SUMMARY OF CROP SAFETY IN SUGARBEET FROM DUAL MAGNUM APPLIED PREEMERGE

Andrew B. Lueck[1] and Thomas J. Peters[2]

[1]Sugarbeet Research Specialist and [2]Extension Sugarbeet Agronomist and Weed Control Specialist Plant Sciences Department, North Dakota State University & University of Minnesota, Fargo, ND

Introduction

S-metolachlor is one of two herbicides applied preemerge in sugarbeet, but concerns about crop safety prevent product labelling that does not force the farmer to assume all liability. The working hypothesis is S-metolachlor applied preemerge at various rates between 0 and 2 pints per acre is safe for sugarbeet (*Beta vulgaris L.*) across different soil textures and environments.

Materials and Methods

Field experiments were conducted near Ada, MN, Belgrade, MN, Crookston, MN, Foxhome, MN, Lake Lillian, MN, and Prosper, ND, in 2015 and . near Foxhome, MN, Murdock, MN, and Prosper, ND in 2016. Plot areas were prepared using an Kongskilde s-tine field cultivator with rolling baskets. 'Crystal 981RR' sugarbeet treated with Tachigaren, Kabina, and Poncho Beta at 45 grams product, 12 grams a.i., and 5.07 fl oz of product, respectively, per 100,000 seeds was seeded 1.25 inches deep with 22-inch row spacing at 60,825 seeds per acre. Herbicide treatments were applied with a bicycle at 17 gpa through 8002 XR flat fan nozzles pressurized with CO_2 at 30 psi to the center four rows of six row plots 30 feet in length. Field experiments were a randomized-complete block design with 6 and 12 replications in 2015 and 2016, respectfully. Stand count and yield data were recorded both years.

Growth chamber experiments were conducted in 2016. A single, susceptible sugarbeet seed variety was selected from preliminary screening. Experiment was a six replication, completely-randomized design, split-plot factorial arrangement with temperature as the whole plot and sub-plot level treatments consisting of S-metolachlor rate, soil-type, and soil field capacity. Experiment considered the interaction of temperature, field capacity, and soil type with five S-metolachlor (Dual Magnum) rates of 0, 0.5, 1, 1.5, and 2 pints per acre applied preemerge on sugarbeet. All treatments were first placed into a 45°F growth chamber for seven days. Experimental units were then split into two other growth chambers set at 57°F and 70°F based on each treatments whole plot designation. Four hundred grams of soil was weighed for each pot and a standardized procedure was developed for an accurate seeding depth of 1.25 inches. Five sugarbeet seeds were planted in each pot. Field capacities of 75% and 100% were calculated for each soil type and water was added accordingly to the pots prior to herbicide application. S-metolachlor was applied at 10.8 gpa through 8001XR nozzle at 3 mph and 40 psi. Fresh weight per pot, average plant fresh weight, average days to emergence, and total emergence observations of the sugarbeets were measured.

Results and Discussion

Field research yield data in 2015 provided evidence that higher rates of Dual Magnum (S-metolachlor) caused reduction in sugarbeet stand. At Crookston, the untreated control and Dual Magnum at 0.5 pints provided the best sugarbeet stand counts, sugarbeet yield (tons/A), and extractable sucrose (lbs sucrose/A) (Table 1). Sugarbeet stand, yield, and extractable sucrose in plots with Dual Magnum at rates of 1 and 2 pints were significantly less than sugarbeet stand at the 0 or 0.5 pint rates. The same relationship with sugarbeet stand counts and Dual Magnum rate were observed at Foxhome, MN. Inversely, at Lake Lillian, MN, and Prosper, ND, higher rates of Dual Magnum gave greater root yields and extractable sucrose. Differences between locations in 2015 is due to soil texture and organic matter content of the different soils. The Crookston, MN, and Foxhome, MN, soils are a loam and sandy loam with 2.2% and 3.3% organic matter, respectfully. The Lake Lillian, MN, and Prosper, ND, soils are clay loams with 7.2% and 4.1% organic matter, respectfully. These soil traits are important because S-metolachlor readily binds to clay complexes, and more readily binds to organic matter. Thus, at the Crookston, MN, and Foxhome, MN, locations, there was less herbicide bound to the soil's clay complexes or organic matter which resulted in more herbicide being present in the soil solution that allowed an increase in uptake by the sugarbeet plants. Field research from 2015 confirmed the effect of soil clay complexes and organic matter on S-metolachlor. Soils higher in organic matter and clay complexes are less likely to express sugarbeet crop injury from Dual Magnum.

