Weed Control on Sugarbeets: Efficacy of Carbanilate Herbicides and Their Mixtures, 1968-72

E. F. SULLIVAN AND L. K. FAGALA[1]

Received for publication May 11, 1977

Introduction

Promising broadleaf weed control from phenmedipham (methyl m-hydroxy carbanilate m-methylcarbanilate) applications on sugarbeets, *Beta vulgaris* (L.), was reported by several European investigators including Arndt and Kötter (3),[2] Detroux et al. (6), Edwards (9), Holmes (11), and Thomas (18). Weedy grass control was improved by phenmedipham mixtures involving grass killers such as dalapon (2,2-dichloropropionic acid). Phenmedipham was shown to be highly selective when applied at 1.1 kg/ha, and no adverse effect on sugarbeet yield or sugar content occurred.

Primary phenmedipham screening trials in America (17) revealed effective control of kochia, *Kochia scoparia* (L.) *Schad.;* black nightshade, *Solanum nigrum* (L.); and green foxtail, *Setaria viridis* (L.) *Beauv.*, although redroot pigweed, *Amaranthus retroflexus* (L.), was resistant as first shown by Arndt and Kötter (3).

This paper describes a series of progressive trials conducted to determine the relative efficacy of carbanilate herbicides and mixtures for broad-spectrum weed control. It is essential for the sugarbeet industry to quickly adopt effective labor-saving production technology in order to remain competitive and profitable. Postemergence application, particularly after a pre-emergence herbicide, has proven to be effective. The challenge now is to discover how to obtain superior control without prior chemical treatment.

Materials and Methods

These investigations were conducted under farm conditions during 1968-72. Trials were established in the northern Great Plains near Longmont, Greeley, and Ovid, Colorado, and Goodland, Kansas. The Great Plains region is semi-arid with prolonged dry weather occurring during the growing season; therefore, irrigation supplemented natural precipitation each year. Soil and surface

[1]Manager, Crop Establishment and Protection; and former Assistant Agronomist, respectively, Agricultural Research Center, The Great Western Sugar Company, Longmont, Colorado USA.

[2]Numbers in parentheses refer to literature cited.

moisture levels at treatment time varied considerably from year to year, but generally environmental conditions were favorable for post-emergence herbicide activity. Air temperatures at application averaged 23.9° C and ranged from 20 to 27.8° C during the five-year period.

Weed population averaged 50 plants per 30.5 cm^2 in untreated controls, and composition consisted of redroot pigweed; kochia; common lambsquarters, *Chenopodium album* (L.); black nightshade; green foxtail; foxtail millet, *Setaria italica;* and barnyardgrass, *Echinochloa crus-galli* (L.) *Beauv.* Common minor weeds present were shepherdspurse, *Capsella bursa-pastoris* (L.) *Medic;* Russian thistle, *Salsola kali* (L.) *var. tennuifolia* Tausch; and common sunflower, *Helianthus annuus* (L.). Herbicides were applied in the seedling stages; for example, cotyledonous to 2-4 true leaf stage for redroot pigweed and 2-3 leaf stage for grasses, while sugarbeets had the first true leaves elongated at least .635 cm. Application dates ranged from May 6 to 29 on April-planted beets.

All treatments were placed in randomized complete blocks with two or four replications for logarithmic and fixed dosage trials, respectively. Under logarithmic establishment, rates reached half-dosage at 7.16 m in a two-row by 30.48 m plot. A tractor-mounted sprayer was operated at 3.62 km/h at 2.25 kg/cm^2 with ES-4 nozzle tips. In fixed rate plots, plot size measured six rows spaced 55.88 cm apart by 9.12 m. Post-emergence chemicals were applied over-the-row in a 17.78 cm band at 130.9 L/ha when applied logarithmically and 168.3 L/ha at fixed rates.

Chemicals evaluated were dalapon, endothall (7-oxabicyclo [2.2.1] heptane-2,3-dicarboxylic acid), desmedipham (ethyl m-hydroxycarbanilate carbanilate), lenacil (3-cyclohexyl-6, 7-dihydro-1 H-cyclopentapyrimidine-2,4 [3H,5H]-dione), ethofumesate (2,ethoxy-2,3-dihydro-3,3-dimethyl -5-benzofuranol methanesulphonate), phenmedipham; pyrazon (5-amino-4-chloro-2-phenyl-3 [2H]-pyridazinone), and phenmedipham + desmedipham.

