

EVALUATION OF ZIDUA[®] (PYROXASULFONE) APPLICATION RATE AND TIMING TO MANAGE WEEDS IN ONION

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Introduction

The herbicide Zidua[®] (pyroxasulfone) received a supplemental label for weed control in onion in 2019. It is a selective, rate-dependent, pre-emergence, soil-residual herbicide belonging to group 15, which controls grassy and broadleaf weeds. It is registered for weed control in various crops. It is important to evaluate field performance when an herbicide is tank-mixed with other registered herbicides for weed control in onion. The objective of this study was to evaluate onion response and weed control with various rates of Zidua herbicide applied pre-emergence alone or in mixtures with Brox[®] 2EC (bromoxynil) and GoalTender[®] (oxyfluorfen) at the 1-, 2-, and 4-leaf onion growth stages.

Materials and Methods

A field study was conducted starting spring 2020 at the Malheur Experiment Station to evaluate the response of the direct-seeded onion variety ‘Vaquero’ to Zidua herbicide when applied at various rates and timings and the level of weed control achieved. The predominant soil was an Owyhee silt loam with a pH of 7.8 and 2.78% soil organic matter. Land was prepared the previous fall by flailing wheat stubble. The field was then irrigated, disked, ripped, plowed, and groundhogged. Based on soil analysis, fertilizer was broadcast during fall 2019 at 100 lb nitrogen (N)/acre, 100 lb phosphorus/acre, 200 lb sulfur/acre, 9 lb manganese/acre, and 2 lb boron/acre.

The field was fumigated with K-Pam[®] at 15 gal/acre and beds were formed at 22-inch spacing on October 18, 2019. The beds were harrowed down, and onion seed of Vaquero was planted on March 20, 2020, in double rows spaced 3 inches apart with 4-inch seed spacing within each row. Each pair of rows was planted on beds spaced 22 inches apart. On April 2, 2020, 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. Herbicide treatments were applied using a CO₂-pressurized backpack sprayer fitted with a boom equipped with 8002EVS TeeJet nozzles calibrated to deliver 20 gal/acre for delayed pre-emergence treatments or 35 gal/acre for post-emergence treatments. Zidua herbicide was applied pre-emergence at 2, 2.75, or 4 fl oz/acre on March 25, 2020 (Tables 1 to 4). Other treatments were Zidua herbicide 2 or 2.75 fl oz/acre tank-mixed with

Brox 2EC[®] 2 fl oz/acre plus GoalTender 1 fl oz/acre to onion plants at the 1-leaf growth stage on May 1, 2020; Zidua 2 or 2.75 fl oz/acre tank-mixed with Brox 2EC 12 fl oz/acre plus GoalTender 4 fl oz/acre to onions at the 2-leaf growth stage on May 11, and Zidua 2 or 2.75 fl oz/acre tank-mixed with Brox 2EC 12 fl oz/acre plus GoalTender 4 fl oz/acre to onions at the 4-leaf stage on June 2, 2020. Treatments beginning when onions were at the 2-leaf and 4-leaf growth stages were preceded by a delayed pre-emergence application of Prowl[®] H₂O at 2 pt/acre (pendimethalin 0.95 lb ai/acre) + glyphosate on April 3, 2020. Untreated and hand-weeded checks were included.

In-season fertilizer was applied according to soil and tissue test results. Fertilizer was applied through drip irrigation on May 30 and June 19 to supply 50 lb N/acre on each incident.

The following insecticide combinations were used on the indicated dates to control onion thrips:

- May 29 and June 5, 2020 — Movento[®] 5 fl oz/acre (spirotetramat 0.078 lb ai/acre) + Aza-Direct[®] 12 fl oz/acre (azadirachtin 0.0093 lb ai/acre) + Persist[®] Ultra 1% v/v (methyl esters of canola oil 85% + alkyl phenol ethoxylate 12%).
- June 18 and June 26, 2020 — Exirel[®] 20.5 fl oz/acre (cyantraniliprole 0.13 lb ai/acre) + Persist Ultra 1% v/v (methyl esters of canola oil 85% + alkyl phenol ethoxylate 12%).
- July 4 and 14, 2020 — Radiant[®] 10 fl oz/acre (spinetoram 0.078 lb ai/acre) + Dyne-Amic[®] adjuvant 0.25% v/v (methyl esters of C16-C18 fatty acids, polyalkyleneoxide modified polydimethylsiloxane, alkylphenol ethoxylate 99%).

