

# HOODED SPRAYER FOR APPLICATION OF NONSELECTIVE HERBICIDES IN SUGARBEET

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## Summary

1. Liberty and Gramoxone are not approved for POST directed application in sugarbeet.
2. Gramoxone at 21 fl oz/A plus non-ionic surfactant (NIS) and Liberty at 32 fl oz/A plus ammonium sulfate (AMS) improved 4- and 6-inch waterhemp control as compared with repeat glyphosate applications at 28 fl oz/A / 28 fl oz/A plus NIS and AMS.
3. PowerMax was more effective than Liberty or Gramoxone for common lambsquarters control.
4. Growth reduction injury was negligible from Gramoxone or Liberty applied at the 6-leaf sugarbeet stage or greater and Gramoxone or Liberty did not reduce root yield, sucrose content or recoverable sucrose as compared to repeat glyphosate application.

## Introduction

Sugarbeet producers recognized waterhemp as their most troublesome weed control challenge on 373,064 acres or 59% of the production acreage in Minnesota and eastern North Dakota in 2020 (survey conducted at 2020 Sugarbeet Growers Seminars, Turning Technologies, Youngstown, OH). Waterhemp control is maximized by using soil residual herbicides applied preemergence, early postemergence, and postemergence in sugarbeet. Optimal control is dependent on timely rainfall following application to move herbicides into the weed seed zone, or from soil surface to 2-cm into soil. Postemergence (POST) applications of Betamix and UpBeet and inter-row cultivation have been used to control escaping weeds. However, remnant inventories of Betamix have been exhausted, UpBeet-resistant waterhemp populations are increasingly common in the production area, and (re)adoption of inter-row cultivation by sugarbeet growers has been slow.

Selective and nonselective herbicides applied through hooded sprayers are used in cotton production to control weeds between rows. The hood protects cotton plants from herbicides that may cause growth reduction injury. The practicality and value of a hooded sprayer is being evaluated in sugarbeet as herbicide-resistance continues to increase in species such as waterhemp and Palmer amaranth. Experiments conducted in 2020 evaluated sugarbeet tolerance and waterhemp and common lambsquarters control from Roundup PowerMax (glyphosate), Liberty (glufosinate) and Gramoxone (paraquat) applied through a hooded sprayer at multiple locations in North Dakota and Minnesota.

## Objectives

Liberty and Gramoxone are not labeled in sugarbeet and will require action by Minnesota and North Dakota Department of Agriculture before use, even between rows through a hooded sprayer. Thus, sugarbeet tolerance and weed control must be measured before support can be solicited from industry and a petition submitted to the Department of Agriculture. The objectives of these research were to determine sugarbeet tolerance and weed control when Liberty or Gramoxone were applied at different rates and timings through a hooded sprayer.

## Materials and Methods

*Sugarbeet Tolerance.* Experiments were conducted near Crookston, MN, Lake Lillian, MN, Hickson, ND, and Prosper, ND in 2020. The Hickson, ND location was not included in the analysis due to erratic sugarbeet stands. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage to each location. Sugarbeet was planted between April 27 and May 27, 2020.

Herbicide treatments were applied between each row within a 30-foot long by six row plot when sugarbeet was at the 2-, 6-, and 10-lf stage using a hooded sprayer traveling 3 mph delivering 22 gpa spray solution through 8002 EVS Teejet nozzles pressurized with CO<sub>2</sub> at 35 psi. The treatment list can be found in Table 1.

**Table 1. Herbicide treatments, rates, and application timing in trials near Prosper, ND and Lake Lillian and Crookston, MN in 2020.**

Herbicide treatment	Rate (fl oz/A)	Sugarbeet stage (lvs)
RU PowerMax / RU PowerMax <sup>1</sup>	28 /28	4 / 6-8
Liberty <sup>2</sup>	86	2-4
Liberty	86	6-8
Liberty	86	10-12
Gramoxone SL 3.0 <sup>3</sup>	32	2-4
Gramoxone SL 3.0	32	6-8
Gramoxone SL 3.0	32	10-12

<sup>1</sup>Treatments with Roundup PowerMax applied with Prefer 90 NIS at 0.25% v/v + N-Pak AMS Liquid at 2.5% v/v.

