Economics of Weed Management Systems in Sugar Beet

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Abstract
Irrigated field studies were conducted at the Research and Extension Centers at Torrington and Powell, Wyoming in 2004 to evaluate weed control and economic returns with conventional weed management systems in sugar beet. Preplant incorporated (PPI) ethofumesate and postemergence (POST) standard program applications were very effective in controlling weeds under high weed pressures. Increasing the number of POST applications of both the standard and microrate program resulted in better weed control at high weed densities. Sugar beet yields were different among treatments and were generally quite closely related to weed control. Standard and microrate treatments applied three and four times respectively resulted in higher net returns than two or three applications. Preplant incorporated ethofumesate produced higher net returns than treatments that had no preplant applications. Hand hoeing after herbicide applications resulted in better yields and net economic returns under high weed pressure.

INTRODUCTION

Sugar beet (*Beta vulgaris*) is the second major cash crop in Wyoming contributing an average income of $50 million to the state's economy annually (Wyoming Agricultural Statistics, 2000). Sugar beet is widely grown in the Big Horn Basin and North Platte River Valley of Wyoming.

Sugar beet are very sensitive to weed competition from the early stages of growth and requires high herbicide inputs under standard husbandry conditions (Scott and Wilcockson, 1976). This results from late canopy closure and the low plant height of the crop, therefore weeds need to be controlled completely until the eight-leaf stage to avoid significant yield losses (Wicks and Wilson, 1983).

Sugar beet producers presently use a combination of chemical, mechanical and manual weed control methods. Herbicide programs in sugar beet consist of either sequential preplant or postemergence applications of herbicides or multiple postemergence applications of herbicide combinations (Dexter et al. 1997). With the increasing cost associated with contract hand labor, producers are relying more on herbicides and cultivation for weed control in sugar beet. However, hand labor still remains an important tool in sugar beet weed control as it is often used to remove weeds that escape chemical control.

The objective of this research was to evaluate several herbicide programs for weed control in sugar beet and determine the most economical program in 38, 56 and 76 cm row spacing with or without manual labor.

MATERIALS AND METHODS

Field experiments were conducted in 2004 at the Torrington Research and Extension Center (TREC) and the Powell Research and Extension Center (PREC) in Wyoming. Soils at the TREC were a sandy loam (77% sand, 13% silt, 10% clay, 1.1% organic matter and pH of 7.9) and at PREC a clay loam (40% sand, 24% silt, 36% clay, 1.3% organic matter and pH 7.6). Sugar beet cultivar Beta 4546 was planted to stand in

38 and 76 cm row spacing at the TREC site, whereas sugar beet cultivar Treasure was planted to stand in 56 cm row spacing at the PREC. The plots were sprinkler and furrow irrigated at the TREC and PREC sites respectively. The experimental design was a randomized complete block with a split plot arrangement with four replications. Each trial consisted of twenty herbicide treatments plus an untreated check (Table 1). Plots were 3 m wide and 15.2 m long for the 38 and 76 cm row spacing and 2.3 m wide and 15.2 m long for the 56 cm row spacing. Herbicide treatments were applied broadcast with a CO_2 pressurized knapsack sprayer delivering 180 L/ha at a pressure of 276 kPa.

Weed control was assessed by weed species counts on June 4 and June 10, 2004 at the TREC and PREC sites respectfully. Weed populations were determined by counting two randomly selected areas 3 m long in the middle two rows in each plot. Evaluations of the sugar beet population were done at the same time as the weed species counts. The plots were split into two equal halves and half of each hand weeded on June 7, 2004 for the 38 and 76 cm row spacing and June 14, 2004 for the 56 cm row spacing using long handle hoes. The hand hoeing was timed to be included in the economic analysis. The center row in each plot was harvested on October 7 and 8 (38 and 76 cm row spacing), and October 14 (56 cm row spacing), 2004 using a one row sugar beet lifter, weighed, and a sub-sample pulled for quality analysis at the Western Sugar tare laboratory.

For economic comparison variable costs associated with weed management including herbicides, herbicide application and hand labor costs were used. All other factors such as seed, fuel, equipment, land, and cultivation costs were not factored into the analysis. Economic returns were calculated from yield data (Kniss et al. 2004). Gross returns were calculated for each plot on the basis of the Western Sugar grower contract payment schedule. Price per ton was dependent on the sucrose content and the average price of sugar from the payment schedule. Gross returns were calculated with the following formula:

$$R_G = ((Y - \text{tare}) \times \%\ \text{sucrose content})\ P \qquad [1]$$

where

Y = root yield

P = price of sugar in $/kg

Net returns were calculated with the following formula:

$$R_N = R_G - VC \qquad [2]$$

where

VC = variable costs

The herbicide costs were derived from data complied by the University of Nebraska Cooperative Extension (University of Nebraska Cooperative Extension EC03-130-D), herbicide application was based on a rate of $9.88/ha[1] and hand labor costs were determined using a rate of $7.50/hr[2].