Plant counts were made approximately two weeks after herbicide application at a place in each logarithmic row estimated to have the highest percentage weed control with the least crop injury (optimal response), and at systematically selected sites on the four innermost rows of each fixed dosage plot within a quadrat which measured 7.62 cm by 1.22 m. Visual estimates of pre-thinning seedling beet retardation and treatment persistence after row closure were made.

Data from these experiments are reported as percentages of the untreated controls.

Results

Carbanilate herbicides

Phenmedipham (Betanal) responded satisfactorily for control of kochia, common lambsquarters, and black nightshade (Tables 1 and 2). Redroot pigweed was consistently resistant to phenmedipham. Klassen and Guccione (13) in Manitoba showed similar results on redroot pigweed, although Cech (4) in Austria reported favorable control at a 2-4 leaf stage. Grass control and sugarbeet selectivity were within commercial limits when phenmedipham was applied at experimental dosages averaging 1.6-2.7 kg/ha (Tables 1 and 2).

Desmedipham (Betanex) greatly improved redroot pigweed control without impairing control of other susceptible weeds or affecting selectivity when compared to phenmedipham responses (Table 2) (14). Post-emergence control on redroot pigweed is essential in most production areas of North America because of universal infestation and potential of the species to escape commonly used herbicides, including cycloate (S-ethyl N-ethylthiocyclohexanecarbamate) or Ro-Neet.

Phenmedipham mixtures

Post-emergence mixtures, principally TCA (trichloroacetic acid) or dalapon + endothall (15) and pyrazon + dalapon (2, 16), have been successfully used in North America for specialized weeding in sugarbeets since 1953 and 1963, respectively. In practice, both mixtures lack reliable effectiveness — especially on complex weed infestations containing redroot pigweed, kochia, and small-seeded grasses. Therefore, phenmedipham mixtures were evaluated during 1968-72 in an attempt to improve broad-spectrum chemical weeding when post-emergence herbicides were applied alone or after a pre-plant herbicide.

A mixture of phenmedipham + desmedipham, at a 1:1 ratio, increased broad-spectrum weed control primarily by improving redroot pigweed kill (Tables 1 and 2). Field observations revealed that residual control of emerging weeds was absent with this mixture as shown originally for phenmedipham (3, 6, 17).

Among other selective mixtures, phenmedipham + dalapon tended to improve grass and kochia control (Tables 1 and 2). Weed control persistence and chemical reaction time were increased somewhat, as reported in other studies (5, 6, 17). Phenmedipham + endothall gave complementary control of common lambsquarters as the mixture had demonstrated on wild buckwheat, *Polygonum convolvulus* (L.), and Pennsylvania smartweed, *P.*

Table 1.—Percent weed control and sugarbeet injury from carbanilate herbicides and their mixtures applied at fixed dosages, 1968-72.

Treatment and Year	No. of Tests	Avg. Dose kg/ha	Sugarbeet Injury	Sugarbeet Stand	Weed Control* PW	KO	LQ	NS	O	BL	GR	Avg.
				(Scores and seedlings counts as % of controls)								
4-Year Average												
Phenmedipham	27	1.6	16	98	26	75	86	95	65	46	79	63
Phenmedipham + dalapon	7	2.3 + 2.2	31	107	30	87	90	93	74	57	84	70
3-Year Average												
Pyrazon + dalapon	9	4.1 + 2.4	17	102	32	21	58	—	43	28	58	43
Pyrazon + phenmedipham	12	3 + 1.3	9	100	70	39	94	—	64	64	77	71
Pyrazon + desmedipham	3	3.1 + 1.3	7	100	98	67	94	99	91	92	52	72
Phenmedipham + desmedipham	8	1.4	11	89	90	69	97	—	66	79	85	82
2-Year Average												
Phenmedipham + endothall	3	2.2 + 1	28	110	23	66	95	—	61	48	80	64
Phenmedipham + lenacil	4	1.9 + 1.6	29	105	63	77	100	—	70	72	89	81

*Weed species symbols refer to: PW (redroot pigweed); KO (kochia); LQ (common lambsquarters); NS (black nightshade); O (Other broadleaf weeds); BL (Broadleaf weeds); GR (Grasses as a composite); and Avg. (Average).

Table 2.—Percent weed control and sugarbeet injury from carbanilate herbicides and their mixtures applied at logarithmic dosages, 1968-72.

