

WEED CONTROL IN DIRECT-SEEDED ONION WITH VARIOUS POST-EMERGENCE HERBICIDE COMBINATIONS

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Introduction

Early season weed control in direct-seeded onions is necessary in order to produce high-quality bulbs. The difficulty in controlling weeds in onion compared to agronomic crops is due to the lack of a complete crop canopy and limited herbicide options. Additionally, early season onion growth is slow and seedlings are susceptible to various herbicides. It is therefore important to identify herbicide combinations that could be used to effectively control early season weeds without exposing onions to injury.

Materials and Methods

A field study was initiated during spring 2019 at the Malheur Experiment Station, Ontario, Oregon, to evaluate onion response and weed control with combinations of various post-emergence herbicides used to control weeds in onion. The predominant soil was an Owyhee silt loam with a pH of 7.8 and 3.78% soil organic matter. Wheat stubble was flailed and the field was irrigated, disked, ripped, plowed, and groundhogged during fall 2018. Based on soil analysis, fertilizer was broadcast applied during fall 2018 to supply 50 lb nitrogen (N)/acre, 50 lb phosphorus (P)/acre, 80 lb sulfur (S)/acre, 12 lb manganese (Mn)/acre, and 1 lb boron (B)/acre. The field was fumigated with K-Pam[®] at 15 gal/acre and beds were formed at 22-inch spacing on October 18, 2018.

The beds were harrowed and onion seed of hybrid ‘Vaquero’ was planted in double rows spaced 3 inches apart with 4-inch seed spacing within each row on March 21, 2019. Each pair of rows was planted on beds spaced 22 inches apart. On April 2, 2019, each onion bed received a 7-inch band of Lorsban[®] 15G at 3.7 oz/1000 ft of row (chlorpyrifos 0.101 lb ai/acre) and the soil surface was rolled.

The study had a randomized complete block design with four replicates. Individual plots were 7.33 ft wide (4 beds) by 27 ft long. All herbicide treatments were applied using a CO₂ pressurized backpack sprayer fitted with a boom equipped with 8002EVS TeeJet nozzles calibrated to deliver 35 gal/acre.

Delayed pre-emergence herbicide application of Prowl[®] H₂O at 2 pt/acre (pendimethalin 0.95 lb ai/acre) was on April 11, 2019. On May 7, Poast[®] at 1.5 pt/acre (sethoxydim 0.28 lb ai/acre) plus a crop oil concentrate at 2 pt/acre was applied to control grassy weeds. Post-emergence treatments for broadleaf weed control that included various rates of Ethotron[®] 4SC (ethofumesate), Brox[®] 2EC (bromoxynil), Starane[®] Ultra (fluroxypyr), and GoalTender[®] (oxyflurfen) were applied on May 7, 2019 when onion seedlings were at the 2-leaf stage (Table 1). On June 17, a tank-mixture of Brox 2EC 12 fl oz/acre (bromoxynil 0.188lb ai/acre)

plus GoalTender at 4 fl oz/acre (oxyfluorfen 0.125 lb/ai acre) was applied when onion seedlings were at the 4-leaf stage. All plots (except untreated control) were hand weeded on June 27, 2019 in order to maintain a weed-free environment for the duration of the season.

In-season fertilizer was applied according to soil and tissue test results. Urea ammonium nitrate solution (URAN) was applied through drip irrigation to supply 50 lb N/acre on June 6 and June 24, and 25 lb N/acre on July 15, 2019. Preventative sprays for diseases and insects were applied aerially by a commercial contractor using various insecticides including Movento[®] (spirotetramat), Radiant[®] (spinetoram), and Lannate[®] (methomyl). All other operations followed recommended local production practices.

Visible onion injury and weed control were assessed based on a scale of 0% (no onion injury or no weed control) to 100% (complete onion plant kill or total weed control). Weed control was assessed on May 24 (15 days after the first post-emergence application) and on June 24, 2019.

The field was drip irrigated 23 times from April 29 to August 26, 2019. Each irrigation event lasted 12 hours.