<sup>2</sup>Treatments with Liberty applied with dry AMS at 3 lb/A.

<sup>3</sup>Treatments with Gramoxone SL 3.0 applied with Prefer 90 NIS at 1 qt/A.

Sugarbeet injury was evaluated as a visual estimate of percent growth reduction (0 to 100% scale, 0 is no visible injury and 100 is complete loss of plant / stand) in the middle four rows of the six-row plot compared to the glyphosate check. Leaf damage ratings were also evaluated by counting the number of sugarbeet plants within treated rows with visual damage. Damage factors included herbicide drift, operator or equipment error, environment, etc. Sugarbeet was harvested from the center two rows within a plot in the fall and assessed for yield and quality. Data were analyzed using either SAS Data Management software PROC MIXED procedure to test for significant differences at p=0.05 or the ANOVA procedure of ARM, version 2020.2 software package depending on variable. Experimental design was randomized complete block with six replications.

*Hooded Sprayer Efficacy.* Experiments were conducted on native populations of common lambsquarters and waterhemp in sugarbeet fields near Moorhead and Lake Lillian, MN and Galchutt and Hickson, ND in 2020. The Galchutt location was dropped due to insufficient waterhemp populations; the Hickson site was dropped due to sprayer mechanical challenges. The experimental area was prepared for planting by applying the appropriate fertilizer and tillage to each location. Sugarbeet was planted April 28<sup>th</sup> and May 19<sup>th</sup> at Lake Lillian and Moorhead, respectively.

Herbicide treatments were applied between each row within a 30-foot long by six row plot when waterhemp was 3- or 6-inches tall using a hooded sprayer delivering 22 gpa spray solution through 8002 EVS Teejet nozzles pressurized with CO<sub>2</sub> at 35 psi. The treatment list can be found in Table 2.

**Table 2. Herbicide treatments, rates, and application timing in trials near Moorhead and Lake Lillian, MN in 2020.**

Herbicide treatment	Rate (fl oz /A)	Waterhemp (inch)
RU PowerMax / RU PowerMax <sup>1</sup>	28 / 28	2 to 4 fb 10 d
Liberty <sup>2</sup>	32	3-4
Liberty	32	6-8
Liberty	43	3-4
Liberty	43	6-8
Gramoxone SL 3.0 <sup>3</sup>	21	3-4
Gramoxone SL 3.0	21	6-8
Gramoxone SL 3.0	32	3-4
Gramoxone SL 3.0	32	6-8

<sup>1</sup>Treatments with Roundup PowerMax applied with Prefer 90 NIS at 0.25% v/v + N-Pak Liquid AMS at 2.5% v/v.

<sup>2</sup>Treatments with Liberty applied with dry AMS at 3 lb/A.

<sup>3</sup>Treatments with Gramoxone SL 3.0 applied with Prefer 90 NIS at 1 qt/A.

Weed control was evaluated as a visual estimate of percent fresh weight reduction (0 is no injury and 100 is complete control) in the four treated rows compared to the glyphosate check at 7, 14, and 21 days (+/- 3 days) after

application. Experimental design was randomized complete block with four replications. Data were analyzed with the ANOVA procedure of ARM, version 2020.4 software package.

### Tolerance Results

*Tolerance Probe.* Experiments conducted by BASF Corp at two locations in 2020 evaluated RR sugarbeet tolerance to glufosinate in an over-the-top application using a rate titration of 1x, 1/10x, 1/100x, and 1/1000x the recommended rate applied to 4- and 8-lf sugarbeet (Table 3). The research simulated sugarbeet injury from spray solution escaping from hoods at two growth stages. Sugarbeet were sensitive to Liberty, especially at 43 fl oz/A at the 4-lf stage. However, injury was less at the 10-lf stage or with the 1/10, 1/100 or 1/1000x Liberty rate. No injury to either the 4- or 10-lf stage sugarbeet was observed at the 1/100x or 1/1000x rate. The experiment demonstrated sugarbeet sensitivity to glufosinate when sprayed over the top of sugarbeet; however, sugarbeet may not be as susceptible to injury when applications are made through a hooded sprayer.

