WEED CONTROL ALTERNATIVES FOR KLAMATH BASIN SUGARBEETS

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Abstract

The cost for weed control in Klamath Basin sugarbeet crops using current chemical or chemical and mechanical combinations represents about 20 percent of variable production costs. Weed control failures result in serious yield reductions or the need to employ expensive hand labor. Recent innovations offer new alternatives for weed control in sugarbeet crops. The insertion of genes for herbicide tolerance has produced varieties with resistance to two low- cost, broad-spectrum herbicides, Roundup and Liberty. Researchers in North Dakota have demonstrated improved herbicide efficacy for low rates of standard herbicides by adding methylated seed oil (MSO), thus reducing the cost of herbicide applications. These studies were initiated in 1999 to evaluate these weed control options under Klamath Basin conditions.

Three separate experiments were conducted. One study evaluated two Roundup resistant varieties at four different Roundup application timings and compared these treatments with an untreated control and a hand-weeded treatment. The varieties Pillar and HM 118 were not different in yield performance. The optimum timing for application of Roundup was at the 5- to 7-leaf stage for Pillar, and at the 2- to 4-leaf stage for HM 118. Yields were not significantly different from yields in the hand-weeded control for the optimum timing treatments.

The second experiment evaluated timing of Liberty applications to the Liberty resistant variety, Beta 2012 LL, contrasted with untreated and hand-weeded controls. Weed control efficacy for Liberty treatments was not as good as in Roundup treatments. All timings of application resulted in significantly lower sugar yield and gross value returns than the hand-weeded control. While later applications of Roundup were slightly superior, early applications of Liberty were more effective for weed control and resulted in slight yield increases compared with 2- to 4-, and 5- to 7- leaf stage applications.

The third study compared the standard variety Bighorn with Roundup resistant Pillar and HM 118, and Liberty resistant Beta 2012 LL under three herbicide combination treatments and an untreated control. The standard herbicide treatment included UpBeet, Stinger, and

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Nortron at standard application rates. Micro-rate treatments included UpBeet, Betamix, and Stinger at reduced rates, in combination with MSO at 1.5 percent. Weed control was similar for all herbicide combinations. Yields of all varieties were depressed slightly by the micro-rate treatments compared with the standard herbicide treatment. This was the result of injury to beets, which was greatest in the Beta 2012 LL variety, and is thought to be due to the MSO. Yield differences among varieties were not significant.

Introduction

Sugarbeets are an important rotation cash crop for the Klamath Basin. Growers are continually looking for improved practices to increase production of high quality sugarbeets. Inadequate weed control continues to be an important factor limiting yields and economic returns. The cost of chemical and mechanical weed control represents 20 percent of variable production costs. Growers must use multiple applications of postemergence herbicides, alone and in combinations, to achieve adequate weed control. Timing applications to coincide with weed seedling vulnerability is essential for optimum efficacy. Windy conditions can force a delay in application and may reduce efficacy. Frost injury may make beet seedlings vulnerable to herbicide injury, resulting in the need to delay herbicide applications. Windy weather and mild frosty injury are common occurrences in the Klamath Basin during May. Growers need other weed control options to improve chances for profitable crop production.

Genetic engineering technology has recently offered a new dimension for weed control in sugarbeets. Genes to provide resistance to the broad spectrum, low cost herbicides, Roundup (glyphosate) and Liberty (glufosinate) have been inserted into several commercially available varieties. This offers the opportunity to use a single, low cost herbicide that is effective for the range of common weed species occurring in the region, and at reduced or no risk of crop injury.

Researchers in North Dakota have developed an additional advance in weed control for sugarbeet crops. The use of methylated seed oil (MSO) in combination with low rates (micro-rates) of herbicides provided good weed control while reducing the cost and amount of pesticide used. The use of MSO and newer postemergence herbicides labeled for use with MSO, allows growers to broadcast applications at the banded rate. This results in nearly a two-thirds reduction in pesticide use and expense. A study to investigate the potential for these new weed control tools was conducted at the Klamath Experiment Station (KES).

Procedures

The study site was previously planted to potatoes in 1998 and spring barley in 1997. The Poe fine sandy loam soil at the site has an organic matter content of about 1.0 percent in the plow layer, a pH of approximately 6.0, and somewhat restricted drainage because of a compacted layer at about 18-inch depth. The field was plowed on April 14. Fertilizer was broadcast at 900 lb / acre of 12-12-12 and incorporated with secondary tillage on April 16. A level seedbed was firmed with a Brillion ring-roller.

