EVALUATION OF FOMESAFEN (REFLEX®) HERBICIDE FOR CROP SAFETY AND WEED CONTROL IN ONIONS

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Introduction

Good weed control in onion is essential for high productivity and quality. There are relatively few herbicides registered for weed control in direct-seeded onion. Thus, evaluation of herbicides for possible use to control weeds in onion is essential in order to minimize yield losses from weed competition and realize acceptable bulb size and overall yield. Onions are vulnerable to weed competition because of their slow early development and lack of a complete canopy cover to shade weeds. The weed control research program at Malheur Experiment Station endeavors to evaluate new herbicides that come on the market and determine whether they fit for weed control in direct-seeded onions grown under local production practices. The objectives of this study were to evaluate the herbicide Reflex® for weed control efficacy and to assess the tolerance of direct-seeded onion under furrow-irrigated conditions.

Materials and Methods

A study was established at the Malheur Experiment Station, Ontario, Oregon in 2014 in a field previously planted to wheat. The wheat stubble was flailed and the field was plowed during fall 2013. The soil was an Owyhee silt loam with a pH 7.2 and 1.25% organic matter. Based on a soil test, 40 lb of nitrogen (N)/acre, 100 lb phosphate/acre, 65 lb of potassium and 100 lb sulfur/acre were broadcast in the fall of 2013 and the field was moldboard plowed and groundhogged. The field was fumigated with Telone® C-17 at 15 gal/acre (1,3 dichloropropene 81.2% plus chloropicrin 16.5%) and simultaneously bedded on a 22-inch centers. On March 19, 2014, the beds were harrowed and flattened and supplemental weed seeds of common lambsquarters, pigweed, hairy nightshade, and kochia were uniformly distributed across the study area using a hand-powered spreader.

Onion variety ‘Vaquero’ was planted on March 20 in double rows spaced 3 inches apart and 4-inch seed spacing within each row on the 22-inch beds. Lorsban® 15G was banded at 3.7 oz/1,000 ft of row (chlorpyrifos 0.101 lb ai/acre) over the top of onion rows on March 21 and the soil surface was rolled.

The entire study area was sprayed with glyphosate at 0.77 lb ae/acre (Roundup PowerMax® at 22 fl oz/acre) plus pendimethalin at 0.95 lb ai/acre (Prow H2O® 32 fl oz/acre) on April 4 to control all emerged weeds prior to onion emergence. The hand-weeded plots were weeded weekly starting on April 23, 2014. The number of onion plants was determined on May 6 by counting all

plants in the two center rows of each plot. The entire study area was sprayed with sethoxydim at 0.28 lb ai/acre (Poast® at 1.5 pt/acre) plus a crop oil concentrate at 2 pt/acre on May 19 to control grassy weeds. All other activities followed the standard local onion production practices.

Postemergence treatments with and without Reflex were applied on May 8 and May 29 when onion plants were at the 2-leaf and 4-leaf stage, respectively. The complete list of herbicide treatments and rates is presented in Tables 1-4. Hand-weeded, untreated, and a grower standard of Prowl H2O followed by bromoxynil (Buctril®) and oxyfluorfen (GoalTender®) treatments were included.

The study was a randomized complete block design with four replications. Individual plots measured 7.33 ft wide (4 beds) and 27 ft long. Herbicide treatments were applied using a CO_2-pressurized backpack sprayer fitted with a boom equipped with four EVS8002 flat-fan nozzles to deliver a spray volume of 20 gal/acre.

The first furrow irrigation was on April 14 and lasted 24 hours to supply about 4 inches of water (including runoff). All subsequent irrigations (17 times from May 29 to August 27, 2014) were the same duration and delivered the same amount of water. Plants were sidedressed with a slow-release urea fertilizer on May 27 to supply 150 lb of N/acre.