**Table 3. RR sugarbeet tolerance to Liberty herbicide following broadcast application.<sup>1</sup>**

Treatment	Rate fl oz/A	Rate	Injury 4 DAT <sup>2</sup>	
			4-lf Sugarbeet	10-lf Sugarbeet
			-----%-----	
Liberty <sup>3</sup>	43	1x	100	70
Liberty	4.3	1/10x	30	15
Liberty	0.43	1/100x	0	0
Liberty	0.043	1/1000x	0	0

<sup>1</sup>Bird Island, MN plot ratings by Dr. Duane Rathmann, BASF Corp.

<sup>2</sup>DAT=Days after treatment.

<sup>3</sup>All Liberty treatments applied with dry AMS at 3 lb/A.

Sugarbeet growth reduction injury from herbicides applied through a hooded sprayer was negligible across application timings (Table 4). Injury was divergence from a uniform stand and tended to represent damage to specific sugarbeet plants and not uniform damage across the plot. Numerically, growth reduction injury was greatest following either Liberty or Gramoxone application at the 2 to 4 leaf sugarbeet. We did not observe any difference in injury between Liberty and Gramoxone. Injury became less as sugarbeet grew and was not observed or was negligible at 14 or 21 DAT (data not presented). Leaf damage counts represent single locations since the cause of damage was experiment specific (Table 4). Leaf damage injury from Gramoxone was generally greater than from Liberty. Leaf damage at the 2- to 4-lf stage at Lake Lillian may have been extenuated by breeze conditions at application. Damage ratings at the 10- to 12-leaf stage is likely from wheel traffic, especially since it was not supported by the growth reduction observations. Damage was less as sugarbeet developed and was negligible 14 or 21 DAT (data not presented). Root yield, % sucrose, and recoverable sucrose from Liberty or Gramoxone through the hooded sprayer was the same as yield parameters treated with repeat glyphosate application (Table 5). However, Liberty and Gramoxone at the 2- to 4-leaf stage applications tended to give root yield less than the glyphosate check.

**Table 4. Growth reduction, averaged across three environments and number of damaged plants in plots, by environment, in response to POST herbicides through the hooded sprayer in 2020.<sup>1</sup>**

Herbicide treatment	Sugarbeet stage	Growth Reduction		Damaged Plants	
		Across Locations	Crookston, MN	Prosper, ND	Lake Lillian, MN
		7 DAT <sup>2</sup>	7 DAT	7 DAT	7 DAT
	--lvs--	--%--	-----# plants/plot-----		
RU PowerMax / RU PowerMax	4 / 6-8	1	6 a	2 a	4 a
Liberty	2-4	15	11 ab	2 a	81 b
Liberty	6-8	7	5 a	2 a	19 ab
Liberty	10-12	9	80 e	45 c	13 a
Gramoxone SL 3.0	2-4	16	23 bc	2 a	134 c
Gramoxone SL 3.0	6-8	10	46 d	9 a	31 ab
Gramoxone SL 3.0	10-12	7	27 c	30 b	30 ab
		-----P-value-----			
		0.0925	<0.0001	<0.0001	<0.0001

<sup>1</sup>Means within a main effect not sharing any letter are significantly different by the LSD at the 5% level of significance.

<sup>2</sup>DAT=Days after treatment.

**Table 5. Root yield, sucrose content, and recoverable sucrose in response to POST herbicides through the hooded sprayer, across three environments, in 2020.<sup>1</sup>**

Herbicide treatment	Sugarbeet stage	Root Yield <sup>2</sup>	Sucrose Content	Rec. Suc <sup>3</sup>
	--lvs--	--Tons/A--	--%--	--lb/A--
RU PowerMax / RU PowerMax	4 / 6-8	30.1	16.2	8,628
Liberty	2-4	27.9	16.4	8,055
Liberty	6-8	29.3	16.2	8,789
Liberty	10-12	29.2	16.0	8,468
Gramoxone SL 3.0	2-4	27.9	16.4	8,392
Gramoxone SL 3.0	6-8	29.2	16.1	8,680
Gramoxone SL 3.0	10-12	28.6	16.0	8,362
		-----P-value-----		
		0.3146	0.8799	0.6049

<sup>1</sup>Means within a main effect not sharing any letter are significantly different by the LSD at the 5% level of significance.