Three separate experiments were established to evaluate two Roundup resistant varieties, one Liberty resistant variety, and the use of MSO and micro-rate technology under Klamath Basin conditions. Initially, the three experiments were planted on April 21 with a hand-operated, one-row, Planet-Junior type planter in 22-inch rows. Frost damage during mid-May resulted in the need to replant all trials. Surviving plants were removed with a rod-weeder and reseeding was accomplished on May 24 using a three-row, modified cone planter. Beets were replanted in 24-inch rows with 3.5-inch seed spacing, and approximately 0.5-inch seeding depth. Plants were hand-thinned to a population of approximately 30,000 plants / acre on June 22. Individual plots were three rows, 25 feet long in each experiment.

Irrigation, totaling 18 inches for the season, was applied with solid-set sprinklers arranged in a 40- by 48-foot pattern. A minor flea beetle infestation was controlled with an application of Sevin (carbaryl) at 1.0 lb ai / acre on June 16. Beet tops were removed with a rubber flail immediately before harvest. Beets were lifted with a one-row, tool-bar-mounted lifter and hand-harvested on October 13. In each trial, the harvest area was the center row, 25 feet long. All beets from the center row were counted and weighed. Beet samples of approximately 25 lb / plot were delivered to Betaseed, Inc. in Kimberly, Idaho on October 14. Samples were analyzed for sugar content and impurities at the Betaseed, Inc. laboratory. As tare weights were not determined, a tare loss of 10 percent was applied to all plots to determine beet yield, based on losses observed in the California Beet Growers Association (CBGA) variety trial. Gross crop values were calculated for each plot based on beet yield and price per ton for beets at the observed sugar content, as determined by the Spreckels Sugar Company contract. The price per ton at a net selling price of $24.00 / cwt is determined by the equation:

Price/ton = (3.518 X % Sugar) – 15.4.

All data were statistically analyzed using MSUSTAT software. Least significant differences (LSD) are based on *student's t* at the 5 percent probability level (p=0.05).

Roundup Resistant Study:

The experiment was a split-plot design with varieties Pillar and HM 118 as main-plot treatments and four timings of Roundup application plus hand-weeded and untreated controls as split-plot treatments, assigned randomly in three replications. Roundup Ultra was applied at 0.75 lb ai / acre with a CO_2 backpack sprayer in 20 gpa of solution at 30 psi. Treatments were applied at beet seedling development stages of cotyledon, cotyledon plus one week (two applications at 0.75 lb ai / acre, each), 2- to 4-leaf stage, and 5- to 7-leaf stage. Hand-weeded control plots were weeded on June 10 and later as needed. Plots were visually rated for weed control on July 13.

Liberty Resistant Study:

The Liberty resistant Beta 2012 LL was evaluated at herbicide application times and under hand-weeded and untreated controls as described for the Roundup resistant study. Treatments were arranged in a randomized complete block design with four replications. The Liberty was applied at 0.26 lb ai/acre at cotyledon, cotyledon plus one week (two applications), 2- to 4-leaf stage, and 5- to 7-leaf stage. Hand-weeded control plots were weeded on June 10 and later as needed. Plots were visually rated for weed control on July 13.

Micro-rate Herbicide Study:

The experiment was a split-plot design with the varieties Bighorn, Pillar, HM 118, and Beta 2012 LL as main plot treatments and three herbicide combinations and an untreated control as split-plot treatments arranged randomly in three replications. The standard herbicide treatment included UpBeet (triflusulfuron) at 0.5 oz/acre, Stinger (clopyralid) at 3.0 oz/acre, Nortron (ethofumesate) at 1.3 pt/acre, and a surfactant at 0.25 percent. Micro-rate treatments included UpBeet at 0.25 or 0.33 oz ai/acre, Betamix (phenmedipham + desmedipham) at 0.5 pt/acre, Stinger at 1.3 oz/acre, and methylated seed oil (MSO) at 1.5 percent. An initial application was made on June 10, when beet seedlings were in the cotyledon stage and weed seedlings were in cotyledon to 2-leaf stage. The second applications were made on June 19, when the sugarbeets were in the 2- to 4-leaf stage and weeds were in various growth stages. Plots were visually rated for beet seedling injury on June 25, and weed control and beet injury on July 13.