To control thrips, onion plants were sprayed with Movento® at 0.50 oz/acre (spirotetramat at 0.078 lb ai/acre) tankmixed with Radiant® at 8 oz/acre (spinetoram at 1 oz ai/acre) and Pierce (crop oil concentrate) at 16 oz/100 gal of water on May 29 and again on June 3, 2014. Onion plants were sprayed again on June 17 using Agri-Mek® at 3.5 oz/acre plus NIS at 10 oz/100 gal of water to control thrips. Later sprays to control thrips were conducted aerially as follows: Agri-Mek 3.5 oz/acre plus NIS at 10 oz/100 gallons of water on June 30, Lannate® at 3 pt/acre (methomyl at 0.9 lb ai/acre) on July 6 and July 13, Radiant at 10 oz/acre (spinetoram at 1.25 oz ai/acre) on July 22 and 27, 2014.

Onions were visually evaluated for crop injury on April 18 and June 6, 2014. Weed control was evaluated subjectively on June 6 and weeds in each plot were counted and removed on June 16, 2014. Weed control evaluations were based on 0 to 100%; where 0% = no weed control or crop injury and 100% = complete weed control or complete crop kill.

Plant tops were flailed and onion bulbs were lifted on September 3 and 5, 2014, respectively. Bulbs were hand-harvested from the two center beds on September 10 and graded on September 12, 2014. Bulbs were graded for quality and yield based on USDA standards. Onion bulbs were graded according to diameter: small (<2¼ inches), medium (2¼-3 inches), jumbo (3-4 inches), colossal (4-4¼ inches), and supercolossal (>4¼ inches). U.S. No.1 and marketable yield are comprised of medium, jumbo, colossal and supercolossal grades. Data were subjected to analysis of variance and the treatment means were compared using protected LSD at 0.05% level of confidence.

Results and Discussion

Onion emergence was observed on April 11, 2014. Onion plant stand on May 6 prior to postemergence herbicide treatments was similar across treatments and ranged from 116,164 to 133,309 plants/acre (Table 1). Evaluations conducted on June 5 indicated onion injury ranging from 0 to 29% across herbicide treatments (Table 1). Injury from Reflex applied alone at 1.125,

0.25, or 0.5 lb ai/acre varied with increasing herbicide rate and ranged from 0 to 29%. Application of a tank mix of Reflex at 0.25 lb ai/acre plus Buctril at 0.125 lb ai/acre when onions were at the 2-leaf stage followed by a tank mix of Buctril at 0.125 lb ai/acre plus GoalTender at 0.125 lb ai/acre at the 4-leaf stage resulted in 18% injury. The injury from the grower standard of sequential application of Buctril at 0.125 lb ai/acre plus GoalTender at 0.125 lb/acre when onions were at the 2- and 4-leaf stage was also 18%. The injury was transient and onion plants recovered to show no injury on May 30 (data not shown).

Common lambsquarters control on June 6 (8 days after last postemergence herbicide application) ranged from 33 to 98% across treatments (Table 1). Application of Reflex alone at 0.125 or 0.25 lb ai/acre followed by a tank mix of Buctril at 0.125 lb ai/acre plus GoalTender at 0.125 lb ai/acre at the 4-leaf stage provided the lowest common lambsquarters control at 34 and 33%, respectively. The reduced common lambsquarters control for these treatments could be attributed to poor weed control from the application of Reflex alone at the 2-leaf stage, suggesting a tank mixture with Buctril may be required. Control for kochia, hairy nightshade, flixweed, and pigweed species on June 6 followed a trend similar to common lambsquarters. Tank-mixing Reflex with Buctril provided weed control similar to the grower standard of Buctril plus GoalTender.

Weeds counted on June 16, 2014 (18 days after the last postemergence herbicide application) corroborated the visual control estimates by showing that the application of Reflex alone at the 2-leaf stage followed by Buctril and GoalTender at the 4-leaf stage resulted in the greatest number of weeds compared to other treatments (Table 2). The number of pigweed species was variable across herbicide treatment, but was greater in Reflex applied alone at the 2-leaf stage. All treatments provided good control for kochia. Similarly, the Reflex-containing treatments provided good control for hairy nightshade and annual sowthistle, resulting in lower weed counts per plot on May 16, similar to the grower standard.

