

EVALUATION OF ZIDUA[®] FOR WEED CONTROL IN DIRECT-SEEDED ONION

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Introduction

Evaluation of recently registered herbicides for weed control in specialty crops is a necessary step before the product can be granted a label for use on the targeted crop. Herbicides are essential to control weeds in direct-seeded onion in order to realize acceptable size and bulb yield. The herbicide Zidua[®] (pyroxasulfone) is a relatively new product on the market and is being evaluated for use on several crops. The product can be applied prior to crop emergence (PRE) or postemergence (POST) to provide soil residual control of susceptible weeds. The objectives of this study were to evaluate onion tolerance of Zidua and weed control efficacy under local conditions.

Materials and Methods

A field study was conducted in 2015 at the Malheur Experiment Station, Ontario, Oregon to evaluate onion response and weed control with Zidua herbicide. The field was previously planted to wheat and was prepared in 2014 to create a seedbed suitable for onion production following local practices. Based on soil tests, fertilizer to supply 75 lb phosphorus/acre, 200 lb potassium/acre, 17 lb elemental sulfur/acre, 7 lb manganese/acre, and 3 lb boron/acre was applied and the field was ripped, moldboard plowed, and groundhogged. The soil was fumigated using Vapam[®] at 15 gal/acre and simultaneously bedded. Beds were 22 inches wide made to facilitate furrow irrigation. The beds were harrowed and flattened on March 10, 2015. Onion seeds of variety 'Vaquero' were planted on March 13 in double rows spaced 3.7 inches apart and 3.9 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 20 as a preventive measure against onion maggot.

The study had a randomized complete block design with four replications of all herbicide treatments; individual plots were 7.3 ft wide (4 rows) by 27 ft long. Zidua preemergence (PRE) treatments were applied on March 19 while late preemergence (LPRE) treatments were applied on March 26. All other treatments (except the untreated control and Zidua plots) were sprayed with Prowl[®] H₂O at 2.1 pt/acre (pendimethalin at 1 lb ai/acre) on March 26. Postemergence treatments were applied on May 8 and 29 when onion plants were at the 2-leaf and 4-6 leaf stages, respectively. All herbicide treatments were applied using a CO₂ pressurized backpack sprayer fitted with a boom equipped with four EVS8002 flat-fan nozzles at a spray volume of 20 gal/acre.

The first irrigation was applied on April 13. All subsequent irrigations were scheduled based on six Watermark soil moisture sensors (Irrometer Co., Riverside, CA) connected to an AM400 data

logger (M.K. Hansen Co., Wenatchee, WA) to prevent the soil at 8-inch depth from drying beyond 25 kPa soil water tension. Fertilizer was applied on June 11 to supply 170 lb nitrogen/acre.

Plants were sprayed with Movento[®] at 5 fl oz/acre (spirotetramat 1.25 oz ai/acre) on June 4 for thrips control. Subsequent spraying for thrips were delivered aerially based on local commercial spray schedule.

Visual evaluations for onion injury and weed control were conducted on May 8 and June 18, 2015. Estimates were based on 0-100% visual scale; where 0% = no injury or no weed control and 100% = total crop damage or complete weed control. Weeds in the two center rows were enumerated by species on July 13. Onion plant tops were flailed and bulbs were lifted on September 9. Bulbs were hand-harvested from the two center beds on September 10 and graded on September 14. The bulbs were graded according to quality as follows: bulbs without blemishes (No. 1s), 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), and bulbs infected with unidentified bacteria in the external scales. The No. 1 bulbs were graded according to diameter: small (<2¼ inches), medium (2¼-3 inches), jumbo (3-4 inches), colossal (4-4¼ inches), and supercolossal (>4¼ inches). Marketable yield consists of No.1 bulbs >2¼ inches. The data were subjected to analysis of variance and means compared using the least significance difference (LSD, *P* = 0.05).

