EVALUATION OF HERBICIDE TANK MIXES FOR WEED CONTROL IN POTATO

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Introduction

Managing weeds is an essential component of potato production. Weeds are a major production concern for potato growers because they often reduce yield, quality, and may possibly serve as alternative hosts for other crop pests. The warm weather in eastern Oregon provides ideal conditions for weed growth, necessitating development of effective herbicide combinations to manage weeds in the region. Metribuzin is applied to more acreage in potato production than any other herbicide, but does not consistently control hairy nightshade and may injure certain potato varieties. Also, yellow nutsedge continues to be a major weed problem in eastern Oregon agriculture. Continued evaluation of herbicides with different modes of action is important in order to provide potato producers with tools to manage weeds and delay development of herbicide-resistant weeds.

Linuron (Linex®) and fomesafen (Reflex®) have been recently labeled for weed control in potato in the Pacific Northwest. Herbicide tank mixes that include linuron could improve grass and broadleaf weed control in potato. Previous studies conducted at the Malheur Experiment Station indicated that fomesafen controls most annual broadleaf weeds and provides partial control of yellow nutsedge. In addition, the experimental products F9312-3 and F9314-3 could improve common lambsquarters, hairy nightshade, and grass control in potato if no adverse effect on potato is found. The objective of this study was to evaluate potato tolerance and weed control of newly registered herbicides and the experimental products applied alone or in tank mixtures with standard herbicides.

Material and Methods

A study was established in 2014 at Malheur Experiment Station, Ontario, Oregon, in a field previously planted to wheat. Tillage operations were completed during the preceding fall following standard practices for potato production. The soil was an Owyhee silt loam with a pH of 7.2 and 1.83% organic matter. Based on a soil test, a fertilizer blend containing 200 lb phosphate/acre, 100 lb potassium/acre, 100 lb sulfur/acre, 1 lb manganese/acre, and 1 lb boron/acre was broadcast on the study area in the fall of 2013. The field was then fumigated with Telone® II (1,3 dichloropropene) at 18 gal/acre and simultaneously bedded on a 36-inch row spacing. On April 3, 2014 100 lb/acre of nitrogen (N) and 7 oz/acre of Admire® (imidacloprid) were injected in the bed centers before planting.

On April 8, 2014 potato seed of variety 'Ranger Russet' were cut by hand into 2-oz pieces and treated with Topsin® M (thiophanate-methyl) dust and stored to suberize. Potato seed pieces were

planted on April 10, 2014 using a 2-row assist-feed planter set at 9-inch seed spacing in 36-inch rows. After planting, the beds were reformed with a Lilliston rolling cultivator on April 11. The study had a randomized complete block design with four replications. Each plot was 9 ft wide (3 rows) by 30 ft long.

The herbicide F9312-3 was evaluated at 0.122, 0.1436, and 0.1907 lb ai/acre and F9314-3 was evaluated at 0.144 lb ai/acre. Other herbicides included Matrix® 1 oz/acre (rimsulfuron at 0.0156 lb ai/acre), Linex at 1.5 pt/acre (linuron at 0.75 lb ai/acre), Sencor® 75DF at 8 oz/acre (metribuzin at 0.375 lb ai/acre), Dual Magnum® at 1.33 pt/acre (s-metolachlor at 1.27 lb ai/acre), Outlook® at 21 fl oz/acre (dimethenamid-p at 0.98 lb ai/acre, Reflex at 1 pt/acre (fomesafen at 0.25 lb ai/acre), Prowl® H2O at 2.1 pt/acre (pendimethalin at 1 lb ai/acre), Boundary® at 2 pt/acre (s-metolachlor at 1.32 lb ai/acre plus metribuzin at 0.313 lb ai/acre), and Eptam® at 3.5 pt/acre (EPTC 3.06 at lb ai/acre). Herbicide combination treatments are listed in Tables 2 to 5.