In comparison to 2015, the 2016 field data provided statistical significance (Table 2) for at least one observation at each location, and a significant sugarbeet stand difference on a combined analysis across all 2016 field locations (Table 3). None of the 2016 results correlated with Dual herbicide rate. These differences, within and across years, are likely due to rainfall. In 2015, each location received at least 4-inches of rain in the month of June, whereas, in 2016 no location received 4-inches of rain in June, and the Foxhome, MN, location only received 1.5-inches in the month of June (Tables 4, 5). Soil applied herbicides, such as S-metolachlor, require rain to activate in the soil solution. In 2015 there was an excess of rainfall which led to increased activation of Dual within the soil solution, and as a result the effects of the S-metolachlor were greater than in 2016.

Growth chamber results provided in-sight as to how S-metolachlor affects the sugarbeet plant. Each main effect, three 2-way interactions, and one 3-way interaction provided statistical significance in at least one of the four observations (Table 6). The main effect of soil type was the only factor that was significant across all four observations. This indicates that soil type is the most important factor when considering the risk associate with S-metolachlor applied preemerge to sugarbeet. Dual Magnum rate did not affect the frequency nor rate of sugarbeet emergence, but did affect the vigor of sugarbeet (Table 7). The only significant two-way interaction involved with herbicide rate was with temperature. This interaction indicated plant vigor was less affected by herbicide rate at cooler temperatures, likely due to slowed adsorption of the herbicide as a result of slowed sugarbeet plant growth.

This growth chamber study provided evidence that sugarbeet stand is more affected by environmental factors (soil, moisture, temperature) and the interaction of environmental factors rather than by S-metolachlor rate. However, the reduction in sugarbeet vigor due to the herbicide rate may contribute to stand loss in unfavorable environmental conditions. Cool, wet environments provide the most unfavorable environmental conditions for sugarbeet emergence, while cool and dry, warm and wet, or warm and dry conditions provide more favorable conditions for sugarbeet emergence.

Table 1. Model source of variation, degrees of freedom, and F-test results across locations and combined. 30.5 meter stand, percent sucrose, percent purity, root yield, and extractable sucrose in 2015

Location	df	Stand	Sucrose	Purity	Root yield	Extractable sucrose
Ada, MN	15	NS[a]	NS	NS	NS	NS
Belgrade, MN	23	NS	NS	NS	NS	NS
Crookston, MN	23	*	NS	NS	*	*
Foxhome, MN	23	**	NS	NS	NS	NS
Lake Lillian, MN	23	NS	NS	NS	**	**
Prosper, ND	23	NS	NS	*	**	NS

[a]NS, *, ** indicates non-significant, or significant at $P< 0.05$ or 0.01 levels, respectively.

Table 2. Model source of variation, degrees of freedom, and F-test results across locations and combined. 30.5 meter stand, percent sucrose, percent purity, root yield, and extractable sucrose in 2016.

Location	df	Stand	Sucrose	Purity	Root yield	Extractable sucrose
Foxhome, MN	71	NS[a]	NS	NS	*	NS
Murdock, MN	71	*	**	*	*	**
Prosper, ND	71	NS	**	**	*	**
Combined 2016	215	**	NS	NS	NS	NS

[a]NS, *, ** indicates non-significant, or significant at $P< 0.05$ or 0.01 levels, respectively.

Table 3. Sugarbeet stand, percent sucrose, percent purity, root yield, and extractable sucrose as influenced by S-metolachlor rates across all locations in 2016.