All other operations followed recommended local production practices for drip-irrigated onion. Visible plant injury and weed control were assessed based on a scale of 0% (no onion injury or weed control) to 100% (complete onion plant kill or total weed control). Weed control and onion response to Zidua alone or tank-mixed with Brox 2EC and GoalTender herbicides were assessed on May 8 and 26 and June 17, 2020. The number of weeds in the two center rows of each plots were counted on June 17, 2020.

The field was drip irrigated from April 20 to August 28, 2020. Plant tops were flailed on September 9, and onion bulbs were lifted and left in the field to cure. Bulbs were hand harvested from the two center beds on September 14, 2020, and placed in burlap bags. Bulbs were graded for yield and quality based on USDA standards as follows: bulbs without blemishes (U.S. No. 1), split bulbs (No. 2), 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 U.S. No. 1 bulbs were graded according to 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.

After harvest, bulbs from a section of two center rows in each plot were rated for single centers. Twenty-five onions ranging in diameter from 3½ to 4¼ inches were rated. The onions were cut equatorially through the bulb middle and separated into single-centered (bullet) and multiple-centered bulbs. The multiple-centered bulbs had the long axis of the inside diameter of the first single ring measured. These multiple-centered onions were ranked according to the inside diameter of the first entire single ring: small had diameters less than 1½ inches, medium had

diameters from 1½ to 2¼ inches, and large had diameters greater than 2¼ inches. Onions were considered "functionally single centered" for processing if they were single centered (bullet) or had a small multiple center.

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

Results and Conclusions

Onion Injury

Onion emergence was observed on April 20, 2020. Evaluation on May 8 (43 days after the pre-emergence herbicide application and 7 days after herbicide application at the 1-leaf stage) indicated no injury to onion (Table 1). On May 26 (25 days after the 1-leaf application and 15 days after the 2-leaf application), injury ranged from 1 to 11% across treatments. Observations on June 17 indicated 0 to 1% injury across herbicide treatments. The injury was characterized by transient leaf chlorosis.

Weed Control

On May 8, common lambsquarters control ranged from 25 to 45% for pre-emergence treatments compared to 31 to 50% for 1-leaf treatments, and 60 to 63% for treatments applied at the 2-leaf stage (Table 1). Hairy nightshade, redroot pigweed, and kochia control ranged from 23 to 63% for 1-leaf, 25 to 55% for 1-leaf treatments, and 49 to 65% for 2-leaf treatments. Zidua applied at the 4-leaf stage in a tank mix with Brox 2EC at 12 fl oz and GoalTender at 4 fl oz/acre provided control ranging from 42 to 80% compared to 48 to 72% for the grower standard. On May 26, control for common lambsquarters, hairy nightshade, and redroot pigweed ranged from 91 to 100% across herbicide rates and application timings, compared to 97 to 100% for the grower standard (Table 2). Similar levels of control for the respective weeds were observed on June 17, 2020.

Enumeration of weeds by species within the two center rows was conducted on June 17, 2020 (Table 3). The number of weeds reflected the levels of control provided by the respective herbicide rates and application timings.

Onion Yield

Onion yield by grade is presented in Table 4. Marketable yield ranged from 971.1 to 1,189.2 cwt/acre across treatments, which included Zidua herbicide applied alone pre-emergence or Zidua tank-mixed with Brox 2EC plus GoalTender at 1-, 2-, or 4-leaf stages.

Functionally single-centered bulbs ranged from 62 to 70% when Zidua was applied pre-emergence and 70% to 76% when applied as a tank-mix with Brox 2EC and GoalTender at 2- or 4-leaf growth stages compared to 65% for the grower standard and 69% for the hand-weeded check (Table 5).

The results suggested improved weed control when Zidua was tank-mixed with Brox 2EC and GoalTender. The study will be repeated in 2021 in order to confirm these results.