Small onion yield was similar across herbicide treatments and ranged from 1 to 13 cwt/acre (Table 3). Yield for medium, jumbo, colossal, and supercolossal onions was variable across herbicide treatments. Marketable onion yield ranged from 1,055 to 1,356 cwt/acre among herbicide treatments compared to 1,317 cwt/acre for the hand-weeded treatment. The total yield ranged from 1,061 to 1,357 cwt/acre across herbicide treatments compared to 1,321 for the hand-weeded. Marketable and total onion yield for the untreated control was 8 and 57 cwt/acre, respectively. The number of bulbs for the different grades including marketable and total yield followed similar trends as the yields for different onion grades.

These results indicated that onion tolerated Reflex when applied postemergence in mixtures with Buctril starting at the 2-leaf stage. A study to confirm these results will be conducted in the 2015 cropping season.

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Table 1. Onion injury, plant stand, and percent weed control on June 6, 2014 in response to fomesafen (Reflex®) herbicide application at the Malheur Experiment Station, Oregon State University, Ontario, OR in 2014.

							Weed control[a]				
	Treatment	Rate	Timing[b]	Injury 4/18/14	Plant stand 5/6/14	Injury 6/6/14	Common lambsquarters	Kochia	Hairy nightshade	Flixweed	Pigweed species
		lb ai/acre		%	No./acre			%			
1	Untreated			0.0 a	123,418 a	0 d	0 c	0 f	0 e	0 c	0 d
2	Prowl H_2O	0.95	A	0.0 a	132,100 a	5 cd	34 b	30 d	66 c	33 b	68 b
	Reflex	0.125	B								
	Buctril	0.125	C								
	GoalTender	0.125	C								
3	Prowl H_2O	0.95	A	0.0 a	131,880 a	6 c	33 b	24 e	30 d	30 b	31 c
	Reflex	0.25	B								
	Buctril	0.125	C								
	GoalTender	0.125	C								
4	Prowl H_2O	0.95	A	0.0 a	130,012 a	29 a	97 a	95 b	97 a	95 a	96 a
	Reflex	0.5	B								
	Buctril	0.125	C								
	GoalTender	0.125	C								
5	Prowl H_2O	0.95	A	0.0 a	133,309 a	5 cd	96 a	95 b	95 a	95 a	96 a
	Reflex	0.125	B								
	Buctril	0.125	B								
	GoalTender	0.125	B								
	Buctril	0.125	C								
	GoalTender	0.125	C								
6	Prowl H_2O	0.95	A	0.0 a	130,012 a	20 b	99 a	100 a	98 a	100 a	100 a
	Reflex	0.25	B								
	GoalTender	0.25	B								
	Buctril	0.125	C								
	GoalTender	0.125	C								
7	Prowl H_2O	0.95	A	0.0 a	116,055 a	18 b	97 a	97 ab	96 a	99 a	98 a
	Reflex	0.25	B								
	Buctril	0.125	B								
	Buctril	0.125	C								
	GoalTender	0.125	C								
8	Prowl H_2O	0.95	A	0.0 a	131,880 a	10 c	95 a	95 b	95 a	95 a	95 a
	Buctril	0.125	B								
	GoalTender	0.125	B								
	Reflex	0.25	C								
9	Prowl H_2O	0.95	A	0.0 a	131,001 a	20 b	98 a	100 a	95 a	100 a	100 a
	Buctril	0.125	B								
	GoalTender	0.125	B								
	Reflex	0.5	C								
10	Prowl H_2O	0.95	A	0.0 a	116,164 a	10 c	90 a	90 c	88 b	95 a	95 a
	Buctril	0.125	B								
	GoalTender	0.125	B								
	Reflex	0.125	C								
	Buctril	0.125	C								
	GoalTender	0.125	C								
11	Prowl H_2O	0.95	A	0.0 a	125,946 a	18 b	98 a	95 b	98 a	95 a	98 a
	GoalTender	0.125	B								
	Buctril	0.125	B								
	GoalTender	0.125	C								
	Buctril	0.125	C								
12	Hand-weeded			0.0 a	126,715 a	0 d	100 a	100 a	100 a	100 a	100 a
LSD (P = 0.05)				NS	NS	4	12	5	6	9	6