Data were analyzed separately by site (38, 56 and 76 cm row spacing) because of differing weed populations. Single degree of freedom orthogonal contrasts were used to

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compare different herbicide programs. All data were analyzed using the Mixed procedure of SAS at the 0.05 level of significance.

RESULTS AND DISCUSSION

Weed Control

38 cm row spacing (TREC). Weeds in the experimental plots included redroot pigweed (*Amaranthus retroflexus* L.), common lambsquarters (*Chenopodium album* L.), and green foxtail (*Setaria viridis* (L.) Beauv.) at densities of 3, 36, and 3 plants/m^2 respectively. The higher numbers of applications of both the standard and micro-rate programs were very effective in controlling of common lambsquarters (Table 2). The standard rate treatments provided better control of common lambsquarters than the micro-rate treatments. Preplant incorporated (PPI) application of ethofumesate increased weed control better than the standard and micro-rate program. The densities of redroot pigweed and green foxtail were low and the only significant difference in their control was in treatments that had ethofumesate.

76 cm row spacing (TREC). Weeds in the experimental plots included common lambsquarters and green foxtail at densities of 13 and 10 plants/m^2. Common lambsquarters and green foxtail control was better in the treatments with preplant incorporated ethofumesate (Table 3).

56 cm row spacing (PREC). The weed density at this site was very low with the redroot pigweed being the only major weed that was observed at a density of 2 plants/m^2. There were no significant differences between the different herbicide treatments with regard to weed control (data not shown).

Sucrose percent, root and extractable sucrose yield

38 cm row spacing (TREC). Sugar beet yield was closely related to weed control (Table 4). Treatments that contained ethofumesate or had more applications of the standard or micro-rate treatment had the highest root and extractable sucrose yields. There were significant differences in sucrose percent between dimethenamid-P (lay-by) treatments and treatments that had no layby application. These results suggest obvious yield benefits from using more applications of the standard and micro-rate program and including preplant herbicides in sugar beet production. Hand hoeing resulted in better root yield and extractable sucrose yield for this study (Table 5).

76 cm row spacing (TREC). The higher applications of standard and micro-rate treatments were not significantly different in root yield from the lower number of applications (Table 6). Differences in root yield, sucrose percent and extractable sucrose yield were observed between the treatments that had ethofumesate versus no ethofumesate. Standard treatments resulted in better root and extractable sucrose yield than the microrate treatments. Hand hoeing resulted in higher root and extractable sucrose yields (Table 4). These differences suggest obvious benefits of hand weeding sugar beet later in the growing season after the normal herbicide treatments (Table 5).

Economics of the weed management

Treatments that provided good weed control in the 38 cm row spacing performed better economically (Table 6). The three standard and four micro-rate applications consistently provided the highest net returns (Table 7). Ethofumesate resulted in greater net returns than treatments with no ethofumesate at all the three study sites; however these differences were only significant in the 76 cm row spacing. There were no differences in net returns between different treatments in the 56 cm row spacing because of the low weed pressure. Under high weed infestations in both the 38 and 76 cm row spacing hand hoeing resulted in greater net returns (Table 8).

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Table 1 Weed control treatment applications rates and timings

Treatment	Herbicides[a]	Rate[b]	Timing[c]
		kg/ha	
Standard rate (x2)	DES + PHEN + ETH	0.28	2 LF
	Triflusulfuron	0.018	2 LF
	DES + PHEN + ETH	0.37	7 D
	Clopyralid	0.105	7 D
Standard rate (x3)	DES + PHEN + ETH	0.28	2 LF
	Triflusulfuron	0.018	2 LF
	DES + PHEN + ETH	0.37	7 D
	Clopyralid	0.105	7 D
	DES + PHEN + ETH	0.37	14 D
Microrate (x3, x4)[g]	DES + PHEN + ETH	0.09	CO, 7 D, 14 D, 21 D
	Triflusulfuron	0.004	CO, 7 D, 14 D, 21 D
	Clopyralid	0.022	CO, 7 D, 14 D, 21 D
	MS	1.0% v/v	CO, 7 D, 14 D, 21 D
Preplant[d]	Ethofumesate	1.1/1.40	PPI
Grass[e]	Clethodim	0.087	7 D, 14 D, 21 D
Layby[f]	Dimethenamid-P	0.807	14 D, 21 D

[a]Abbreviations: DES, desmedipham; PHEN, phenmedipham; ETH, ethofumesate; MS methylated seed oil
[b]All rates are given in ai, MS given in volume/volume
[c]Timing: CO, cotyledon stage of sugar beet; 2 LF, 2 leaf stage of sugar beet; 7 D, 14 D, 21 D, days after the first herbicide treatment
[d]1.1 kg/ha for 38 and 76 cm row spacing; 1.4 kg/ha for 56 cm row spacing
[e]7 D for standard rate applied 2 times; 14 D standard rate applied 3 times and microrate applied 3 times ; 21 D for microrate applied 4 times
[f]14 D for standard treatments, 21 D for microrate treatments
[g]21D for fourth microrate treatment

Table 2 Differences in weed control as influenced by weed control treatments in 38 cm row spacing (TREC)