Acknowledgements

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Table 1. Onion injury and weed control on May 8, 2020, in response to Zidua® SC applied at various rates and timings, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

Treatment ¹	Rate fl oz/acre	Growth Application		Onion injury ²			Weed control ²			
		stage	date	May 8	May 26	June 17	Common lambsquarters	Hairy nightshade	Redroot pigweed	Kochia
Untreated				0a	0e	0a	0e	0d	0d	0c
Hand weeded				0a	0e	0a	100a	100a	100a	100a
Zidua SC	2	PRE	Mar 25	0a	8abc	1a	25de	25cd	23cd	23bc
Zidua SC	2.75	PRE	Mar 25	0a	11a	0a	45bcd	46bc	49bc	49b
Zidua SC	4	PRE	Mar 25	0a	10ab	1a	45bcd	45bc	63ab	58b
Zidua SC	2	1 leaf	May 1	0a	10ab	0a	31cde	48bc	36bcd	28bc
Brox 2EC	2	1 leaf	May 1							
GoalTender	1	1 leaf	May 1							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
Zidua SC	2.75	1 leaf	May 1	0a	8abc	0a	50bcd	55bc	28bcd	25bc
Brox 2EC	2	1 leaf	May 1							
GoalTender	1	1 leaf	May 1							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
Prowl H ₂ O	32	LPRE	Apr 3	0a	1de	0a	63a-d	65ab	55bc	55b
Zidua SC	2	2 leaf	May 11							
Brox 2EC	12	2 leaf	May 11							
GoalTender	4	2 leaf	May 11							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
Prowl H ₂ O	32	LPRE	Apr 3	0a	1de	0a	60bcd	62abc	49bc	49b
Zidua SC	2.75	2 leaf	May 11							
Brox 2EC	12	2 leaf	May 11							
GoalTender	4	2 leaf	May 11							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
Prowl H ₂ O	32	LPRE	Apr 3	0a	6bc	0a	53bcd	43bc	42bc	42b
Brox 2EC	12	2 leaf	May 11							
GoalTender	4	2 leaf	May 11							
Zidua SC	2	4 leaf	Jun 2							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
Prowl H ₂ O	32	LPRE	Apr 3	1a	5cd	0a	80ab	75ab	63ab	63ab
Brox 2EC	12	2 leaf	May 11							
GoalTender	4	2 leaf	May 11							
Zidua SC	2.75	4 leaf	Jun 2							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
(Grower std) Prowl H ₂ O	32	LPRE	Apr 3	0a	5cd	0a	64abc	72ab	48bc	48b
Brox 2EC	12	2 leaf	May 11							
GoalTender	4	2 leaf	May 11							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
LSD (P = 0.05)				NS	4	NS	38	39	39	40

¹All late-pre-emergence treatments (LPRE) included Roundup 22 fl oz/acre = glyphosate 0.75 lb ae/acre. Zidua SC 2 fl oz/acre = pyroxasulfone 1.04 lb ai/acre; Zidua SC 2.75 fl oz/acre = pyroxasulfone 1.43 lb ai/acre; Brox 2EC 12 fl oz/acre = bromoxynil 0.188 lb ai/acre; GoalTender 4 fl oz/acre = oxyfluorfen 0.125 lb ai/acre; Prowl H₂O 32 fl oz/acre = pendimethalin 0.95 lb ai/acre.

²Means within a column followed by the same letter are not significantly different (P = 0.05, LSD).

Table 2. Weed control on May 26 and June 17, 2020, with Zidua® SC applied at various rates and timings, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