[a] Means within a column followed by same letter do not significantly differ (P = 0.05, LSD).
[b] Application timing A = Preemergence on 4/6; B and C = Postemergence at 2- and 6-leaf on 5/8 and 5/29/2014.

Table 2.Weed number per plot (198 ft^2) on June 16, 2014 (18 days after the last application) in direct-seeded onions sprayed with various herbicides at the Malheur Experiment Station, Oregon State University, Ontario, OR in 2014.

	Treatment	Herbicide rate lb ai/acre	Application[a] timing	Weed count[bc] Common lambsquarters	Pigweed species	Kochia	Hairy nightshade	Annual sowthistle
				weed number per plot[c]				
1	Untreated control			1,089	2,673	347	1,436	594
2	Prowl H_2O	0.95	A	48b	79a	12b	187b	3a
	Reflex	0.125	B					
	Buctril	0.125	C					
	GoalTender	0.125	C					
3	Prowl H_2O	0.95	A	76a	31bc	11b	129b	4a
	Reflex	0.25	B					
	Buctril	0.125	C					
	GoalTender	0.125	C					
4	Prowl H_2O	0.95	A	59b	16c	8b	23b	1a
	Reflex	0.5	B					
	Buctril	0.125	C					
	GoalTender	0.125	C					
5	Prowl H_2O	0.95	A	44b	28bc	6b	15b	0a
	Reflex	0.125	B					
	Buctril	0.125	B					
	GoalTender	0.125	B					
	Buctril	0.125	C					
	GoalTender	0.125	C					
6	Prowl H_2O	0.95	A	53b	9c	5b	33b	0a
	Reflex	0.25	B					
	GoalTender	0.25	B					
	Buctril	0.125	C					
	GoalTender	0.125	C					
7	Prowl H_2O	0.95	A	12b	13c	6b	28b	0a
	Reflex	0.25	B					
	Buctril	0.125	B					
	Buctril	0.125	C					
	GoalTender	0.125	C					
8	Prowl H_2O	0.95	A	2b	19c	11b	5b	0a
	Buctril	0.125	B					
	GoalTender	0.125	B					
	Reflex	0.25	C					
9	Prowl H_2O	0.95	A	3b	19c	5b	20b	0a
	Buctril	0.125	B					
	GoalTender	0.125	B					
	Reflex	0.5	C					
10	Prowl H_2O	0.95	A	50b	34bc	4b	16b	0a
	Buctril	0.125	B					
	GoalTender	0.125	B					
	Reflex	0.125	C					
	Buctril	0.125	C					
	GoalTender	0.125	C					
11	Prowl H_2O (Grower-	0.95	A	8b	24bc	4b	10b	1a
	GoalTender standard)	0.125	B					
	Buctril	0.125	B					
	GoalTender	0.125	C					
	Buctril	0.125	C					
12	Hand-weeded			10b	52ab	0b	22b	1a
LSD (*P* = 0.05)				60	31	10	614	NS

[a] A = Pre-emergence on 4/4; B = Onion at the 2-leaf stage on May 8; C = Onion at the 4-leaf stage on May 29, 2014.

[b] Analysis of variance did not include the untreated control.

[c] Means within a column followed by same letter do not significantly differ (*P* = 0.05, LSD).

Table 3. Onion yield in response to application of various herbicide combinations to control weeds in onion at the Malheur Experiment Station, Oregon State University, Ontario, OR in 2014.