Results

Onion emergence started on April 6, 2015. Onion plant stand on May 8 ranged from 104,955 to 119,352 plants/acre (Table 1). Moderate onion injury was observed with incremental Zidua rate. Onion injury from PRE application of Zidua at 2.5 and 3.75 oz/acre was estimated at 1 and 5%, respectively. Onion injury for LPRE application of Zidua at 1.87 to 3.73 oz/acre was less than 8% compared to less than 5% for Prowl H₂O at 2 pt/acre at the same application timing.

Zidua applied preemergence

Early season (May 8) control for common lambsquarters, pigweed species, hairy nightshade, lady's thumb, and kochia with Zidua applied PRE or LPRE was between 55 and 98% (Table 2). The level of control was similar to Prowl H₂O applied LPRE, which ranged from 56 to 97% across the weed spectrum.

Zidua applied postemergence

Control of common lambsquarters, pigweed species, hairy nightshade, spotted lady's thumb, and kochia improved with the increased Zidua rate. Postemergence application of Zidua alone at 1.87 oz/acre when onions were at the 2-leaf stage provided less than 25% control compared to 48-89% for Zidua at 3.73 oz/acre. Zidua at 1.87 oz/acre applied sequentially at the 2-leaf and 4- to 6-leaf stages provided 5-25% control across the weed spectrum at the site. These results suggest that Zidua has potential to be applied safely at LPRE timing without causing adverse effects. Moisture availability in the form of rainfall is critical in March to activate the herbicide. Application of Zidua at 2.5, 3.73, or 5 oz/acre at the 2-leaf stage followed by Buctril[®] at 0.75 pt/acre plus GoalTender[®] at 0.5 pt/acre when onions were at the 4- to 6-leaf stage provided 53-76%, 48-89%, and 66-91% control, respectively, across the weed spectrum (Table 2). The weed

control provided by Zidua followed by Buctril plus GoalTender was similar to Prowl H₂O followed by sequential application of Buctril at 0.75 pt/acre plus GoalTender at 0.5 pt/acre at the 2-leaf and 4- to 6-leaf stages.

Number of weeds/plot on July 13

The number of common lambsquarters, hairy nightshade, spotted ladythumb, and kochia plants/plot on June 13 was similar across herbicide treatments and application timing (Table 3). The number of pigweed plants varied across treatments; plots sprayed with Zidua at 3.73 oz/acre contained the lowest (9 plants) compared to 66 plants for the standard Prowl H₂O followed by sequential Buctril at 0.75 pt/acre plus GoalTender at 0.5 pt/acre.

Onion yield

Onion yield varied greatly across herbicide treatments (Table 4). Marketable yield with Zidua at 2.5 or 3.73 oz/acre applied PRE or LPRE followed by sequential applications of Buctril at 0.75 pt/acre plus GoalTender at 0.5 pt/acre when onions were at the 2-leaf and 4- to 6-leaf stages was similar to the standard application of Prowl H₂O LPRE followed by sequential application of Buctril plus GoalTender at the 2-leaf and 4- to 6-leaf stages. The number of onion bulbs also varied greatly across herbicide treatments (Table 5).

These results indicate that Zidua has potential for weed control in onion. The use of Zidua as a PRE-applied product in onion will largely depend on the availability of moisture for activation and its ability to control the parasitic weed, dodder, which was not present at the 2015 study site. It may also be a good candidate for postemergence tank-mixing with Buctril to provide soil residual weed control in onion.

Acknowledgements

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Table 1. Onion response to preemergence application of Prowl H₂O or Zidua and weed control on May 8 (43 days after herbicide application), Malheur Experiment Station, Ontario, OR, 2015.

