Weed Control on Sugarbeets: Efficacy of Preplant Nortron + Hoelon and Other Mixtures 1975-77*

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INTRODUCTION

Researchers discovered in the sixties that among first generation herbicides, mixtures of Tillam (pebulate) + Avadex (diallate) (7, 32) or Pyramin (pyrazon) + TCA (1, 6, 10, 26) controlled weeds more effectively than did single herbicides. Later, certain postemergence herbicides, such as, Pyramin + Betanal (phenmedipham) (6, 11, 19) and Betanal + Betanex (desmedipham) (18, 22, 34) were found to improve broad-spectrum weed control, particularly when they were used in sequence with a soil-applied herbicide. Evans in Utah (16) and Schweizer in Colorado (27) showed that the Betanal + Betanex mixture was more effective than only Betanal for broad-spectrum weed kill, and particularly for control of redroot pigweed, *Amaranthus retroflexus* L. Moreover, sugarbeets were more sensitive to carbanilates (Betanal + Betanex) at the cotylendonous stage than at 4-6 leaf stage (28).

More recent studies indicate that Nortron (ethofumesate) mixtures, namely, Nortron + Ro-Neet (cycloate) (3, 8, 17, 25, 34) applied preplant, and Nortron + carbanilate herbicides (22, 24, 34) applied postemergence, are very effective and often synergistic (14).

The postemergence mixtures may cause increased crop injury depending on dosages, growth stages and environmental conditions (15, 24). Europeans also report excellent

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efficacy from the Nortron + carbanilate mixture (11, 12, 18), and Dexter, of North Dakota, (9) reported that Nortron + Betanex gave excellent control of prostrate pigweed, *Amaranthus blitoides* S. Wats., and common lambsquarters, *Chenopodium album* L.

In Canada, Sexsmith (30) inferred that Kochia, *Kochia scoparia* (L.) Schrad., control was improved by Nortron + Ro-Neet, while in France, (25) the mixture gave very little crop injury. Frequently, a 1.1 + 1.1 kg/ha application Nortron + Ro-Neet produces greater efficacy than 2.2 kg/ha of each chemical applied singly.

The purpose of this paper is to present results from preplant applications of Nortron + Hoelon (diclofop) during 1975-77 in an attempt to advance the concept that chemical mixtures can be developed which enhance lethal activity on weeds while promoting crop vigor and yield. It is reasonable to speculate that such mixtures will permit planting to stand, eliminate cultivation, and complete machine production of the sugarbeet crop.

MATERIALS AND METHODS

Trials were established under commercial production conditions during the springs of 1975-77 in Colorado, Kansas, Montana, Nebraska, and Wyoming. This central high plains and inter-mountain region is semi-arid with prolonged dry weather during crop development, thus surface irrigation has to supplement natural precipitation each year. Although soil and surface moisture varied considerably each year, conditions were quite favorable for preplant chemical activity and plant growth. April establishment soil temperatures at the 5 cm depth, averaged 16.7°C, and maximum-minimum ambient temperatures ranged from 17.2-2.2°C for the three-year period. Soil textures varied among research sites, and consisted of loam, sandy clay loam, silt loam, and clay soils. Soil pH levels ranged from 7.3-8.1, averaging 7.6; and organic matter percentages ranged from 0.9 to 2.8 percent, averaging 1.6. Additional weed seed were sown in these soils each year in a 17.8 cm band simultaneously with crop planting and chemical application. Major weeds that emerged in the untreated controls were redroot pigweed; kochia; green foxtail, *Setaria viridis* L. Beauv.; and foxtail millet, *S. italaca*. Primary volunteer weeds were common lambsquarters; black nightshade, *Solanum nigrum* L.; shepherdspurse, *Capsella bursapastoris* L. Medic; wild buckwheat, *Polygonum convolvulus* L.; common purslane, *Portulaca oleracea* L.; and barnyardgrass, *Echinochloa crus-galli* [L] Beauv. Weed densities averaged 247 plants per sq m with a botanical composition of 50/50 broadleaf and grassy weeds.

Monogerm sugarbeet seed, MONO HY D_2, was sown at 4 seeds per 30.5 cm of row and at 2.5 cm soil depth.

Herbicides were incorporated at the 3.8 cm soil depth with a power tiller simultaneously with crop planting which occurred in early to late April each year. Applications were made at constant and logarithmic dosages in a 17.8 cm band at 132 l/ha. Under logarithmic conditions, the plots were 2 rows by 30.5 m and the original dosage within the row was decreased 50 percent each time the tractor traveled 7.16 m. A tractor-mounted sprayer was operated at 3.62 km/h at 2.25 kg/cm^2 with LE-2 nozzle tips. In constant rate plots, plot size measured six rows spaced 56 cm apart by 9.12 m.