					Marketable yield[b]				
			<2¼	2¼-3 in	3-4 in	4-4¼ in	>4¼ in	Marketable	Total
	Treatment	Rate	Timing[a]	Small	Medium	Jumbo	Colossal	Super-colossal	U.S. No. 1	yield
		lb ai/acre		---------- cwt/acre ----------						
1	Untreated control			49.2 a	8.0 d	0.0 e	0.0 c	0.0 e	8.0 c	57.2 c
2	Prowl H_2O	0.95	A	12.6 b	49.9 ab	696.1 a-d	352.7 ab	55.8 cde	1,154.5 ab	1,167.1 ab
	Reflex	0.125	B							
	Buctril	0.125	C							
	GoalTender	0.125	C							
3	Prowl H_2O	0.95	A	6.1 b	55.9 a	722.8 abc	342.9 ab	66.0 cde	1,187.6 ab	1,193.7 ab
	Reflex	0.25	B							
	Buctril	0.125	C							
	GoalTender	0.125	C							
4	Prowl H_2O	0.95	A	5.3 b	27.7 bcd	642.2 bcd	442.4 ab	108.9 abc	1,221.2 ab	1,226.6 ab
	Reflex	0.5	B							
	Buctril	0.125	C							
	GoalTender	0.125	C							
5	Prowl H_2O	0.95	A	4.7 b	38.8 abc	799.0 ab	280.8 b	30.4 de	1,148.9 ab	1,153.6 ab
	Reflex	0.125	B							
	Buctril	0.125	B							
	GoalTender	0.125	B							
	Buctril	0.125	C							
	GoalTender	0.125	C							
6	Prowl H_2O	0.95	A	5.9 b	25.8 bcd	700.8 a-d	397.5 ab	76.2 bcd	1,200.3 ab	1,206.2 ab
	Reflex	0.25	B							
	GoalTender	0.25	B							
	Buctril	0.125	C							
	GoalTender	0.125	C							
7	Prowl H_2O	0.95	A	5.6 b	30.3 bcd	560.7 cd	394.7 ab	69.7 b-e	1,055.4 a	1,061.0 b
	Reflex	0.25	B							
	Buctril	0.125	B							
	Buctril	0.125	C							
	GoalTender	0.125	C							
8	Prowl H_2O	0.95	A	1.3 b	20.1 cd	759.0 ab	473.5 ab	103.8 abc	1,356.3 a	1,357.6 a
	Buctril	0.125	B							
	GoalTender	0.125	B							
	Reflex	0.25	C							
9	Prowl H_2O	0.95	A	4.7 b	17.6 cd	826.5 a	422.7 ab	54.6 cde	1,321.4 a	1,326.1 a
	Buctril	0.125	B							
	GoalTender	0.125	B							
	Reflex	0.5	C							
10	Prowl H_2O	0.95	A	3.8 b	26.9 bcd	541.0 d	515.5 a	139.2 ab	1,222.6 ab	1,226.4 ab
	Buctril	0.125	B							
	GoalTender	0.125	B							
	Reflex	0.125	C							
	Buctril	0.125	C							
	GoalTender	0.125	C							
11	Prowl H_2O	0.95	A	5.2 b	18.9 cd	702.2 a-d	428.3 ab	111.2 abc	1,260.6 ab	1,265.9 ab
	GoalTender	0.125	B							
	Buctril	0.125	B							
	GoalTender	0.125	C							
	Buctril	0.125	C							
12	Hand-weeded			3.7 b	25.7 bcd	677.4 a-d	464.2 ab	150.1 a	1,317.4 a	1,321.1 a
LSD (*P* = 0.05)				17.5	24.2	168.6	212.3	71.8	222.3	220.7

[a] A = Pre-emergence on 4/4; B = Onion at the 2-leaf stage on May 8; C = Onion at the 4-leaf stage on May 29, 2014.
[b] Means within a column followed by same letter do not significantly differ (*P* = 0.05, LSD).