Treatment	Amount per acre	Application timing ^a	Plant stand plants/acre	Weed control ^b					
				Injury	Common lambsquarters	Redroot pigweed	Hairy nightshade	Spotted ladysthumb	Kochia
Prowl H2O	2.0 pt	PRE	119,352 a	5 ab	94 ab	95 a	88 ab	86 ab	79 abc
Zidua	2.5 oz	2-3 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H2O	2.0 pt	PRE	119,352 a	5 ab	86 bc	90 bc	81 bcd	53 d	54 f
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	2.5 oz	4-6 leaf							
Prowl H2O	2.0 pt	PRE	117,483 ab	0 d	98 a	97 a	88 ab	84 ab	85 ab
Zidua	3.73 oz	2-3 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H2O	2.0 pt	PRE	118,802 a	5 ab	93 ab	96 a	80 bcd	83 ab	89 a
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	3.73 oz	4-6 leaf							
Prowl H2O	2.0 pt	PRE	119,022 a	3 bcd	93 ab	90 bc	78 cd	80 abc	76 bcd
Zidua	5 oz	2-3 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H2O	2.0 pt	PRE	112,867 ab	3 bcd	93 ab	95 a	86 abc	76 abc	80 ab
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	5 oz	4-6 leaf							
Prowl H2O	2.0 pt	PRE	119,132 a	0 d	97 ab	98 a	93 a	89 a	89 a
Zidua	1.87 oz	2-3 leaf							
Zidua	1.87 oz	4-6 leaf							
Zidua	1.87 oz	LPRE	117,373 ab	4 bc	55 f	90 bc	88 ab	71 bc	56 ef
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	1.87 oz	4-6 leaf							
Zidua	2.5 oz	PRE	117,593 a	1 cd	64 ef	95 a	88 ab	78 abc	75 bcd
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Zidua	3.73 oz	PRE	114,626 ab	5 ab	73 de	96 a	89 ab	76 abc	49 f
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	26 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Zidua	2.5 oz	LPRE	118,362 a	4 bc	80 cd	94 ab	84 abc	80 abc	66 de
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Zidua	3.73 oz	LPRE	104,955 b	8 a	81 cd	86 c	74 d	65 cd	68 cde
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H2O	2 pt	LPRE	120,670 a	4 bc	95 ab	96 a	78 cd	88 ab	83 ab
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Untreated control			119,571 a	0 d	0 g	0 d	0 e	0 e	0 g
LSD (<i>P</i> = 0.05)			12,634	3	11	5	9	16	12

^aApplication timing: PRE = preemergence on March 19; LPRE = late preemergence on March 26; 2-leaf = May 8; 4-6 leaf = May 28.

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

Table 2. Onion response and weed control on June 18 (20 days after herbicide application) after postemergence application of Zidua or Buctril and GoalTender when onions were at the 2-leaf stage, Malheur Experiment Station, Ontario, OR, 2015.