Herbicide treatments were applied on April 29 before potato and weed emergence using a CO_2-pressurized backpack sprayer fitted with a boom equipped with six EVS8002 flat-fan nozzles to provide a spray volume of 20 gal/acre. Plots in the weed-free treatments were hand-weeded as needed starting on May 27, 2014. Plots were sprinkler irrigated immediately after herbicide application to incorporate herbicides in the soil. Subsequent irrigations were scheduled based on six Watermark soil moisture sensors (Irrometer Co., Riverside, CA) connected to an AM400 data logger (M.K. Hansen Co., Wenatchee, WA) to prevent the soil at the seed-piece depth from drying beyond 60 kPa soil water tension on the dates indicated in Table 1.

Based on leaf petiole tests, fertilizer to supply 20 lbs N/acre was applied through sprinkler irrigation on July 7, 2014. All other activities including aerial fungicide sprays followed standard local practices for potato production.

Plants were evaluated subjectively for injury based on a scale of 0% (no apparent injury) to 100% (complete crop damage). The same scale was used to evaluate weed control in each plot at 13, 30, and 113 days after herbicide application.

Potatoes were harvested on September 22, 2014 and tubers were placed into burlap sacks and placed in a barn where they were kept under tarps until grading. Tubers were graded by market class (U.S. No. 1 and U.S. No. 2) and weight (<4 oz, 4-6 oz, 6-12 oz, and >12 oz) on September 25, 2014. Tubers were graded as U.S. No. 2 if they had growth cracks, bottleneck shape, abnormally curved shape, or two or more knobs. Marketable tubers are comprised of U.S. No. 1 and U.S. No. 2 larger than 4 oz.

Data were subjected to analysis of variance using PROCGLM in SAS and means were compared using Fisher's protected least significant difference procedure at $P \leq 0.05$.

Results and Discussion

Observations conducted at 13 days after herbicide application (May 27, 2014) indicated potato injury was less than 4% the across herbicide treatments (Table 2). Control for common lambsquarters was over 83%, with F9312-3 and Linex plus Dual Magnum treatments providing the lowest control. Hairy nightshade control ranged from 78 to 100% across herbicide treatments, while control for pigweed species was greater than 85%. Barnyardgrass control ranged between 94 and 100% across herbicide treatments.

Evaluations at 30 days after herbicide application indicated no potato injury from any of the herbicide or herbicide combinations (Table 3). Control of common lambsquarters, hairy nightshade, and pigweed species with F9312-3 herbicide alone at 0.122 to 0.1907 lb ai/acre (41-94%) was lower compared to previous evaluations at 13 days after herbicide application. Application of F9312-3 at 0.122 lb ai/acre plus metribuzin improved control of common lambsquarters, hairy nightshade, and pigweed species to 73-100%, which was similar to the control provided by the other herbicide combinations. Control of common lambsquarters, hairy nightshade, and pigweed species with Linex 0.75 lb ai/acre alone or Linex 0.75 lb ai/acre plus Dual Magnum 1.27 lb ai/acre ranged from 65 to 86%. A three-way tank mixture of Linex plus Dual Magnum plus metribuzin or Linex plus Outlook plus metribuzin or a two-way tank mixture of Linex plus Reflex provided complete control for common lambsquarters, hairy nightshade, and pigweed species at 30 days after herbicide application. Control for barnyardgrass at 30 days after herbicide application ranged from 80 to 100% across the herbicide treatments. Potato row closure at 30 days after herbicide application ranged from 84 to 94% across herbicide treatments compared to 48% for the untreated control or 89% for the handweeded treatment.

Evaluations conducted before potato harvest at 113 days after herbicide application indicated no potato injury from any of the herbicides evaluated (Table 4). This late-season evaluation indicated control for common lambsquarters with F9312-3 herbicide alone had deteriorated to 21-58% across the rates. Control of hairy nightshade and pigweed species with F9312-3 alone at 0.122 to 0.1902 lb ai/acre ranged from 78 to 91% and 80 to 93%, respectively. Late-season control of common lambsquarters, hairy nightshade, and pigweed species with linuron or linuron plus Dual Magnum was 59 and 71%, 75 and 80%, and 58 and 83%, respectively. Linuron plus Reflex provided more than 83% control of common lambsquarters, hairy nightshade, and pigweed species. All three-way herbicide tank mixtures that included linuron plus Outlook, Dual Magnum, Prowl H_2O, Reflex, and Eptam provided complete control of common lambsquarters, hairy nightshade, and pigweed species. Late-season control for barnyardgrass ranged from 83 to 100% across the herbicide treatments.