Table 4. Number of onion bulbs in response to application of various herbicide combinations to control weeds in onion at the Malheur Experiment Station, Oregon State University, Ontario, OR in 2014.

				Marketable yield[b]					
			< 2¼ in	2¼-3 in	3-4 in	4-4¼ in	>4¼ in	Marketable	Total
Treatment	Rate	Timing[a]	Small	Medium	Jumbo	Colossal	Super Colossal	U.S. No. 1	yield
	lb ai/acre		---------- Number of bulbs/acre ----------						
1 Untreated control			70,028 a	3,264 d	0 e	0 c	0 e	3,264 c	73,292 c
2 Prowl H_2O	0.95	A	5,044 b	11,869 ab	81,601 abc	26,409 ab	3,264 cde	123,143 ab	128,187 a
Reflex	0.125	B							
Buctril	0.125	C							
GoalTender	0.125	C							
3 Prowl H_2O	0.95	A	2,374 b	14,540 a	84,568 abc	26,112 ab	3,857 cde	129,078 a	131,452 a
Reflex	0.25	B							
Buctril	0.125	C							
GoalTender	0.125	C							
4 Prowl H_2O	0.95	A	2,077 b	7,122 bcd	72,402 bcd	32,640 ab	6,231 abc	118,395 ab	120,472 ab
Reflex	0.5	B							
Buctril	0.125	C							
GoalTender	0.125	C							
5 Prowl H_2O	0.95	A	1,780 b	10,089 abc	94,657 a	21,365 b	1,780 de	127,891 a	129,671 a
Reflex	0.125	B							
Buctril	0.125	B							
GoalTender	0.125	B							
Buctril	0.125	C							
GoalTender	0.125	C							
6 Prowl H_2O	0.95	A	2,374 b	6,825 bcd	78,337 a-d	30,563 ab	4,451 bcd	120,176 ab	122,550 ab
Reflex	0.25	B							
GoalTender	0.25	B							
Buctril	0.125	C							
GoalTender	0.125	C							
7 Prowl H_2O	0.95	A	1,780 b	8,012 a-d	64,094 cd	29,376 ab	3,857 cde	105,339 b	107,120 b
Reflex	0.25	B							
Buctril	0.125	B							
Buctril	0.125	C							
GoalTender	0.125	C							
8 Prowl H_2O	0.95	A	890 b	4,748 cd	81,898 abc	35,904 ab	6,231 abc	128,781 a	129,671 a
Buctril	0.125	B							
GoalTender	0.125	B							
Reflex	0.25	C							
9 Prowl H_2O	0.95	A	2,671 b	4,748 cd	90,206 ab	32,047 ab	3,264 cde	130,265 a	132,935 a
Buctril	0.125	B							
GoalTender	0.125	B							
Reflex	0.5	C							
10 Prowl H_2O	0.95	A	1,484 b	6,231 bcd	60,236 d	38,278 a	8,308 ab	113,054 ab	114,538 ab
Buctril	0.125	B							
GoalTender	0.125	B							
Reflex	0.125	C							
Buctril	0.125	C							
GoalTender	0.125	C							
11 Prowl H_2O	0.95	A	2,077 b	5,044 cd	77,150 a-d	32,344 ab	6,231 abc	120,769 ab	122,846 ab
GoalTender	0.125	B							
Buctril	0.125	B							
GoalTender	0.125	C							
Buctril	0.125	C							
12 Hand-weeded			1,484 b	6,528 bcd	76,556 a-d	35,014 ab	8,902 a	127,001 a	128,484 a
LSD (*P* = 0.05)			11,866	6,792	20,808	15,375	4,073	19,848	20,995

[a] A = Pre-emergence on 4/4; B = Onion at the 2-leaf stage May 8; C = Onion at the 4-leaf stage on May 29, 2014.
[b] Means within a column followed by same letter do not significantly differ (*P* = 0.05, LSD).