Treatment	Amount per acre	Application timing ^a	Injury	Weed control ^b				
				Common lambsquarters	Redroot pigweed	Hairy nightshade	Spotted ladysthumb	Kochia
				----- % -----				
Prowl H2O	2.0 pt	PRE	16 b	76 c	71 c	46 d	53 c	55 b
Zidua	2.5 oz	2-3 leaf						
Buctril	0.75 pt	4-6 leaf						
GoalTender	0.5 pt	4-6 leaf						
Prowl H2O	2.0 pt	PRE	6 c	96 ab	95 ab	96 a	96 a	95 a
Buctril	0.75 pt	2 leaf						
GoalTender	0.5 pt	2 leaf						
Zidua	2.5 oz	4-6 leaf						
Prowl H2O	2.0 pt	PRE	18 b	81 c	89 b	61 c	48 c	61 b
Zidua	3.73 oz	2-3 leaf						
Buctril	0.75 pt	4-6 leaf						
GoalTender	0.5 pt	4-6 leaf						
Prowl H2O	2.0 pt	PRE	5 cd	97 ab	95 ab	97 a	97 a	95 a
Buctril	0.75 pt	2 leaf						
GoalTender	0.5 pt	2 leaf						
Zidua	3.73 oz	4-6 leaf						
Prowl H2O	2.0 pt	PRE	25 a	90 b	91 ab	71 b	70 b	66 b
Zidua	5 oz	2-3 leaf						
Buctril	0.75 pt	4-6 leaf						
GoalTender	0.5 pt	4-6 leaf						
Prowl H2O	2.0 pt	PRE	6 c	96 ab	96 ab	98 a	97 a	96 a
Buctril	0.75 pt	2 leaf						
GoalTender	0.5 pt	2 leaf						
Zidua	5 oz	4-6 leaf						
Prowl H2O	2.0 pt	PRE	29 a	15 d	25 d	10 e	5 d	5 c
Zidua	1.87 oz	2-3 leaf						
Zidua	1.87 oz	4-6 leaf						
Zidua	1.87 oz	LPRE	7 c	95 ab	97 ab	97 a	94 a	91 a
Buctril	0.75 pt	2 leaf						
GoalTender	0.5 pt	2 leaf						
Zidua	1.87 oz	4-6 leaf						
Zidua	2.5 oz	PRE	5 cd	95 ab	98 a	90 a	95 a	92 a
Buctril	0.75 pt	2 leaf						
GoalTender	0.5 pt	2 leaf						
Buctril	0.75 pt	4-6 leaf						
GoalTender	0.5 pt	4-6 leaf						
Zidua	3.73 oz	PRE	6 c	95 ab	97 ab	97 a	95 a	90 a
Buctril	0.75 pt	2 leaf						
GoalTender	0.5 pt	26 leaf						
Buctril	0.75 pt	4-6 leaf						
GoalTender	0.5 pt	4-6 leaf						
Zidua	2.5 oz	LPRE	5 cd	99 a	99 a	99 a	99 a	95 a
Buctril	0.75 pt	2 leaf						
GoalTender	0.5 pt	2 leaf						
Buctril	0.75 pt	4-6 leaf						
GoalTender	0.5 pt	4-6 leaf						
Zidua	3.73 oz	LPRE	4 cde	97 ab	99 a	99 a	99 a	97 a
Buctril	0.75 pt	2 leaf						
GoalTender	0.5 pt	2 leaf						
Buctril	0.75 pt	4-6 leaf						
GoalTender	0.5 pt	4-6 leaf						
Prowl H2O	2 pt	LPRE	1 de	99 a	99 a	98 a	96 a	97 a
Buctril	0.75 pt	2 leaf						
GoalTender	0.5 pt	2 leaf						
Buctril	0.75 pt	4-6 leaf						
GoalTender	0.5 pt	4-6 leaf						
Untreated control			0 e	0 e	0 e	0 f	0 d	0 c
LSD ($P = 0.05$)			4	7	8	9	14	15

^aApplication timing: PRE = preemergence on March 19; LPRE = late preemergence on March 26; 2-leaf = May 8; 4-6 leaf = May 28.

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

Table 3. Number of weeds per plot on July 13 (45 days after herbicide application) in response to postemergence application of Zidua or Buctril and GoalTender when onions were at the 2- and 4-leaf stages, Malheur Experiment Station, Ontario, OR, 2015.