Plant tops were flailed on September 10 and onion bulbs lifted on September 11, 2019 and left in the field to cure. Bulbs were hand harvested from the middle 15 ft of the two center beds on September 20, 2019. Bulbs were graded for yield and quality based on USDA standards as follows: bulbs without blemishes (U.S. No. 1), split bulbs (No. 2s), bulbs infected with the fungus *Botrytis allii* in the neck or side, bulbs infected with the fungus *Fusarium oxysporum* (plate rot), bulbs infected with the fungus *Aspergillus niger* (black mold), bulbs infected with unidentified bacteria in the external scales. The bulbs were graded according to the diameter: small (<2¼ inches), medium (2¼–3 inches), jumbo (3–4 inches), colossal (4–4¼ inches), and super colossal (>4¼ inches). Marketable yield consisted of U.S. No.1 bulbs greater than 2¼ inches in diameter.

Data were subjected to analysis of variance and the treatment means were compared using protected LSD at the 0.05% level of confidence.

Results

Onion emergence was observed on April 17, 2019. Evaluations on May 24, 2019 indicated visible onion injury ranging from 11 to 25% across herbicide treatments (Table 1). The greatest injury was observed with the tank-mixture of Ethotron at 16 fl oz/acre + Brox 2EC at 8 fl oz/acre + GoalTender at 4 fl oz/acre applied when onions were at the 2-leaf stage. There was a complete control of common lambsquarters across herbicide treatments. Redroot pigweed control was greater than 96% and hairy nightshade control was greater than 98%. Similarly, control for lady's thumb was greater than 99% across herbicide treatments. Evaluations made on June 24 indicated onion injury was less than 10% and weed control was greater than 95% across herbicide treatments (data not shown).

The number of harvested bulbs in response to different herbicide treatments is presented in Table 2. The number of marketable bulbs (2¼ to >4¼ in), which is composed of medium, jumbo, colossal and super colossal grades, ranged from 64,746 to 99,792 bulbs/acre across herbicide treatments, compared to 89,100 bulbs/acre for the hand-weeded treatment. The lowest number of harvested bulbs (64,746 bulbs/acre) was associated with the application of Brox 2EC at

16 fl oz/acre tank-mixed with GoalTender at 4 fl oz/acre when onions were at the 2-leaf stage followed by Brox 2EC at 8 fl oz/acre tank-mixed with GoalTender at 4 fl oz/acre.

Marketable yield varied across herbicide treatments (Table 3). Marketable yield seemed to be directly related to the number of harvested bulbs. Application of Brox 2EC at 16 fl oz/acre tank-mixed with GoalTender at 4 fl oz/acre when onions were at the 2-leaf stage followed by Brox 2EC at 8 fl oz/acre tank-mixed with GoalTender at 4 fl oz/acre significantly reduced the jumbo-size bulbs (3–4 inch diameter) compared to application of Brox 2EC at 8 to 12 fl oz/acre. In turn, the overall marketable yield for this treatment (834.6 cwt/acre) was greatly reduced compared to the grower standard of Brox 2EC 12 fl oz/acre plus GoalTender 4 fl oz/acre at both the 2- and 4-leaf stages (1,076 cwt/acre) and the hand-weeded control (1,100.4 cwt/acre). Similarly, the marketable yield was reduced for plants sprayed with a combination of Ethotron 4SC at 8 fl oz/acre + Brox 2EC at 8 fl oz/acre + Starane Ultra at 3 fl oz/acre when onions were at the 2-leaf stage followed by a tank-mix of Brox 2EC 6 fl oz/acre + GoalTender at 6 fl oz/acre when onions were at the 4-leaf stage (997.2 cwt/acre).

The results demonstrate that tank mixing Ethotron 4SC plus Brox 2EC plus GoalTender or Starane Ultra could be a viable option for growers to manage troublesome weeds like kochia. However, those mixes need to take the rate into consideration in order to avoid onion injury, which could result in reduced yield. Similarly, application of Brox 2EC at the higher rate of 16 fl oz/acre to onions at the 2-leaf stage seem too injurious and could result in onion yield reduction.

