

ONION RESPONSE TO MOXY[®] 2EC AND/OR GOALTENDER[®] HERBICIDE AT LOW RATES AND APPLICATION TIMING

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Introduction

Early season weed management in direct-seeded onion presents a challenge to growers because of seedling sensitivity to most herbicides. The current label for use of bromoxynil (marketed as Moxy[®] 2EC, Brox[®] 2EC, and various other names) and oxyfluorfen (GoalTender[®]) allows application starting when onion seedlings are at the two true leaf stage. This presents a challenge because by the time onions reach the two-leaf stage, weeds that emerged at the same time as onions have increased in size and started to compete with the crop for space, moisture, and nutrients. There is evidence to suggest that onions grown in the Treasure Valley of eastern Oregon and southwestern Idaho could tolerate low rates of bromoxynil (Moxy 2EC as well as other generic names) and/or GoalTender starting as early as the one true leaf stage. Moxy 2EC applied at the low rate when onions are at the one-leaf stage is effective at controlling small weeds and therefore allowing the crop to grow without early competition with weeds. The objective of this study was to evaluate the response of onion variety ‘Vaquero’ to Moxy 2EC and/or GoalTender at low rates with the intent of using the data to support a request for changes to the current labels.

Materials and Methods

A field study was initiated during spring 2021 at the Malheur Experiment Station to evaluate the response of direct-seeded onion variety Vaquero to Moxy 2EC herbicide at various low application rates starting when onions were at the 1-leaf stage. 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.

The study area was sprayed with Roundup[®] at 1 quart/acre (1.13 lb ae/acre) on March 18, 2021 to control all emerged weeds prior to establishing the study. Beds were harrowed down on March 24 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 three 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. All treatments (except the untreated control) were preceded by a delayed pre-emergence application of glyphosate at 22 fl oz/acre (glyphosate 0.77 lb ae/acre). Untreated and the grower standard checks were included.

Delayed pre-emergence herbicide treatment was applied on April 12, 2021. Moxy 2EC herbicide was applied at 2, 4, or 6 fl oz/acre (bromoxynil 0.0313, 0.0625, or 0.094 lb ai/a) to onion seedlings at the 1-leaf stage on May 5, 2021. The complete list of treatments including application rates and timing are presented in tables 1-4 in this report. On May 11, all treatments (except the untreated control) were sprayed with Poast[®] herbicide at 1.5 pints/acre (sethoxydim 0.287 lb ai/acre) plus COC at 1 pint/acre (0.41 % v/v) to control grassy weeds.

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 pint/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 Moxy 2EC and/or GoalTender herbicides was assessed on May 12 and May 20, 2021 (Table 1). Weeds were counted in the two center rows on July 3, 2021 (Table 2) and the study was hand-weeded (except for untreated 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, 2021. Bulbs were hand harvested from 15 ft lengths of the two center beds in each plot 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 on September 14, 2021. 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

Weather condition in the Treasure Valley was generally warm and dry during the winter 2020, which extended to dry conditions during onion planting time in spring 2021. Consequently, onions were irrigated within 10 days of seeding (April 5). Onion emergence was observed on April 20, 2021. Plant count on May 7 indicated variable plant population density ranging from 124,960 to 132,880/acre across herbicide treatments (Table 1). The variability in plant stand could be attributed to dry soil conditions during spring 2021. Evaluation on May 12 (7 days after Moxy 2EC application to onion at the 1-leaf) indicated no visible injury (Table 1). Onion injury on May 20 (15 days after 1-leaf and 7 days after 2-leaf application timings) was <5% across herbicide treatments (data not shown). Warmer weather during 2021 may have resulted in substantial buildup and maintenance of waxy leaf cuticle that prevented injury from herbicides.

Evaluations on May 12 indicated variation across treatments for the control of common lambsquarters, hairy nightshade, and pigweed species (Table 1). Plots that were treated with Moxy 2EC at 2 to 6 fl oz/acre had the best control for common lambsquarters and hairy nightshade (67 to 92%). Application of GoalTender at 1 to 4 fl oz/acre provided 43 to 53% control for common lambsquarters and hairy nightshade and 27 to 33% for pigweed species. Tank-mixing Moxy 2EC (2 or 4 fl oz/acre) with GoalTender (1 fl oz/acre) provided 67 to 83% control for common lambsquarters and hairy nightshade and 30 to 83% for pigweed species. Evaluations on May 20, 2021 indicated control for common lambsquarters, hairy nightshade, and pigweed species at ≥93% compared to 90 to 98% for the grower standard where Moxy 2EC was applied starting when onions were at the 2-leaf stage (Table 1).

