EVALUATING POTENTIAL HORMETIC EFFECTS OF FOUR HERBICIDES ON SUGAR BEET

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Introduction

Hormesis is a term used by toxicologists to refer to a response of a subject to a sublethal dose of some kind of introduced agent that results in a positive reaction. It is a phenomenon that has been observed in humans, other animals, and plants. With plants, hormesis is the response to an environmental agent characterized by a low dose stimulation or beneficial effect and a high dose inhibitory or toxic effect. The use of this phenomenon might be beneficial to sugar beet production if the hormetic effect boosts sugar beet yield or better yet, boosts sucrose content without increasing sugar beet root biomass yield. Several herbicides and other chemicals have been found to cause hormesis in other crops.

Glyphosate at a nonlethal dose is actually registered for use on sugarcane to increase sugar content of plants prior to harvest. Another herbicide, sulfometuron (Oust®), which is a Group 2 herbicide, has been shown to increase sugar content in sugarcane when applied at rates ranging from 0.14 to 0.28 oz ai/acre. Because sugar beet is known to be extremely sensitive to sulfometuron, some other Group 2 herbicide could be explored with sugar beet. Several Group 4 growth regulator herbicides including 2,4-D, MCPA, and 2,4-DP have been used for growth stimulation of various crops, and have even improved the color of certain red potato varieties. There are many Group 2 and Group 4 herbicides that are commonly used for weed control in crops grown in Idaho and Oregon. The potential to increase sucrose content without increasing sugar beet root biomass could be of great benefit to the sugar beet industry.

The objective of this study was to evaluate multiple herbicides applied at sublethal rates towards the end of the growing season to determine if any of these products possess the potential for hormesis effects on sugar beet. The hormetic response will be determined by measuring sugar beet yield, sucrose content, and quality in response to the herbicides applied at various rates.

Materials and Methods

Sugar beet field studies were initiated during summer 2017 at the Malheur Experiment Station, Ontario, Oregon and the University of Idaho, Kimberly Research and Extension Center, Kimberly, Idaho, in fields previously planted to wheat. Production practices typical for each area were followed as closely as possible. The primary difference between growing practices at Malheur and Kimberly was surface furrow irrigation at Malheur and sprinkler irrigation at Kimberly.

Hybrid 27RR20 sugar beet seed was planted on April 21 at Malheur, while Holly hybrid SX1534RR sugar beet seed was planted on April 17 at Kimberly. The trials had factorial designs (4 herbicides at 4 rates each) arranged in randomized complete blocks with 6 replications. An untreated check was included. Weeds were controlled by applying glyphosate at 1.13 lb ae/acre plus ammonium sulfate at 2.5% v/v at the 2-leaf stage (May 3 at Malheur and May 16 at Kimberly) and at the 6-leaf stage (May 19 at Malheur and May 27 at Kimberly). The application at the 6-leaf stage included Outlook at 0.98 lb ai/acre. All other production practices including fertilization, irrigation, and preventative sprays for insects and diseases followed standard local practices.

Herbicide treatments to induce hormetic effects were applied on August 29 at Malheur and August 20 at Kimberly using a CO_2-pressurized backpack sprayer (Tables 1 and 2). Roots were harvested on September 19 at Malheur and October 9 at Kimberly. Percent sugar content and other sugar yield variables were determined at the Amalgamated Sugar Factory in Paul, Idaho. Data were subjected to analysis of variance using SAS and means compared using protected LSD at $P = 0.05\%$ level of confidence.

Results and Discussion

At the Malheur Experiment Station visible plant injury ranging from 5 to 20% was observed at 7 days after herbicide application on plants treated with Starane® Ultra at 0.8 fl oz/acre. Visual injury also was observed at the Kimberly site ranging from 10 to 27% at 7 days after treatment. Starane Ultra (fluroxypyr) and Defendor® (florasulam) applied at 0.8 and 0.4 fl oz/acre (10% of the 1X rate) had the most injury at Kimberly.

Sugar beet yield (52.2 to 58.1 ton/acre) and root conductivity (0.79 to 0.89 mmhos) were similar across treatments at Malheur (Table 1). Nitrate content and the estimated recoverable sugar varied widely across treatments. Application of Matrix® (rimsulfuron) at 0.001 to 0.01 oz/acre increased sucrose content by about 5% at Malheur, whereas MCPA at 0.00114, or Starane Ultra at 0.0008 to 0.008 fl oz/acre increased sucrose content by about 2% compared to the untreated check (Table 1).

No statistically significant differences were observed for any of the variables at Kimberly (Table 2). At Kimberly, application of Matrix at 0.001 oz/acre (0.1% of 1X) and MCPA at 0.114 fl oz/acre (1% of 1X) had improved sucrose content, though not statistically different from the check (Table 2).

The differences in results at the two sites may be related to the time lag between application and root harvest. Sugar beet was harvested 21 days after herbicide application at Malheur compared to 50 days at Kimberly. Studies in other crops have shown a decline in hormesis effects after 30 days of treatment. Follow-up studies in 2018 will be harvested not later than 30 days after treatment.

Disclaimer: products used in this study are for experimental purpose only and NOT registered for use in sugar beet production.