Treatment ¹	Rate fl oz/acre	Growth stage	Application date	Weed control ²					
				5/26/20			6/17/20		
				Common lambsquarters	Hairy nightshade	Redroot pigweed	Common lambsquarters	Hairy nightshade	Redroot pigweed
Untreated ³				0	0	0	0	0	0
Hand weeded ³				100	100	100	100	100	100
Zidua SC	2	PRE	Mar 25	95 a	100 a	100 a	95 a	100 a	100 a
Zidua SC	2.75	PRE	Mar 25	95 a	100 a	100 a	94 a	100 a	100 a
Zidua SC	4	PRE	Mar 25	95 a	100 a	100 a	93 a	100 a	100 a
Zidua SC	2	1 leaf	May 1	91 a	99 a	99 a	90 a	99 a	99 a
Brox 2EC	2	1 leaf	May 1						
GoalTender	1	1 leaf	May 1						
Brox 2EC	12	4 leaf	Jun 2						
GoalTender	4	4 leaf	Jun 2						
Zidua SC	2.75	1 leaf	May 1	95 a	100 a	100 a	95 a	100 a	100 a
Brox 2EC	2	1 leaf	May 1						
GoalTender	1	1 leaf	May 1						
Brox 2EC	12	4 leaf	Jun 2						
GoalTender	4	4 leaf	Jun 2						
Prowl H ₂ O	32	LPRE	Apr 3	95 a	100 a	100 a	95 a	100 a	100 a
Zidua SC	2	2 leaf	May 11						
Brox 2EC	12	2 leaf	May 11						
GoalTender	4	2 leaf	May 11						
Brox 2EC	12	4 leaf	Jun 2						
GoalTender	4	4 leaf	Jun 2						
Prowl H ₂ O	32	LPRE	Apr 3	95 a	100 a	100 a	94 a	100 a	100 a
Zidua SC	2.75	2 leaf	May 11						
Brox 2EC	12	2 leaf	May 11						
GoalTender	4	2 leaf	May 11						
Brox 2EC	12	4 leaf	Jun 2						
GoalTender	4	4 leaf	Jun 2						
Prowl H ₂ O	32	LPRE	Apr 3	97 a	100 a	100 a	97 a	100 a	100 a
Brox 2EC	12	2 leaf	May 11						
GoalTender	4	2 leaf	May 11						
Zidua SC	2	4 leaf	Jun 2						
Brox 2EC	12	4 leaf	Jun 2						
GoalTender	4	4 leaf	Jun 2						
Prowl H ₂ O	32	LPRE	Apr 3	95 a	100 a	100 a	97 a	100 a	100 a
Brox 2EC	12	2 leaf	May 11						
GoalTender	4	2 leaf	May 11						
Zidua SC	2.75	4 leaf	Jun 2						
Brox 2EC	12	4 leaf	Jun 2						
GoalTender	4	4 leaf	Jun 2						
(Grower std) Prowl H ₂ O	32	LPRE	Apr 3	97 a	100 a	100 a	94 a	100 a	100 a
Brox 2EC	12	2 leaf	May 11						
GoalTender	4	2 leaf	May 11						
Brox 2EC	12	4 leaf	Jun 2						
GoalTender	4	4 leaf	Jun 2						
LSD (P = 0.05)				NS	NS	NS	NS	NS	NS

¹All late-pre-emergence treatments (LPRE) included Roundup 22 fl oz/acre = glyphosate 0.75 lb ae/acre. Zidua SC 2 fl oz/acre = pyroxasulfone 1.04 lb ai/acre; Zidua SC 2.75 fl oz/acre = pyroxasulfone 1.43 lb ai/acre; Brox 2EC 12 fl oz/acre = bromoxynil 0.188 lb ai/acre; GoalTender 4 fl oz/acre = oxyfluorfen 0.125 lb ai/acre; Prowl H₂O 32 fl oz/acre = pendimethalin 0.95 lb ai/acre.

²Means within a column followed by the same letter are not significantly different (P = 0.05, LSD).

³Untreated and hand-weeded controls were not included in statistical analysis.

Table 3. Weed counts and weights on June 17, 2020 in onion plots sprayed with Zidua® SC at various rates and onion growth stages, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