The average number of weeds counted in the two center rows of each plot on July 3 varied across herbicide application rates and application timing (Table 2). The total number of weeds on July 3 ranged from 4 to 15 weed plants/99 ft² (two center rows) in plots treated with Moxy 2EC herbicide starting when onion was at the 1-leaf stage, compared to 56 plants/99 ft² for the grower standard. The total number of weeds was generally higher in the plots that were treated with GoalTender 1 to 4 fl oz/acre when onions were at the 1-leaf stage (36 to 51 plants/99 ft²). Overall, the total number of weeds was influenced by hairy nightshade in all cases. The average total weed fresh weight was very low in plots treated with Moxy 2EC when onions were at the 1-leaf stage compared to other treatments including the grower standard.

Onion yield reflected the level of weed control (Table 3). The marketable yield, which is composed of medium, jumbo, colossal, and super colossal grades was generally higher for treatments that received Moxy 2EC starting when onions were at the 1-leaf stage (1,215.5 to 1,348.9 cwt/acre) comparable to the grower standard herbicide practice (1,146.5 cwt/acre). Not surprising, the total onion yield (all grades combined) followed a similar trend.

Bulb single centeredness is very important for growers contracting with processors of onion rings. The percentage of functionally single-centered bulbs (bullet plus small multiple center bulbs) varied across herbicide treatments and ranged from 65.3 to 82.7% across Moxy 2EC and/or GoalTender treatments compared to 74.7% for the grower standard (Table 4).

These results suggested improved weed control in onion variety ‘Vaquero’ when Moxy 2EC was applied starting when onions were at the 1-leaf stage. It is possible that warm weather conditions during the application period may have aided onion plants to build the waxy leaf cuticle that helped plants to tolerate bromoxynil starting at the 1-leaf stage. A follow up study to confirm these results will be conducted in 2022.

Acknowledgements

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Table 1. Weed control ratings in response to application of bromoxynil (Moxy 2EC) at various rates and onion growth stages to manage weeds in onion variety Vaquero at the Malheur Experiment Station, Oregon State University, Ontario, OR 2021.

Treatment ¹	Rate fl oz/a	Growth stage	Application date	Percent weed control ²						
				5/12/2021				5/20/2021		
				Plant population	Common lambsquarters	Hairy nightshade	Redroot pigweed	Common lambsquarters	Hairy nightshade	Pigweed species
Untreated				132,147a	0-	0-	0c-	0-	0-	0-
Moxy 2EC	2	1-Leaf	May 5	132,880a	70b	67bcd	33bc	98b	100a	100a
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
Moxy 2EC	4	1-Leaf	May 5	129,067ab	77ab	82ab	67ab	100a	100a	100a
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
Moxy 2EC	6	1-Leaf	May 5	130,240ab	92a	92a	92a	100a	100a	100a
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
GoalTender	1	1-Leaf	May 5	126,720b	43de	50de	27c	99a	95c	97b
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
GoalTender	2	1-Leaf	May 5	129,360ab	50cd	43e	18c	96c	90d	93c
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
GoalTender	4	1-Leaf	May 5	124,960b	43de	53cde	33bc	99ab	98b	98b
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
Moxy 2EC	2	1-Leaf	May 5	128,333ab	67bc	70bc	30c	100a	98b	98b
GoalTender	1	1-Leaf	May 5							
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
Moxy 2EC	4	1-Leaf	May 5	126,573b	83ab	83ab	83a	100a	100a	100a
GoalTender	1	1-Leaf	May 5							
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
Prowl H2O	32	LPRE	LPRE	127,747ab	32e	40e	0c	95c	90d	98b
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
LSD (P=0.05)				5,334	18	17	36	1	0	2

¹All treatments (except the untreated control) received a late-pre-emergence application of Roundup 22 fl oz/acre = glyphosate 0.75 lb ae/acre + Prowl H₂O 32 fl oz/acre = pendimethalin 0.95 lb ai/acre. Moxy 2EC 2 fl oz/acre = bromoxynil 0.0313 lb ai/acre GoalTender 1 fl oz/acre = oxyfluorfen 0.0313 lb ai/acre. The untreated control was not included in statistical analysis.

