EVALUATION OF KIH-485 HERBICIDE FOR WEED CONTROL IN DIRECT-SEEDED ONION

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Introduction

Herbicide evaluation for weed control in specialty crops is a necessary step before the product can be registered by the U.S. Environmental Protection Agency (EPA) for use. Weed control in direct-seeded onion is essential in order to realize acceptable size and bulb yield. The herbicide KIH-485 (pyroxasulfone) is being evaluated and developed by Kumiai Chemical Industry for use on several crops. The weed program at the Malheur Experiment Station endeavors to evaluate new herbicides and determine use rates for direct-seeded onions grown under furrow irrigation. The objective of this study was to evaluate onion tolerance of KIH-485 and weed efficacy under local conditions.

Materials and Methods

A field study was conducted in 2010 at the Malheur Experiment Station, Ontario, Oregon to evaluate onion response and weed control with KIH-485 herbicide. The field was plowed and disked to create a seedbed suitable for onion production. Twenty-two-inch- wide beds were made to facilitate furrow irrigation.

The study had a randomized complete block design with 4 replications of all herbicide treatments and individual plots were 7.33 ft wide (4 rows) by 30.0 ft long. Pre-plant-incorporated (PPI) treatments were applied on March 23 and the soil was harrowed twice to incorporate the herbicide in the soil. Onion seeds of variety 'Vaquero' were planted on March 24, 2010 in double rows spaced 3.7 inches apart and 3.93 inches within the row on 22-inch beds. Lorsban® 15G (chlorpyrifos) was banded at 3.7 oz/1,000 ft of row (0.125 lb ai/acre) over the entire field on March 29 as a preventive measure against onion maggot. The study area was irrigated on March 30 to stimulate onion germination and emergence. Pre-emergence herbicide treatments were applied on April 6 and at the 1-leaf stage on May 14. All plots (except the untreated control) were sprayed with Prowl® H_2O at 2.1 pt/acre (pendimethalin at 1 lb ai/acre) on April 27. The 2-leaf post-emergence herbicide treatments were applied on May 31. All herbicide treatments were applied using a CO_2-pressurized backpack sprayer fitted with a boom equipped with four Teejet 8002EVS nozzles and calibrated to deliver 20 gal/acre of spray solution.

Plants were sprayed with Lorsban® 4E at 1 qt/acre (chlorpyrifos at 1 lb ai/acre) on May 6 to control onion maggot. Fertilizer was applied on June 8 to supply 250, 180, 9, 5, 4, and 1 lb/acre of nitrogen, phosphorus, potassium, zinc, manganese, and boron, respectively. Plants were sprayed with Movento® at 5 fl oz/acre (spirotetramat at 1.25 oz ai/acre) on June 23 for thrips control. Subsequent spraying for thrips control on June 30 used Success® at 8 oz/acre plus Aza-Direct® at 16 oz/acre plus Ad-wet® non-ionic surfactant at 1 qt/acre (spinosad at 0.125 lb ai/acre + azadirachtin at 0.0123 lb ai/acre + Ad-wet at 1.25% V/V). The trial was sprayed for thrips control again on August 26 using Lannate® at 3 pt/acre (methomyl at 0.9 lb ai/acre). Irrigation was scheduled to maintain moisture at a level suitable for onion production.

Visual evaluations for onion injury and weed control were conducted on June 7, July 22, and September 7 based on a visual scale of 0-100 percent where 0 percent = no injury or no weed control and 100 percent = total crop damage or complete weed control. Onions were lifted on September 14 and hand harvested from 27 ft of the 2 center rows on September 16. Onions were graded based on USDA standards on September 20, 2010. The data were subjected to analysis of variance and means compared using the least significance difference (LSD, $P = 0.05$).

Results and Discussion

Visual evaluations on June 7 indicated complete weed control for all treatments (data not presented). Onion plant injury on June 7 was moderate, ranging from 8 to 18 percent for the different herbicide treatments (Table 1). The average onion injury was 14 percent when KIH-485 was applied at 1.25 or 2 oz/acre and incorporated (PPI) in the soil before onions were planted. Application of KIH-485 at 1.25 or 2.0 oz/acre before onion emergence (PRE) resulted in 14 to 18 percent onion injury. Visual evaluations on July 22 indicated onion injury had subsided and only ranged from 1 to 6 percent (Table 1). Control of pigweed on July 22 ranged from 88 to 99 percent, with few differences among herbicide treatments. Hairy nightshade control ranged from 87 to 97 percent and again with few differences among herbicide treatments. Control for common lambsquarters ranged from 69 to 94 percent, with the PPI application of KIH-485 providing the greatest control. Late season control for common lambsquarters ranged from 68 to 94 percent. The results indicated reduced control for common lambsquarters when KIH-485 was applied, starting when the onions were at the 2-leaf stage.

The total number of onion bulbs per acre varied among herbicide treatments (Table 2). The lowest number of onion bulbs (98,890/acre) was recorded when KIH-485 was applied PPI at 2 oz/acre. Similarly, the number of onion bulbs was reduced when KIH-485 was applied PPI at 1.25 oz/acre. The total dry bulb onion yield varied among herbicide treatments and ranged from 564 to 698 cwt/acre. The marketable yield ranged from 368 to 551 cwt/acre. The results suggest that KIH-485 may be a suitable herbicide for weed control in onion; however, more studies are needed to verify these results and gather more data before contacting the product manufacture for a label expansion to include onions.

Table 1. Early, mid- and late-season weed control in direct-seeded onion treated with KIH-485 and other herbicides at Malheur Experiment Station, Ontario, OR 2010.

	Treatment	Rate	Timing	Crop injury[a]		Weed control: Redroot pigweed	Weed control: Hairy nightshade	Weed control: Common lambsquarters	
				Jun 7	Jul 22	Jul 22	Jul 22	Jul 22	Sep 7
		per acre		%					
1	Untreated			0 e	34 a	0 c	0 c	0 e	0 e
2	KIH-485	1.25 oz	PPI	15 ab	4 b	97 ab	97 a	94 ab	94 ab
	GoalTender	0.25 pt	2-lf						
3	KIH-485	1.25 oz	PRE	16 a	6 b	97 ab	92 ab	76 bcd	70 cd
	GoalTender	0.25 pt	2-lf						
4	KIH-485	1.25 oz	2-lf	13 a-d	1 b	89 b	88 b	69 d	68 d
	GoalTender	0.25 pt	2-lf						
5	KIH-485	2.0 oz	PPI	13 a-d	6 b	100 a	97 a	96 a	95 a
	GoalTender	0.25 pt	2-lf						
6	KIH-485	2 oz	PRE	14 abc	5 b	97 ab	87 b	84 a-d	83 a-d
	GoalTender	0.25 pt	2-lf						
7	KIH-485	2 oz	2-lf	13 a-d	3 b	88 b	90 ab	71 cd	70 cd
	GoalTender	0.25 pt	2-lf						
8	KIH-485	1.25 oz	1-lf	9 cd	1 b	97 ab	91 ab	84 a-d	81 a-d
	GoalTender	0.25 pt	2-lf						
9	KIH-485	1.25 oz	PRE	18 a	4 b	95 ab	90 ab	78 bcd	74 bcd
	GoalTender	0.5 pt	3-lf						
10	KIH-485	1.25 oz	2-lf	10 bcd	1 b	99 a	97 a	89 abc	89 abc
	Buctril	0.5 pt	2-lf						
11	Grower std.[b]			8 d	3 b	92 ab	90 ab	88 abc	88 a-d

[a] Means within a column followed by the same letter do not significantly differ (LSD, P = 0.05).
[b] Grower standard was treated with Prowl H_2O at 2 pt/acre (pendimethalin at 1 lb ai/acre) before onion emergence, followed by Buctril and Goal 2XL herbicides at 0.5pt /acre (bromoxynil and oxyfluorfen at 0.125 lb ai/acre).

Table 2. Dry bulb onion yield in response to KIH-485 herbicide applied to control weeds at Malheur Experiment Station, Ontario, OR, 2010.

Treatment		Rate	Timing	Onion	Onion yield[a] Total	Small	Medium	Jumbo	Colossal	Marketable
		per acre		bulbs/acre	cwt/acre					
1	Untreated			88440 e	98 c	70 a	24 e	5 d	0 a	17 d
2	KIH-485	1.25 oz	PPI	110990 cd	644 ab	14 b	104 d	520 ab	6 a	526 ab
	GoalTender	0.25 pt	2-lf							
3	KIH-485	1.25 oz	PRE	118470 abc	633 ab	14 b	163 abc	449 abc	8 a	457 abc
	GoalTender	0.25 pt	2-lf							
4	KIH-485	1.25 oz	2-lf	119130 abc	583 b	16 b	199 ab	368 c	0 a	368 c
	GoalTender	0.25 pt	2-lf							
5	KIH-485	2.0 oz	PPI	98890 de	564 b	16 b	91 d	453 abc	4 a	457 abc
	GoalTender	0.25 pt	2-lf							
6	KIH-485	2 oz	PRE	123530 abc	617 ab	19 b	196 ab	399 bc	3 a	402 bc
	GoalTender	0.25 pt	2-lf							
7	KIH-485	2 oz	2-lf	127160 ab	615 ab	17 b	210 a	387 bc	1 a	388 bc
	GoalTender	0.25 pt	2-lf							
8	KIH-485	1.25 oz	1-lf	128150 a	641 ab	19 b	182 abc	439 abc	1 a	441 abc
	GoalTender	0.25 pt	2-lf							
9	KIH-485	1.25 oz	PRE	114400 bc	604 b	16 b	146 bcd	441 abc	1 a	442 abc
	GoalTender	0.5 pt	3-lf							
10	KIH-485	1.25 oz	2-lf	123530 abc	698 a	14 b	133 cd	548 a	2 a	551 a
	Buctril	0.5 pt	2-lf							
11	Grower std[b]	1.5 pt		125730 ab	597 b	19 b	217 a	361 c	0 a	361 c

[a] Means within a column followed by the same letter do not significantly differ (LSD, P = 0.05).
[b] Grower standard was treated with Prowl H_2O at 2 pt/acre (pendimethalin at 1 lb ai/acre) before onion emergence, followed by post-emergence application of Buctril and Goal 2XL herbicides at 0.5 pt/acre (bromoxynil and oxyfluorfen at 0.125 lb ai/acre) when onions were at the 2-leaf stage.

DOSE RESPONSE OF ACTIVATED CHARCOAL TO DETOXIFY DUAL MAGNUM® AND OUTLOOK® APPLIED PRE-EMERGENCE ON DIRECT-SEEDED ONIONS

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Introduction

Yellow nutsedge is a problem in onion fields in the Treasure Valley of eastern Oregon and southwestern Idaho. Dual Magnum® (*s*-metolachlor) and Outlook® (dimethenamid-p) are registered for yellow nutsedge control in onions. The application timing of Dual Magnum and Outlook (starting when onions are at 2-leaf stage) makes these herbicides less effective. This is because Dual Magnum and Outlook are more effective in controlling yellow nutsedge when applied prior to yellow nutsedge emergence. The potential to use activated carbon to neutralize the two herbicides within the onion row was demonstrated in previous studies (Felix and Ishida 2009). However, determination of the most effective rate for activated charcoal to provide adequate crop protection will suggest the cost effectiveness of the practice in direct-seeded onion productions. The objective of this study was to determine the optimum rate of activated charcoal to be applied to neutralize the herbicides Dual Magnum and Outlook over the onion row when the herbicides are applied prior to onion emergence (PRE). **Dual Magnum and Outlook herbicides are not currently registered for pre-emergence application on direct-seeded dry bulb onions. Always read herbicide labels to ensure that the product is registered for the intended use.**

Materials and Methods

A field study was conducted in 2010 at the Malheur Experiment Station, Ontario, Oregon to determine the dose response of activated charcoal to detoxify Dual Magnum and Outlook applied PRE on direct-seeded onions. The field was harrowed and planted to onion variety 'Vaquero' on March 24, 2010. The study followed a split-plot design with charcoal rates forming the main plots to which herbicide rates were imposed as subplots. The study had 4 replications and the plots were 4 rows on 22-inch beds by 30 ft long. Activated charcoal was applied at the time of planting and herbicide treatments were applied on March 29, 2010.