Treatment ¹	Rate fl oz/acre	Growth stage	Application date	Common lambsquarters	Redroot pigweed	Hairy nightshade	Barnyardgrass		Total weeds	
							Number	Weight lb/99 ft ²	Number No./99 ft ²	Weight lb/99 ft ²
				----- ² Number of weeds/99 ft ² -----						
Untreated ³				1054	124	1856	198	8.2	4,232	853.1
Hand weeded ³				0	0	0	0	0.0	0	0.0
Zidua SC	2	PRE	Mar 25	32 b	1 a	1 a	95 a	13.30 a	129 a	25.0 a
Zidua SC	2.75	PRE	Mar 25	26 b	0 a	0 a	18 a	2.56 a	44 a	16.9 a
Zidua SC	4	PRE	Mar 25	25 b	0 a	0 a	13 a	2.05 a	38 a	10.2 a
Zidua SC	2	1 leaf	May 1	82 a	0 a	0 a	45 a	7.53 a	128 a	24.6 a
Brox 2EC	2	1 leaf	May 1							
GoalTender	1	1 leaf	May 1							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
Zidua SC	2.75	1 leaf	May 1	45 b	1 a	0 a	26 a	3.48 a	72 a	16.7 a
Brox 2EC	2	1 leaf	May 1							
GoalTender	1	1 leaf	May 1							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
Prowl H ₂ O	32	LPRE	Apr 3	15 b	1 a	0 a	20 a	2.70 a	35 a	7.7 a
Zidua SC	2	2 leaf	May 11							
Brox 2EC	12	2 leaf	May 11							
GoalTender	4	2 leaf	May 11							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
Prowl H ₂ O	32	LPRE	Apr 3	15 b	1 a	3 a	40 a	6.61 a	58 a	15.4 a
Zidua SC	2.75	2 leaf	May 11							
Brox 2EC	12	2 leaf	May 11							
GoalTender	4	2 leaf	May 11							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
Prowl H ₂ O	32	LPRE	Apr 3	33 b	2 a	1 a	82 a	10.15 a	118 a	19.6 a
Brox 2EC	12	2 leaf	May 11							
GoalTender	4	2 leaf	May 11							
Zidua SC	2	4 leaf	Jun 2							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
Prowl H ₂ O	32	LPRE	Apr 3	18 b	0 a	1 a	23 a	3.11 a	41 a	8.9 a
Brox 2EC	12	2 leaf	May 11							
GoalTender	4	2 leaf	May 11							
Zidua SC	2.75	4 leaf	Jun 2							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
(Grower std)										
Prowl H ₂ O	32	LPRE	Apr 3	26 b	0 a	1 a	50 a	5.73 a	80 a	18.4 a
Brox 2EC	12	2 leaf	May 11							
GoalTender	4	2 leaf	May 11							
Brox 2EC	12	4 leaf	Jun 2							
GoalTender	4	4 leaf	Jun 2							
LSD (P = 0.05)				31.7	1.4	2.6	95.6	11.576	104.5	18.50

¹All late-pre-emergence treatments (LPRE) included Roundup 22 fl oz/acre = glyphosate 0.75 lb ae/acre. Zidua SC 2 fl oz/acre = pyroxasulfone 1.04 lb ai/acre; Zidua SC 2.75 fl oz/acre = pyroxasulfone 1.43 lb ai/acre; Brox 2EC 12 fl oz/acre = bromoxynil 0.188 lb ai/acre; GoalTender 4 fl oz/acre = oxyfluorfen 0.125 lb ai/acre; Prowl H₂O 32 fl oz/acre = pendimethalin 0.95 lb ai/acre.

²Means within a column followed by the same letter are not significantly different (P = 0.05, LSD).

³Untreated and hand-weeded controls were not included in statistical analysis.

Table 4. Onion yield (cwt/acre) in response to Zidua® SC herbicide applied at various rates and growth stages, Malheur Experiment Station, Oregon State University, Ontario, OR, 2020.