Acknowledgements

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Table 1. Weed control in response to tank-mixtures of herbicides applied starting when onion seedlings were at the two-leaf stage at the Malheur Experiment Station, Oregon State University, Ontario, OR 2019

Treatment ^a	Rate	Product rate	Timing ^b	Crop injury	Weed control (5/24/2019) ^c			
					Common lambsquarters	Redroot pigweed	Hairy nightshade	Lady's thumb
	lb ai/acre	fl oz/acre			----- % -----			
Ethotron 4SC	0.0625	2	2 leaf	19 a	100 a	100 a	100 a	100 a
Brox 2EC	0.125	8	2 leaf					
GoalTender	0.125	4	2 leaf					
Brox 2EC	0.094	6	4 leaf					
GoalTender	0.188	6	4 leaf					
Ethotron 4SC	0.125	4	2 leaf	24 a	100 a	100 a	100 a	100 a
Brox 2EC	0.125	8	2 leaf					
GoalTender	0.125	4	2 leaf					
Brox 2EC	0.094	6	4 leaf					
GoalTender	0.188	6	4 leaf					
Ethotron 4SC	0.25	8	2 leaf	13 ab	100 a	100 a	100 a	100 a
Brox 2EC	0.125	8	2 leaf					
GoalTender	0.125	4	2 leaf					
Brox 2EC	0.094	6	4 leaf					
GoalTender	0.188	6	4 leaf					
Ethotron 4SC	0.5	16	2 leaf	25 a	100 a	100 a	100 a	100 a
Brox 2EC	0.125	8	2 leaf					
GoalTender	0.125	4	2 leaf					
Brox 2EC	0.094	6	4 leaf					
GoalTender	0.188	6	4 leaf					
Brox 2EC	0.25	16	2 leaf	19 a	100 a	100 a	100 a	100 a
GoalTender	0.125	4	2 leaf					
Brox 2EC	0.125	8	4 leaf					
GoalTender	0.125	4	4 leaf					
Ethotron 4SC	0.25	8	2 leaf	14 ab	100 a	100 a	100 a	100 a
Brox 2EC	0.125	8	2 leaf					
Starane Ultra	0.0438	2	2 leaf					
Brox 2EC	0.094	6	4 leaf					
GoalTender	0.188	6	4 leaf					
Ethotron 4SC	0.25	8	2 leaf	23 a	98 b	96 b	98 b	100 a
Brox 2EC	0.125	8	2 leaf					
Starane Ultra	0.0656	3	2 leaf					
Brox 2EC	0.094	6	4 leaf					
GoalTender	0.188	6	4 leaf					
Ethotron 4SC	0.25	8	2 leaf	13 ab	100 a	99 a	100 a	99 b
Brox 2EC	0.125	8	2 leaf					
Starane Ultra	0.0875	4	2 leaf					
Brox 2EC	0.094	6	4 leaf					
GoalTender	0.188	6	4 leaf					
Ethotron 4SC	0.25	8	2 leaf	16 a	100 a	100 a	100 a	100 a
Brox 2EC	0.125	8	2 leaf					
Starane Ultra	0.109	5	2 leaf					
Buctril	0.094	6	4 leaf					
GoalTender	0.188	6	4 leaf					
Brox 2EC	0.188	12	2 leaf	11 ab	100 a	100 a	100 a	100 a
GoalTender	0.125	4	2 leaf					
Brox 2EC	0.188	12	4 leaf					
GoalTender	0.125	4	4 leaf					
Hand weeded				0 b	100 a	100 a	100 a	100 a
Untreated				0 b	0 c	0 c	0 c	0 c
LSD (P = 0.05)				16	2	2	2	1

^aHerbicide treatments: All plots received a late pre-emergence application of Prowl H₂O 32 fl oz/acre = pendimethalin 0.95 lb ai/acre on April 11, 2019; Brox 2EC = bromoxynil 0.188 lb ai/acre; GoalTender = oxyfluorfen 4 fl oz/acre = 0.125 lb ai/acre; Ethotron 4SC = ethofumesate; Starane Ultra = fluroxypyr.

^bApplication timing: 2 & 4 leaf = onion at 2- & 4-leaf stage applied on May 7, 2019 and June 17, 2019.

^cMeans followed by same letter do not significantly differ (P = 0.05, LSD).