Treatment and Year	No. of Tests	Avg. Dose kg/ha	Sugarbeet Injury	Sugarbeet Stand	Weed Control PW	KO	LQ	NS	O	BL	GR	Avg.
				(Scores and seedling counts as % of controls)								
5-Year Average												
Pyrazon + dalapon	13	4.5 + 2.5	25	105	79	59	80	89	59	74	70	72
Phenmedipham	13	2.7	16	95	51	81	80	92	85	68	79	74
Phenmedipham + dalapon	24	1.8 + 2.2	19	105	49	81	94	93	78	63	86	75
4-Year Average												
Desmedipham	10	2	13	94	85	76	77	90	75	83	74	78
Pyrazon + phenmedipham	9	4.1 + 1.6	16	103	73	79	100	95	76	80	84	82
3-Year Average												
Phenmedipham + endothall	5	2 + 2.4	19	95	62	71	100	98	76	71	88	79
Phenmedipham + lenacil	6	1.9 + 2.1	21	98	69	94	92	97	87	77	85	81
Phenmedipham + desmedipham	12	1.5 + 1.4	14	101	89	86	98	—	80	88	80	84
2-Year Average												
Ethofumesate	4	6.7	13	94	82	40	—	—	44	69	74	72
Ethofumesate + phenmedipham	10	2.7 + 1.1	15	104	73	90	100	99	—	83	94	89

pennsylvanicum (L.), in supplemental trials and field observations. Phenmedipham + lenacil gave 81 percentage points average weed control; however, redroot pigweed control averaged only 66 percent of the untreated (Table 1 and 2). Detroux and co-workers (7), Varbanov and Savov (19), and Eddowes (8), showed that phenmedipham + lenacil had better activity on weeds than other phenmedipham mixtures. The mixture, pyrazon + phenmedipham, although more effective than pyrazon + dalapon, was also relatively ineffective for redroot pigweed control. In limited comparison, pyrazon + desmedipham effectively controlled redroot pigweed but grass control was adversely affected (Tables 1 and 2).

Ethofumesate (Nortron) revealed some post-emergence activity, which was significantly enhanced by the addition of phenmedipham, except redroot pigweed response was below average at the time plant counts were made (Table 2). Field observations later revealed weed control persistence from ethofumesate + phenmedipham was due to the complementary effect from phenmedipham when foliar-applied and the residual pre-emergence activity from ethofumesate on emerging weeds; subsequently this response was confirmed by workers in England (1). Supplemental data, obtained at four research sites in 1972, showed that ethofumesate + desmedipham applied post-emergence at 1.9 + .9 kg/ha controlled 98 percent of a representative weed infestation without crop damage. Apparently, ethofumesate + phenmedipham mixtures applied post-planting, particularly in humid regions or under overhead irrigation, offer great chemical weeding promise.

Discussion

Under normal field conditions in the northern Great Plains region, phenmedipham + desmedipham can be expected to be more effective for controlling representative weed infestations in sugarbeets than the other post-emergence herbicides evaluated in these studies. Ability to effectively control redroot pigweed and kochia, particularly weeds escaping a pre-plant herbicide, is the main advantage of this mixture. The main disadvantage is lack of residual control. Single species weed stands may be effectively controlled by specialty herbicides, as examplified by desmedipham on redroot pigweed (Table 2) or enhancement of wild oat, *Avena fatua* (L.), control by addition of phenmedipham to dalapon (11) or barban (10, 12). Practical field observations suggest that the phenmedipham + desmedipham mixture should be applied at .84 to 1.4 kg/ha with the 1.1 kg dose being optimal alone or following a preplant herbicide.

These results and field observations suggest that improved post-emergence weed control persistence can be obtained by adding pyrazon in mixtures with carbanilate herbicides at 3.36 + 1.1 kg/ha, respectively. European workers had obtained similar results (7, 8). It seems possible that further improvement of chemical weeding in sugarbeets can be accomplished by post-plant application of an effective foliar-acting herbicide (phenmedipham) with an effective soil-acting herbicide having beneficial persistence (ethofumesate). Such a system would simplify weed control technology and production practices on sugarbeets.

Summary

Carbanilate herbicides and their mixtures were shown to be selectively effective for weed control on sugarbeets. Desmedipham was significantly more effective on redroot pigweed than phenmedipham. Phenmedipham + desmedipham had promising broad-spectrum efficacy without crop damage. Addition of pyrazon or ethofumesate in tank mixture with carbanilate herbicides enhanced weed control and treatment persistence when compared to post-emergence applications of phenmedipham or pyrazon + dalapon.