Potato yield varied widely across the herbicide treatments (Table 5). Marketable yield for treatments that included F9312-3 alone at 0.122 to 0.1907 lb ai/acre ranged from 271 to 386 cwt/acre compared to 513 cwt/acre for the hand-weeded control. The yield for the different herbicide tank mixtures reflected the level of weed control. The results suggest that Reflex would improve hairy nightshade control in potato. The experimental product F9312-3 would be a viable tank-mix partner with Reflex to manage weeds in potato.

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Table 1. Rainfall and irrigation dates for the herbicide study to evaluate several herbicides for weed control in potato at the Malheur Experiment Station, Oregon State University, Ontario, OR in 2014.

	Date	Duration (hours)	Amount (inches)	Type Description
1	4/02/2014		0.22	rain
2	4/23/2014		0.13	rain
3	4/24/2014		0.18	rain
4	4/25/2014		0.18	rain
5	4/26/2014		0.11	rain
6	4/28/2014		0.1	rain
7	4/29/2014	8		sprinkler
8	5/06/2014		0.04	rain
9	5/09/2014		0.28	rain
10	5/10/2014		0.09	rain
11	5/11/2014		0.02	rain
12	5/15/2014	6		sprinkler
13	5/18/2014		0.01	rain
14	5/19/2014		0.01	rain
15	5/30/2014	8		sprinkler
16	6/5/2014	8.5		sprinkler
17	6/8/2014	5		sprinkler
18	6/18/2014	8		sprinkler
19	6/23/2014	10		sprinkler
20	6/27/2014	4		sprinkler
21	6/30/2014	10		sprinkler
22	7/05/2014	10		sprinkler
23	7/09/2014	10		sprinkler
24	7/14/2014	10		sprinkler
25	7/18/2014	8		sprinkler
26	7/21/2014	11		sprinkler
27	7/27/2014	10		sprinkler
28	8/01/2014	10		sprinkler
29	8/08/2014	9		sprinkler
30	8/14/2014	9		sprinkler
31	8/21/2014	8.5		sprinkler
32	8/28/2014	8		sprinkler
33	9/05/2014	8		sprinkler

Table 2. Potato injury and weed control on May 27, 2014 in response to preemergence application of various herbicide combinations, Malheur Experiment Station, Oregon State University, Ontario, OR 2014.

	Treatment	Rate	Crop injury	Control[a]			
				Common lambsquarters	Hairy nightshade	Pigweed species[b]	Barnyardgrass
		lb ai/acre			%		
1	Untreated		0b	0 f	0 c	0 e	0 d
2	Hand-weeded		0b	100 a	100 a	100 a	100 a
3	F9312-3	0.122	0b	83 e	94 a	96 ab	98 ab
4	F9312-3	0.1436	0b	84 de	93 a	90 c	98 ab
5	F9312-3	0.1907	0b	92 bc	95 a	95 b	98 ab
6	F9312-3	0.122	0b	100 a	100 a	100 a	98 ab
	Metribuzin	0.375					
7	F9312-3	0.144	0b	100 a	100 a	100 a	100 a
	Metribuzin	0.375					
8	F9312-3	0.144	4a	100 a	100 a	100 a	100 a
	Rimsulfuron	0.0156					
9	F9314-3	0.196	0b	100 a	100 a	100 a	100 a
10	Linuron	0.75	1b	94 bc	89 ab	85 d	94 c
11	Linuron	0.75	0b	89 cd	96 a	98 ab	100 a
	S-metolachlor	1.27					
12	Linuron	0.75	0b	100 a	100 a	100 a	100 a
	S-metolachlor	1.27					
	Metribuzin	0.38					
13	Linuron	0.75	1b	100 a	78 b	100 a	100 a
	Dimethenamid-p	0.98					
	Fomesafen	0.25					
14	Linuron	0.75	0b	96 ab	100 a	100 a	96 bc
	Fomesafen	0.25					
15	Boundary	1.63	0b	100 a	100 a	100 a	100 a
	Fomesafen	0.25					
16	Boundary	1.63	1b	100 a	100 a	100 a	100 a
	Fomesafen	0.25					
	Metribuzin	0.2					
17	Boundary	1.22	1b	100 a	100 a	100 a	100 a
	Fomesafen	0.25					
	Pendimethalin	1					
18	*S*-metolachlor	1.27	0b	100 a	100 a	100 a	100 a
	Fomesafen	0.25					
	Pendimethalin	1					
19	Boundary	1.63	1b	100 a	100 a	100 a	100 a
	Fomesafen	0.25					
	Rimsulfuron	0.0234					
20	*S*-metolachlor	1.33	1b	100 a	100 a	100 a	100 a
	Fomesafen	0.25					
	EPTC	3.06					
	LSD (*P* = 0.05)		2.1	5.7	14.7	4.3	2.5