Treatment ¹	Rate (fl oz/acre)	Growth stage	Application date	Marketable yield by grade ²							Total	
				Rot	US No. 2	Small	2¼-3 in	3-4 in	4-4¼ in	>4¼ in		
Untreated ³				0	0	0	0	0.0	0.0	0.0	0.0	0.00
Hand weeded ³				2.0 a	0.0 a	3.5 a	11.4 a	266.3 a	444.5 a	415.0 a	1137.2 a	1137.2 a
Zidua SC	2	PRE	March 25	1.1 a	0.3 a	6.0 a	13.2 a	303.6 a	419.5 a	234.8 a	971.1 a	971.1 a
Zidua SC	2.75	PRE	March 25	0.0 a	9.2 a	4.9 a	17.4 a	338.6 a	461.1 a	277.1 a	1094.2 a	1094.2 a
Zidua SC	4	PRE	March 25	0.0 a	0.0 a	3.1 a	9.3 a	338.0 a	518.6 a	308.0 a	1173.9 a	1173.9 a
Zidua SC	2	1 leaf	May 1	0.6 a	1.0 a	8.0 a	18.3 a	384.5 a	443.4 a	203.0 a	1049.3 a	1049.3 a
Brox 2EC	2	1 leaf	May 1									
GoalTender	1	1 leaf	May 1									
Brox 2EC	12	4 leaf	Jun 2									
GoalTender	4	4 leaf	Jun 2									
Zidua SC	2.75	1 leaf	May 1	0.0 a	0.0 a	8.0 a	18.1 a	374.1 a	451.9 a	332.6 a	1176.6 a	1176.6 a
Brox 2EC	2	1 leaf	May 1									
GoalTender	1	1 leaf	May 1									
Brox 2EC	12	4 leaf	June 2									
GoalTender	4	4 leaf	June 2									
Prowl H ₂ O	32	LPRE	April 3	0.0 a	0.7 a	4.5 a	13.0 a	359.5 a	503.3 a	259.3 a	1135.1 a	1135.1 a
Zidua SC	2	2 leaf	May 11									
Brox 2EC	12	2 leaf	May 11									
GoalTender	4	2 leaf	May 11									
Brox 2EC	12	4 leaf	Jun 2									
GoalTender	4	4 leaf	Jun 2									
Prowl H ₂ O	32	LPRE	April 3	0.0 a	0.0 a	5.3 a	19.1 a	410.2 a	429.3 a	260.0 a	1118.5 a	1118.5 a
Zidua SC	2.75	2 leaf	May 11									
Brox 2EC	12	2 leaf	May 11									
GoalTender	4	2 leaf	May 11									
Brox 2EC	12	4 leaf	June 2									
GoalTender	4	4 leaf	June 2									
Prowl H ₂ O	32	LPRE	April 3	2.9 a	0.0 a	6.1 a	12.4 a	345.4 a	459.1 a	241.7 a	1058.7 a	1058.7 a
Brox 2EC	12	2 leaf	May 11									
GoalTender	4	2 leaf	May 11									
Zidua SC	2	4 leaf	June 2									
Brox 2EC	12	4 leaf	June 2									
GoalTender	4	4 leaf	June 2									
Prowl H ₂ O	32	LPRE	April 3	0.0 a	1.8 a	3.3 a	12.7 a	426.8 a	492.9 a	256.8 a	1189.2 a	1189.2 a
Brox 2EC	12	2 leaf	May 11									
GoalTender	4	2 leaf	May 11									
Zidua SC	2.75	4 leaf	June 2									
Brox 2EC	12	4 leaf	June 2									
GoalTender	4	4 leaf	June 2									
Prowl H ₂ O (Grower std)	32	LPRE	April 3	0.0 a	2.9 a	5.8 a	13.7 a	378.1 a	524.0 a	284.3 a	1200.0 a	1200.0 a
Brox 2EC	12	2 & 4 leaf	May1&6/2									
GoalTender	4	2 & 4 leaf	May1&6/2									
LSD (P=0.05)				3.3	6.3	7.2	14.7	151.1	145.4	199.0	247.9	247.9

¹All late-pre-emergence treatments (LPRE) included Roundup 22 fl oz/acre = glyphosate 0.75 lb ae/acre. Zidua SC 2 fl oz/acre = pyroxasulfone 1.04 lb ai/acre; Zidua SC 2.75 fl oz/acre = pyroxasulfone 1.43 lb ai/acre; Brox 2EC 12 fl oz/acre = bromoxynil 0.188 lb ai/acre; GoalTender 4 fl oz/acre = oxyfluorfen 0.125 lb ai/acre; Prowl H₂O 32 fl oz/acre = pendimethalin 0.95 lb ai/acre.

²Means within a column followed by the same letter are not significantly different (P = 0.05, LSD).

³Untreated and hand-weeded controls were not included in statistical analysis.

Table 5. Single and multiple center bulb rating in response to application of tank mixes that included Zidua® SC (pyroxasulfone) at various rates and onion growth stages at the Malheur Experiment Station, Oregon State University, Ontario, OR 2020.