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

Table 2. Number of weeds (number/99 ft²) on July 3, 2021 in response to application of bromoxynil (Moxy 2EC) at various rates and onion growth stages to manage weeds in onion variety Vaquero at the Malheur Experiment Station, Oregon State University, Ontario, OR 2021.

Treatment ^{1*}	Rate	Growth stage	Application date	Number of weeds ²						Total weed fresh weight
				Common lambsquarters	Pigweeds	Hairy nightshade	Grasses	Other weeds ^b	Total weeds	
				Number per 99 ft ²						
Untreated				1,254*	330*	6,534*	0*	99*	8,217*	11.9*
Moxy 2EC	2	1-Leaf	May 5	7a	1c	6bc	0a	1a	15cd	1.9bc
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
Moxy 2EC	4	1-Leaf	May 5	2a	2c	1c	0a	0a	5cd	0.2c
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
Moxy 2EC	6	1-Leaf	May 5	1a	1c	1c	1a	0a	4d	0.2c
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
GoalTender	1	1-Leaf	May 5	8a	6b	36ab	0a	1a	51a	9.9ab
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
GoalTender	2	1-Leaf	May 5	4a	2c	41a	1a	0a	49ab	10.3ab
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
GoalTender	4	1-Leaf	May 5	4a	2c	29abc	1a	0a	36abc	4.0abc
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
Moxy 2EC	2	1-Leaf	May 5	7a	3bc	7bc	1a	0a	19bcd	2.9abc
GoalTender	1	1-Leaf	May 13							
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
Moxy 2EC	4	1-Leaf	May 5	2a	1c	1c	1a	0a	5cd	0.2c
GoalTender	1	1-Leaf	May 5							
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
Prowl H2O	32	LPRE	May 5	6a	12a	36ab	1a	1a	56a	11.4a
Moxy 2EC	12	2-Leaf	May 13							
GoalTender	4	2-Leaf	May 13							
LSD (P=0.05)				NS	3	31	NS	NS	31	8.7

¹All treatments (except the untreated control) received a late-pre-emergence application of Roundup 22 fl oz/acre = glyphosate 0.75 lb ae/acre + Prowl H₂O 32 fl oz/acre = pendimethalin 0.95 lb ai/acre. Moxy 2EC 2 fl oz/acre = bromoxynil 0.0313 lb ai/acre GoalTender 1 fl oz/acre = oxyfluorfen 0.0313 lb ai/acre. The untreated control was not included in statistical analysis.

*Untreated not included in statistical analysis.

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

Table 3. Onion yield (cwt/acre) in response to application of bromoxynil (Moxy 2EC) and/or Goal tender (oxyfluorfen) at various rates and onion growth stages to manage weeds in onion variety Vaquero at the Malheur Experiment Station, Oregon State University, Ontario, OR 2021.