Table 1. Sugar beet yield, quality, and recoverable sucrose in response to various herbicides tested for possible hormesis effects at the Malheur Experiment Station, Ontario, OR, 2017.

Treatment[z]			Conductivity	Nitrate		Sucrose		Clean root yield	ERS [x]	
Rate			mmhos	ppm		%		t/acre	lb/acre	
Check	--		0.82	371	a-d[y]	14.3	bcd	53.4	12,476	abc[w]
Rimsulfuron	0.1	oz/acre	0.79	323	b-f	14.3	bcd	56.5	13,568	a
Rimsulfuron	0.01	oz/acre	0.84	281	ef	14.7	ab	53.9	13,208	a
Rimsulfuron	0.001	oz/acre	0.87	299	def	15.0	a	54.5	13,524	a
Rimsulfuron	0.0001	oz/acre	0.87	395	abc	13.8	cd	56.2	12,853	ab
Florasulam	0.4	fl oz/acre	0.88	249	f	13.0	e	53.3	11,375	c
Florasulam	0.04	fl oz/acre	0.85	298	def	13.7	d	56.1	12,679	ab
Florasulam	0.004	fl oz/acre	0.95	411	ab	14.2	bcd	57.2	13,232	a
Florasulam	0.0004	fl oz/acre	0.81	310	c-f	14.4	abc	52.8	12,746	ab
MCPA	1.14	fl oz/acre	0.78	337	b-e	14.1	bcd	54.0	12,794	ab
MCPA	0.114	fl oz/acre	0.83	344	b-e	14.3	bcd	54.6	13,013	ab
MCPA	0.0114	fl oz/acre	0.83	341	b-e	14.1	bcd	54.9	12,945	ab
MCPA	0.00114	fl oz/acre	0.82	290	def	14.6	ab	55.3	13,566	a
Fluroxypyr	0.8	fl oz/acre	0.93	459	a	12.6	e	58.1	11,921	bc
Fluroxypyr	0.08	fl oz/acre	0.89	305	def	14.3	bcd	53.7	12,642	ab
Fluroxypyr	0.008	fl oz/acre	0.87	350	b-e	14.4	abc	56.2	13,348	a
Fluroxypyr	0.0008	fl oz/acre	0.79	355	b-e	14.6	ab	52.2	12,775	ab
LSD (0.05)	Herbicide		NS	NS		0.3		NS	791	
	Dose		NS	NS		0.3		NS	791	
	Herbicide x dose		NS	98.5		0.7		NS	NS	

[z] Rimsulfuron = Matrix SG; florasulam = Defendor; MCPA = Sword; fluroxypyr = Starane Ultra.
[y] Treatment means followed by the same letter within the column are not significantly different according to Fisher's protected least significant difference (LSD) $P \leq 0.05$.
[x] ERS = Estimated recoverable sucrose.
[w] Means within a column followed by the same letter are not significantly different according to Fisher's protected least significant difference (LSD) $P \leq 0.05$.

Table 2. Sugar beet yield, quality, and recoverable sucrose in response to various herbicides tested for possible hormesis effects at the Kimberly Research and Extension Center, Kimberly, ID, 2017.

Treatment[z]			Conductivity	Nitrate	Sucrose	Clean root yield	ERS [x]
Rate			mmhos	ppm	%	t/acre	lb/acre
Check	--		0.69	233	14.10	47.9	12,248
Rimsulfuron	0.1	oz/acre	0.62	174	14.00	50.5	12,806
Rimsulfuron	0.01	oz/acre	0.72	251	14.12	54.2	13,985
Rimsulfuron	0.001	oz/acre	0.68	267	14.64	48.4	12,689
Rimsulfuron	0.0001	oz/acre	0.66	279	13.56	51.2	12,508
Florasulam	0.4	fl oz/acre	0.74	229	13.09	43.7	10,087
Florasulam	0.04	fl oz/acre	0.67	286	13.42	54.1	13,047
Florasulam	0.004	fl oz/acre	0.67	254	13.88	49.7	12,405
Florasulam	0.0004	fl oz/acre	0.72	189	12.91	47.8	10,770
MCPA	1.14	fl oz/acre	0.66	262	13.49	51.8	12,588
MCPA	0.114	fl oz/acre	0.71	227	14.43	51.0	13,092
MCPA	0.0114	fl oz/acre	0.66	268	13.61	52.7	13,188
MCPA	0.00114	fl oz/acre	0.65	278	13.31	48.2	11,632
Fluroxypyr	0.8	fl oz/acre	0.78	256	12.53	46.7	10,249
Fluroxypyr	0.08	fl oz/acre	0.69	254	13.73	51.4	12,582
Fluroxypyr	0.008	fl oz/acre	0.67	226	14.15	48.9	12,430
Fluroxypyr	0.0008	fl oz/acre	0.66	192	14.19	49.3	13,053
LSD (0.05)	Herbicide		NS	NS	NS	NS	NS
	Dose		NS	NS	NS	NS	NS
	Herbicide x dose		NS	NS	NS	NS	NS

[z] Rimsulfuron = Matrix SG; florasulam = Defendor; MCPA = Sword; fluroxypyr = Starane Ultra.
[x] ERS = Estimated recoverable sucrose.