Treatment	Amount per acre	Application timing ^a	Number of weeds/plot (2.67 x 27 ft) ^b						
			Common lambsquarters	Redroot pigweed	Hairy nightshade	Spotted ladythumb	Kochia	Grasses	Total weeds
Prowl H ₂ O	2.0 pt	PRE	9 b	55 bc	23 b	2 b	36 b	8 b	133 b
Zidua	2.5 oz	2-3 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	1 b	43 bc	3 b	2 b	12 b	4 b	65 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	2.5 oz	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	13 b	44 bc	39 b	3 b	71 b	3 b	173 b
Zidua	3.73 oz	2-3 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	1 b	47 bc	1 b	1 b	11 b	3 b	64 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	3.73 oz	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	11 b	56 bc	28 b	3 b	57 b	12 b	167 b
Zidua	5 oz	2-3 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	4 b	43 bc	9 b	3 b	19 b	5 b	82 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	5 oz	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	7 b	62 bc	28 b	2 b	55 b	2 b	155 b
Zidua	1.87 oz	2-3 leaf							
Zidua	1.87 oz	4-6 leaf							
Zidua	1.87 oz	LPRE	3 b	29 bc	0 b	3 b	15 b	5 b	54 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	1.87 oz	4-6 leaf							
Zidua	2.5 oz	PRE	8 b	21 bc	5 b	7 b	37 b	5 b	82 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Zidua	3.73 oz	PRE	3 b	9 c	0 b	7 b	4 b	4 b	27 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	26 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Zidua	2.5 oz	LPRE	1 b	17 bc	1 b	1 b	7 b	10 b	37 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Zidua	3.73 oz	LPRE	2 b	9 bc	1 b	2 b	5 b	4 b	22 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H ₂ O	2 pt	LPRE	10 b	66 b	57 b	3 b	60 b	4 b	199 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Untreated control			322 a	396 a	964 a	198 a	816 a	297 a	2,993 a
LSD (<i>P</i> = 0.05)			37	57	261	31	243	53	477

^aApplication timing: PRE = preemergence on March 19; LPRE = late preemergence on March 26; 2-leaf = May 8; 4-6 leaf = May 28.

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

Table 4. Onion yield by grade in response to applications of Prowl H₂O, Zidua, Buctril and GoalTender to control weeds in direct-seeded onion, Malheur Experiment Station, Ontario, OR, 2015.

Treatment	Amount per acre	Application timing ^a	Onion marketable yield ^{bc}					Total	Total yield
			< 2¼ Small	2¼-3 in Medium	3-4 in Jumbo	4-4¼ in Colossal	>4¼ in Supercolossal		
Prowl H ₂ O	2.0 pt	PRE	46.5 a-d	129.3 ab	385.2 cd	7.8 ef	0.0 b	522.4 ef	568.8 de
Zidua	2.5 oz	2-3 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	3.7 e	43.6 ab	828.5 a	156.0 bcd	4.7 ab	1,032.8 abc	1,036.5 ab
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	2.5 oz	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	46.9 a-d	145.9 ab	365.4 cd	7.6 ef	0.0 b	518.9 ef	565.8 de
Zidua	3.73 oz	2-3 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	7.5 e	126.5 ab	839.7 a	161.8 bcd	13.5 ab	1,141.6 a	1,149.1 a
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	3.73 oz	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	14.1 de	150.0 ab	505.6 bc	32.3 def	0.0 b	687.9 de	702.0 cd
Zidua	5 oz	2-3 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	22.4 cde	71.5 ab	603.0 abc	146.9 b-e	0.0 b	821.3 bcd	843.8 bc
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	5 oz	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	60.5 ab	147.6 ab	177.7 de	0.0 f	0.0 b	325.3 f	385.8 e
Zidua	1.87 oz	2-3 leaf							
Zidua	1.87 oz	4-6 leaf							
Zidua	1.87 oz	LPRE	6.5 e	48.7 ab	761.1 ab	161.7 bcd	14.0 ab	985.5 abc	992.0 ab
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	1.87 oz	4-6 leaf							
Zidua	2.5 oz	PRE	30.6 b-e	169.0 a	513.2 bc	103.7 c-f	0.0 b	785.9 cde	816.5 bcd
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Zidua	3.73 oz	PRE	4.7 e	45.7 ab	704.9 ab	184.1 bc	14.7 ab	949.4 a-d	954.1 abc
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Zidua	2.5 oz	LPRE	4.5 e	20.5 b	830.8 a	247.9 ab	24.0 a	1,123.3 a	1,127.8 a
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Zidua	3.73 oz	LPRE	1.3 e	16.1 b	763.5 ab	373.7 a	23.1 ab	1,176.5 a	1,177.8 a
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H ₂ O	2 pt	LPRE	53.5 abc	173.5 a	753.2 ab	148.4 b-e	18.9 ab	1,093.9 ab	1,147.4 a
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Untreated control			69.9 a	13.6 b	1.9 e	0.0 f	0.0 b	15.5 g	85.3 f
LSD (P = 0.05)			35.6	137.4	260.2	143.6	23.5	278.1	256.0

^aApplication timing: PRE = preemergence on March 19; LPRE = late preemergence on March 26; 2-leaf = May 8; 4-6 leaf = May 28.

