

EVALUATION OF ZIDUA[®] HERBICIDE RATE AND APPLICATION TIMING TO MANAGE WEEDS IN ONION

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Introduction

It has been two years since the herbicide Zidua[®] (pyroxasulfone) received a supplemental label for weed control in onion in 2019. Zidua is a selective, pre-emergence, rate-dependent, 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 in order to broaden the weed control spectrum in onion. The objective of this study was to evaluate onion variety ‘Vaquero’ response and weed control with various rates of Zidua herbicide applied prior to onion emergence (pre-emergence) alone or post emergence in mixtures with Brox[®] 2EC (bromoxynil) and GoalTender[®] (oxyfluorfen) at the 1-, 2-, or 4-leaf onion growth stages.

Materials and Methods

A field study was established during spring 2021 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 applied during fall 2020 at 100 lb nitrogen (N)/acre, 100 lb phosphorus/acre, 4 lb zinc/acre, and 2 lb boron/acre.

The field was fumigated with K-Pam[®] at 15 gal/acre (Potassium N-methyldithiocarbamate 5.8 lb ai/gal) and beds were formed at 22-inch spacing on October 2, 2020. Beds were harrowed down on March 24, 2021 and onion seed of variety ‘Vaquero’ was planted on March 26, 2021, in double rows spaced 3 inches apart with 3.71-inch seed spacing within each row. Each pair of rows was planted on beds spaced 22 inches apart. On March 26, 2021, 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. Irrigation drip tape was installed thereafter.

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 calibrated to deliver 20 gal/acre for delayed pre-emergence treatments or 35 gal/acre for post-emergence treatments.

On April 2, 2021, 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.

Zidua herbicide was applied pre-emergence at 2, 2.75, or 4 fl oz/acre on April 12, 2021 (Tables 1 to 5). Other treatments were Zidua herbicide at 2 or 2.75 fl oz/acre tank-mixed with Brox 2EC[®] at 2 fl oz/acre plus GoalTender at 1 fl oz/acre to onion plants at the 1-leaf growth stage on May 5, 2021; Zidua 2 or 2.75 fl oz/acre tank-mixed with Brox 2EC at 12 fl oz/acre plus GoalTender at 4 fl oz/acre to onions at the 2-leaf growth stage on May 13, and Zidua 2 or 2.75 fl oz/acre tank-mixed with Brox 2EC at 12 fl oz/acre plus GoalTender 4 fl oz/acre to onions at the 4-leaf stage on June 1, 2021. Zidua treatments applied when onions were at the 2-leaf or 4-leaf growth stages were preceded by a delayed pre-emergence application of Prowl[®] H₂O at 2 pints/acre (pendimethalin 0.95 lb ai/acre) + glyphosate on April 12, 2021. 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 June 1 and June 22 to supply 100 lb N/acre on each incident.

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

- June 4, 2021 — M-Pede 5.6 pints/acre + Aza-Direct[®] 12 fl oz/acre (azadirachtin 0.0093 lb ai/acre)
- June 11, 2021 — Aza-Direct[®] 16 fl oz/acre (azadirachtin 0.0123 lb ai/acre) + Movento[®] 5 fl oz/acre (spirotetramat 0.078 lb ai/acre)
- June 14, 2021 - Aza-Direct[®] 16 fl oz/acre (azadirachtin 0.0123 lb ai/acre) + Persist[®] Ultra 1% v/v (methyl esters of canola oil 85% + alkyl phenol ethoxylate 12%).
- June 22, 2021 — Movento[®] 3.5 fl oz/acre (spirotetramat 0.051 lb ai/acre) + Exirel[®] 13.5 fl oz/acre (cyantraniliprole 0.0875 lb ai/acre) + Persist Ultra 1% v/v (methyl esters of canola oil 85% + alkyl phenol ethoxylate 12%).
- July 2, 2021 — Exirel[®] 20 fl oz/acre (cyantraniliprole 0.13 lb ai/acre) + Dyne- Amic[®] adjuvant 0.25% v/v (methyl esters of C16-C18 fatty acids, polyalkyleneoxide modified polydimethylsiloxane, alkylphenol ethoxylate 99%).
- July 12, 2021 — Exirel[®] 20 fl oz/acre (cyantraniliprole 0.13 lb ai/acre) + HSMOC 0.125% v/v.
- July 21, 2021 — Agri-Mek[®] 3.5 fl oz/acre (abamectin 0.0191 lb ai/acre) + Dyne- Amic[®] adjuvant 0.125% 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 killed or total weed control). Onion response to Zidua[®] herbicide was assessed on May 7, May 12, May 20, and June 8, 2021 (Table 1). Weed control was assessed on May 8, May 20, and June 8 (Table 2). Weeds were counted in the center two rows on June 29, 2021 (Table 3) and the study was hand-weeded (except for untreated control plots) thereafter.