The activated charcoal brand used was GRO-SAFE® (Norit Americas Inc., Atlanta, GA) and was applied using a modified planter fitted with a 25-gal Rear's NIFTY Tank Series (Rear's Manufacturing Co., Eugene, OR) with a 1-inch band of activated charcoal slurry sprayed directly over the onion row. Activated charcoal was applied at the rates of 5, 10, 15, 20, and 25 lb/acre in

50 gal of water on the soil surface directly behind the press wheel of the onion planter. Dual Magnum was applied at a rate of 1.33 pt/acre (1.27 lb ai/acre) and Outlook at 21 fl oz/acre (0.98 lb ai/acre). The study also included a grower standard, which was treated with Prowl® H_2O at 2 pt/acre (pendimethalin at 1 lb ai/acre) before onion emergence, followed by Buctril® and Goal® 2XL herbicides at 0.5 pt/acre (bromoxynil and oxyfluorfen at 0.125 lb ai/acre) with and without charcoal. An untreated control treatment was also included.

Lorsban® 15G was applied at a rate of 3.7 oz/1,000 ft of row over the entire field on March 29 as a preventive measure against onion maggots. Plants were counted in the center 2 rows of the plot by 15 ft length on May 12 to evaluate onion plant population density in response to herbicide treatments. A tankmix of Buctril at 16 oz/acre plus Goal at 8 oz/acre (bromoxynil at 0.25 lb ai/acre plus oxyfluorfen at 0.25 lb ai/acre) and Poast at 1.5 pt/acre (sethoxydim at 0.287 lb ai/acre) was applied on May 25 to control weeds. Fertilizer was applied on June 8 to supply 250 lb/acre of nitrogen, 180 lb/acre of phosphorus, 90 lb/acre of potassium, 5 lb/acre of zinc, 4 lb/acre of manganese, and 1 lb/acre of boron.

Movento® insecticide was applied on June 23 at a rate of 4 fl oz/acre plus Ad-Wet® non-ionic surfactant at 8 fl oz/100 gal of water for onion thrips control. Onions were sprayed for thrips control again on June 30 using Success® at 8 oz/acre plus Aza-Direct® at 16 oz/acre (spinosad at 0.125 lb ai/acre plus azadirachtin at 0.0123 lb ai/acre). Lannate® at 3 pt/acre (methomyl at 0.9 lb ai/acre) was applied on July 15, July 27, and August 26 for onion thrips control. Irrigation was scheduled to maintain proper moisture levels in the top 12 inches of soil profile.

Onions were lifted on September 14 from 27 ft of the center 2 rows and bulbs were hand harvested on September 16. Dry bulb onions were graded on September 20 using USDA standard categories. The data collected were subjected to analysis of variance and means compared using LSD at $P = 0.05$.

Results and Discussion

No significant reduction in plant stand or onion yield was observed with the various rates of activated charcoal when Dual Magnum and Outlook were applied PRE. However, the Dual Magnum treatment had significantly greater plant stand on May 12 relative to plots treated with Outlook or the grower standard treatment (data not shown). Generally, the onion yield results did not indicate significant differences among treatments for the different onion grade yields and total marketable yield (Table 1). Even though Dual Magnum did not show any significant reduction in plant stand and/or yield, it is not known what the response would be under extreme moisture conditions. Therefore, a separate study was conducted to evaluate onion response to Dual Magnum and Outlook applied PRE on direct-seeded dry bulb onions with the addition of sprinkler irrigation to simulate rain immediately after herbicide application. The results for that study are reported separately.

The dose response study will be repeated in 2011 to evaluate onion response to simulated rain after PRE application of herbicides. More studies are needed to evaluate crop response to Dual magnum and Outlook applied prior to onion emergence with different rates of activated charcoal. If a favorable crop response is demonstrated, we will work with the manufacturers to pursue future registration of Dual Magnum and Outlook for pre-emergence use on direct-seeded onions.

References

Felix, J., and J. Ishida. 2009. Use of activated charcoal to detoxify Dual Magnum® and Outlook® applied pre-emergence on direct-seeded onions. Oregon State University Malheur Agricultural Station Annual Report 2010:115-118.

Table 1. Onion yield in response to herbicides and activated charcoal rate at Malheur Experiment Station, Ontario, OR 2010

				Onion yield					
Treatment	Rate	Unit	Charcoal	Small	Medium	Jumbo	Colossal	Super Colossal	Marketable Yield
				---------- cwt/acre ----------					
Grower standard[a]			0 lb/a	13.8	165.2	493.0	2.0	0.0	660.2
Dual Magnum	1.33	pt/a	0 lb/a	11.5	109.6	611.8	7.5	0.0	728.9
Dual Magnum	1.33	pt/a	5 lb/a	15.7	154.3	496.8	2.4	0.0	653.6
Dual Magnum	1.33	pt/a	10 lb/a	17.2	169.5	511.5	2.7	0.0	683.7
Dual Magnum	1.33	pt/a	15 lb/a	14.4	153.4	593.5	10.6	0.0	757.6
Dual Magnum	1.33	pt/a	20 lb/a	21.7	173.1	488.9	1.2	0.0	663.2
Dual Magnum	1.33	pt/a	25 lb/a	53.5	253.1	423.8	0.0	0.0	676.9
Outlook	21.00	fl oz/a	0 lb/a	10.8	117.8	575.0	9.9	0.0	702.7
Outlook	21.00	fl oz/a	5 lb/a	10.7	131.8	534.6	4.4	0.0	670.9
Outlook	21.00	fl oz/a	10 lb/a	15.8	157.9	470.7	2.5	0.0	631.1
Outlook	21.00	fl oz/a	15 lb/a	10.9	129	600.5	4.9	0.0	734.5
Outlook	21.00	fl oz/a	20 lb/a	23.9	217.5	452.7	0.9	0.0	671.2
Outlook	21.00	fl oz/a	25 lb/a	21.1	176.4	497.1	2.3	0.0	675.8
				NS	NS	NS	NS	--	NS

[a] The grower standard was treated with Prowl H_2O at 2 pt/acre (pendimethalin at 1 lb ai/acre) before onion emergence, followed by Buctril and Goal 2XL herbicides at 0.5pt/acre (bromoxynil and oxyfluorfen at 0.125 lb ai/acre).

EVALUATION OF DUAL MAGNUM® AND OUTLOOK® USED PRE-EMERGENCE ON DIRECT-SEEDED DRY BULB ONIONS WITH ACTIVATED CHARCOAL

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Introduction

Yellow nutsedge has become an ever-growing threat to direct-seeded onions throughout the Treasure Valley of eastern Oregon and southwestern Idaho. A previous study indicated the effectiveness of activated charcoal to neutralize Dual Magnum® (*s*-metolachlor) and Outlook® (dimethenamid-p) in the onion row when applied pre-emergence (PRE) on direct-seeded onions (Felix and Ishida 2009). Dual Magnum and Outlook control yellow nutsedge best when applied prior to weed emergence. The objective of this study was to evaluate the potential use of activated charcoal to neutralize Dual Magnum and Outlook immediately within the onion row when applied PRE with and without simulated rain after herbicide application. **Dual Magnum and Outlook herbicides are not currently registered for pre-emergence application on direct-seeded dry bulb onions. Always read herbicide labels to ensure that the product is registered for the intended use.**

Materials and Methods

A field study was conducted in 2010 at the Malheur Experiment Station, Ontario, Oregon to evaluate the potential use of activated charcoal to neutralize Dual Magnum and Outlook within the onion row to protect emerging plants from the herbicide effects. The study also evaluated the effect of simulated rain (0.5 inches) shortly after herbicide application but before onion emergence. The beds formed during fall 2009 were harrowed and planted to onion variety 'Vaquero' on April 1, 2010. The study followed a split-plot design with simulated rain (with and without) forming the main blocks into which herbicide rates were imposed as subplots. The study had 4 replications and the plot size was 4 rows of 22-inch-wide beds by 22 ft long. Lorsban® 15G (chlorpyrifos at 0.125 lb ai/acre) was banded at 3.7 oz/1,000 ft of row over the entire field immediately after planting as a preventive measure against onion maggots. Activated charcoal was applied at the time of planting and herbicide treatments were applied on April 2, 2010.

The activated charcoal brand used was GRO-SAFE® (Norit Americas Inc., Atlanta, GA). Activated charcoal was applied using a modified planter fitted with a 25-gal Rear's NIFTY Tank Series (Rear's Manufacturing Co., Eugene, OR) and set to apply a 1-inch band of activated charcoal slurry directly over the onion row. Activated charcoal was applied at a rate of 25 lb/acre in 50 gal of water on the ground directly behind the onion planter's press wheel. Dual Magnum was applied PRE at the rates of 1.00 pt/acre or 1.33 pt/acre (0.95 lb ai/acre or 1.27 lb ai/acre) and Outlook at 10.5 fl oz/acre PRE followed by 10.5 fl oz/acre (0.49 lb ai/acre) or 21 fl oz/acre (0.98 lb ai/acre) when onions were at the 2-leaf stage. The study also included a grower standard, which was treated with Prowl® H_2O at 2 pt/acre (pendimethalin at 1 lb ai/acre) before onion emergence, followed by Buctril® and Goal® 2XL herbicides at 0.5 pt/acre (bromoxynil and oxyfluorfen at 0.125 lb ai/acre). An untreated control treatment was also included.

Half of the main plots received a sprinkler irrigation on April 7, 2010 simulating 0.5 inches of rainfall in 1 hour. The entire trial was sprayed with Roundup® at 1 qt/acre (1.13 ae/acre) on April 13 to control volunteer wheat. The study area was furrow irrigated on April 26. Plants were sprayed with Lorsban® 4E at the rate of 1 qt/acre (chlorpyrifos at 1 lb ai/acre) on May 6 to control onion maggots. The study area was furrow irrigated on May 19 to incorporate the insecticide in the soil.

Plant stand evaluations were accomplished by counting plants in 15 ft of the center 2 rows of the plot on May 4 and June 9. The entire study area was sprayed with a tankmix of Buctril® at 16 oz/acre plus Goal® 2XL at 8 oz/acre plus Poast® at 1.5 pt/acre (bromoxynil at 0.25 lb ai/acre plus oxyfluorfen at 0.25 lb ai/acre and sethoxydim at 0.287 lb ai/acre) on May 25 to control emerged weeds. Plants were fertilized on June 8 to supply 250 lb/acre of nitrogen, 180 lb/acre of phosphorus, 90 lb/acre of potassium, 5 lb/acre of zinc, 4 lb/acre of manganese, and 1 lb/acre of boron.

Plants were sprayed with Movento® at 4 fl oz/acre plus Ad-wet® non-ionic surfactant at 1 qt/acre (spirotetramat at 1.25 oz ai/acre plus Ad-wet at 1.25% V/V) on June 23 to control onion thrips. Subsequent spray for thrips control on June 30 used Success® at 8 oz/acre plus Aza-Direct® at 16 oz/acre plus Ad-wet non-ionic surfactant at 1 qt/acre (spinosad at 0.125 lb ai/acre + azadirachtin at 0.0123 lb ai/acre + Ad-wet at 1.25% V/V). The trial was sprayed for thrips control again on July 15 and 27 using Lannate® at 3 pt/acre (methomyl at 0.9 lb ai/acre).