Acknowledgments

Appreciation is expressed to BASF Wyandotte Corporation, the Dow Chemical Corporation, E. I. DuPont DeNemours & Co., Fisons Corporation, Pennwalt Corporation, and Nor-Am Agricultural Products, Inc., for supplying the herbicides.

References

(1) ANONYMOUS. 1973. Nortran, an experimental residual herbicide for use in sugarbeet and certain other crops. Technical Bulletin, Fisons AgroChemical Division, Saffron Walden, Essex, England, 16p.

(2) ANDERSON, G. W. 1963. Weed control in sugarbeets in 1963. Res. Rpt. National Weed Committee of Canada, Eastern Section, Guelph, p. 38.

(3) ARNDT, F. AND C. KÖTTER. 1968. Selectivity of phenmedipham as a post-emergence herbicide in sugarbeets. Weed Res. 8:259-271.

(4) CECH, O. 1969. Two-years' experience with Betanal in Austria. Shering A. G. Conf., Scientific and practical experience in using phenmedipham for weed control in beets, Berlin, p. 48-50.

(5) COLES, P. G. AND A. E. JONES. 1969. A new post-emergence herbicide for beets. Proc. 22nd N.Z. Weed Pest Control Conf., p. 68-73.

(6) DETROUX, L., M. MARTENS, AND J. M. BELIEN. 1967. Etude du déscherbage en postémergence en culture betteravierè à láide du pyrazon et du phenmedipham. Institut belge pour l'amélioration de la betterave, 1967/IV, Tienen, 23 p.

(7) DETROUX, L., J. M. BELIEN, AND G. LATTEUR. 1969. Au sujet des possibîlîtès d'associer le phenmedipham à d'autres herbicides. Institut belge pour l'amérlioration de la betterave, 1969/I, Tienen, 12 p.

(8) EDDOWES, MAURICE. 1970. A comparison of pre-emergence and post-emergence herbicides for weed control in sugarbeet. Proc. 2nd Int. Meet. Selective Weed Control Beet Crops, Rotterdam, 1, 19-25.

(9) EDWARDS, C. J. 1968. Experiments on the field performance of phenmedipham. Proc. 9th Brit. Weed Control Conf., p. 575-579.

(10) GRIFFITHS, W. 1970. Mixtures of phenmedipham and barban for control of *Avena fatua* and other weeds in sugarbeet. Proc. 2nd Int. Meet. Selective Weed Control Beet Crops, Rotterdam, 1, 27-31.

(11) HOLMES, H. M. 1969. Observations on the herbicidal properties of phenmedipham under British conditions. Schering A. G. Conf., Scientific and practical experience in using phenmedipham for weed control in beets, Berlin, p. 33-34.

(12) KAMPE, W. 1969. Tank mixture of Betanal with wild oat, *Avena futua,* herbicides for application of sugarbeets. Schering A. G. Conf., Scientific and practical experience in using phenmedipham for weed control in beets, Berlin, p. 56-57.

(13) KLASSEN, M. AND G. GUCCIONE. 1971. Evaluation of herbicides for weed control in Manitoba. J. Am. Soc. Sugar Beet Technol. 16:552-560.

(14) NORRIS, R. F., R. A. LARDELLI, F. R. KEGEL, AND J. BRICKEY. 1973. Timing of post-emergence herbicide treatments in sugarbeets. Res. Rpt. West. Soc. Weed Sci., Spokane, p. 155-156.

(15) REEVE, PERC A. 1953. Results from the use of TCA and endothall for weed control in sugarbeets. Proc. Am. Soc. Sugarbeet Technol. 7:90.

(16) SULLIVAN, E. F., R. R. WOOD, R. L. ABRAMS, AND S. G. WALTER. 1963. Pre-plant and post-emergence chemical weeding in sugarbeets, 1963. Res. Rpt. No. Central Weed Control Conf., 20:68-75.

(17) SULLIVAN, E. F., P. J. DECKER, AND T. L. DOLLERSCHELL. 1968. Phenmedipham weed control responses in sugarbeets. Proc. No. Central Weed Control Conf., 25:68-74.

(18) THOMAS, T. M. 1968. Weed control in sugarbeet with phenmedipham. Proc. 9th Brit. Weed Control Conf., p. 568-574.

(19) VARBANOV, V. AND N. SAVOV. 1971. The investigation of some herbicides with regard to weed control in sugarbeet fields. Rastenievod Nauki 8:143-152.