Results and Discussion

Frequent frosts through mid-May resulted in very slow and uneven emergence of plants and seedling mortality in major frost events, including May 9, May 10, and May 15, when minimum temperatures recorded at the KES weather station were 20^0F or lower. By May 20, stands were less than 25 percent in most plots. The remnants of the April 21 planting were removed with a rod-weeder on May 23. This procedure also eliminated early emerging weeds.

Beet seedling emergence for the May 24 planting was more uniform, occurring within 7 to 10 days. Early development was slowed by unseasonably cool weather. Frosts recorded at KES on June 7 (26^0F), 8 (26^0F), 9 (28^0F), and 10 (31^0F) predisposed beet seedlings to injury from initial herbicide applications on June 10. After an additional frost on July 4 (31^0F), weather conditions remained favorable through the rest of the season.

Roundup Resistant Study:

Pillar and HM 118 did not appear to be injured by Roundup applications. No injury ratings were made in this experiment. Weed control was not significantly different among the herbicide timing treatments. However, there was a trend for later applications providing better control, particularly in the Pillar variety (Table 1). Averaged over both varieties, the two early herbicide applications were significantly less effective than hand weeding, but not different than later applications in weed control rating. The main weed species present were lambsquarter, hairy nightshade, mallow, and redstem filaree. Mallow and redstem filaree were the dominant species that escaped control in the treatments receiving early Roundup applications. While filaree is not very competitive, uncontrolled mallow is a hardy competitor. The untreated control experienced high populations of mallow and nightshade. Beet plants were severely stunted and yields were about 40 percent of yields for the hand-weeded control.

Sugar production and gross crop value were the same for the hand-weeded control and late applications of Roundup. The two early Roundup application treatments experienced about 1,000 lb/acre less sugar production and $170/acre less crop value than late application or hand-weeded treatments. Yield and sugar production was similar for the two varieties. Where weed control was adequate, these varieties produced yields comparable to those observed in the CBGA variety trial.

Liberty Resistant Study:

Liberty did not provide adequate weed control to avoid yield reductions (Table 2). Late applications were significantly less effective in weed control than early applications. Poor control for the early application was probably due partly to late emerging weeds. Application at the 5- to 7-leaf stage was least effective. The weeds were apparently too advanced for control at the application rate used. The double application for cotyledon stage plus one week later, and the application at the 2- to 4-leaf stage were not significantly lower than the hand-weeded control in weed control rating, but yields were significantly reduced for the 2- to 4-leaf stage application. The yield reduction in the untreated control treatment was similar to results observed in the Roundup resistant study.

Micro-rate Herbicide Study:

Standard and micro-rate herbicide treatments were equally effective in providing acceptable weed control in all varieties (Table 3). However, beet seedling injury was noted for all varieties at one or both observation dates. Pillar injury was not evident on June 25, but was recorded on July 13. Beta 2012 LL was more susceptible to injury than HM 118 or Bighorn. Averaged over three herbicide treatments, the June 25 injury ratings were 57, 39, and 33 for Beta 2012 LL, HM 118, and Bighorn, respectively. Injury was significantly greater for the micro-rate treatments than the standard herbicide treatment. The fact that beet seedlings were exposed to frost on four consecutive days before the first herbicide application, was undoubtedly a factor in the high susceptibility to injury. Because of these factors, the standard herbicide treatment produced significantly higher sugar, recoverable sugar, and gross value than either micro-rate treatment or the untreated control.

Summary

The experiments were designed to evaluate new alternatives for weed management in Klamath Basin sugarbeet production. The Roundup resistant varieties Pillar and HM 118 produced yields comparable to commercial varieties under conditions relatively free of weed competition. Roundup Ultra applications at 0.75 lb ai/acre at 2- to 4- or 5- to 7-leaf stages resulted in acceptable weed control with no apparent herbicide injury to either variety. The Liberty resistant variety Beta 2012 LL was subjected to greater weed competition than Pillar or HM 118 in all plots receiving Liberty applications. The Liberty product did not provide good weed control at an application rate of 0.26 lb ai/acre. A double application at cotyledon stage and one week later was not rated more effective than a single application at the 2- to 4-leaf stage, but it did result in a significantly higher beet yield. In the hand-weeded control, Beta 2012 LL produced beet and sugar yields only slightly less than average yields in the CBGA variety trial.