The beds were corrugated and the study irrigated on June 25. Otherwise irrigation was scheduled to maintain proper moisture levels in the top 12 inches of soil profile.

Onions were lifted on September 14 and hand harvested from 22 ft of the 2 center rows on September 17. The onions were graded on September 21. During grading, bulbs were separated according to quality: bulbs without blemishes (No. 1), split bulbs (No. 2), neck rot (bulbs infected with the fungus *Botrytis allii* in the neck or side), plate rot (bulbs infected with the fungus *Fusarium oxysporum*), and black mold (bulbs infected with the fungus *Aspergillus niger*). The No. 1 bulbs were graded according to diameter: small (<2.25 inches), medium (2.25-3 inches), jumbo (3-4 inches), colossal (4-4.25 inches), and supercolossal (>4.25 inches). The data collected were subjected to analysis of variance and means compared using LSD at $P = 0.05$.

Results and Discussion

The onion plants suffered a high incidence of onion maggot, which possibly contributed to the observed differences in plant stand among treatments. The analysis of variance indicated differences in plant stand for treatments with and without charcoal and irrigation (Table 1). Evaluations on May 4 indicated reduced plant stand in irrigated plots that were not sprayed with charcoal. The plant stand was similar for plots treated with activated charcoal with or without irrigation. Plant count on June 9 indicated higher plant population density in treatments that received charcoal but no irrigation.

There also was a combined effect of herbicide and irrigation for onion plant stand (Table 2). Onion stand on May 4 ranged from 50,598 to 92,681 plants/acre across treatments. Onion stand was reduced when Dual Magnum was applied at 1 pt/acre and Outlook at 10.5 fl oz/acre followed by irrigation. Plant count on June 9 was greatly variable, likely due to onion maggot infestation experienced at the test site.

There were differences in onion yield attributed to the use of activated charcoal (Table 3). The marketable onion yield was 384 cwt/acre compared to 341 cwt/acre in plots treated with and without activated charcoal, respectively. Onion yield was also influenced by the combined effects of charcoal and irrigation (Table 4). The marketable onion yield was similar for plots treated with charcoal with and without irrigation. However, the yield was not significantly different from plots that were not treated with activated charcoal or irrigated. Again, the effect of onion maggot on plant stand may have contributed to the variability in onion plant stand, which in turn affected the final yield.

Onion yield was also affected by a combination of herbicide treatments and irrigation (Table 5). The onion marketable yield was generally low when herbicide treatments were followed by irrigation. The lowest yield was recorded in plots treated with Outlook at 21 fl oz/acre and irrigated. The highest yield was recorded in plots treated with Dual Magnum at 1 or 1.33 pt/acre and not irrigated. However, onion yields for Dual Magnum- treated plots were similar to the grower standard. These results lead us to believe that under ideal conditions the application of Dual Magnum and Outlook may not pose significant risk to the crop. However, in case of extreme conditions such as a rain incident after application of herbicides, there may be potential harm to direct-seeded onions when both herbicides are applied prior to onion emergence.

Yellow nutsedge control with Dual Magnum was not significantly different from the grower standard, mainly due to uneven distribution across the field. Outlook provided significantly less control at all treatment levels. The results may also have been influenced by the weather in 2010, which was cooler than normal. The study will be repeated in 2011 to further evaluate the treatments and refine the methodology for activated charcoal application. We are still convinced that yellow nutsedge control will be significantly better when Dual Magnum and/or Outlook herbicides are applied prior to nutsedge emergence.

References

Felix, J., and J. Ishida. 2009. Use of activated charcoal to detoxify Dual Magnum® and Outlook® applied pre-emergence on direct-seeded onions. Oregon State University Malheur Experiment Station Annual Report 2010:115-118.

Table 1. Onion plant population (plants/acre) in response to pre-emergence application of Dual Magnum and Outlook herbicides with and without activated charcoal and irrigation at Malheur Experiment Station, Ontario, OR 2010.

	Plant stand	
	May 4	**Jun 9**
Treatment[a]	**-------------------------- plants/acre --------------------------**	
Charcoal, with irrigation	83,109 b[b]	75,551 b
Charcoal, without irrigation	88,225 b	82,482 a
No charcoal, with irrigation	66,408 c	51,456 c
No charcoal, no irrigation	89,314 a	81,855 a

[a] Charcoal was applied at 25 lb/acre in 50 gal of water. Irrigation was applied to supply an equivalent of 0.5 inch of rain immediately after planting and application of herbicides.
[b] Means within a column followed by the same letter are not significantly different (LSD, $P \leq 0.05$)

Table 2. Onion plant population (plants/acre) in response to pre-emergence application of Dual Magnum and Outlook herbicides with and without irrigation at Malheur Experiment Station, Ontario, OR 2010.

				Plant stand[b]	
				5/4/10	6/9/10
Treatment	Active rate	Product rate	Irrigation	Plants/acre	
Grower standard[a]			--	92,681 a	96,444 a
Dual Magnum	0.95 lb ai/a	1.00 pt/a	Yes	73,035 b	57,727 e
Dual Magnum	0.95 lb ai/a	1.00 pt/a	No	93671 a	87,334 a
Dual Magnum	1.27 lb ai/a	1.33 pt/a	Yes	79,610 ab	62,480 cde
Dual Magnum	1.27 lb ai/a	1.33 fl oz/a	No	88,621 a	82,680 ab
Outlook	0.49 lb ai/a	10.50 fl oz/a	Yes	72,877 b	60,599 de
Outlook	0.49 lb ai/a	10.50 fl oz/a	No	88,819 a	83,274 ab
Outlook	0.98 lb ai/a	21.00 fl oz/a	Yes	50,598 c	36,142 f
Outlook	0.98 lb ai/a	21.00 fl oz/a	No	87,532 ab	79,908 abc
Untreated			Yes	79,710 ab	67,629 bcd
Untreated			No	81,294 ab	63,372 cde

[a] Grower standard treatment received pre-emergence Prowl H_2O at 2 pt/acre (0.95 lb ai/acre) followed by Goal Tender at 0.25 pt/acre (0.125 la ai/acre) when onions were at the 2-leaf stage. Dual Magnum was also applied to grower standard when onions were at the 2-leaf stage.
[b] Means within a column followed by the same letter are not significantly different (LSD, $P \leq 0.05$).

Table 3. Dry bulb onion yield in response to activated charcoal application at Malheur Experiment Station, Ontario, OR, 2010.

		Onion yield[a]					
Treatment	Charcoal rate	Small	Medium	Jumbo	Colossal	Super-colossal	Marketable yield
		------------------------------ cwt/acre ------------------------------					
Charcoal	25 lb/a	21 a	106 a	275 a	3 a	0	384 a
No charcoal	-- --	16 b	84 b	250 a	7 a	0	341 b

[a] Means within a column followed by the same letter are not significantly different (LSD, $P \leq 0.05$).

Table 4. Dry bulb onion yield in response to the application of activated charcoal and irrigation (0.5 inch) at Malheur Experiment Station, Ontario, OR, 2010.

		Onion yield[a]					
Treatment	Charcoal rate	Small	Medium	Jumbo	Colossal	Super-colossal	Marketable yield
		------------------------------ cwt/acre ------------------------------					
Charcoal, with irrigation	25 lb/a	19.1 a	99.5 a	254.8 a	2.5 a	0	356.8 a
Charcoal, no irrigation	25 lb/a	23.6 a	112.8 a	294.6 a	3.6 a	0	411.0 a
No charcoal, with irrigation	-- --	14.7 a	68.4 b	185.1 b	9.6 a	0	263.4 b
No charcoal, no irrigation	-- --	18.2 a	98.7 b	314.0 a	4.9 a	0	417.8 a

[a] Means within a column followed by the same letter are not significantly different (LSD, $P \leq 0.05$)

Table 5. Dry bulb onion yield in response to pre-emergence application of Dual Magnum and Outlook with or without irrigation (0.5 inch) at Malheur Experiment Station, Ontario, OR, 2010.

			Onion yield[a]					
Treatment	Rate	Irrigation	Small	Medium	Jumbo	Colossal	Super-colossal	Marketable yield
			-----	-----	-----	cwt/acre	-----	-----
Grower standard[b]		--	21 a	162.3 a	301.7 bcd	0.0 a	0.0 a	464.0 a
Dual Magnum	1.0 pt/a	Yes	18 a	82.6 a	249.9 cd	17.0 a	1.2 a	350.6 bc
Dual Magnum	1.0 pt/a	No	17 a	103.6 a	412.1 a	7.4 a	0.8 a	523.8 a
Dual Magnum	1.33 pt/a	Yes	9 a	49.6 a	259.7 cd	10.3 a	0.0 a	350.6 bc
Dual Magnum	1.33 pt/a	No	17 a	75.5 a	367.1 ab	6.3 a	0.0 a	449.0 a
Outlook	10.5 fl oz/a	Yes	15 a	69.0 a	235.2 de	6.5 a	0.0 a	310.7 c
Outlook	10.5 fl oz/a	No	14 a	98.0 a	344.9 ab	5.5 a	0.0 a	448.5 a
Outlook	21.0 fl oz/a	Yes	9 a	43.3 a	153.4 ef	2.3 a	0.0 a	198.9 e
Outlook	21.0 fl oz/a	No	15 a	93.3 a	319.5 bc	6.4 a	0.0 a	419.2 b
Untreated		Yes	30 a	97.0 a	119.8 f	0.0 a	0.0 a	216.8 de
Untreated		No	42 a	101.8 a	80.2 f	0.0 a	0.0 a	182.1 e

[a]Means with a column followed by the same letter are not significantly different (LSD, $P \leq 0.05$).
[b]Grower standard was treated with Prowl H_2O at 2 pt/acre pre-emergence followed by Goal Tender at 0.25 pt/a when onions were at the 2-leaf stage. Dual Magnum was also applied to grower standard when onions were at the 2-leaf stage.

Table 6. Yellow nutsedge control with Dual Magnum and Outlook applied prior to onion emergence using activated carbon at Malheur Experiment Station, Ontario, OR, 2010.

Treatment	Rate	Yellow nutsedge control (%)
Grower standard[a]		84.8 a[b]
Dual Magnum	1.33 pt/a	92.2 ab
Dual Magnum	1.00 pt/a	89 ab
Outlook	21.00 fl oz/a	83.9 bc
Outlook	10.50 fl oz/a	78.1 c
Untreated		0 d

[a] The grower standard was treated with Prowl® H_2O at 2 pt/acre (pendimethalin at 1 lb ai/acre) before onion emergence, followed by Buctril® and Goal® 2XL herbicides at 0.5pt/acre (bromoxynil and oxyfluorfen at 0.125 lb ai/acre).
[b] Means within a column followed by the same letter are not significantly different (LSD, $P \leq 0.05$)

EVALUATION OF SEVERAL HERBICIDES FOR POSSIBLE USE TO CONTROL WEEDS IN DIRECT-SEEDED ONION

Joel Felix and Joey Ishida, Malheur Experiment Station, Oregon State University, Ontario, OR

Introduction

Very few herbicides are available for weed control in direct-seeded onions. Evaluation of herbicides for weed control in specialty crops is necessary because most product labels include only major crops (wheat, corn, soybean, and cotton) when they are first registered. Therefore, evaluation of herbicide performance is the first step before products can be registered by the U.S. Environmental Protection Agency for use on any specialty crop. Weed control in direct-seeded onion is essential in order to realize acceptable bulb size and yield. The weed program at the Malheur Experiment Station endeavors to evaluate new herbicides that come on the market and to determine the use rates for direct-seeded onions grown under furrow-irrigation system. The objective of this study was to evaluate herbicides recently registered in other crops for weed efficacy and tolerance by direct-seeded dry bulb onions.