Chemicals evaluated alone and in mixtures were Antor (diethatylethyl), Avadex, Hoelon, Nortron, Pyramin and Ro-Neet.

Field constant dosages ranged mainly from 1.7 to 3.4 for Nortron and Hoelon alone and 1.7 + 1.1 to 3.4 + 2.2 kg/ha for the mixture, respectively. The maximum initial logarithmic dosages were 9 kg/ha for Nortron and Hoelon alone and in mixtures.

Treatments in the logarithmic trials were replicated twice and those in the constant dosage trials four times in randomized complete block designs. Plant counts were made approximately five weeks after soil application. Observations were taken in each logarithmic row at a place estimated to have the highest percentage weed control with the least crop injury (optimal response), and on the four innermost rows of each constant-rate plot within a quadrat which measured 7.6 cm by 1.2 m. Visual estimates of prethinning seedling beet retardation and herbicide persistence in the soil after row closure were made.

Weed control and crop selectivity data from these experiments were subjected to computer analysis and the results are reported as percentages of the untreated controls. Harvest data on root yield and percentage sugar and purity of the roots also are given.

RESULTS AND DISCUSSION

Single Herbicides

Nortron (ethofumesate) when soil-applied has effectively controlled weeds in sugarbeets over a wide range of soils and climatic conditions, including humid regions of Europe (12, 20, 38) and semi-arid regions in North America (22, 23, 30). Kochia and Russian thistle, *Salsola kali* L. var. tenuifolia Tausch, were controlled (31), as well as volunteer small grains (13). Early work by Great Western researchers had established efficacy on redroot pigweed, kochia, Russian thistle, black nightshade, foxtail spp. and barnyardgrass under surface irrigation (33), and subsequent results from later trials are substantiative (Table 1).

Calculations indicate that approximately 87 percentage points broad-spectrum weed control can be expected from 2.5 kg/ha (2.25 lb/A) dose of Nortron (Table 1). Results from trials conducted under constant and logarithmic rate establishments were similar. When results from 114 constant dosage trials were averaged for 1970-77 over a five-

Table 1. Percent weed control and sugarbeet injury from Nortron and Hoelon applied preplant at constant and logarithmic dosages, 1970-77.

Treatment	No. of Trials	Avg. Dose kg/ha	Sugarbeet[a] Injury	Sugarbeet[a] Stand	Weed Control Pigweed	Weed Control Kochia	Weed Control Brdlv.	Weed Control Grass	Weed Control Total
				Constant Dosage					
Nortron	13	1.7	9	104	90	72	79	90	81
	29	2.2	9	104	92	74	82	92	85
	13	2.8	11	100	98	83	88	95	89
	40	3.4	14	98	97	89	89	94	91
	19	3.9-4.5	13	97	98	86	92	98	93
				Log Dosage					
	36	2.5	13	106	97	70	83	97	89
				Constant Dosage					
Hoelon[b]	5	1.7	0	103	--	--	--	87	--
	3	2.2	3	108	--	--	--	95	--
	2	3.4	3	96	--	--	--	100	--
				Log Dosage					
	13	3.1	9	108	--	--	--	98	--

[a]Injury scale, 0 equals no retardation and 100 equals kill.

[b]Average constant dosage 1975-77 and log dosage 1973-77.

state area, Nortron gave 88 percent total weed control (dosage range 1.7-4.5 kg/ha). Extrapolation reveals that a dosage range of 2.2-3.4 kg/ha (2-3 lb/A) was optimal for prevalent soil textures. Redroot pigweed and foxtail sensitivities to Nortron averaged 90-98 percent; whereas, kochia was less sensitive with greater control at dosages above 2.2 kg/ha. Crop tolerance remained well within commercial limits for all dosages evaluated (Table 1).

Hoelon (diclofop) soil-applied results are given in Table 1. Although discrete dosage responses are limiting, we can expect that a dosage range of 1.7-3.4 kg/ha will control 90-100 percent of grassy weeds, with little or no crop injury. Concurrent field observations show that equivalent annual grass control can be obtained from Hoelon soil applications ranging from 1.7-2.2 kg/ha.

Confirming results demonstrate that Hoelon soil-or foliar-applied, not only controls wild oats, *Avena fatua* L., and weed millets excellently (5, 21); but also giant foxtail, *S. faberi* Herrm, and volunteer corn (2), and other foxtails (36).

