0
	6	19	95	10
Endothal + Dalapon	3 + 4	21	95	90
Check	0	23	0	0
LSD P = .05		4		

[1] Percent weed control was based on a visual estimate with 0% indicating approximately 7 to 9 broadleaved weeds per square foot and 20 to 23 grass weeds per square foot.

Southern California (Hand Plots)

The plots in Southern California reported in Table 2 consisted of diuron applied by hand as a directed spray. The area selected was weed free at the time of application, but was infested with annual weed seeds, primarily canarygrass (*Phalaris canariensis* L.), silversheath knotweed (*Polygonum argyrocoleon* Steud.), sour clover (*Melilotus indica* (L.) All.), spiny sow thistle (*Sonchus asper* (L.) Hill), wild mustard (*Brassica arvensis* (L.) B.S.P.), and nettleleaf goosefoot (*Chenopodium murale* L.).

There were no typical diuron symptoms on the sugar beets at 2 lb/acre of diuron, regardless of soil type. However, there was some leaf burn on the sugar beets receiving 4 lb/acre of diuron on sandy soil. This leaf burn was not typical of diuron

Table 2.—Sugar beet yields and percent weed control from hand applied direct postemergence applications of diuron in Southern California.

Trial	Lb/acre active ingredient	Beets/100 ft row	Roots tons/acre	% weed control[1]	
				Broadleaved	Grass
Experiment #1	1.6	91	19.6	98	99
	3.2	104	21.2	100	100
	0	91	20.9	0	0
Experiment #2	1.6	188	26.7	75	90
	3.2	176	25.0	90	98
	0	195	28.0	0	0
LSD P = 0.5			NS		

[1] Percent weed control was based on a visual estimate with 0% indicating approximately 10 to 12 weeds per square foot in Experiment #1; 12 to 15 weeds per square foot in Experiment #2.

Table 3.—Sugar beet yields and percent weed control from field scale plots under Southern California conditions. Directed lay-by applications of diuron were made using commercial equipment.

Trial	Lb/acre active ingredient	Roots tons/acre	% sucrose	Sucrose (cwts/acre)	% weed control[1]
Location #1	1.6	16.9	14.3	48.4	90
Applied 1-17	3.2	13.4	12.9	34.7	98
Harvested 4-20 & 21	0	16.4	14.1	46.4	0
	0	16.6	14.4	48.0	0
Location #2	1.6	13.6	14.0	38.1	80
Applied 1-9	3.2	11.8	11.8	27.9	95
Harvested 4-28 & 30	0	13.7	13.2	36.2	0
	0	12.5	12.5	31.2	0
Location #3	1.6	25.9	14.7	76.2	95
Applied 1-23	2.4	23.0	15.1	69.5	98
Harvested 4-20	0	24.0	14.7	70.5	0
	0	23.8	15.3	72.9	0
LSD P = .05		2.8			

[1] Percent weed control was based on a visual estimate with 0% indicating approximately 3 to 4 weeds per square foot in Location #1; 10 to 12 weeds per square foot in Location #2; over 50 weeds per square foot in Location #3.

injury on other crops. It appeared to be more like a burn or necrosis resulting from drought or a soil condition of excess salt.

Southern California (½ and 1 Acre Plots)

Additional trials were established to determine if the herbicides could be applied with commercial equipment with satisfactory results. The results of three of these trials using diuron are reported in Table 3. The other two trials using IPC, endothal, and dalapon were not harvested for yield data. However, IPC did show promise, particularly for the control of canarygrass, with no visual injury to the sugar beets.

The beets were dug with a commercial digger and weighed by truck load. Weed control was satisfactory at all rates. Obvious

injury to the sugar beets occurred only at the 3.2 lb/acre rate of diuron on sandy soil (location #1). However, yield data in Table 3 indicate that some injury at the higher rates may have occurred that was not apparent visually.

Discussion

Postemergence weed control has long been recognized as a desirable practice; but to date, no herbicide has all the necessary requirements. Dalapon may be used as a postemergence treatment for the control of annual grasses in some areas. The rate used will depend on the species, stage of growth, environmental conditions, etc. In California, dalapon is suggested for use only as an emergency measure for heavy grass infestations, as it will usually cause temporary stunting of the sugar beet plants. Unsatisfactory results have been experienced in the desert valleys of Southern California.

When properly applied, approximately 4 lb/acre of dalapon are required to control barnyardgrass. The barnyardgrass should not be sprayed until the seedlings produce secondary roots and are growing vigorously. It frequently takes from ten days to two weeks after seedlings first appear before secondary roots develop. Treatment before this time is usually not effective. Treatment after the watergrass has reached the boot stage is likewise not effective. These plants generally are not killed and will produce viable seed. If volunteer barley or wild oats are a problem, higher rates will be required to obtain satisfactory control. These high rates are more likely to injure the sugar beets.