Materials and Methods

A field study was conducted in 2010 at the Malheur Experiment Station, Ontario, Oregon to evaluate onion response and weed control with several herbicides. The field was plowed and disked to create a seedbed suitable for onion production. Twenty-two- inch-wide beds were made to facilitate furrow irrigation. Onion seeds of variety 'Vaquero' were planted on March 24, 2010 in double rows spaced 3.7 inches apart and 3.9 inches within the row on 22-inch beds. Lorsban® 15G was banded at 3.7 oz/1,000 ft of row (chlorpyrifos at 0.125 lb ai/acre) over the entire field on March 29 as a preventive measure against onion maggot. The study area was irrigated on March 30 to stimulate onion germination and emergence.

The study followed a randomized complete block design with 4 replications; individual plots were 7.3 ft wide (4 rows) by 30.0 ft long. The products tested included Sharpen™ at 3 oz/acre (saflufenacil at 1.07 oz ai/acre), which was applied pre-emergence. The following herbicides were applied post-emergence when onions were at the 2-leaf stage. Integrity™ at 6.5 or 13 fl oz/acre (premix of saflufenacil and dimethenamid-p at 4.53 or 9.05 oz ai/acre); MON63410 at 0.187 pt/acre (acetochlor at 1.125 oz ai/acre); Huskie® at 11 or 15 fl oz/acre (premix of pyrasulfotole plus bromoxynil at 2.94 or 4 oz ai/acre); and Starane® at 0.35 pt/acre (1.96 oz ae/acre) alone or tankmixed with GoalTender at 0.25 or 0.5 pt/acre (oxyfluorfen at 2 or 4 oz ai/acre). The study also included a grower standard, which was treated with Prowl H_2O® at 2.1 pt/acre (pendimethalin at 1 lb ai/acre) pre-emergence followed by a tankmix of Goal 2XL® and Buctril® post-emergence when onion plants were at the 2-leaf stage. An untreated control was also included. The pre-emergence herbicide treatment was applied on April 9 and at the 2-leaf stage on May 31. All herbicide treatments were applied using a CO_2-pressurized backpack sprayer fitted with a boom equipped with four Teejet 8002EVS nozzles and calibrated to deliver 20 gal/acre of spray solution.

Plants were sprayed with Lorsban® 4E at 1 qt/acre (chlorpyrifos at 1 lb ai/acre) on May 6 to control onion maggot. Fertilizer was applied on June 8 to supply 250, 180, 9, 5, 4, and 1 lb/acre of nitrogen, phosphorus, potassium, zinc, manganese, and boron, respectively. Plants were sprayed with Movento® at 5 fl oz/acre (spirotetramat at 1.25 oz ai/acre) on June 23 for thrips control. Subsequent spraying for thrips control on June 30 used Success® (8 oz/acre) plus Aza-Direct® (16 oz/acre) plus Ad-wet® non-ionic surfactant at 1 qt/acre (spinosad at 0.125 lb ai/acre + Azadirachtin at 0.0123 lb ai/acre + Ad-wet at 1.25% V/V). The trial was sprayed for thrips control again on August 26 using Lannate® at 3 pt/acre (methomyl at 0.9 lb ai/acre). Irrigation was scheduled to maintain moisture at a level suitable for onion production.

Visual evaluations for onion injury and weed control were conducted on June 7, July 27, and September 7 based on a scale of 0-100 percent, where 0 percent = no injury or no weed control and 100 percent = total crop damage or complete weed control. Onions were lifted on September 14 and hand harvested from 27 ft of the 2 center rows on September 16. Onions were graded based on USDA standards on September 20, 2010. The data were subjected to analysis of variance and means compared using the least significance difference (LSD, $P = 0.05$).

Results and Discussion

Visual evaluations on June 7 indicated variability in onion injury among herbicide treatments (Table 1). Onion injury ranged from 9 percent with the grower standard and MON63410 to 80 percent with Sharpen at 3 oz/acre applied prior to onion emergence (PRE). All herbicides provided complete control for redroot pigweed, hairy nightshade, and common lambsquarters on June 7. Evaluations on July 27 indicated onion injury had subsided for plants treated with Starane Ultra, MON63410, and the grower standard (Table 2). However, onion injury was still high for plants treated with Sharpen pre-emergence at 3 oz/acre. Control for redroot pigweed on July 27 was 97 percent or greater across herbicide treatments. Hairy nightshade control was complete at 100 percent across herbicide treatments. Control for common lambsquarters ranged from 69 to 100 percent on July 27 and 64 to 100 percent on September 7.

The number of onion bulbs per acre varied among herbicide treatments (Table 3). The lowest number of bulbs per acre (26,510 and 40,920) was observed when Integrity at 3 oz/acre and Sharpen at 13 fl oz/acre were applied pre-emergence and post-emergence when onions were at the 2-leaf stage, respectively. The total onion yield varied among herbicide treatments with the lowest yield recorded when Integrity at 13 fl oz/acre was applied to onions at the 2-leaf stage. The lowest marketable onion yield was also recorded when Integrity was applied at 13 fl oz/acre. The results indicate that there is potential for MON63410 to be developed for weed control in onions. However, more studies are needed to confirm weed efficacy, crop tolerance, and low pesticide residues in the produce as well as the best application timing of MON63410 to onions.

Table 1. Early weed control and onion response to several ***unregistered*** herbicides applied to control weeds in onions at Malheur Experiment Station, Ontario, OR, 2010.

	Treatment	Rate (per acre)	Timing	Onion injury Jun 7	Weed control[a] Redroot pigweed	Weed control[a] Hairy nightshade	Weed control[a] Common lambsquarters
				%	%	%	%
1	Untreated			0 g	0 b	0 b	0 c
2	Sharpen	3 oz	PRE	80 b	100 a	100 a	100 a
	GoalTender	0.5 pt	2-leaf				
3	Integrity	6.5 fl oz	2-leaf	29 cde	100 a	100 a	100 a
4	Integrity	13 fl oz	2-leaf	95 a	100 a	100 a	100 a
5	MON63410	0.187 pt	2-leaf	9 fg	100 a	100 a	100 a
6	HUSKIE	11 fl oz	2-leaf	33 cd	100 a	100 a	100 a
7	HUSKIE	15 fl oz	2-leaf	39 c	100 a	100 a	100 a
8	STARANE Ultra	0.35 pt	2-leaf	18 ef	100 a	100 a	100 a
9	STARANE Ultra	0.35 pt	2-leaf	25 cde	100 a	100 a	99 b
	GoalTender	0.25 pt					
10	STARANE Ultra	0.35 pt	2-leaf	29 cde	100 a	100 a	100 a
	GoalTender	0.5 pt					
11	STARANE Ultra	0.35 pt	2-leaf	28 cde	100 a	100 a	100 a
	GoalTender	0.5 pt					
	Buctril	0.5 pt					
12	STARANE Ultra	0.35 pt	2-leaf	23 def	100 a	100 a	100 a
	Buctril	0.5 pt					
13	Grower standard[b]	2.1 pt	2-leaf	9 fg	100 a	100 a	100 a
	GoalTender	0.5 pt					

[a]Means within a column followed by same letter do not significantly differ (*P* = 0.05, LSD)
[b] Grower standard was treated with Prowl H2O at 2 pt/a (pendimethalin at 1 lb ai/acre) before onion emergence, followed by Buctril and Goal 2XL herbicides at 0.5 pt/acre (bromoxynil and oxyfluorfen at 0.125 lb ai/acre).

Table 2. Mid- and late-season weed control and onion response to several ***unregistered*** herbicides at Malheur Experiment Station, Ontario, OR 2010.

	Treatment	Rate (per acre)	Timing	Weed control[a] July 27 Onion injury	Redroot pigweed	Hairy nightshade	Common lambsquarters	Sept. 7 Common lambsquarters
				----------	----------	%	----------	----------
1	Untreated			0 e	0 c	0 b	0 d	0 d
2	Sharpen	3 oz	PRE	86 a	99 a	100 a	69 c	64 c
	GoalTender	0.5 pt	2-leaf					
3	Integrity	6.5 fl oz	2-leaf	16 cd	98 ab	100 a	94 ab	93 a
4	Integrity	13 fl oz	2-leaf	88 a	98 ab	100 a	96 ab	95 a
5	MON63410	0.187 pt	2-leaf	5 de	96 ab	100 a	88 ab	73 bc
6	HUSKIE	11 fl oz	2-leaf	24 bc	99 a	100 a	100 a	98 a
7	HUSKIE	15 fl oz	2-leaf	34 b	99 a	100 a	98 ab	97 a
8	STARANE Ultra	0.35 pt	2-leaf	5 de	97 ab	100 a	91 ab	88 ab
9	STARANE Ultra	0.35 pt	2-leaf	5 de	95 b	100 a	84 bc	73 bc
	GoalTender	0.25 pt						
10	STARANE Ultra	0.35 pt	2-leaf	6 de	99 a	100 a	91 ab	87 ab
	GoalTender	0.5 pt						
11	STARANE Ultra	0.35 pt	2-leaf	6 de	99 a	100 a	100 a	100 a
	GoalTender	0.5 pt						
	Buctril	0.5 pt						
12	STARANE Ultra	0.35 pt	2-leaf	5 de	98 ab	100 a	95 ab	94 a
	Buctril	0.5 pt						
13	Grower standard[b]	2.1 pt	2-leaf	4 e	99 a	100 a	91 ab	90 a
	GoalTender	0.5 pt						

[a]Means within a column followed by same letter do not significantly differ (*P* = 0.05, LSD)
[b] Grower standard was treated with Prowl H_2O at 2 pt/acre (pendimethalin at 1 lb ai/acre) before onion emergence, followed by Buctril and Goal 2XL herbicides at 0.5pt/acre (bromoxynil and oxyfluorfen at 0.125 lb ai/acre).

Table 3. Dry bulb onion yield in response to several ***unregistered*** herbicides used to control weeds at Malheur Experiment Station, Ontario, OR, 2010.