Nortron + Hoelon Mixture

Since Nortron and Hoelon, applied singly, controlled many annual weeds in sugarbeets, it was logical to evaluate them in preplant mixtures (35). Results from early preliminary field trials at the Great Western Agricultural Research Center revealed that this mixture should be effective (37). Additional field studies from 1975-77 substantiated that this mixture was effective (Table 2).

Computations reveal that total weed control responses for the mixture and for Nortron were similar at Nortron dosages from 2-3.4 kg/ha and those responses averaged 90 percent (Table 2). Apparently, the mixture ratio had little affect on response, although weed killing activity increased somewhat with increasing Nortron dosage.

Table 2. Percent weed control and sugarbeet injury from Nortron, Hoelon and mixture applied preplant at constant and logarithmic dosages, 1975-77.

Treatment	No. of Trials	Avg. Dose kg/ha	Sugarbeet Injury	Sugarbeet Stand	Weed Control Pigweed	Weed Control Kochia	Weed Control Brdlv.	Weed Control Grass	Weed Control Total
				Constant Dosage					
Nortron	16	2.2	11	102	92	86	87	90	86
	11	2.8	10	101	99	85	91	97	93
	30	3.4	15	97	98	93	93	94	92
Hoelon	5	1.7	0	103	--	--	--	87	--
	3	2.2	3	108	--	--	--	95	--
Nortron + Hoelon	8	2+1.1	11	100	93	98	86	95	86
	8	2.5+2	4	97	91	98	86	93	89
	10	3.4+2.2	9	98	92	94	89	97	92
				Log Dosage					
Nortron	14	2.3	14	104	99	75	90	96	93
Hoelon	9	3.5	7	112	--	--	--	99	--
Nortron + Hoelon	8	2.1+2.1	8	111	97	83	88	100	94

Specific results from average computations of dosages indicate that kochia control was improved 8 percent by tank-mixing Hoelon with Nortron. Nortron alone averaged 85 percent kochia control. Redroot pigweed control was slightly less (4 percent) for the mixture than for Nortron (97 percent). Grass control remained the same for all preplant herbicides (94-96 percent) (Table 2).

It is worthy of note that crop injury from the mixture was reduced particularly at the 2.5 + 2 kg/ha dose when compared to Nortron alone. Visual observations later on indicated an antidotal effect from Hoelon addition which was more pronounced at the 2.2 kg/ha dose and after the crop was thinned. Moreover, the effective field dosages for the mixture on different soil textures were indicated as follows: light soils, 1.7-2 + 1.1; medium soils, 2.2-2.5 + 1.7-2; and heavy textured soils, 2.8-3.4 + 2.2 kg/ha for Nortron + Hoelon, respectively.

Results from single chemicals during 1975-77 period were similar to those observed during 1970-77 (Tables 1 and 2).

Other Preplant Mixtures

Results obtained from 26-29 trials established during 1975-77, show nearly complete control of weeds from mixtures of Nortron with Ro-Neet or Antor (97 percent); whereas, Nortron + Hoelon applied at an average dose of 2.7 + 1.8 kg/ha had somewhat less efficacy (89 percent) at the time ratings were made. Nevertheless, crop injury at thinning was 50 percent less for Nortron + Hoelon when compared to Nortron + Ro-Neet or Antor mixtures, although crop selectivity for all mixtures remained well within commercial limits (Table 3). Ro-Neet + Hoelon applied at 2.7 + 1.7 kg/ha was significantly less effective on all weed species (80 percent) than the control obtained with other mixtures.

Log and constant dosage trial results were similar except kochia control was less with the Nortron + Antor mixture

Table 3. Percent weed control and sugarbeet injury from preplant mixtures applied at constant and logarithmic dosages, 1975-77.

Treatment	No. of Trials	Avg. Dose kg/ha	Sugarbeet Injury	Sugarbeet Stand	Weed Control Pigweed	Weed Control Kochia	Weed Control Brdlv.	Weed Control Grass	Weed Control Total
				Constant Dosage					
Nortron + Ro-Neet	29	2.2	15	96	98	97	97	98	97
Nortron + Antor	28	2.3+2.3	16	98	97	96	95	99	97
Nortron + Hoelon	26	2.7+1.8	8	98	92	96	87	95	89
Ro-Neet + Hoelon	11	2.7+1.7	4	103	75	48	73	86	80
				Log Dosage					
Nortron + Ro-Neet	8	1.5+1.5	15	103	100	89	94	98	96
Nortron + Antor	8	1.9+1.9	17	102	95	78	88	97	92

established under log screening conditions in Colorado, Kansas and Nebraska (Table 3).

Yield and Quality Responses

Comparisons were made to determine the affect Nortron + Hoelon had on yield, since the herbicide mixture exhibited excellent crop safety. Results from 1976-77 are shown in Tables 4 and 5.