The field was drip irrigated from April 5 to August 17, 2021. Plant tops were flailed on August 30, and onion bulbs were lifted on August 31. Bulbs were hand harvested from 15 ft length of the two center beds on September 3, 2021, placed in burlap bags, and kept in the storage barn until graded. Bulbs were graded for yield and quality on September 20 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 purposes 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

Due to unseasonably warm and dry conditions during winter 2020 that extended to onion planting time during spring 2021, the study area was irrigated within 10 days of seeding. Onion emergence was observed on April 20, 2021. Onion plants in the two center rows were counted on May 10 and was similar across treatments ranging from 120,670 to 128,920 plants/acre across treatments (120,120 plants/acre for the grower standard). No onion injury was observed at any Zidua application rate and timing (data not shown).

Weed Control

Control for common lambsquarters on May 20 (38 days after the delayed pre-emergence herbicide application or 8 days after herbicide application at the 1-leaf stage) was variable across treatments (Table 1). Application of Zidua at either 2 or 2.75 fl oz/acre tank-mixed with Brox 2EC at 2 fl oz/acre to onions at the 1-leaf stage provided the best control for common lambsquarters at 95% compared to 23 to 30% for treatments that received a delayed pre-emergence application of Prowl at 32 fl oz/acre. Similar results were observed for hairy nightshade and pigweed control on the same date (Table 1). Subsequent evaluation on May 28 indicated 99 to 100% control for common lambsquarters, 91 to 95% for hairy nightshade, and 93 to 97% control for pigweed species across Zidua-containing treatments compared to 99, 94, and 94% for the grower standard in respective weed species. Evaluation on June 8, 2021 indicated the level of control for common lambsquarters, hairy nightshade, and pigweed species was still >97% across weed species and herbicide treatments (Table 1).

The number of weeds in the two center rows on July 1, 2021 further supported the visible control ratings for common lambsquarters, hairy nightshade, grassy weeds, and other weeds (Table 2).

The total number of common lambsquarters in the two center rows (99 ft²) was ≤9 weeds, ≤10 for pigweed species, 33 to 95 for hairy nightshade, ≤2 for grass weeds, and ≤1 for the other weeds (Table 2). The number of weeds reflected the levels of control provided by the respective herbicide rates and application timings.

Onion Yield

The number of harvested bulbs was similar across herbicide treatments (Table 2). Total marketable bulbs (bulbs 2¼ to >4¼ inches in diameter) was similar across treatments and ranged from 115,434 to 119,196 bulbs/acre compared to 117,216 bulbs/acre for the grower standard. It is worth noting that bulbs in the colossal category (4 to 4¼ inches in diameter) varied across herbicide treatments with most of the Zidua-containing treatments yielding a higher number of colossal bulbs compared to the grower standard. The differences in this category are also reflected in the marketable yield (Table 4).

Onion yield by grade is presented in Table 4. Total marketable yield (bulbs 2¼ to >4¼ inches in diameter) was similar across herbicide treatments and ranged from 1,081.3 to 1,242.9 cwt/acre across treatments that included Zidua herbicide applied alone pre-emergence or Zidua tank-mixed with Brox 2EC plus GoalTender at 1-, 2-, or 4-leaf stages compared to 1,104 cwt/acre for the grower standard.

Functionally single-centered bulbs (bullet plus bulbs with small double-center) was better in Zidua-containing treatments compared to the grower standard (Table 5). Functionally single centered bulbs for treatments containing Zidua averaged 66 to 79% compared to 67% for the grower standard and 81% for the hand weeded control.

These results suggested improved weed control when Zidua was tank-mixed with Brox 2EC and GoalTender at various onion growth stages. The study will be repeated in 2022 in order to confirm these results.