	Treatment	Rate	Timing	Onion	Onion yield[a] Total	Small	Medium	Jumbo	Colossal	Marketable
		per acre		bulbs/acre	cwt/acre					
1	Untreated			93720 b	90.4 g	67.9 a	16.7 f	5.8 h	0.0 a	22.6 g
2	Sharpen	3 oz	PRE	40920 c	206.3 f	10.6 f	47.0 f	148.7 ef	0.0 a	195.7 f
	GoalTender	0.5 pt	2-leaf							
3	Integrity	6.5 fl oz	2-leaf	118580 a	450.0 cd	23.7 def	195.3 a-d	231.0 def	0.0 a	426.3 cd
4	Integrity	13 fl oz	2-leaf	26510 c	95.5 g	14.4 ef	45.6 f	35.5 gh	0.0 a	81.1 g
5	MON 63410	0.187 pt	2-leaf	119240 a	532.0 abc	35.4 bcd	224.5 a	269.6 bcd	2.5 a	496.6 abc
6	HUSKIE	11 fl oz	2-leaf	104500 ab	403.4 de	49.7 abc	168.9 cde	183.5 def	0.0 a	353.7 de
7	HUSKIE	15 fl oz	2-leaf	96250 b	320.3 e	52.8 ab	139.6 e	127.9 fg	0.0 a	267.5 ef
8	STARANE Ultra	0.35 pt	2-leaf	110770 ab	546.1 ab	20.6 def	157.8 de	367.7 ab	0.0 a	525.5 ab
9	STARANE Ultra	0.35 pt	2-leaf	119020 a	518.8 abc	27.7 def	217.8 ab	273.3 bcd	0.0 a	491.1 abc
	GoalTender	0.25 pt								
10	STARANE Ultra	0.35 pt	2-leaf	116160 a	490.1 a-d	23.1 def	178.4 b-e	288.6 bcd	0.0 a	467.0 bc
	GoalTender	0.5 pt								
11	STARANE Ultra	0.35 pt	2-leaf	119900 a	516.0 abc	18.9 def	154.3 de	342.8 abc	0.0 a	497.1 abc
	GoalTender	0.5 pt								
	Buctril	0.5 pt								
12	STARANE Ultra	0.35 pt	2-leaf	106260 ab	578.2 a	13.6 ef	151.8 de	410.2 a	2.5 a	564.6 a
	Buctril	0.5 pt								
13	Grower standard[b]	2.1 pt	2-leaf	110880 ab	483.0 bcd	31.6 cde	212.7 abc	238.7 cde	0.0 a	451.4 bc
	GoalTender	0.5 pt								

[a] Means within a column followed by the same letter do not significantly differ (LSD, P = 0.05).
[b] Grower standard was treated with Prowl H_2O at 2 pt/acre (pendimethalin at 1 lb ai/acre) before onion emergence, followed by Buctril and Goal 2XL herbicides at 0.5 pt/acre (bromoxynil and oxyfluorfen at 0.125 lb ai/acre) when onions were at the 2-leaf stage.

EVALUATION OF REFLEX® (FOMESAFEN) HERBICIDE FOR YELLOW NUTSEDGE CONTROL IN POTATO

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Abstract

A field study was conducted in 2010 at the Malheur Experiment Station, Ontario, Oregon to evaluate Reflex® herbicide weed efficacy and compatibility with spray mix partners. The experiment design was a randomized complete block with four replications. Potato variety 'Ranger Russet' was planted on 36-inch beds and all herbicide treatments were applied before potato emergence. Reflex was applied alone at rates of 0.25 lb ai/acre or 0.5 lb ai/acre followed by post-emergence application of clethodim (Select®) at 0.125 lb ai/acre with crop oil concentrate at 1% V/V. Other treatments were tankmixes of fomesafen at 0.25 lb ai/acre with Dual Magnum® (*s*-metolachlor) at 1.27 lb ai/acre; Sencor® (metribuzin) at 0.31 lb ai/acre; Boundary® (s-metolachlor + metribuzin) at 1.625 lb ai/acre; and Outlook® (dimethenamid-p) at 0.98 lb ai/acre. When applied alone, Reflex controlled yellow nutsedge 86 to 87 percent. Control for common lambsquarters and pigweeds was 100 percent. None of the tested herbicide combinations caused injury to potato. Yellow nutsedge control improved to 98 to 99 percent when Reflex was used as a tankmix partner with Dual Magnum, Outlook, or Boundary. Marketable potato yield ranged from 263 cwt/acre to 455 cwt/acre. The results suggest that Reflex does not cause injury to potato when applied alone or in combination with other products already on the market. Reflex will contribute greatly to yellow nutsedge control when registered for use on potato. The study will be repeated to confirm these results.

Introduction

The overarching goal of this study was to evaluate and develop herbicide combinations to enable growers to manage weeds in potato. Weeds are major production concerns for potato growers since they often reduce potato yield, quality, and may possibly serve as alternative hosts for other crop pests. Once registered, Reflex (fomesafen) will bring a new herbicide group into potato weed control programs. Use of different herbicide families is recommended as a tactic to avoid selection for weed resistance to herbicides. The specific objective of this project was to evaluate Reflex herbicide for yellow nutsedge control when applied alone or as a tankmix partner with standard potato herbicides.

Materials and Methods

The field was plowed and disked during fall 2009 to create a favorable seedbed for potato production. The field was disked again on April 9, 2010 and 36-inch beds were formed. Ranger Russet potato seed pieces were planted on April 23 using a two-row potato planter. The experiment design was a randomized complete block with four replications. Plots were 9 ft (3 rows) wide by 27 ft in length. The fertilizer was broadcast on May 3 to provide 170 lb nitrogen (N)/acre, 150 lb phosphorus (P)/acre, 100 lb potassium (K)/acre, 1 lb zinc (Zn)/acre, 1 lb manganese (Mn)/acre, and 2 lb boron (B)/acre. The beds were immediately rehilled using a Lilleston. Pre-emergence herbicides were applied on May 13 using a compressed CO_2-backpack sprayer with a boom equipped with six Teejet 8002EVS nozzles. Treatments including post-emergence products were applied on June 24. The first furrow irrigation was on June 14 for 24 hours. Visual assessment for potato plant injury and early weed control was made on June 17 and on August 23 to assess late weed control. Visual evaluations were based on a scale of 0 to 100 percent, where 0 = no crop injury or no weed control and 100 = complete crop damage or total weed control. Preventative sprays for late blight were done on June 21 and August 15. The field was irrigated for 24 hours on June 22, July 7, 15, 19, 27, August 3, 14, and 23. Potato vines were flailed on September 7 and the center row harvested on September 13 to determine yield. Potato tubers were graded following USDA standards on September 24-27, 2010. Potatoes were sorted into grades as follows; less than 4 oz, U.S. No.1 (4-6 oz, 6-12 oz, and >12 oz), and U.S. No.2. There were no culls or rotten potatoes. Marketable category was comprised of 4-6 oz to over 12-oz tubers. The data were subjected to analysis of variance using the Statistical Analysis Software (SAS, Institute, Inc., Cary, NC) and means were compared using LSD at $P \leq 0.05$.

Results and Discussion

Visual evaluation indicated no potato injury from any of the herbicide combinations in this study (Table 1). Early weed control was excellent for all treatments. Evaluation for potato row closure on July 6, 2010 indicated no significant difference among plants treated with different herbicide combinations. Late season yellow nutsedge control was 85-to 88 percent for plots treated with Reflex (fomesafen) at 0.25 lb ai/acre and 0.50 lb ai/acre, respectively, followed by post emergence application of Select at 0.125 lb ai/acre. A tank mix of Reflex at 0.25 lb ai/acre plus Sencor (metribuzin) at 0.31 lb ai/acre provided 88 percent yellow nutsedge control. Yellow nutsedge control with Reflex at 0.25 lb ai/acre plus Dual magnum (*s*-metolachlor) at 1.27 lb ai/acre was 99 percent, which was similar to Reflex at 0.25 lb ai/acre plus Outlook (dimethenamid-p) at 0.98 lb ai/acre. Control for common lambsquarters was 88 percent when Reflex was applied at 0.25 lb ai/acre and 0.50 lb ai/acre. Control of lambsquarters with tank mixtures of Reflex at 0.25 lb ai/acre with Dual Magnum at 1.27 lb ai/acre, or Sencor at 0.31 lb ai/acre, or Boundary (s-metolachlor + metribuzin) at 1.625 lb ai/acre, or Outlook at 0.98 lb ai/acre ranged from 94 to 100 percent. Pigweed control ranged from 99 to 100 percent for all the treatments evaluated. Even when applied alone at 0.25 lb ai/acre and 0.50 lb ai/acre, Reflex provided 99 to 100 percent pigweed control. Barnyardgrass was controlled 100 percent with all the treatments evaluated. These results suggest improved broadleaf weed control even when Refelex was applied alone. However, a grass herbicide will be needed to provide complete grass control. Tank-mixing Reflex with herbicides already on the market provided superior weed control in potatoes. The study will be repeated to confirm these preliminary results.

Potato tuber yield reflected the level of early season weed control. There was no difference in U.S. No. 2 potato yield among herbicide treatments tested, which ranged from 27 to 62 cwt/acre (Table 2). Small size tuber yield (<4 oz) was similar across treatments and ranged from 80 to 104 cwt/acre. Similarly, there was no significant difference among treatments for the 4- to 6-oz tuber size. The 4- to 6-oz tuber yield ranged from 72 to 105 cwt/acre with the untreated plots producing the lowest yield. The untreated control also produced the lowest 6- to 12-oz tuber yield, which was 120 cwt/acre compared to 176 cwt/acre to 243 cwt/acre for herbicide treatments. The U.S. No.1 potato tuber yield was similar for the different herbicide treatments and ranged from 320 cwt/acre to 414 cwt/acre. The untreated control produced the lowest U.S. No.1 tubers at 236 cwt/acre. These results further confirm that Reflex will provide needed yellow nutsedge control and is not injurious to potato plants or tubers.

Table 1. Late season weed control in potato with Reflex (fomesafen) alone and with tankmix partners at the Malheur Experiment Station, Ontario, OR, 2010.

				Control[a]			
		Crop injury	Row closure	Yellow nutsedge	Pigweed species	Common lambsquarters	Barnyard grass
		Jun 17	Jul 6	Aug 23		Aug 23	
Treatment	Rate	%					
1 Untreated		0 a	94 a	0 c	0 c	0 c	0 b
2 Dimethenamid-p	0.84 lb ai/a	0 a	96 a	95 a	100 a	98 a	100 a
Flumioxazin	0.047 lb ai/a						
Metribuzin	0.31 lb ai/a						
3 Fomesafen	0.25 lb ai/a	0 a	96 a	85 b	99 ab	88 b	100 a
Clethodim	0.125 lb ai/a						
COC	1 % v/v						
4 Fomesafen	0.5 lb ai/a	0 a	98 a	88 b	100 a	89 b	100 a
Clethodim	0.125 lb ai/a						
COC	1 % v/v						
5 Fomesafen	0.25 lb ai/a	0 a	98 a	99 a	99 b	94 ab	100 a
s-metolachlor	1.27 lb ai/a						
6 Fomesafen	0.25 lb ai/a	0 a	99 a	88 b	100 a	99 a	100 a
Metribuzin	0.31 lb ai/a						
7 Fomesafen	0.25 lb ai/a	0 a	99 a	98 a	100 a	96 a	100 a
Boundary	1.625 lb ai/a						
8 Boundary	1.625 lb ai/a	0 a	96 a	100 a	100 a	98 a	100 a
9 Fomesafen	0.25 lb ai/a	0 a	100 a	98 a	100 a	100 a	100 a
Boundary	1.625 lb ai/a						
Sencor 4 FL	0.25 lb ai/a						
10 Fomesafen	0.25 lb ai/a	0 a	98 a	99 a	100 a	99 a	100 a
Dimethenamid-p	0.98 lb ai/a						

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

Table 2. Potato tuber yield in response to application of Reflex (fomesafen) herbicide alone or with tankmix partners to control weeds at the Malheur Experiment Station, Ontario, OR, 2010