Comparison	CHEAL % Diff	p>|t|	AMARE % Diff	p>|t|	SETVI % Diff	p>|t|
Standard (x2)v. Standard (x3)	-12.30	0.0009*	-1.65	0.7537	-8.90	0.2601
Microrate (x3) v. Microrate (x4)	-8.50	0.0181*	5.05	0.3386	-7.35	0.3515
Standard v. Microrate	16.05	<.0001*	0.00	1.0000	-1.88	0.7359
Ethofumesate (PPI0 v. No PPI	23.60	<.0001*	15.21	0.0024*	25.19	0.0008*
Dimethenamid-P (Layby) v. No Layby	3.15	0.3281	12.45	0.0116*	7.15	0.3213
Clethodim v. Dimethenamid-P	-5.06	0.2001	-18.69	0.0023*	17.75	0.0471*

*Denotes significance (0.05)

Table 3 Differences in weed control as influenced by weed control treatments in 76 cm row spacing (TREC)

Comparison	CHEAL % Diff	p>|t|	SETVI % Diff	p>|t|
Standard (x2)v. Standard (x3)	3.30	0.4562	5.35	0.0554
Microrate (x3) v. Microrate (x4)	-7.30	0.1025	-4.80	0.0847
Standard v. Microrate	10.50	0.0013*	-0.92	0.6344
Ethofumesate (PPI0 v. No PPI	6.67	0.1023	6.77	0.0089*
Dimethenamid-P (Layby) v. No Layby	0.92	0.8202	2.15	0.3939
Clethodim v. Dimethenamid-P	0.81	0.8693	5.13	0.0993

*Denotes significance (0.05)

Table 4 Differences in root yield, sucrose percent and extractable sucrose yield as influenced by weed control treatments in 38 cm row spacing (TREC)

Comparison	Root yield Mg/ha Diff	p>|t|	Sucrose % Diff	p>|t|	Extractable sucrose % Diff	p>|t|
Standard (x2)v. Standard (x3)	1.68	0.0377*	0.05	0.7961	-1.68	0.0377*
Microrate (x3) v. Microrate (x4)	-2.38	0.0043*	0.19	0.3220	-2.38	0.0043*
Standard v. Microrate	-0.23	0.6855	-0.22	0.1187	-0.23	0.6855
Ethofumesate (PPI0 v. No PPI	0.88	0.2514	-0.31	0.0881	0.88	0.2514
Dimethenamid-P (Layby) v. No Layby	-0.14	0.8526	-0.52	0.0036*	-0.14	0.8526

*Denotes significance (0.05)

Table 5 Root yield, sucrose and extractable sucrose yield as affected by hand weeding (38 cm and 76 cm row spacing, TREC)

Treatment	Root Mg/ha	Sucrose %	Extractable sucrose Mg/ha	Root Mg/ha	Sucrose %	Extractable sucrose Mg/ha
	--------------------38 cm	------------------------		------------------------76 row	------------------------	
Hand weeded	51.94a	15.71a	8.26a	59.36a	16.35a	9.73a
Non-hand weeded	37.87b	15.20a	5.81b	48.09a	16.07a	7.71b

Least square means within a column that are followed by the same letters are not significantly different (0.05)

Table 6 Differences in root yield, sucrose percent and extractable sucrose yield as influenced by weed control treatments in 38 cm row spacing (TREC)

Comparison	Root yield Mg/ha Diff	p>|t|	Sucrose % Diff	p>|t|	Extractable sucrose % Diff	p>|t|
Standard (x2)v. Standard (x3)	-0.29	0.9018	0.17	0.1620	0.05	0.8895
Microrate (x3) v. Microrate (x4)	-0.10	0.9658	-0.08	0.4884	0.03	0.9446
Standard v. Microrate	4.40	0.0102*	-0.08	0.3492	0.65	0.0193*
Ethofumesate (PPI0 v. No PPI	7.83	0.0005*	0.17	0.1214	1.19	0.0010*
Dimethenamid-P (Layby) v. No Layby	4.18	0.0571	0.07	0.5361	0.64	0.0697

*Denotes significance (0.05)

Table 7 Differences in net economic returns as influenced by weed treatments

Comparison	38 cm net returns $ Diff	p>|t|	76 cm net returns $ Diff	p>|t|	56 cm net returns $ Diff	p>|t|
Standard (x2)v. Standard (x3)	1179	0.0084*	113	0.601	363	0.0924
Microrate (x3) v. Microrate (x4)	-1244	0.0063*	23	0.9148	120	0.3597
Standard v. Microrate	-163	0.6007	281	0.0683	-0.4	0.998
Ethofumesate (PPI0 v. No PPI	262	0.5203	603	0.0027*	-26	0.8957
Dimethenamid-P (Layby) v. No Layby	-173	0.6635	380	0.0557	141	0.4724

*Denotes significance (0.05)

Table 8 Net economic returns as affected by hand hoeing

	Net returns $	
Row spacing	Hand hoeing	No hand hoeing
38 cm	4167a	2896b
76 cm	5104a	3987b
56 cm	7475b	7796a

Means followed by the same letter significantly different (0.05)