<sup>2</sup>Root yield reported in ton per acre.

<sup>3</sup>Recoverable sucrose reported in pound per acre.

### Efficacy Results

The first observation of symptomology was herbicide specific in efficacy experiments. A necrosis phenotype was observed from Gramoxone 1 DAT on waterhemp and common lambsquarters. Symptomology from Liberty was observed first on waterhemp and second on lambsquarters 5- to 7-DAT. Symptomology from glyphosate was slowest to be observed, especially on waterhemp. Gramoxone applied through the hooded sprayer improved waterhemp control compared to repeat glyphosate applications (Table 6). Waterhemp control from Gramoxone was not influenced by weed size or application rate. Waterhemp control from Liberty was dependent on rate and weed size. Liberty at 32 fl oz/A provided or tended to provide control of 3- to 4-inch waterhemp greater than 6- to 8-inch waterhemp. Waterhemp size did not influence control when Liberty was applied at 43 fl oz/A. However, Liberty applied at 43 fl oz/A tended to provide greater control of 3- to 4-inch waterhemp compared to 6-to 8-inch waterhemp.

**Table 6. Waterhemp and common lambsquarters control in response to POST herbicides applied through the hooded sprayer, 2020.<sup>1</sup>**

Herbicide treatment	Rate	Weed Height	Waterhemp	Common Lambsquarters	
				Lake Lillian	Moorhead
	-fl oz/A-	---inch---		-----%-----	
RU PowerMax / RU PowerMax	28 / 28	2 to 4 fb 10 d	55 c	94 a	99 a
Liberty	32	3-4	81 ab	65 c	77 de
Liberty	32	6-8	56 c	29 e	81 cd
Liberty	43	3-4	86 ab	79 b	85 bcd
Liberty	43	6-8	70 bc	41 d	86 bcd
Gramoxone SL 3.0	21	3-4	90 a	89 a	77 de
Gramoxone SL 3.0	21	6-8	90 a	65 c	73 e
Gramoxone SL 3.0	32	3-4	96 a	94 a	93 ab
Gramoxone SL 3.0	32	6-8	96 a	85 ab	89 bc
				-----P-value-----	
			0.0020	<0.0001	<0.0001

<sup>1</sup>Means within a main effect not sharing any letter are significantly different by the LSD at the 5% level of significance.

Common lambsquarters ranged from 6- to 12-inches at Lake Lillian due to high wind conditions in June which delayed application timings. Lambsquarters was sprayed according to protocol at Moorhead, MN. Thus, lambsquarters control was not combined and are reported separately for each experiment. Glyphosate was equally effective at controlling small and large common lambsquarters in this experiment. At Lake Lillian, control from Liberty was dependent on rate and lambsquarters size at application. However, common lambsquarters control from Liberty was the same across rates and height at Moorhead where applications were successfully timed to protocol. Lambsquarters control from Liberty was less than control from glyphosate and tended to be less than control from Gramoxone at both locations. Common lambsquarters control differences from Liberty and Gramoxone were much less at Moorhead than at Lake Lillian where Gramoxone gave greater lambsquarters control at a given weed size compared with control from Liberty. At Moorhead, common lambsquarters height did not affect control from Gramoxone at 21 fl oz/A. However, at Lake Lillian, applying Gramoxone to smaller lambsquarters resulted in greater control at both 21 and 32 fl oz/A.

### Conclusions

Liberty and Gramoxone are effective herbicides for controlling waterhemp and can be safely applied inter-row through a hooded sprayer when sugarbeet are at the 6-8 leaf stage or greater. Liberty might be slightly safer than Gramoxone. Weed control from Liberty generally decreases as weed height increases and numerically was better on waterhemp than common lambsquarters. Waterhemp control from Gramoxone was not influenced by rate or height but control of taller lambsquarters was less at Lake Lillian as compared to Moorhead. Waterhemp should be the primary weed control focus when using a hooded sprayer since glyphosate remains highly effective for common lambsquarters control. Liberty at 32 fl oz/A applied to small weeds or Gramoxone at 21 fl oz/A applied to small or large weeds provided improved waterhemp control than glyphosate.

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