			Yield[a]						
					U.S. No.1				Total
			U.S. No. 2	<4 oz	4-6 oz	6-12 oz	>12 oz	Total	marketable
	Treatment	Rate	----	----	----	cwt/acre	----	----	----
1	Untreated		27 a	89 a	72 a	120 b	43 a	236 b	263 b
2	Dimethenamid-p	0.84 lb ai/a	45 a	88 a	90 a	252 a	66 a	408 a	453 a
	Flumioxazin	0.047 lb ai/a							
	Metribuzin	0.31 lb ai/a							
3	Fomesafen	0.25 lb ai/a	34 a	93 a	105 a	238 a	60 a	403 a	437 a
	Clethodim	0.125 lb ai/a							
	COC	1 % v/v							
4	Fomesafen	0.5 lb ai/a	36 a	80 a	88 a	185 ab	64 a	338 ab	374 a
	Clethodim	0.125 lb ai/a							
	COC	1 % v/v							
5	Fomesafen	0.25 lb ai/a	41 a	97 a	116 a	233 a	66 a	414 a	455 a
	s-metolachlor	1.27 lb ai/a							
6	Fomesafen	0.25 lb ai/a	46 a	99 a	89 a	203 a	51 a	343 a	389 a
	Metribuzin	0.31 lb ai/a							
7	Fomesafen	0.25 lb ai/a	40 a	96 a	92 a	244 a	72 a	407 a	447 a
	Boundary	1.625 lb ai/a							
8	Boundary	1.625 lb ai/a	54 a	98 a	102 a	232 a	66 a	400 a	454 a
9	Fomesafen	0.25 lb ai/a	45 a	104 a	103 a	196 ab	54 a	353 a	398 a
	Boundary	1.625 lb ai/a							
	Sencor 4 FL	0.25 lb ai/a							
10	Fomesafen	0.25 lb ai/a	62 a	100 a	88 a	176 ab	56 a	319 ab	381 a
	Dimethenamid-p	0.98 lb ai/a							

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

EVALUATION OF STRIP TILLAGE IN SUGAR BEETS UNDER FURROW IRRIGATION

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Introduction

Sugar beet growers in eastern Oregon and southwestern Idaho have expressed interest in adopting strip tillage in their production operations. Strip tillage, also known as zone tillage or conservation tillage, has been adopted and is widely used in the rainfed areas of the U.S. Midwest and other parts of the world. However, the practice has been largely restricted to large seeded crops like corn and soybeans (Al-Kaisi and Licht 2004). Strip tillage is a system combining the benefits of no-till and full tillage to produce row crops. It has been reported that strip tillage maintains about two-thirds to three-quarters as much residue as no-till systems. With fall strip tillage, narrow strips, typically 5 to 9 inches deep and 7 to 9 inches wide, are tilled in the center of the crop row to incorporate the stubble into the soil, while the area between rows is left undisturbed. Since the tilled strips correspond to planter row width, the crop is subsequently planted into the cleared areas during spring.

Strip tillage addresses a common concern of conservation tillage related to soil warm-up in the spring by clearing stubble in the row while maintaining high residue levels overall. Besides many environmental benefits, strip tillage can yield economic benefits as well. Fuel costs can be reduced as field operations (trips across the field) are decreased and fertilizer costs can be decreased with banding instead of broadcasting. Fertilizer banding is a key feature of strip tillage and allows for nutrient placement in the strip zone and may reduce surface nitrogen loss and underground water contamination.

For small-seeded crops like sugar beet, strip tillage has not been nearly as successful, primarily due to poor seed-to-soil contact. Older strip tillage equipment did not make a seedbed firm enough and tended to leave air pockets, largely due to their inability to break and incorporate the stubble within strips. Recent improvements in strip tillage equipment have created an interest for growers of small-seeded crops to adopt strip tillage. In fact, strip tillage for sugar beets has been evaluated and partly adopted by growers in Montana and Nebraska. Recently, sugar beet growers in Idaho and eastern Oregon have expressed a desire to use strip tillage as a goal towards environmental stewardship and reducing the cost of production. Adoption of strip tillage for sugar beets has largely been restricted to growers who exclusively use overhead irrigation (sprinklers and center pivots) for irrigation. There is a need to evaluate the usefulness of strip tillage for furrow-irrigated fields in the Treasure Valley.

Materials and Methods

A field study was conducted at the Malheur Experiment Station, Ontario, Oregon during 2010 in a field previously planted to wheat on 30-inch bed centers. Wheat stubble was cut to 6-inch height on August 4, 2009. The field was irrigated to encourage volunteer wheat emergence. Glyphosate at 22 fl oz/acre (0.77 lb ae/acre) was applied on October 18 to control all volunteer wheat and weeds. The strip-cat tiller was used to create 7- to 9-inch-wide strips on November 23, 2009. On April 15, 2010, Saber Cat row cleaners were used to prepare the strips before planting. The study followed a split-plot design with nitrogen (N) level as main plots and herbicide treatments as subplots. The plot size was 7.33 ft (4 rows wide) by 27 ft. The study had four replications. Sugar beet hybrid 'Betaseed 27RR10' was planted on April 16, 2010 using a John Deere 71 flex planter. The first furrow irrigation was delivered on April 27 and lasted for 24 hours. Soil samples were pulled from 1-inch, 2-inch, and 3-inch depth to determine soil fertility. Based on soil analyses and estimated crop needs, plots were fertilized to supply 267, 200, 134, and 0 lb N/acre, which corresponded to 1x, 0.75x, 0.5x, and 0x of the recommended N rate. The field was later corrugated and furrow irrigated for 24 hours.

Herbicide treatments were applied sequentially when sugar beets were at the 2-leaf (May 14) and at 4-leaf stage (May 25) using a backpack CO_2 sprayer. Treatments included; sequential glyphosate at 22 fl oz/acre; glyphosate 22 fl oz/acre followed by glyphosate at 22 fl oz/acre + Nortron at 12 fl oz/acre (ethofumesate at 0.38 lb ai/acre); glyphosate at 22 fl oz/acre followed by glyphosate at 22 fl oz/acre + Outlook at 18 fl oz/acre (dimethenamid-p at 0.98 lb ai/acre); glyphosate at 22 fl oz/acre followed by glyphosate at 22 fl oz/acre + Stinger® at 12 fl oz/acre (chlopyralid at 0.28 lb ae/acre).

A tank mixture of Proline® fungicide at 5 oz/acre (prothioconazole at 0.156 lb ai/acre) plus sulfur 5 lb/acre was applied on June 26 as a preventive measure against powdery mildew. Subsequent tank mixture of Proline fungicide at 12 fl oz/acre plus sulfur at 5 lb/acre was applied on July 18. The field was furrow irrigated for 24 hours each on June 28, 30, July 8, 14, 23, 29, August 4, 13, 20, September 1, and 14, 2010. Soil sampling to estimate nitrate and ammonium levels at 1-ft and 2-ft depth was done on July 27. Soil samples at each depth were comprised of 10 subsamples per plot.

Visual plant injury and weed control was performed on June 14 and August 9 based on a scale of 0 to 100 percent (0 percent = no weed control or crop injury and 100 percent = complete weed control or crop damage).

Sugar beet foliage was flailed and the crowns removed with rotating disks on October 18. Roots were hand harvested from 10 ft of the 2 center rows of each plot on October 18 and 19, 2010. The roots were counted, weighted, and samples transported daily to the Snake River Sugar factory in Nampa, Idaho for laboratory analysis to determine percentage sucrose content, nitrate, and root conductivity. Sugar concentrations were adjusted by multiplying the measured sucrose by 0.98 to estimate the sugar that would have been lost to respiration if the beets had been stored in a pile.

Data were subjected to statistical analysis and means compared with the use of the least significant difference (LSD) at $P \leq 0.05$.

Results and Discussion

There was an N level and herbicide treatment interaction for the level of weed control. Visual evaluation on June 14 indicated that sugar beet injury across herbicide treatments and N rates ranged from 0 to 10 percent (Table 1). The injury was characterized by transient yellowing of the leaves. Crop injury in the untreated treatment ranged from 4 to 11 percent mainly due to excessive competition with weeds. Control of common lambsquarters (*Chenopodium album*) ranged from 90 to 100 percent and was generally reduced in plots that did not receive N. Pigweed (*Amaranthus* spp.) control ranged from 46 to 100 percent and was lowest in plots without N application and when glyphosate at 22 fl oz/acre was applied sequentially without soil active herbicides. All treatments provided 100 percent control for kochia (*Kochia scoparia*) and annual sowthistle (*Sonchus oleraceus*). Control for hairy nightshade (*Solanum sarrachoides*) ranged from 95 to 100 percent across N rates and herbicide treatments. Barnyardgrass (*Echinochloa crus-galli*) control ranged from 95 to 100 percent.

Late season crop injury and weed control was evaluated on August 9. Crop injury ranged from 3 to 54 percent (Table 2). The highest injury was observed in plots that did not receive N fertilizer, regardless of the herbicides used. Sugar beet plants in the untreated treatment were greatly stunted. Common lambsquarters control ranged from 85 to 100 percent across N rates and herbicide treatments. Control of pigweed ranged from 9 to 100 percent. Plots that were not fertilized had the lowest pigweed control, regardless of the herbicide treatment used. Late season kochia control was still high at 95 to 100 percent. Control of hairy nightshade was 100 percent across treatments. Annual sowthistle control ranged from 73 to 100 percent. Control for barnyardgrass ranged from 55 to 100 percent.

There was no statistical difference among treatments for sugar beet plant stand, which ranged from 32,370 to 46,031 plants/acre (Table 3). Root yield ranged from 18.2 to 62.8 ton/acre across treatments. The highest yield was observed when N was applied at 267 lb/acre and weeds controlled by glyphosate at 22 fl oz/acre followed by a tank mixture of glyphosate at 22 fl oz/acre + Outlook at 18 fl oz/acre. Sucrose content ranged from 16.4 to 19.5 percent. The estimated recoverable sugar ranged from 5,479 to 18,253 lb/acre. Mid-season soil nitrate content (July 27) ranged from 5.7 to 48.8 ppm and 2.5 to 22.2 ppm at the 1-ft and 2-ft depth, respectively. The corresponding ammonium content ranged from 3.3 to 21.6 and 1.6 to 8 ppm. The soil nitrate and ammonium content directly reflected N rates used.

References

Al-Kaisi, M., and M.A. Licht. 2004. Effect of strip tillage on corn nitrogen uptake and residual soil nitrate accumulation compared with no tillage and chisel plow. Agronomy Journal 96:1164-1171.

Table 1. Effect of nitrogen levels on weed control on June 14, 2011 in sugar beets under a furrow-irrigation system at Malheur Experiment Station, Ontario, OR, 2010.

	Treatment	Rate	Timing[a]	Nitrogen rate	Crop injury	Weed control: Common lambsquarters	Weed control: Pigweed	Weed control: Kochia	Weed control: Hairy nightshade	Weed control: Barnyardgrass	Weed control: Annual sowthistle
				lb N/acre	%	%	%	%	%	%	%
1	Untreated control			0	10	0	0	0	0	0	0
2	Untreated control			134	6	0	0	0	0	0	0
3	Untreated control			200	11	0	0	0	0	0	0
4	Untreated control			267	4	0	0	0	0	0	0
5	Glyphosate	0.77 lb ae/a	A; B	0	10	93	46	100	100	96	100
6	Glyphosate	0.77 lb ae/a	A; B	134	1	100	90	100	100	95	100
7	Glyphosate	0.77 lb ae/a	A; B	200	0	95	91	100	100	100	100
8	Glyphosate	0.77 lb ae/a	A; B	267	0	100	85	100	100	100	100
9	Glyphosate Glyphosate Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	0	10	95	85	100	100	100	100
10	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	134	0	100	90	100	100	95	100
11	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	200	0	100	100	100	100	100	100
12	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	267	0	90	95	100	100	95	100

Table 1. Continued……

	Treatment	Rate	Timing[a]	Nitrogen rate	Crop Injury	Weed control: Common lambsquarters	Pigweed	Kochia	Hairy nightshade	Barnyardgrass	Annual sowthistle
				lb N/acre	%						
13	Glyphosate	0.77 lb ae/a	A	0	4	100	100	100	100	100	100
	Glyphosate	0.77 lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
14	Glyphosate	0.77 lb ae/a	A	134	0	100	98	100	100	100	100
	Glyphosate	0.77 lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
15	Glyphosate	0.77 lb ae/a	A	200	5	95	95	100	100	100	100
	Glyphosate	0.77 lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
16	Glyphosate	0.77 lb ae/a	A	267	0	100	85	100	100	100	100
	Glyphosate	0.77 lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
17	Glyphosate	0.77 lb ae/a	A	0	13	96	95	100	100	0	100
	STINGER	0.28 lb ae/a	B								
	Glyphosate	0.77 lb ae/a	B								
18	Glyphosate	0.77 lb ae/a	A	134	1	96	100	100	100	100	100
	STINGER	0.28 lb ae/a	B								
	Glyphosate	0.77 lb ae/a	B								
19	Glyphosate	0.77 lb ae/a	A	200	0	100	95	100	100	95	100
	STINGER	0.28 lb ae/a	B								
	Glyphosate	0.77 lb ae/a	B								
20	Glyphosate	0.77 lb ae/a	A	267	0	100	75	100	100	100	100
	STINGER	0.28 lb ae/a	B								
	Glyphosate	0.77 lb ae/a	B								
	LSD (*P*=0.05)				5	4	2	NS	NS	1	NS

[a] A = glyphosate applied when sugar beets were at the 2-leaf stage; B = glyphosate applied when sugar beets were at the 4-leaf stage. Glyphosate application at each time included ammonium sulfate at 5% v/v. Roundup PowerMax® was the brand of glyphosate used.