Acknowledgements

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Table 1. Onion plant stand and weed control 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	Plant population	Percent weed Control ²								
					5/20/2021			5/28/2021			6/8/2021		
					Common lambquarters	Hairy nightshade	Pigweed	Common lambquarters	Hairy nightshade	Pigweed	Common lambquarters	Hairy nightshade	Pigweed
Untreated ³				0	0 ³	0	0	0	0	0	0	0	0
Hand weeded ³				127,710 ⁻³	100 a	100 a	100 a	100 a	100 a	100 a	100 a	100 a	100 a
Zidua SC	2	PRE	March 25	128,260 a	38 b	41 b	30 bc	99 a	91 a	97 a	100 a	97 a	100 a
Zidua SC	2.75	PRE	March 25	123,200 a	33 b	33 b	30 bc	99 a	92 a	93 b	100 a	98 a	100 a
Zidua SC	4	PRE	March 25	121,660 a	45 b	46 b	45 b	99 a	95 a	96 ab	100 a	97 a	100 a
Zidua SC	2	1 leaf	May 5	124,740 a	95 a	97 a	96 a	95 a	92 a	97 a	100 a	97 a	100 a
Brox 2EC	2	1 leaf	May 5										
GoalTender	1	1 leaf	May 5										
Brox 2EC	12	4 leaf	Jun 1										
GoalTender	4	4 leaf	Jun 1										
Zidua SC	2.75	1 leaf	May 5	120,670 a	95 a	96 a	91 a	99 a	94 a	97 a	100 a	98 a	100 a
Brox 2EC	2	1 leaf	May 5										
GoalTender	1	1 leaf	May 5										
Brox 2EC	12	4 leaf	June 1										
GoalTender	4	4 leaf	June 1										
Prowl H ₂ O	32	LPRE	April 13	127,160 a	30 b	38 b	0 d	100 a	93 a	98 a	100 a	97 a	100 a
Zidua SC	2	2 leaf	May 13										
Brox 2EC	12	2 leaf	May 13										
GoalTender	4	2 leaf	May 13										
Brox 2EC	12	4 leaf	Jun 1										
GoalTender	4	4 leaf	Jun 1										
Prowl H ₂ O	32	LPRE	April 12	126,280 a	25 b	35 b	13 cd	100 a	93 a	98 a	100 a	98 a	100 a
Zidua SC	2.75	2 leaf	May 13										
Brox 2EC	12	2 leaf	May 13										
GoalTender	4	2 leaf	May 13										
Brox 2EC	12	4 leaf	June 1										
GoalTender	4	4 leaf	June 1										
Prowl H ₂ O	32	LPRE	Apr 12	121,330 a	38 b	45 b	0 d	100 a	91 a	97 a	100 a	97 a	100 a
Brox 2EC	12	2 leaf	May 13										
GoalTender	4	2 leaf	May 13										
Zidua SC	2	4 leaf	June 1										
Brox 2EC	12	4 leaf	June 1										
GoalTender	4	4 leaf	June 1										
Prowl H ₂ O	32	LPRE	Apr 12	128,920 a	23 bcd	30 bcd	1 b	99 a	91 a	96 ab	100 a	97 a	100 a
Brox 2EC	12	2 leaf	May 13										
GoalTender	4	2 leaf	May 13										
Zidua SC	2.75	4 leaf	June 1										
Brox 2EC	12	4 leaf	June 1										
GoalTender	4	4 leaf	June 1										
Prowl H ₂ O (Grower std)	32	LPRE	April 12	120,120 a	35 b	38 bc	0 b	99 a	94 a	97 a	100 a	97 a	100 a
Brox 2EC	12	2 & 4 leaf	May13&6/1										
GoalTender	4	2 & 4 leaf	May13&6/1										
LSD (P=0.05)				NS	23	22	22	NS	NS	3	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 2. Number and total weight of weeds on July 1 in response to Talinor herbicide application rate and timing, Malheur Experiment Station, Oregon State University, Ontario, OR, 2021.