[a] Means within a column followed by same letter do not significantly differ (*P* = 0.05, LSD).
[b] Pigweed species = red root pigweed plus Powell amaranth.

Table 3. Potato injury and weed control on June 13, 2014 in response to preemergence application of various herbicide combinations, Malheur Experiment Station, Oregon State University, Ontario, OR 2014.

Treatment	Rate	Crop injury	Control[a]				
			Common lambsquarters	Hairy nightshade	Pigweed species[b]	Barnyardgrass	Row closure
	lb ai/acre	%					
1 Untreated		0 a	0 e	0 d	0 E	0 d	48 e
9 Hand-weeded		0 a	100 a	100 a	100 A	100 a	89 abc
2 F9312-3	0.122	0 a	49 d	81 bc	83 C	98 a	84 bcd
3 F9312-3	0.1436	0 a	41 d	86 bc	83 C	96 ab	89 abc
4 F9312-3	0.1907	0 a	73 c	91 ab	94 Ab	96 ab	88 a-d
5 F9312-3	0.122	0 a	100 a	99 a	100 A	96 ab	91 ab
Metribuzin	0.375						
6 F9312-3	0.144	0 a	100 a	100 a	100 A	100 a	91 ab
Metribuzin	0.375						
7 F9312-3	0.144	0 a	100 a	100 a	100 A	98 a	83 cd
Rimsulfuron	0.0156						
8 F9314-3	0.196	0 a	100 a	100 a	100 A	98 a	88 a-d
10 Linuron	0.75	0 a	86 b	80 c	65 D	79 c	84 bcd
11 Linuron	0.75	0 a	81 bc	83 bc	85 Bc	100 a	88 a-d
S-metolachlor	1.27						
12 Linuron	0.75	0 a	100 a	100 a	100 A	100 a	94 a
S-metolachlor	1.27						
Metribuzin	0.38						
13 Linuron	0.75	0 a	100 a	100 a	100 A	100 a	91 ab
Dimethenamid-p	0.98						
Fomesafen	0.25						
14 Linuron	0.75	0 a	93 ab	99 a	100 A	89 b	90 abc
Fomesafen	0.25						
15 Boundary	1.63	0 a	100 a	100 a	100 A	100 a	88 a-d
Fomesafen	0.25						
16 Boundary	1.63	0 a	100 a	100 a	100 A	100 a	91 ab
Fomesafen	0.25						
Metribuzin	0.2						
17 Boundary	1.22	0 a	100 a	100 a	100 A	100 a	80 d
Fomesafen	0.25						
Pendimethalin	1						
18 *S*-metolachlor	1.27	0 a	100 a	100 a	100 A	100 a	91 ab
Fomesafen	0.25						
Pendimethalin	1						
19 Boundary	1.63	0 a	100 a	100 a	100 A	100 a	88 a-d
Fomesafen	0.25						
Rimsulfuron	0.0234						
20 *S*-metolachlor	1.33	0 a	100 a	100 a	100 A	100 a	89 abc
Fomesafen	0.25						
EPTC	3.06						
LSD (*P* = 0.05)		NS	13	10	10	8	9

[a] Means within a column followed by same letter do not significantly differ (*P* = 0.05, LSD).
[b] Pigweed species = red root pigweed plus Powell amaranth.