Table 2. Number of harvested bulbs by grade in response to tank-mixtures of herbicides applied to control weeds in direct-seeded onion at the 2- and 4-leaf stages, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Treatment ^a	Product			Unmarketable ^c			Marketable ^c			Total	
	Rate	rate	Timing ^b	Neck rot	U.S. No. 2	<2¼ in	2¼-3 in	3-4 in	4-4¼ in		>4¼ in
	lb ai/acre	fl oz/acre		Number of bulbs/acre							
Ethotron 4SC	0.0625	2	2 leaf	0 b	990 abc	2,178ab	4,752 a	32,472 abc	24,354 a	24,552 a	86,130 ab
Brox 2EC	0.125	8	2 leaf								
GoalTender	0.125	4	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Ethotron 4SC	0.125	4	2 leaf	594 a	396 bc	3,366ab	4,554 a	40,392 ab	25,542 a	18,414 a	88,902 a
Brox 2EC	0.125	8	2 leaf								
GoalTender	0.125	4	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Ethotron 4SC	0.25	8	2 leaf	198 ab	594 bc	4,752ab	6,534 a	43,956 a	27,126 a	22,176 a	99,792 a
Brox 2EC	0.125	8	2 leaf								
GoalTender	0.125	4	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Ethotron 4SC	0.5	16	2 leaf	0 b	396 bc	2,574ab	4,356 a	27,918 bc	23,958 a	26,334 a	82,566 ab
Brox 2EC	0.125	8	2 leaf								
GoalTender	0.125	4	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Brox 2EC	0.25	16	2 leaf	0 b	396 bc	3,366ab	4,554 a	21,582 cd	20,592 a	18,018 a	64,746 b
GoalTender	0.125	4	2 leaf								
Brox 2EC	0.125	8	4 leaf								
GoalTender	0.125	4	4 leaf								
Ethotron 4SC	0.25	8	2 leaf	0 b	396 bc	4,950ab	4,752 a	34,848 abc	27,126 a	17,226 a	83,952 ab
Brox 2EC	0.125	8	2 leaf								
Starane Ultra	0.0438	2	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Ethotron 4SC	0.25	8	2 leaf	0 b	1782 a	4,554ab	4,752 a	28,908 abc	21,780 a	21,978 a	77,418 ab
Brox 2EC	0.125	8	2 leaf								
Starane Ultra	0.0656	3	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Ethotron 4SC	0.25	8	2 leaf	0 b	198 bc	5,940a	7,524 a	36,234 abc	24,750 a	25,146 a	93,654 a
Brox 2EC	0.125	8	2 leaf								
Starane Ultra	0.0875	4	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Ethotron 4SC	0.25	8	2 leaf	396 ab	396 bc	5,742a	6,138 a	32,868 abc	28,116 a	23,562 a	90,684 a
Brox 2EC	0.125	8	2 leaf								
Starane Ultra	0.109	5	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Brox 2EC	0.188	12	2 leaf	0 b	594 bc	4,356ab	4,554 a	31,680 abc	27,522 a	21,186 a	84,942 ab
GoalTender	0.125	4	2 leaf								
Brox 2EC	0.188	12	4 leaf								
GoalTender	0.125	4	4 leaf								
Hand weeded				198 ab	1188 ab	4,950ab	5,940 a	35,442 abc	28,116 a	19,602 a	89,100 a
Untreated				0 b	0 c	1,188b	396 b	6,732 d	3,960 b	5,544 b	16,632 c
LSD (P = 0.05)				446	1,129	3,767	3,716	15,828	8,796	9,244	24,143

^aHerbicide treatments: All plots received a late pre-emergence application of Prowl H₂O 32 fl oz/acre = pendimethalin 0.95 lb ai/acre on April 11, 2019; Brox 2EC = bromoxynil 0.188 lb ai/acre; GoalTender = oxyfluorfen 4 fl oz/acre = 0.125 lb ai/acre; Ethotron 4SC = ethofumesate; Starane Ultra = fluroxypyr.

^bApplication timing: 2 & 4 leaf = onion at 2- & 4-leaf stage applied on May 7, 2019 and June 17, 2019.

^cMeans followed by same letter do not significantly differ (P = 0.05, LSD).

Table 3. Onion yield by grade in response to tank-mixtures herbicides applied to control weeds in direct-seeded onion at the 2- and 4-leaf stages, Malheur Experiment Station, Oregon State, University, Ontario, OR, 2019.