Treatment ¹	Rate fl oz/acre	Growth stage	Application Date	Multiple Centers ²³			Single Center ²³	
				Large	Medium	Small	Functional ⁴	Bullet
Hand-weeded				17 a	14 a	22 a	69 a	47 a
Zidua SC	2	PRE	Mar 25	11 a	27 a	15 a	62 a	47 a
Zidua SC	2.75	PRE	Mar 25	11 a	20 a	15 a	69 a	54 a
Zidua SC	4	PRE	Mar 25	13 a	17 a	23 a	70 a	48 a
Zidua SC	2	1 leaf	May 1	11 a	19 a	25 a	71 a	46 a
Brox 2EC	2	1 leaf	May 1					
GoalTender	1	1 leaf	May 1					
Brox 2EC	12	4 leaf	Jun 2					
GoalTender	4	4 leaf	Jun 2					
Zidua SC	2.75	1 leaf	May 1	11 a	22 a	20 a	67 a	47 a
Brox 2EC	2	1 leaf	May 1					
GoalTender	1	1 leaf	May 1					
Brox 2EC	12	4 leaf	Jun 2					
GoalTender	4	4 leaf	Jun 2					
Prowl H ₂ O	32	LPRE	Apr 3	8 a	22 a	25 a	70 a	45 a
Zidua SC	2	2 leaf	May 11					
Brox 2EC	12	2 leaf	May 11					
GoalTender	4	2 leaf	May 11					
Brox 2EC	12	4 leaf	Jun 2					
GoalTender	4	4 leaf	Jun 2					
Prowl H ₂ O	32	LPRE	Apr 3	7 a	23 a	13 a	70 a	57 a
Zidua SC	2.75	2 leaf	May 11					
Brox 2EC	12	2 leaf	May 11					
GoalTender	4	2 leaf	May 11					
Brox 2EC	12	4 leaf	Jun 2					
GoalTender	4	4 leaf	Jun 2					
Prowl H ₂ O	32	LPRE	Apr 3	8 a	18 a	22 a	74 a	52 a
Brox 2EC	12	2 leaf	May 11					
GoalTender	4	2 leaf	May 11					
Zidua SC	2	4 leaf	Jun 2					
Brox 2EC	12	4 leaf	Jun 2					
GoalTender	4	4 leaf	Jun 2					
Prowl H ₂ O	32	LPRE	Apr 3	6 a	18 a	26 a	76 a	50 a
Brox 2EC	12	2 leaf	May 11					
GoalTender	4	2 leaf	May 11					
Zidua SC	2.75	4 leaf	Jun 2					
Brox 2EC	12	4 leaf	Jun 2					
GoalTender	4	4 leaf	Jun 2					
(Grower std) Prowl H ₂ O	32	LPRE	Apr 3	9 a	26 a	21 a	65 a	44 a
Brox 2EC	12	2 leaf	May 11					
GoalTender	4	2 leaf	May 11					
Brox 2EC	12	4 leaf	Jun 2					
GoalTender	4	4 leaf	Jun 2					
LSD (P = 0.05)				NS	NS	NS	NS	NS

¹All late-pre-emergence treatments (LPRE) included Roundup 22 fl oz/acre = glyphosate 0.75 lb ae/acre. Zidua SC 2 fl oz/acre = pyroxasulfone 1.04 lb ai/acre; Zidua SC 2.75 fl oz/acre = pyroxasulfone 1.43 lb ai/acre; Brox 2EC 12 fl oz/acre = bromoxynil 0.188 lb ai/acre; GoalTender 4 fl oz/acre = oxyfluorfen 0.125 lb ai/acre; Prowl H₂O 32 fl oz/acre = pendimethalin 0.95 lb ai/acre.

²Means within a column followed by the same letter are not significantly different (P = 0.05, LSD).

³Multiple-centered onions were ranked according to the inside diameter of the first entire single ring: small had diameters <1½ inches, medium had diameters 1½ to 2¼ inches, and large had diameters >2¼ inches.

⁴"Functionally single centered" are the bullet or had a small multiple center.