^bMeans within a column followed by same letter do not significantly differ (P = 0.05, LSD).

^cOnions were harvested on September 14 and graded on September 15, 2015.

Table 5. Number of onion bulbs by grade in response to applications of ProwlH₂O, Zidua, Buctril, and GoalTender to control weeds in direct-seeded onion, Malheur Experiment Station, Ontario, OR, 2015.

Treatment	Amount per acre	Application timing ^a	Onion marketable bulbs ^{bc}					Total	Total bulbs
			<2¼ Small	2¼-3 in Medium	3-4 in Jumbo	4-4¼ in Colossal	>4¼ in Supercolossal		
Prowl H ₂ O	2.0 pt	PRE	21,958 bcd	36,795 abc	53,708 cd	593 ef	0 b	91,096 cd	113,054 b
Zidua	2.5 oz	2-3 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	1,484 e	10,979 efg	92,580 a	12,759 bcd	297 ab	116,615 ab	118,099 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	2.5 oz	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	24,629 bc	40,059 ab	54,302 bcd	593 ef	0 b	94,954 bcd	119,582 b
Zidua	3.73 oz	2-3 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	4,154 de	5,341 fg	96,437 a	12,463 bcd	297 ab	114,538 abc	118,692 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	3.73 oz	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	7,715 cde	31,750 bcd	67,655 abc	2,671 def	0 b	102,075 abc	109,790 b
Zidua	5 oz	2-3 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	12,759 b-e	19,881 def	68,248 abc	11,276 b-e	0 b	99,405 a-d	112,164 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	5 oz	4-6 leaf							
Prowl H ₂ O	2.0 pt	PRE	32,047 b	48,960 a	27,893 de	0 f	0 b	76,853 d	108,900 b
Zidua	1.87 oz	2-3 leaf							
Zidua	1.87 oz	4-6 leaf							
Zidua	1.87 oz	LPRE	3,264 de	12,463 efg	91,690 a	12,759 bcd	593 ab	117,505 ab	120,769 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Zidua	1.87 oz	4-6 leaf							
Zidua	2.5 oz	PRE	17,210 b-e	22,552 cde	64,984 abc	8,012 c-f	0 b	95,547 bcd	112,758 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Zidua	3.73 oz	PRE	2,077 e	12,463 efg	82,491 abc	14,243 bc	890 ab	110,087 abc	112,164 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Zidua	2.5 oz	LPRE	2,077 e	4,748 g	91,096 a	19,287 ab	1,484 a	116,615 ab	118,692 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Zidua	3.73 oz	LPRE	890 e	4,451 g	82,788 abc	29,673 a	1,484 a	118,395 ab	119,286 b
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Prowl H ₂ O	2 pt	LPRE	29,376 b	22,848 cde	85,458 ab	11,869 bcd	1,187 ab	121,363 a	150,739 a
Buctril	0.75 pt	2 leaf							
GoalTender	0.5 pt	2 leaf							
Buctril	0.75 pt	4-6 leaf							
GoalTender	0.5 pt	4-6 leaf							
Untreated control			59,643 a	6,528 fg	297 e	0 f	0 b	6,825 e	66,468 c
LSD (<i>P</i> = 0.05)			19,357	14,574	31,630	11,074	1,459	24,071	16,481

^aApplication timing: PRE = preemergence on March 19; LPRE = late preemergence on March 26; 2-leaf = May 8; 4-6 leaf = May 28.

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

^cOnions were harvested on September 14 and graded on September 15, 2015.