To minimize injury, directed sprays should be used whenever possible, especially if applications are made during periods of high temperature, or when higher rates per acre are applied. If the temperatures are high during application, use directed sprays only, as dalapon is less selective under these conditions and will cause stunting and yellowing of the sugar beet plants.

The combination of endothal plus dalapon provided satisfactory weed control but appeared to cause similar injury symptoms on the sugar beet plants to that caused by dalapon alone, although not as severe. However, the weeds following application showed typical endothal effects except at the low rates of endothal where grass kill was more complete than would be expected from endothal alone.

Injury to the sugar beet plants was questionable with the endothal treatment. While it did not stunt the sugar beets, it did burn some of the foliage. This burning appeared to be the

most severe when application was made to young sugar beet plants during high temperature conditions. Broadleaved weed control was satisfactory, but endothal did not control the grasses.

Further testing of barban and DPA was discontinued because DPA caused mild contact burn to both the sugar beet plants and the weeds at rates of 6 to 12 lb/acre but did not control the weeds. Barban controlled only the oat species but did not visually injure the sugar beets.

IPC showed some promise as a lay-by treatment when applied to weed free sugar beets. It was necessary to activate the herbicide by thorough irrigation. The primary disadvantage of IPC is its relatively short soil residual life (4). By the end of the trial, weeds had started to invade these plots.

Good weed control and no injury to the sugar beets resulted when using 2 lb/acre of diuron. Rates of 3.2 and 4 lb/acre of diuron caused some visual injury to sugar beets on sandy soil. This injury was not evident on heavier soils; however, yield data might indicate a slight reduction at the higher rates. Diuron should be applied as a directed spray to weed free beds and followed by a thorough irrigation. If applied as a broadcast topical spray, serious injury to the sugar beets will result.

A factor to consider in the use of diuron as a lay-by treatment in sugar beets is the long residual life of the herbicide in the soil (6). In one of the trials, sorghum was planted following the sugar beet harvest. Four months had elapsed between treatment and planting. Some stunting of the sorghum seedlings was present in the plots receiving the 1.6 lb/acre rate of diuron. Both stunting and stand reduction were evident in the plots receiving 2.4 lb/acre of diuron, but injury at maturity was not apparent.

Summary and Conclusions

Several trials were conducted to control late season weeds in sugar beets with herbicides applied postemergence to the sugar beets and either pre- or postemergence to the weeds. These results are still experimental and additional work should be governed accordingly.

Dalapon provided some control of grass weeds but caused some stunting and yellowing of the sugar beet plants. This treatment usually causes temporary stunting of the sugar beets and should be used only as a directed spray when possible.

The combination of endothal plus dalapon showed some promise for controlling mixed populations of broadleaved and grass weeds.

Endothal did not control emerged grass weeds satisfactorily but did control the emerged broadleaved weeds.

Diuron showed promise as a lay-by treatment when applied as a directed spray. Rates of 1.6 and 2 lb/acre of diuron gave satisfactory weed control under the conditions of this study without injuring the sugar beets. Consideration should be given to the soil residual life of diuron because of possible injury to succeeding crops.

Acknowledgment

The authors express grateful acknowledgment for the contributions of J. K. Reynolds and F. H. McDiarmid, E. I. du Pont de Nemours and Company for their cooperation in this study.

Literature Cited

(1) ALLEY, H. P., D. W. BOHMONT and H. M. HEPWORTH. 1961. The effects of dalapon on pectic substances and on root growth of sugar beets. J. Am. Soc. Sugar Beet Technol. 11 (5) : 365-375.

(2) BANDEEN, J. D., G. E. JONES, and C. M. SWITZER. 1960. Further studies on the control of weeds in sugar beets with herbicides. J. Am. Soc. Sugar Beet Technol. 11 (2) : 160-163.

(3) BURTCH, L. M. and C. M. CARLSON. 1958. Yield comparisons from chemically and hand-weeded sugar beets under several watergrass conditions in California. J. Am. Soc. Sugar Beet Technol. 10 (6) : 467-477.

(4) FREED, V. H. 1951. Some factors influencing the herbicidal efficacy of isopropyl N-phenylcarbamate. Weeds. 1 (1) : 48-60.

(5) SOUTHWICK, L., J. W. GIBSON, R. N. RAYNOR, and R. L. WARDEN. 1957. The use of dalapon for grass control in sugar beets. J. Am. Soc. Sugar Beet Technol. 9 (4) : 305-312.

(6) WELDON, L. W. and F. L. TIMMONS. 1961. Penetration and persistence of diuron in soil. Weeds. 9 (2) : 195-203.