Treatment ¹	Rate fl oz/a		Growth stage date	Application	Marketable yield by grade ²						Total	Total Yield
					US No. 2	Small	2¼-3 in	3-4 in	4-4¼ in	>4¼ in		
				cwt/a								
Untreated				0.0*	0*	0*	0*	0*	0*	0*	0*	0*
Moxy 2EC	2	1-Leaf	May 5	0.0a	4.2a	12.5ab	24.3a	780.3ab	384.0abc	47.3b	1,235.9abc	1,252.6abc
Moxy 2EC	12	2-Leaf	May 13									
GoalTender	4	2-Leaf	May 13									
Moxy 2EC	4	1-Leaf	May 5	0.0a	0.0a	8.3ab	38.1a	767.3abc	464.6abc	70.6ab	1,340.6ab	1,348.9ab
Moxy 2EC	12	2-Leaf	May 13									
GoalTender	4	2-Leaf	May 13									
Moxy 2EC	6	1-Leaf	May 5	3.6a	0.0a	5.9ab	17.8a	790.6ab	477.9abc	79.5ab	1,365.9a	1,375.4a
Moxy 2EC	12	2-Leaf	May 13									
GoalTender	4	2-Leaf	May 13									
GoalTender	1	1-Leaf	May 5	0.0a	0.0a	10.8ab	13.1a	781.2ab	352.4bc	58.0ab	1,204.6bc	1,215.5bc
Moxy 2EC	12	2-Leaf	May 13									
GoalTender	4	2-Leaf	May 13									
GoalTender	2	1-Leaf	May 5	2.6a	0.0a	3.8b	21.8a	740.9abc	412.9abc	53.0ab	1,228.6abc	1,235.0abc
Moxy 2EC	12	2-Leaf	May 13									
GoalTender	4	2-Leaf	May 13									
GoalTender	4	1-Leaf	May 5	0.0a	0.0a	7.8ab	10.1a	668.7c	531.2a	111.6a	1,321.5ab	1,329.3ab
Moxy 2EC	12	2-Leaf	May 13									
GoalTender	4	2-Leaf	May 13									
Moxy 2EC	2	1-Leaf	May 5	0.0a	0.0a	4.4ab	22.1a	706.7bc	488.2ab	79.8ab	1,296.8abc	1,301.2abc
GoalTender	1	1-Leaf	May 13									
Moxy 2EC	12	2-Leaf	May 13									
GoalTender	4	2-Leaf	May 13									
Moxy 2EC	4	1-Leaf	May 5	2.0a	3.4a	8.3ab	12.6a	811.7a	419.5abc	62.8ab	1,306.6ab	1,320.3ab
GoalTender	1	1-Leaf	May 5									
Moxy 2EC	12	2-Leaf	May 13									
GoalTender	4	2-Leaf	May 13									
Prowl H2O	32	LPRE	May 5	0.0a	0.0a	13.2a	28.5a	748.3abc	331.9c	37.8b	1,146.5c	1,159.7c
Moxy 2EC	12	2-Leaf	May 13									
GoalTender	4	2-Leaf	May 13									
LSD (P=0.05)				NS	NS	8.9	NS	103.0	150.8	60.7	152.1	145.9

¹All treatments (except the untreated control) received a late-pre-emergence application of Roundup 22 fl oz/acre = glyphosate 0.75 lb ae/acre + Prowl H₂O 32 fl oz/acre = pendimethalin 0.95 lb ai/acre. Moxy 2EC 2 fl oz/acre = bromoxynil 0.0313 lb ai/acre GoalTender 1 fl oz/acre = oxyfluorfen 0.0313 lb ai/acre. *The untreated control was not included in statistical analysis.

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

Table 4. Single and multiple center bulb rating in response to application of bromoxynil (Moxy 2EC) at various rates and onion growth stages to manage weeds in onion variety Vaquero at the Malheur Experiment Station, Oregon State University, Ontario, OR 2021.

Treatment ¹	Growth Application			Multiple Centers ^{2,3}			Single Center ^{2,3}	
	Rate	stage	Date	Large	Medium	Small	Bullet	Functional ⁴
Untreated				---	---	---	---	---
Moxy 2EC	2	1-Leaf	May 5	2.7a	18.7ab	13.3a	65.3ab	78.7a
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
Moxy 2EC	4	1-Leaf	May 5	5.3a	12.0b	14.7a	68.0a	82.7a
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
Moxy 2EC	6	1-Leaf	May 5	5.3a	16.0ab	16.0a	62.7abc	78.7a
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
GoalTender	1	1-Leaf	May 5	5.3a	21.3ab	18.7a	54.7abc	73.3ab
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
GoalTender	2	1-Leaf	May 5	2.7a	18.7ab	17.3a	61.3abc	78.7a
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
GoalTender	4	1-Leaf	May 5	8.0a	20.0ab	14.7a	57.3abc	72.0ab
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
Moxy 2EC	2	1-Leaf	May 5	5.3a	21.3ab	24.0a	49.3bc	73.3ab
GoalTender	1	1-Leaf	May 13					
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
Moxy 2EC	4	1-Leaf	May 5	8.0a	26.7a	18.7a	46.7c	65.3b
GoalTender	1	1-Leaf	May 5					
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
Prowl H2O (Grower std)	32	LPRE	May 5	6.7a	18.7ab	13.3a	61.3abc	74.7ab
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
LSD (P=0.05)				7.4	13.4	13.7	17.5	10.9

¹All treatments (except the untreated control) received a late-pre-emergence application of Roundup 22 fl oz/acre = glyphosate 0.75 lb ae/acre plus Prowl H₂O 32 fl oz/acre = pendimethalin 0.95 lb ai/acre; Moxy 2EC 2 fl oz/acre = bromoxynil 0.0313 lb ai/acre GoalTender 1 fl oz/acre = oxyfluorfen 0.0313 lb ai/acre. The untreated control was not included in statistical analysis.

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.