Treatment ^a	Rate fl oz/acre	Growth stage	Application date	Number of weeds ^c						Total weeds	Total weed fresh weight lb/99 ft ²
				C. lambs- quarters	Pigweeds	Hairy nightshade	Grasses	Other weeds ^b			
Untreated ³	-	-	-	91 - ³	19 -	916 -	0-	44 -	1,070 -	124.8 -	
Hand weeded ³	-	-	-	0 - ³	0 -	0 -	0-	0 -	0 -	0 -	
Zidua SC	2	PRE	March 25	2 c	9 a	75 ab	1 a	1 b	87 ab	18.5 a	
Buctril	12	2 & 4 leaf	May 13 & Jun 1								
GoalTender	4	2 & 4 leaf	May 13 & Jun 1								
Zidua SC	2.75	Apr 12	March 25	3 bc	9 a	53 ab	2 a	1 b	68 ab	15.6 a	
Buctril	12	2 & 4 leaf	May 13 & Jun 1								
GoalTender	4	2 & 4 leaf	May 13 & Jun 1								
Zidua SC	4	Apr 12	Apr 12	1 c	8 a	82 ab	1 a	1 ab	93 ab	17.9 a	
Buctril	12	2 & 4 leaf	May 13 & Jun 1								
GoalTender	4	2 & 4 leaf	May 13 & Jun 1								
Roundup PowerMax	32	LPRE	Apr 12								
Zidua SC	2	1 leaf	May 5	5 ab	3 a	37 ab	1 a	2 ab	48 ab	12.0 a	
Brox 2EC	2	1 leaf	May 5								
GoalTender	1	1 leaf	May 5								
Brox 2EC	12	4 leaf	Jun 1								
GoalTender	4	4 leaf	Jun 1								
Roundup PowerMax	32	LPRE	Apr 12								
Zidua SC	2.75	1 leaf	May 5	9 a	6 a	95 a	1 a	1 ab	111 a	18.0 a	
Brox 2EC	2	1 leaf	May 5								
GoalTender	1	1 leaf	May 5								
Brox 2EC	12	4 leaf	June 1								
GoalTender	4	4 leaf	June 1								
Prowl H ₂ O	32	LPRE	Apr 12	1 c	10 a	55 ab	1 a	3 a	70 ab	14.8 a	
Roundup PowerMax	32	LPRE	Apr 12								
Zidua SC	2	2 leaf	May 13								
Brox 2EC	12	2 leaf	May 13								
GoalTender	4	2 leaf	June 1								
Brox 2EC	12	4 leaf	June 1								
GoalTender	4	4 leaf	June 1								
Roundup PowerMax	32	LPRE	Apr 12								
Prowl H ₂ O	32	LPRE	Apr 12	1 c	3 a	33 b	0 a	1 b	38 b	10.8 a	
Brox 2EC	12	2 leaf	May 13								
GoalTender	4	2 leaf	May 13								
Zidua SC	2.75	4 leaf	June 1								
Brox 2EC	12	4 leaf	June 1								
GoalTender	4	4 leaf	June 1								
Roundup PowerMax	32	LPRE	Apr 12								
Prowl H ₂ O	32	LPRE	Apr 12	1 c	4 a	63 ab	1 a	1 b	68 ab	18.9 a	
Brox 2EC	12	2 leaf	May 13								
GoalTender	4	2 leaf	May 13								
Zidua SC	2	4 leaf	June 1								
Brox 2EC	12	4 leaf	June 1								
GoalTender	4	4 leaf	June 1								
Roundup PowerMax	32	LPRE	Apr 12								
Prowl H ₂ O	32	LPRE	Apr 12	2 bc	7 a	77 ab	1 a	2 ab	87 ab	21.4 a	
Brox 2EC	12	2 leaf	May 13								
GoalTender	4	2 leaf	May 13								
Zidua SC	2.75	4 leaf	June 1								
Brox 2EC	12	4 leaf	June 1								
GoalTender	4	4 leaf	June 1								
Prowl H ₂ O (Grower std)	32	LPRE	Apr 12	1 c	4 a	43 ab	1 a	1 b	50 ab	12.8 a	
Brox 2EC	12	2 leaf	May 13								
GoalTender	4	2 leaf	May 13								
Brox 2EC	12	4 leaf	Jun 1								
GoalTender	4	4 leaf	Jun 1								
LSD (P = 0.05)				4	8	60	2	2	66	14	