S-metolachlor rate	Stand	Sucrose	Purity	Root yield	Extractable sucrose
kg ai ha^{-1}	30.5 m	%	%	1000 kg ha^{-1}	kg ha^{-1}
0	167 ab	15.3	90.0	67.4	10,365
0.54	172 a	15.4	89.8	66.7	10,295
1.08	169 a	15.3	89.8	67.8	10,380
1.61	162 b	15.5	89.8	65.4	10,152
2.15	168 a	15.4	89.7	67.1	10,364
4.30	166 ab	15.3	89.6	67.0	10,269
LSD (0.05)[a]	6.27**	NS[b]	NS	NS	NS

[a]LSD=Least Significant Difference.
[b]NS, ** indicates non-significant or significant at $P < 0.01$ levels, respectfully.

Table 4. Rainfall by month across locations in 2015.

Soil	Rainfall		
	April	May	June
	cm		
Ada, MN	2.0	11.9	10.0
Belgrade, MN	2.4	11.9	9.4
Crookston, MN	1.2	9.4	6.0
Foxhome, MN	1.4	15.3	6.2
Lake Lillian, MN	1.6	11.4	10.8
Prosper, ND	2.0	14.9	11.0

Table 5. Rainfall by month across locations in 2016.

Soil	Rainfall		
	April	May	June
	cm		
Foxhome, MN	9.1	3.7	2.4
Murdock, MN	4.5	8.6	10.6
Prosper, ND	4.3	8.2	3.8

Table 6. Sources of variation, degrees of freedom, and F-test results. Sugarbeet average plant fresh weight, total pot fresh weight, average days to emergence, and total pot emergence was evaluated.

Source of variation	df	Average fresh weight	Fresh weight	Days to emergence	Emergence
Temp	1	NS[a]	NS	**	NS
Soil	2	**	**	**	**
Rate	4	**	**	NS	NS
Field Capacity	1	**	NS	*	**
Soil*Temp	2	NS	NS	NS	**
Rate*Temp	4	*	NS	NS	NS
Field Capacity*Temp	1	NS	NS	*	**
Soil*Rate	8	NS	NS	NS	NS
Soil*Field Capacity	2	NS	**	**	**
Rate*Field Capacity	4	NS	NS	NS	NS
Soil*Rate*Temp	8	NS	NS	NS	NS
Soil*Field Capacity*Temp	2	NS	NS	**	**
Rate*Field Capacity*Temp	4	NS	NS	NS	NS
Soil*Rate*Field Capacity	8	NS	NS	NS	NS
Soil*Rate*Field Capacity*Temp	8	NS	NS	NS	NS

[a]NS, *, ** indicates non-significant, or significant at $P< 0.05$ or 0.01 levels, respectively.

Table 7. S-metolachlor rate main effect. Sugarbeet average plant fresh weight, total pot fresh weight, average days to emergence, and total pot emergence.

Rate	Average fresh weight	Fresh weight	Days to emergence	Emergence
kg ha^{-1}	g $plant^{-1}$	g	days	plants
0.00	0.130 a	0.550 a	13.61	3.958
0.54	0.125 a	0.541 a	13.80	3.958
1.08	0.117 ab	0.494 ab	13.80	3.903
1.61	0.109 b	0.455 bc	13.66	3.986
2.15	0.090 c	0.395 c	13.98	4.083
LSD (0.05)[a]	0.013**	0.063**	NS[b]	NS

[a]LSD=Least significant difference.
[b]NS, ** indicates non-significant or significant at $P < 0.01$ levels, respectfully.

CONCLUSIONS

Rates of Dual Magnum greater than 1 pint per acre may reduce sugarbeet plant vigor and amplify the environmental effect on sugarbeet stand, especially in soils with low organic matter and clay complexes. The risk for reduced plant vigor from S-metolachlor is less in soils with organic matter above 3.5% and high clay content. Dual Magnum at rates of 1 pint or less are safe across all soil types and environmental conditions in non-saturated conditions. Planting early with a low risk of soil saturation in the forecast, or planting later with a high risk of soil saturation in the forecast, will reduce the risk for stand loss with or without a preemerge application of S-metolachlor.