Table 4. Potato injury and weed control on September 4, 2014 in response to preemergence application of various herbicide combinations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

	Treatment	Rate	Crop injury	Control[a]			
				Common lambsquarters	Hairy nightshade	Pigweed species[b]	Barnyardgrass
		lb ai/acre			%		
1	Untreated		0a	0 e	0 d	0 e	0 c
2	Hand-weeded		0a	94 a	98 a	93 ab	94 a
3	F9312-3	0.122	0a	31 d	78 c	80 c	94 a
4	F9312-3	0.1436	0a	21 d	81 bc	78 c	96 a
5	F9312-3	0.1907	0a	58 c	91 ab	93 ab	96 a
6	F9312-3	0.122	0a	100 a	98 a	100 a	99 a
	Metribuzin	0.375					
7	F9312-3	0.144	0a	100 a	100 a	100 a	100 a
	Metribuzin	0.375					
8	F9312-3	0.144	0a	99 a	100 a	100 a	98 a
	Rimsulfuron	0.0156					
9	F9314-3	0.196	0a	100 a	100 a	100 a	100 a
10	Linuron	0.75	0a	59 c	75 c	58 d	78 b
11	Linuron	0.75	0a	71 bc	80 c	83 bc	100 a
	S-metolachlor	1.27					
12	Linuron	0.75	0a	100 a	100 a	100 a	100 a
	S-metolachlor	1.27					
	Metribuzin	0.38					
13	Linuron	0.75	0a	100 a	100 a	100 a	100 a
	Dimethenamid-p	0.98					
	Fomesafen	0.25					
14	Linuron	0.75	0a	83 ab	98 a	100 a	83 b
	Fomesafen	0.25					
15	Boundary	1.63	0a	100 a	100 a	100 a	100 a
	Fomesafen	0.25					
16	Boundary	1.63	0a	100 a	100 a	100 a	100 a
	Fomesafen	0.25					
	Metribuzin	0.2					
17	Boundary	1.22	0a	100 a	100 a	100 a	100 a
	Fomesafen	0.25					
	Pendimethalin	1					
18	*S*-metolachlor	1.27	0a	100 a	100 a	100 a	100 a
	Fomesafen	0.25					
	Pendimethalin	1					
19	Boundary	1.63	0a	100 a	100 a	100 a	100 a
	Fomesafen	0.25					
	Rimsulfuron	0.0234					
20	*S*-metolachlor	1.33	0a	99 a	100 a	100 a	100 a
	Fomesafen	0.25					
	EPTC	3.06					
	LSD (*P* = 0.05)		NS	18	11	11	9

[a] Means within a column followed by same letter do not significantly differ (*P* = 0.05, LSD).
[b] Pigweed species = red root pigweed plus Powell amaranth.

Table 5. Potato yield in response to preemergence application of various herbicide combinations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2014.