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. Number of harvested onion bulbs (number/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	Number of marketable bulbs by grade ²								Total	Total bulbs
				Rot	US No. 2	Small	2¼-3 in	3-4 in	4-4¼ in	>4¼ in			
Untreated ³				0 ⁻³	0-	0-	0-	0-	0-	0-	0-	0-	0-
Hand weeded ³				198 a	396 a	4,554 a	6,138 a	90,090 a	23,364 ab	3,366 a	122,958 a	128,106 a	
Zidua SC	2	PRE	March 25	0 a	198 a	5,148 a	7,524 a	84,546 a	21,780 b	4,356 a	118,206 a	123,552 a	
Zidua SC	2.75	PRE	March 25	198 a	0 a	4,356 a	4,752 a	80,982 a	30,294 ab	3,168 a	119,196 a	123,750 a	
Zidua SC	4	PRE	March 25	198 a	396 a	7,128 a	7,920 a	76,626 a	25,344 ab	3,366 a	113,256 a	120,978 a	
Zidua SC	2	1 leaf	May 1	0 a	198 a	6,138 a	9,900 a	81,378 a	23,760 ab	4,158 a	119,196 a	125,532 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 a	396 a	6930 a	7326 a	74844 a	25740 ab	3762 a	111,672 a	118,998 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 a	0 a	6,138 a	8,712 a	84,150 a	22,770 b	3,168 a	118,800 a	124,938 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	198 a	0 a	2,970 a	5,544 a	77,220 a	31,482 a	4,950 a	119,196 a	122,364 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	198 a	198 a	6,534 a	7,920 a	79,596 a	24,354 ab	3,762 a	115,632 a	122,562 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 a	198 a	4,752 a	7,524 a	81,180 a	22,374 b	4,356 a	115,434 a	120,384 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	198 a	198 a	7,524 a	10,098 a	82,368 a	22,176 b	2,574 a	117,216 a	125,136 a	
Brox 2EC	12	2 & 4 leaf	May1&6/2										
GoalTender	4	2 & 4 leaf	May1&6/2										
LSD (P=0.05)				NS	NS	NS	NS	NS	8,544	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 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	Total Yield
				Rot	US No. 2	Small	2¼-3 in	3-4 in	4-4¼ in	>4¼ in		
Untreated ³				0 ⁻³	0-	0-	0-	0 -	0 -	0 -	0 -	0 -
Hand weeded ³				1.3 a	5.9 a	9.9 b	27.9 a	808.5 a	322.3 ab	64.7 a	1,223.5 a	1,240.6 a
Zidua SC	2	PRE	March 25	0.0 a	1.2 ab	11.4 b	30.9 a	757.7 ab	297.2 b	76.7 a	1,162.4 a	1,175.0 a
Zidua SC	2.75	PRE	March 25	1.1 a	0.0 b	7.2 b	18.6 a	700.4 ab	401.8 ab	59.6 a	1,180.4 a	1,188.7 a
Zidua SC	4	PRE	March 25	1.9 a	2.5 ab	13.9 b	32.5 a	669.7 ab	341.3 ab	64.4 a	1,108.0 a	1,126.3 a
Zidua SC	2	1 leaf	May 1	0.0 a	2.3 ab	136.3 a	40.7 a	720.7 ab	316.7 ab	77.2 a	1,155.3 a	1,294.0 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	2.9 ab	15.2 b	31.6 a	636.3 b	340.7 ab	72.7 a	1,081.3 a	1,099.4 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	0.0 b	12.5 b	35.6 a	735.9 ab	302.7 b	57.5 a	1,131.7 a	1,144.3 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	2.3 a	0.0 b	5.4 b	22.2 a	703.3 ab	426.8 a	90.5 a	1,242.9 a	1,250.5 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	0.8 a	1.0 ab	11.7 b	31.1 a	685.1 ab	332.7 ab	72.8 a	1,121.7 a	1,135.1 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	1.5 ab	8.3 b	31.2 a	704.6 ab	298.6 b	83.3 a	1,117.7 a	1,127.4 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	2.3 a	2.4 ab	16.4 b	38.9 a	713.8 ab	298.3 b	53.1 a	1,104.0 a	1,125.1 a
Brox 2EC	12	2 & 4 leaf	May1&6/2									
GoalTender	4	2 & 4 leaf	May1&6/2									
LSD (P=0.05)				NS	5.0	104.2	NS	172.0	118.2	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 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 2021.

Treatment ¹	Rate fl oz/acre	Growth Application		Multiple Centers ^{2,3}			Single Center ^{2,3}	
		stage	date	Large	Medium	Small	Bullet	Functional ⁴
				----- % -----				
Hand-weeded				3.0 b	16.0 bc	22.0 abc	59.0 ab	81.0 ab
Zidua SC	2	PRE	Mar 25	4.0 b	30.0 a	29.0 a	37.0 c	66.0 c
Zidua SC	2.75	PRE	Mar 25	5.0 b	23.0 abc	25.0 ab	47.0 bc	72.0 abc
Zidua SC	4	PRE	Mar 25	4.0 b	12.0 c	18.0 bc	66.0 a	84.0 a
Zidua SC	2	1 leaf	May 1	6.0 b	19.0 abc	17.0 bc	58.0 ab	75.0 abc
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	5.0 b	21.0 abc	23.0 abc	51.0 abc	74.0 abc
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	3.0 b	18.0 abc	28.0 a	51.0 abc	79.0 abc
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	5.0 b	25.0 ab	21.0 abc	49.0 bc	70.0 bc
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	13.0 a	18.0 abc	22.0 abc	47.0 bc	69.0 bc
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	2.0 b	27.0 ab	18.0 bc	53.0 abc	71.0 abc
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	5.0 b	28.0 ab	14.0 c	53.0 abc	67.0 c
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)				5.6	12.6	9.4	16.1	13.0

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" is composed of bullet and small multiple center.