Under the conditions experienced, micro-rate herbicide applications using standard products at low application rates in combination with methylated seed oil, resulted in seedling injury which reduced yields in four varieties. The standard herbicide treatment also produced some injury in seedlings preconditioned by four consecutive days of frosts. Pillar was less affected by herbicide injury than HM 118 or Beta 2012 LL. The micro-rate treatments provided acceptable weed control in this study.

Weed pressure at the KES site is generally less severe than in many commercial fields in the region. Kochia, wild oats, quackgrass, and other species that are common in the basin do not occur at this site. Results from herbicide studies at KES must be viewed with this limitation in mind.

The commercialization of genetically modified, herbicide-resistant varieties is currently in doubt. Several major users of refined sugar are requiring product free from any genetically modified organisms. Commercial quantities of seed are available for several herbicide-resistant varieties, but their use awaits public acceptance of this new technology. If and when acceptance occurs, the Roundup resistant varieties may have a place in Klamath Basin sugarbeet production. Additional research is needed to further evaluate micro-rate technology under less stressful spring conditions.

Table 1. Effect of weed control treatments on percent weed control and performance of Roundup-resistant sugarbeet varieties Pillar and HM118 at the Klamath Experiment Station, Klamath Falls, OR, 1999.

Variety	Treatment[1]	Population	Weed control	Beet yield	Sugar content	Sugar production	Recoverable sugar	Gross value
		1,000/acre	%	ton/acre	%	lb/acre	lb/acre	$/acre
Pillar	1	34.3	88	18.9	18.8	7090	6750	960
	2	28.5	78	18.1	19.2	7060	6690	963
	3	30.5	93	21.3	19.9	8480	8050	1160
	4	29.0	92	25.5	18.5	9450	8910	1270
	5	31.4	100	23.1	19.5	8960	8470	1220
	6	31.9	0	10.1	18.4	3720	3550	500
HM 118	1	31.4	80	21.7	18.9	8160	7700	1100
	2	27.3	95	20.9	19.7	8190	7680	1120
	3	30.2	97	22.9	19.8	9070	8620	1240
	4	27.6	97	21.0	19.3	8090	7650	1100
	5	29.6	100	23.8	18.6	8830	8330	1190
	6	28.2	0	9.7	18.6	3670	3490	500
Variety main effect:								
Pillar		30.9	75	18.2	19.0	6950	6580	940
HM 118		29.0	78	18.9	19.1	7220	6820	980
CV (%)		6.4	7.6	27.5	5.0	26.6	26.4	26.6
LSD (p = 0.05)		NS[2]	NS	NS	NS	NS	NS	NS
	Treatment effect:							
	1	32.8	84	20.3	18.9	7630	7220	1030
	2	27.9	87	19.5	19.5	7620	7190	1040
	3	30.4	95	22.1	19.9	8780	8330	1200
	4	28.3	95	23.3	18.9	8770	8280	1190
	5	30.5	100	23.4	19.0	8890	8400	1200
	6	30.1	0	9.9	18.5	3700	3520	500
	CV (%)	12.0	13.0	24.3	3.3	23.8	23.7	23.8
	LSD (p = 0.05)	4.3	12.0	5.8	0.8	2170	2040	290

[1]
1. Roundup Ultra @ 0.75 lb ai/acre @ cotyledon stage
2. Roundup Ultra @ 0.75 lb ai/acre @ cotyledon stage + 1 week
3. Roundup Ultra @ 0.75 lb ai/acre @ 2 - 4 leaf stage
4. Roundup Ultra @ 0.75 lb ai/acre @ 5 - 7 leaf stage
5. Hand weeded control
6. Untreated control

[2]NS - not statistically significant at p=0.05

Table 2. Effects of weed control treatments on percent weed control and performance of Liberty-resistant Beta 2012 LL sugarbeet variety at the Klamath Experiment Station, Klamath Falls, OR, 1999.