Table 2. Effect of nitrogen levels on weed control on August 9, 2011 in sugar beets under a furrow-irrigation system at Malheur Experiment Station, Ontario, OR, 2010.

	Treatment	Rate	Timing [a]	Nitrogen rate	Crop injury	Weed control: Common lambsquarters	Pigweed	Kochia	Hairy nightshade	Barnyardgrass	Annual sowthistle
				lb N/acre	%						
1	Untreated control			0	46	0	0	0	0	0	0
2	Untreated control			134	21	0	0	0	0	0	0
3	Untreated control			200	33	0	0	0	0	0	0
4	Untreated control			267	13	0	0	0	0	0	0
5	Glyphosate	0.77 lb ae/a	A; B	0	50	85	9	100	100	96	73
6	Glyphosate	0.77 lb ae/a	A; B	134	9	98	56	95	100	98	100
7	Glyphosate	0.77 lb ae/a	A; B	200	3	96	70	100	100	100	100
8	Glyphosate	0.77 lb ae/a	A; B	267	5	95	46			99	100
9	Glyphosate Glyphosate Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	0	48	95	23	100	100	98	98
10	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	134	3	98	90	100	100	98	100
11	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	200	3	99	90	100	100	100	100
12	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	267	3	93	91	100	100	95	100

Table 2. Continued……

	Treatment	Rate	Timing[a]	Nitrogen rate	Crop injury	Weed control: Common lambsquarters	Pigweed	Kochia	Hairy nightshade	Barnyardgrass	Annual sowthistle
				lb N/acre	%						
13	Glyphosate	0.77 lb ae/a	A	0	43	100	45	100	100	98	100
	Glyphosate	0.77 lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
14	Glyphosate	0.77 lb ae/a	A	134	3	100	93	100	100	99	100
	Glyphosate	0.77 lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
15	Glyphosate	0.77 lb ae/a	A	200	0	99	98	100	100	99	100
	Glyphosate	0.77 lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
16	Glyphosate	0.77 lb ae/a	A	267	0	100	100	100	100	100	100
	Glyphosate	0.77 lb ae/a	B								
	OUTLOOK	0.84 lb ai/a	B								
17	Glyphosate	0.77 lb ae/a	A	0	54	100	58	100	100	55	100
	STINGER	0.28 lb ae/a	B								
	Glyphosate	0.77 lb ae/a									
18	Glyphosate	0.77 lb ae/a	A	134	8	100	80	95	100	98	100
	STINGER	0.28 lb ae/a	B								
	Glyphosate	0.77 lb ae/a									
19	Glyphosate	0.77 lb ae/a	A	200	5	100	88	98	100	96	100
	STINGER	0.28 lb ae/a	B								
	Glyphosate	0.77 lb ae/a									
20	Glyphosate	0.77 lb ae/a	A	267	3	100	80	100	100	93	100
	STINGER	0.28 lb ae/a	B								
	Glyphosate	0.77 lb ae/a									
	LSD (*P*=0.05)				8	NS	28	NS	NS	17	NS

[a] A = glyphosate applied when sugar beets were at the 2-leaf stage; B = glyphosate applied when sugar beets were at the 4-leaf stage. Glyphosate application at each time included ammonium sulfate at 5% v/v. Roundup PowerMax® was the brand of glyphosate used.

Table 3. Sugar beet root yield and yield components as affected by nitrogen levels and weed control under a furrow-irrigation system at Malheur Experiment Station, Ontario, OR, 2010.

	Treatment	Rate	Timing[a]	Nitrogen rate	Plant stand	Root yield and yield components				Soil N content[b]			
						Yield	Sugar content	Nitrate	ERS[c]	NO_3 (1 ft)	NO_3 (2 ft)	NH_4 (1 ft)	NH_4 (2 ft)
				lb N/acre	plants/a	tons/a	%	ppm	lb/a	ppm	ppm	ppm	ppm
1	Untreated control			0	40,388	24.3	19.4	75.3	8,114	6.6	2.5	3.3	1.6
2	Untreated control			134	44,546	32.7	18.7	169.5	10,391	5.7	3.6	4.2	2.0
3	Untreated control			200	32,370	18.2	17.8	174.8	5,479	23.0	7.6	16.6	4.9
4	Untreated control			267	42,764	41.3	16.4	559.8	11,362	15.9	6.7	8.1	3.5
5	Glyphosate	0.77 lb ae/a	A; B	0	36,825	41.6	19.5	100.0	13,695	9.3	5.8	3.4	4.1
6	Glyphosate	0.77 lb ae/a	A; B	134	38,903	49.9	17.6	247.8	14,716	10.0	8.1	4.0	4.8
7	Glyphosate	0.77 lb ae/a	A; B	200	41,576	51.1	17.3	398.0	14,709	15.8	6.0	6.0	2.2
8	Glyphosate	0.77 lb ae/a	A; B	267	38,310	48.9	16.6	463.5	13,285	21.7	9.9	9.6	3.1
9	Glyphosate Glyphosate Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	0	40,388	44.6	18.5	154.0	13,824	6.8	5.3	3.6	2.7
10	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	134	45,140	55.6	18.9	109.5	17,738	17.5	9.1	4.4	2.2
11	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B	200	42,467	57.3	17.7	273.0	16,915	21.0	13.4	18.2	8.0
12	Glyphosate Glyphosate + Nortron	0.77 lb ae/a 0.77 lb ae/a 0.375 lb ai/a	A B B	267	46,031	58.7	17.6	284.8	16,982	52.3	10.6	16.9	3.6

Table 3. Continued……

	Treatment	Rate	Timing[a]	Nitrogen rate	Plant stand	Root yield and yield components: Yield	Sugar content	Nitrate	ERS[c]	Soil N content[b]: NO_3 (1 ft)	NO_3 (2 ft)	NH_4 (1 ft)	NH_4 (2 ft)
				lb N/a	plants/a	tons/a	%	ppm	lb/a	ppm	ppm	ppm	ppm
13	Glyphosate	0.77 lb ae/a	A	0	43,655	52.3	17.9	198.3	15,418	7.6	6.7	5.1	2.6
	Glyphosate	0.77 lb ae/a	B										
	OUTLOOK	0.84 lb ai/a	B										
14	Glyphosate	0.77 lb ae/a	A	134	38,903	59.5	18.0	288.5	17,701	11.1	7.6	4.5	1.9
	Glyphosate	0.77 lb ae/a	B										
	OUTLOOK	0.84 lb ai/a	B										
15	Glyphosate	0.77 lb ae/a	A	200	43,952	58.5	18.0	257.5	17,512	26.6	22.2	9.5	8.0
	Glyphosate	0.77 lb ae/a	B										
	OUTLOOK	0.84 lb ai/a	B										
16	Glyphosate	0.77 lb ae/a	A	267	40,685	62.8	17.4	375.0	18,253	25.1	17.4	5.7	2.9
	Glyphosate	0.77 lb ae/a	B										
	OUTLOOK	0.84 lb ai/a	B										
17	Glyphosate	0.77 lb ae/a	A	0	43,061	43.5	18.8	248.0	13,217	10.0	5.5	4.5	2.1
	Glyphosate	0.77 lb ae/a	B										
	STINGER	0.28 lb ae/a	B										
18	Glyphosate	0.77 lb ae/a	A	134	40,091	49.5	17.8	199.8	14,506	9.7	10.8	3.6	2.5
	Glyphosate	0.77 lb ae/a	B										
	STINGER	0.28 lb ae/a	B										
19	Glyphosate	0.77 lb ae/a	A	200	45,734	60.6	17.3	361.3	17,314	48.8	17.5	21.6	5.6
	Glyphosate	0.77 lb ae/a	B										
	STINGER	0.28 lb ae/a	B										
20	Glyphosate	0.77 lb ae/a	A	267	39,200	54.2	16.9	444.3	14,860	18.1	8.2	7.5	3.2
	Glyphosate	0.77 lb ae/a	B										
	STINGER	0.28 lb ae/a	B										
	LSD (*P*=0.05)				NS	13	NS	NS	1,858	13.2	5.6	9.8	3.9

[a] A = glyphosate applied when sugar beets were at the 2-leaf stage; B = glyphosate applied when sugar beets were at 4-leaf stage. Glyphosate application at each time included ammonium sulfate at 5% v/v. Roundup PowerMax® was the brand of glyphosate used.
[b] NO_3 = nitrate; NH_4 = ammonium. Soil nitrate and ammonium at 1-ft and 2-ft depth was determined on July 27, 2010.
[c] ERS = estimated recoverable sugar.

CONTROL OF YELLOW NUTSEDGE WITH EFFECTIVE CROP ROTATIONS

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Introduction

Yellow nutsedge has become a major crop production threat in many agricultural fields in the Treasure Valley of eastern Oregon and southwestern Idaho. The severity and negative effects of yellow nutsedge are especially noticeable when fields are planted to direct-seeded onions. Field surveys have indicated an average of 42 percent in heavily infested fields. Control of yellow nutsedge presents a challenge because of its ability to reproduce by rhizomes and tubers that are able to survive in the soil for 3 to 4 years. Farming activities play a significant role in yellow nutsedge distribution in infested fields. Successful control of yellow nutsedge will therefore require integrated approaches including effective crop rotations and use of herbicides with proven efficacy. The objective of this study was to evaluate the effect of tillage, crop rotation, and herbicides on yellow nutsedge control.

Materials and Methods

The study was initiated in 2007 in a field heavily infested with yellow nutsedge near the Malheur Experiment Station, Ontario, Oregon. The study was a split-plot design with tillage (reduced and conventional) forming the main plots onto which three rotational crops and herbicide treatments were imposed as subplots. Each year the crops were planted on 22-inch beds. The rotations were designed so that the terminal crop will be onions in 2011. Rotations were: (1) corn/corn/sugar beet/wheat/onions; (2) corn/sugar beet/corn/wheat/onions; and (3) corn/corn (late planting)/pinto beans/wheat/onions.