			U.S. No. 1[a]								
	Treatment	Rate	4-6 oz	6-12 oz	>12 oz	Total	U.S. No. 2	Marketable[b]	<4 oz	Cull	Total yield
		lb ai/a	cwt/acre								
1	Untreated		15.3 d	10.8 f	0.9 f	27.0 g	1.6 g	28.6 h	72.6 de	2.5 g	103.7 h
2	Hand-weeded		108.1 abc	268.3 ab	113.5 abc	489.9 abc	23.5 b-g	513.4 a-d	92.5 a-e	25.9 d-g	631.8 abc
3	F9312-3	0.122	99.6 bc	128.3 de	35.3 ef	263.2 ef	10.5 fg	273.6 fg	104.1 a-d	6.1 g	383.8 fg
4	F9312-3	0.1436	95.9 bc	127.8 de	33.8 ef	257.6 ef	13.8 efg	271.4 fg	123.1 a	12.0 fg	406.4 efg
5	F9312-3	0.1907	104.0 abc	215.3 abc	47.9 def	367.1 cde	18.9 d-g	386.0 def	99.1 a-e	36.2 c-f	521.3 c-f
6	F9312-3	0.122	113.5 abc	249.9 abc	88.6 bcd	452.0 a-d	44.4 abc	496.4 a-d	113.9 abc	72.5 a	682.9 ab
	Metribuzin	0.375									
7	F9312-3	0.144	119.5 ab	235.2 abc	92.4 a-d	447.1 a-d	35.5 a-e	482.6 a-e	89.2 b-e	66.0 ab	637.8 abc
	Metribuzin	0.375									
8	F9312-3	0.144	95.0 bc	247.7 abc	131.4 ab	474.2 abc	38.6 a-d	512.7 a-d	92.4 a-e	45.3 a-e	650.5 abc
	Rimsulfuron	0.0156									
9	F9314-3	0.196	103.0 abc	268.1 ab	121.5 ab	492.7 ab	46.4 ab	539.1 abc	91.3 a-e	63.2 abc	693.6 ab
10	Linuron	0.75	107.5 abc	111.5 e	18.8 ef	237.8 f	3.8 g	241.7 g	120.1 abc	6.4 g	368.1 g
11	Linuron	0.75	105.9 abc	191.0 cd	50.7 def	347.5 def	10.6 fg	358.1 efg	105.6 abc	16.3 efg	480.0 d-g
	S-metolachlor	1.27									
12	Linuron	0.75	120.8 ab	281.8 a	133.4 ab	536.1 a	16.1 d-g	552.2 abc	71.8 de	65.2 abc	689.1 ab
	S-metolachlor	1.27									
	Metribuzin	0.38									
13	Linuron	0.75	106.7 abc	271.5 ab	129.0 ab	507.2 ab	23.6 b-g	530.8 abc	93.0 a-e	43.4 a-e	667.2 abc
	Dimethenamid-p	0.98									
	Fomesafen	0.25									
14	Linuron	0.75	138.8 a	225.7 abc	63.1 cde	427.6 a-d	20.8 c-g	448.5 b-e	121.1 ab	23.7 d-g	593.3 a-d
	Fomesafen	0.25									
15	Boundary	1.63	123.0 ab	269.6 ab	122.2 ab	514.9 a	29.9 a-f	544.8 abc	87.6 cde	47.4 a-d	679.8 ab
	Fomesafen	0.25									
16	Boundary	1.63	102.9 abc	267.9 ab	115.7 ab	486.4 abc	48.3 a	534.8 abc	103.5 a-d	50.7 a-d	689.0 ab
	Fomesafen	0.25									
	Metribuzin	0.2									
17	Boundary	1.22	119.4 ab	287.4 a	142.8 a	549.7 a	35.6 a-e	585.3 a	88.9 b-e	48.9 a-d	723.1 a
	Fomesafen	0.25									
	Prowl H2O	1									
18	*S*-metolachlor	1.27	116.4 abc	275.8 a	142.3 a	534.5 a	40.2 a-d	574.7 ab	89.2 b-e	62.1 abc	725.9 a
	Fomesafen	0.25									
	Prowl H2O	1									
19	Boundary	1.63	80.5 c	196.5 bcd	111.3 abc	388.3 bcd	44.1 abc	432.4 cde	68.7 e	41.8 b-e	542.9 b-e
	Fomesafen	0.25									
	Matrix	0.0234									
20	*S*-metolachlor	1.33	118.0 ab	245.4 abc	106.5 abc	470.0 a-d	37.2 a-e	507.1 a-d	95.6 a-e	60.2 abc	662.9 abc
	Fomesafen	0.25									
	EPTC	3.06									
LSD (*P* = 0.05)			37.2	75.7	51.2	123.8	24.7	133.9	32.9	29.7	150.8

[a] Means within a column followed by same letter do not significantly differ (*P* = 0.05, LSD).
[b] Marketable tubers are comprised of U.S. No. 1 and U.S. No. 2 that were larger than 4 oz each.