Treatment ^a	Product			Unmarketable ^c			Marketable ^c			Total	
	Rate lb ai/acre	rate fl oz/acre	Timing ^b	Neck rot	US. No. 2	<2¼ in	2¼-3 in	3-4 in	4-4¼ in		>4¼ in
Ethotron 4SC	0.0625	2	2 leaf	0.0 b	9.3 ab	5.7 ab	15.4 ab	294.4 abc	344.2 a	451.0 a	1105.0 ab
Brox 2EC	0.125	8	2 leaf								
GoalTender	0.125	4	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Ethotron 4SC	0.125	4	2 leaf	3.6 a	3.7 b	6.8 ab	16.2 a	371.7 ab	349.3 a	330.4 a	1,067.5 ab
Brox 2EC	0.125	8	2 leaf								
GoalTender	0.125	4	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Ethotron 4SC	0.25	8	2 leaf	1.3 ab	7.2 ab	10.5 a	25.3 a	390.6 a	371.1 a	399.4 a	1,186.3 a
Brox 2EC	0.125	8	2 leaf								
GoalTender	0.125	4	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Ethotron 4SC	0.5	16	2 leaf	0.0 b	5.0 ab	6.5 ab	15.7 a	254.2 bc	331.8 a	491.1 a	1,092.8 ab
Brox 2EC	0.125	8	2 leaf								
GoalTender	0.125	4	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Brox 2EC	0.25	16	2 leaf	0.0 b	6.2 ab	7.2 ab	16.7 a	197.4 c	284.8 a	335.7 a	834.6 b
GoalTender	0.125	4	2 leaf								
Brox 2EC	0.125	8	4 leaf								
GoalTender	0.125	4	4 leaf								
Ethotron 4SC	0.25	8	2 leaf	0.0 b	5.5 ab	11.0 a	18.7 a	307.5 abc	370.7 a	321.1 a	1,017.9 ab
Brox 2EC	0.125	8	2 leaf								
Starane Ultra	0.0438	2	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Ethotron 4SC	0.25	8	2 leaf	0.0 b	16.3 a	9.1 ab	18.3 a	258.8 abc	310.7 a	409.4 a	997.2 ab
Brox 2EC	0.125	8	2 leaf								
Starane Ultra	0.0656	3	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Ethotron 4SC	0.25	8	2 leaf	0.0 b	3.9 b	12.4 a	28.2 a	328.1 abc	343.0 a	466.5 a	1,165.9 a
Brox 2EC	0.125	8	2 leaf								
Starane Ultra	0.0875	4	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Ethotron 4SC	0.25	8	2 leaf	3.4 a	6.4 ab	10.9 a	21.2 a	280.5 abc	381.5 a	425.3 a	1,108.5 ab
Brox 2EC	0.125	8	2 leaf								
Starane Ultra	0.109	5	2 leaf								
Brox 2EC	0.094	6	4 leaf								
GoalTender	0.188	6	4 leaf								
Brox 2EC	0.188	12	2 leaf	0.0 b	8.2 ab	10.0 a	17.1 a	292.0 abc	379.2 a	387.7 a	1,076.0 ab
GoalTender	0.125	4	2 leaf								
Brox 2EC	0.188	12	4 leaf								
GoalTender	0.125	4	4 leaf								
Hand-weeded				1.0 ab	11.9 ab	10.6 a	23.1 a	322.4 abc	390.4 a	364.4 a	1,100.4 ab
Untreated				0.0 b	0.0 b	2.3	1.8 b	58.0 d	55.9 b	100.6 b	216.3 c
LSD (P=0.05)				3.3	11.9	7.6	13.7	135.3	120.1	173.1	298.8

^aHerbicide treatments: All plots received a late pre-emergence application of Prowl H₂O 32 fl oz/acre = pendimethalin 0.95 lb ai/acre on April 11, 2019; Brox 2EC = bromoxynil 0.188 lb ai/acre; GoalTender = oxyfluorfen 4 fl oz/acre = 0.125 lb ai/acre; Ethotron 4SC = ethofumesate; Starane Ultra = fluroxypyr.

^bApplication timing: 2 & 4 leaf = onion at 2- & 4-leaf stage applied on May 7, 2019 and June 17, 2019.

^cMeans followed by same letter do not significantly differ (P = 0.05, LSD).