Conventionally tilled plots were moldboard plowed each year and disked twice before forming beds to facilitate furrow irrigation. Reduced-tillage plots were disked only twice to avoid deep tillage, which is believed to redistribute tubers within the soil profile. Fertilizer was applied to provide nutrients as determined by soil tests in 2007-2010. In 2007, the entire study was planted to Dekalb Roundup Ready® (RR) corn hybrid 'DK-51-39' with seeds spaced 7 inches within the row. Rotational crops in 2008 were RR corn hybrid 'DK C52-59' planted on May 15 and RR sugar beet variety Beta 'CT 01RR07' planted on April 18. Rotational crops in 2009 were RR corn hybrid ‘DKC 52-59’, RR sugar beet ‘BTS 26RR14’, and ‘Othello’ pinto beans. Corn and sugar beets were mechanically planted in respective plots at 7 inches within the row and 8 seeds per ft of row, respectively. Pinto beans were seeded at 80 lb/acre. Counter® 15-G (terbufos) insecticide was banded over the sugar beet rows at 7.4 lb/acre immediately after planting. Sugar beet rows were sidedressed with Temik® 15G at 10 lb/acre (aldicarb 1.5 lb ai/acre) 53 days after planting. Sugar beets and pinto beans were sprayed with Quadris® at 4 oz/acre (azoxystrobin + chlorothalonil at 2.75 oz ai/acre) on May 22 and June 11. Sugar beets were thinned on May 28, 2008 to 8-inch spacing within the row.

Soil sampling to quantify initial yellow nutsedge tuber density was conducted during spring 2007 after beds were made and the field irrigated. The process was repeated at the end of each crop year to quantify changes in yellow nutsedge tubers in response to treatments. Five soil cores measuring 4.25 inches in diameter and 12 inches deep each were taken randomly from each plot. The soil was processed to recover yellow nutsedge tubers using the washing and sieving procedure. Tubers from each plot were placed in a ziplock plastic bag and stored in the dark at 40°F until they were counted and weighed. The study was furrow irrigated as needed on a calendar schedule to maintain moisture in the top 12 inches of the soil profile. Crops were harvested for yield at maturity from 20 ft of the 2 center rows of each plot.

Herbicides used on corn in 2007 and rotational crops in 2008-2010 are presented in Table 1. All herbicide treatments were applied using a tractor with a sprayer boom equipped with 8002EVS Teejet nozzles calibrated to deliver 20 gal of solution per acre. The data were subjected to analysis of variance and the means compared using Fisher's protected LSD at $P = 0.05$.

Results and Discussion

Yellow nutsedge tubers were uniformly distributed at the beginning of the study (Table 2). At the end of the 2007 growing season, yellow nutsedge tuber population density was reduced by herbicide treatments relative to the untreated control. Since there was no significant difference among tillage in 2007 for yellow nutsedge tuber population density, the average is presented in Table 1. The reduction in yellow nutsedge tubers was greater in conventionally tilled plots in 2008 through 2010 (Table 2). Yellow nutsedge population density dramatically increased in the untreated treatment in 2008 and 2009 relative to plots treated with herbicides. The conventionally tilled corn/corn/sugar beet/wheat rotation resulted in the fewest yellow nutsedge tubers. The entire study area will be planted to onions in 2011 to assess the tillage and herbicide treatment effects on yellow nutsedge during the last 4 years.

Table 1. List of yearly treatments used in the rotational study to control yellow nutsedge in different crops at Malheur Experiment Station, Ontario, OR 2007-2010.

2007[a]

Conventional and reduced till
Corn
1. Untreated
2. Dual II Magnum 1.67 pt/a (PRE)[b]; Roundup 32 fl oz/a (POST) +AMS 3.2 pt/a
3. Dual II Magnum 1.67 pt/a (PRE); Dual II Magnum 1.67 pt/a (POST) + Roundup 32 fl oz/a + AMS 3.2 pt/a
4. Dual II Magnum 2.5 pt/a (PRE); Basagran 1.5 pt/a (POST) + Roundup 32 fl oz/a +AMS 3.2 pt/a
5. Dual II Magnum 3 pt/a (PRE); Basagran 2 pt/a (POST) + Roundup 32 fl oz/a +AMS 3.2 pt/a

2008

Rotational crops in conventional and reduced till		
Corn	**Sugar beet**	**Corn (late)**
Untreated	Untreated	Untreated
Roundup 22 oz/a (POST1) +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +AMS 3.2 pt/a	Roundup 22 oz/a (POST1) +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +AMS 3.2 pt/a	Eptam 4.5 pt/a (PPI)[c] Roundup 22 oz/a (POST1) +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +AMS 3.2 pt/a
Outlook 14 oz/a (PPI) Roundup 22 oz/a (POST1) +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +AMS 3.2 pt/a	Nortron 12 oz/a (PPI) Roundup 22 oz/a (POST1) +AMS 3.2 pt/a Roundup 22 oz/a (POST2) + Eptam 3.5 pt/a (POST2) +AMS 3.2 pt/a	Outlook 14 oz/a (PPI) Roundup 22 oz/a (POST1) +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +AMS 3.2 pt/a
Eradicane 6 pt/a (PPI) Roundup 22 oz/a (POST1) + Basagran 1.5 pt/a +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +AMS 3.2 pt/a	Outlook 21 oz/a (PPI) Roundup 22 oz/a (POST1) +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +Nortron 12 oz/a (POST2) +AMS 3.2 pt/a	Dual II Mag 1.33 pt/a (PPI) Roundup 32 oz/a (POST1) + Basagran 1.5 pt/a +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +AMS 3.2 pt/a
Outlook 18 oz/a (PPI) Roundup 22 oz/a (POST1) + Basagran 2 pt/a +AMS 3.2 pt/a Roundup 22 oz/a (POST2) + Dual II Mag 1.33 pt/a +AMS 3.2 pt/a	Dual IIM 1.33pt/a (POST1) +Roundup 22 oz/a (POST1) +AMS 3.2 pt/a Dual IIM 1.33pt/a (POST2) Roundup 22 oz/a (POS2) +AMS 3.2 pt/a	Dual II Mag 1.33 pt/a (PPI) Eptam 4.5 pt/a (PPI) Roundup 32 oz/a (POST1) + Basagran 1.5 pt/a +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +AMS 3.2 pt/a

[a] All plots were planted to corn in 2007. Conventional and reduced tillage plots were sprayed with the same herbicide rates as indicated for each year. The main plots were divided into three plots and the rotational crops planted as shown in 2008 and 2009.
[b]PRE = preemergence of crop; POST = postemergence.
[c]PPI = preplant incorporated.

Table 1. continued

2009		
Rotational crops in conventional and reduced till		
Sugar beet	**Corn**	**Pinto beans**
1. Untreated	Untreated	Untreated
2. Roundup 22 oz/a (POST1) +Outlook 21 oz/a (POST1) +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +AMS 3.2 pt/a	Roundup 22 oz/a (POST1) +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +AMS 3.2 pt/a	Outlook 21 oz/a (PPI) Raptor 4 oz/a (POST) +Basagran 0.75 pt/a +AMS 3.2 pt/a
3. Roundup 22 oz/a (POST1) +Outlook 10.5 oz/a (POST1) +AMS 3.2 pt/a	Outlook 21 oz/a (PPI) Roundup 22 oz/a (POST1) +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +AMS 3.2 pt/a	Outlook 14 oz/a (PPI) Outlook 7 oz/a (POST1) +Basagran 0.75 pt/a +AMS 3.2 pt/a Basagran 1.5 pt/a (POST2) +AMS 3.2 pt/a
4. Roundup 21 oz/a (POST1) +Outlook 21 oz/a +AMS 3.2 pt/a Roundup 21 oz/a (POST2) +Nortron 5 oz/a +AMS 3.2 pt/a Roundup 22 oz/a (POST3) +AMS 3.2 pt/a	Dual II Magnum 1.5 pt/a (PPI) Roundup 22 oz/a (POST1) +Basagran 2 pt/a +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +AMS 3.2 pt/a +AMS 3.2 pt/a	Dual Magnum 1.33 (PPI) Basagran 1 pt/a (POST1) +Raptor 4 oz/a +AMS 3.2 pt/a Basagran 1.5 pt/a (POST2) +AMS 3.2 pt/a
5. Roundup 22 oz/a (POST1) +Outlook 21 oz/a (POST1) +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +Dual Mag 1.33 pt/a (POST2) +AMS 3.2 pt/a Roundup 22 oz/a (POST3) +AMS 3.2 pt/a	Dual II Magnum 1.5 pt/a (PPI) Roundup 22 oz/a (POST1) +Basagran 2 pt/a +AMS 3.2 pt/a Roundup 22 oz/a (POST2) +Basagran 1.5 pt/a +AMS 3.2 pt/a	Dual Magnum 1.33 (PPI) +Treflan 1.5 pt/a Basagran 1 pt/a (POST1) +Outlook 18 oz/a +AMS 3.2 pt/a Basagran 2 pt/a +COC 2 pt/a

2010[d]		
Conventional and reduced till		
Wheat	**Wheat**	**Wheat**
1. Untreated	Untreated	Untreated
2. Bronate advanced 1.66 pt/a	Bronate advanced 1.66 pt/a	Bronate advanced 1.66 pt/a
3. Bronate advanced 1.66 pt/a	Bronate advanced 1.66 pt/a	Bronate advanced 1.66 pt/a
4. Bronate advanced 1.66 pt/a	Bronate advanced 1.66 pt/a	Bronate advanced 1.66 pt/a
5. Bronate advanced 1.66 pt/a	Bronate advanced 1.66 pt/a	Bronate advanced 1.66 pt/a

[d] All wheat plots in 2010 were treated with Bronate Advanced at 1.66 pt/acre.

Table 2. Yellow nutsedge tuber (tubers/yd^2) changes in response to tillage and herbicide treatments at Malheur Experiment Station, Ontario, OR from 2007 to 2010.

	2007	
	Spring	Fall
Treatment[a]	Corn	
	------- tubers/yd^2 --------	
1	5,988 a	9,962 a
2	5,146 a	2,197 b
3	5,867 a	2,559 b
4	5,707 a	3,178 b
5	4,274 a	2,155 b

	2008					
	Conventional tillage			Reduced tillage		
Treatment	Corn	Sugar beet	Corn (late)	Corn	Sugar beet	Corn (late)
	-- tubers/yd^2 --					
1	11,173 a	15,187 a	8,541 a	14,843 a	20,040 a	8,964 a
2	984 b	1,056 b	966 b	1,431 b	1,412 b	996 b
3	1,129 b	670 b	875 b	1,243 b	990 b	1,630 b
4	1,835 b	1,388 b	1,044 b	1,612 b	1,497 b	1,243 b
5	1,750 b	1,756 b	736 b	1,738 b	911 b	1,038 b

	2009					
	Conventional tillage			Reduced tillage		
Treatment	Sugar beet	Corn	Pinto bean	Sugar beet	Corn	Pinto bean
	-- tubers/yd^2 --					
1	17,040 a	14,366 a	10,243 a	13,376 a	24,567 a	13,841 a
2	537 b	773 b	453 b	984 b	990 b	1,008 b
3	869 b	1,086 b	531 b	797 b	881 b	1,014 b
4	917 b	1,195 b	435 b	857 b	1,262 b	954 b
5	392 c	887 b	513 b	972 b	525 c	839 b

	2010					
	Conventional tillage			Reduced tillage		
Treatment	Wheat	Wheat	Wheat	Wheat	Wheat	Wheat
	-- tubers/yd^2 --					
1	4,992 a	10,720 a	7,418 a	6,084 a	11,855 a	7,292 a
2	254 b	423 b	447 b	410 b	471 b	954 b
3	175 c	332 b	453 b	338 b	386 b	718 b
4	380 b	314 b	392 b	332 b	598 b	899 b
5	145 c	368 b	290 b	338 b	435 b	592 b

[a]Herbicides used in each treatment and year are listed in table 1.