Variety	Treatment [1]	Population	Weed control	Beet yield	Sugar content	Sugar production	Recoverable sugar	Gross value
		1000/acre	%	ton/acre	%	lb/acre	lb/acre	$/acre
Beta 2012 LL	1	32.5	68	17.1	19.8	6760	6440	930
	2	28.5	80	18.3	19.2	6960	6600	940
	3	26.6	87	14.1	19.5	5500	5220	750
	4	28.1	55	13.3	19.5	5170	4930	700
	5	28.7	100	21.7	20.4	8820	8380	1220
	6	27.9	0	9.8	19.1	3720	3550	500
Mean		28.7	65	15.7	19.6	6160	5850	840
CV (%)		8.6	26.3	15.4	4.0	14.9	14.9	15
LSD (p = 0.05)		NS[2]	26	3.6	NS	1380	1310	190

[1]
1. Liberty @ 0.26 lb ai/acre @ cotyledon stage
2. Liberty @ 0.26 lb ai/acre @ cotyledon stage + 1 week
3. Liberty @ 0.26 lb ai/acre @ 2 - 4 leaf stage
4. Liberty @ 0.26 lb ai/acre @ 5-7 leaf stage
5. Hand weeded control
6. Untreated

[2] Not statistically significant at p=0.05

Table 3. Effect of standard and micro-rate herbicide treatments on weed control, crop injury, and performance of four varieties at the Klamath Experiment Station, Klamath Falls, OR, 1999.

Variety	Treatment[1]	Population	Weed control	Injury 6/25	Injury 7/13	Beet yield	Sugar content	Sugar production	Recoverable sugar	Gross value
		1,000/acre	%	%	%	ton/acre	%	lb/acre	lb/acre	$/acre
HM Bighorn	1	27.3	95	23	0	18.1	19.3	6990	6630	950
	2	27.0	93	42	7	17.6	18.9	6650	6300	900
	3	30.8	92	33	7	15.5	19.3	6020	5700	820
	4	25.5	0	0	0	8.8	18.7	3280	3130	440
Pillar	1	29.6	98	0	10	20.3	19.0	7700	7290	1040
	2	30.5	99	0	3	17.6	19.1	6740	6360	910
	3	30.8	99	0	10	19.0	19.5	7390	7010	1010
	4	24.7	0	0	0	7.8	18.5	2920	2750	390
HM 118	1	23.8	99	23	0	20.0	19.0	7590	7100	1030
	2	28.5	97	37	7	16.0	19.5	6220	5840	850
	3	29.6	97	58	3	17.3	19.5	6750	6350	920
	4	25.5	0	0	0	9.9	18.8	3760	3570	510
Beta 2012 LL	1	29.0	99	40	3	16.8	19.9	6700	6330	920
	2	29.0	97	70	17	13.1	19.9	5200	4930	715
	3	28.2	98	62	10	12.4	19.8	4940	4690	680
	4	26.7	0	0	0	5.2	18.0	1920	1820	260
Variety main effect:										
HM Bighorn		27.6	70	25	4	15.0	19.1	5740	5440	780
Pillar		28.9	74	0	6	16.2	19.0	6190	5850	840
HM 118		26.9	73	30	3	15.8	19.2	6080	5720	830
Beta 2012 LL		28.2	74	43	8	11.9	19.4	4690	4440	640
CV (%)		9.5	2.5	37.0	107.2	32.4	3.5	32.3	32.8	32.3
LSD (*p = 0.05)*		NS[2]	1.5	8.0	NS	NS	NS	NS	NS	NS
	Treatment effect									
	1	27.4	98	22	3	18.8	19.3	7240	6840	980
	2	28.7	97	37	9	16.1	19.3	6200	5860	840
	3	29.8	97	38	8	16.1	19.5	6780	5940	860
	4	25.6	0	0.0	0	7.9	18.5	2970	2820	400
	CV (%)	11.6	3.4	12.5	114.0	15.0	4.4	15.9	15.9	16.3
	LSD (*p = 0.05*	2.7	2.5	3.3	5.5	1.9	0.7	760	720	110

[1]
1. UpBeet (0.5 oz/acre)/Stinger (3.0 oz/acre)/Nortron (1.3 pt/acre)/Surfactant (0.25%)
2. UpBeet (0.25 oz/acre)/Betamix (0.5 pt/acre)/Stinger (1.3 oz/acre)/MSO (1.5%)
3. UpBeet (0.33 oz)/Betamix (0.5 pt/acre)/Stinger (1.3 oz/acre)/MSO (1.5%)
4. Untreated

[2] NS - not statistically significant at p=0.05