The tank-mix especially at the 3.4 + 2.2 kg/ha dose, tended to increase tonnage, expressed as metric tons/ha, when compared to Nortron only (Table 4). Weeds were controlled similarly at thinning with Nortron and the Nortron + Hoelon mixture at the 3.4 kg/ha dose (Table 2). Additional visual observations after crop thinning revealed less crop suppression and more residual chemical weeding from the mixture which may account for the increase in root yield. Blair et al. (4) have reviewed beneficial antidotal effects of herbicide mixtures on crop production.

Effects on root quality (sugar and purity) were absent except for an apparent 0.3 percent increase in purity at the 1.7 + 1.1 kg/ha dose (Table 4). Those quality results have been separated by dosage and soil conditions and these are given in Table 5.

As shown in Table 5, soils sampled were light (loam) to heavy (clay loam) textured. For comparative purposes, responses are related to soil textural class. Overdosages occurred by design on both soil classes, but the dosage of 3.4 + 2.2 kg/ha was particularly higher on the Nebraska site because of the lighter textured soil. The Nebraska overdosage appeared to reduce root yield, quality and recoverable sugar when these data were compared to responses from the 1.7 + 1.1 kg/ha dose. At the Colorado site, the overdosage appeared to increase recoverable sugar and quality, but it reduced yield. In general, these trends were reversed from those obtained in Nebraska which indi-

Table 4. Sugarbeet yield and quality responses from preplant Nortron and Nortron + Hoelon, 1976-77[c].

Treatment	No. of Trials	Avg. Dose kg/ha	Recoverable Sugar kg/ha	Yield T/ha	% Sugar	% Purity
Nortron	5	3.4	6938	49.0	16.6	92.9
Nortron + Hoelon	5	1.7+1.1	7002	49.7	16.5	93.2
Nortron + Hoelon	5	3.4+2.2	7079	50.2	16.5	92.9
Control		0	6491	45.7	16.6	92.9
L.S.D. (P.05)			N.S.	N.S.	N.S.	N.S.
C.V. (%)			10.8	10.9	1.2	0.9

[c]Average from trials conducted in Colorado, Nebraska and Wyoming.

Table 5. Sugarbeet yield and quality responses from preplant Nortron + Hoelon at two sites, 1976-77.

Site Soil Texture (OM%, pH)	No. of Trials	Avg. Dose kg/ha	Recoverable Sugar kg/ha	Yield T/ha	% Sugar	% Purity
Colorado - Clay Loam	2	1.7+1.1	8720	63.2	16.4	92.6
(2.1%, 7.8)		3.4+2.2	8932	62.6	16.7	93.4
Nebraska - Loam	2	1.7+1.1	6122	44.1	15.8	93.7
(2%, 7.3)		3.4+2.2	5858	43.8	15.6	92.5
Colorado Control		0	8474	59.7	16.6	93.1
L.S.D. (P.05)			N.S.	N.S.	N.S.	N.S.
C.V. (%)			8.6	9.2	1.2	0.7
Nebraska Control		0	5625	41.0	15.9	92.8
L.S.D. (P.05)			N.S.	N.S.	N.S.	N.S.
C.V. (%)			10.7	10.4	1.2	1.3

cates less herbicide efficacy on sugarbeet production from the lower dosage, even though the 3.4 + 2.2 kg/ha dose was considered somewhat too high for the soil textural class (Table 5).

These results tend to suggest that dosage selection dependent on soil texture is as important with safe herbicides like Nortron + Hoelon as with more phytotoxic sugarbeet herbicides. Schweizer (29) reported very effective performance results from Nortron + Hoelon applied preplant at 2.2 + 1.7 kg/ha followed by Betanal + Betanex applied postemergence at 0.56 + 0.56 kg/ha, respectively. Production was substantially improved from this sequence.

SUMMARY AND CONCLUSIONS

Progressive studies on chemical weeding systems during 1975-77 indicate that Hoelon, Nortron and their mixtures are very effective preplant herbicides for the central high plains and intermountain sugarbeet region. Hoelon gave nearly complete control of annual grassy weeds. Furthermore, this grass herbicide improved crop selectivity and broad-spectrum weed kill in mixtures with Nortron. Visual observations after row closure and data interpretation demonstrate that the mixture may improve residual weed control and crop production potential.

These studies suggest that Nortron + Hoelon, among other mixtures, offer considerable promise for future use on sugarbeets. Dosage ranges for Nortron + Hoelon were indicated as follows: light soils, 1.7-2 + 1.1; medium soils, 2.2-2.5 + 1.7-2; and heavy textured soils, 2.8-3.4 + 2.2 kg/ha, respectively.

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