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

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Introduction

Onion growers experience challenges to manage weeds before the 2-leaf stage. The current label for 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 2-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 lower 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 2022 at the Malheur Experiment Station to evaluate the response of direct-seeded onion variety 'Vaquero' at 1-leaf stage to low rates of Moxy 2EC herbicide (with and without GoalTender) and the level of weed control. 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 and irrigated. Once dry, the field was disked, ripped, plowed, and groundhogged. Based on soil analysis, fertilizer was broadcast applied during fall 2021 at 100 lb N/acre, 180 lb K/acre, 100 lb S/acre, 3 lb Zn/acre, 13 lb Mn/acre, and 1 lb B/acre. The field fumigated and beds were formed at 22-inch spacing.

The study area was sprayed with Roundup at 1 quart/acre (1.13 lb ae/acre) on March 7, 2022 to control all emerged weed prior to establishing the study. Beds were harrowed on March 21 and onion variety 'Vaquero' (Nunhems, Parma, ID) was seeded at about 125,000 seeds/acre (3.8 inches between seeds) on March 23, 2022. Onion seeds were planted in double rows spaced 3 inches apart on each 22-inch bed. Drip tape (with emitters spaced 8 inches apart and an emitter flow rate of 0.09 gallons per hour (0.22 gal/min/100 ft, Toro Aqua-Traxx, Toro Co., El Cajon, CA) was laid at 2-inch depth between each pair of beds on March 22. The distance between the tape and the center of each double row of onions was 11 inches. Because of dry soil conditions, the study area was drip irrigated on March 28, 2022 (5 days after seeding) to enable seed germination.

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 CO_2-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) + Prowl H2O at 2 pints/acre (pendimethalin 0.95 lb ai/acre). Untreated and the grower standard comprised of Moxy® 2EC at 12 fl oz/acre (bromoxynil 0.188 lb ai/acre) plus GoalTender at 4 fl oz/acre (oxyfluorfen 0.125 lb/ai acre) when onion plants were at the 2- and 4-leaf stage checks were included.

Delayed pre-emergence herbicide treatment was applied on April 7, 2022. Moxy 2EC herbicide was applied at 2, 4, or 6 fl oz/acre (bromoxynil 0.0313, 0.0625, or 0.094 lb ai/acre) to onion seedlings at the 1-leaf stage on May 12, 2022. Other treatments included standalone GoalTender 1 fl oz/acre, tank-mixture of Moxy 2EC + GoalTender, Moxy 2EC + Nortron at 4 or 8 fl oz/acre. The complete list of treatments including application rates and timing are presented in Tables 1-3 in this report. On May 11, 2022, 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 5, June 21, and July 12, 2022, to supply 50 lb N/acre on each incident.

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

- June 3, 2022 — M-Pede 5.6 pt/acre + Aza-Direct 20 fl oz/acre (azadirachtin 0.0155 lb ai/acre) + BB5 NC 0.1% v/v (2.8 fl oz/100 gal)
- June 10, 2022 - Aza-Direct 20 fl oz/acre (azadirachtin 0.0155 lb ai/acre) + Movento 2.5 fl oz/acre (spirotetramat 0.039 lb ai/acre) + Dyne-Amic 0.25 v/v + 0.25 v/v + BB5 NC 4.25 fl oz/acre.
- June 17, 2022 - Movento 2.5 fl oz/acre (spirotetramat 0.039 lb ai/acre) + Aza-Direct 20 fl oz/acre (azadirachtin 0.0155 lb ai/acre) + Dyne-Amic 0.25 v/v + BB5 NC 4.25/100 gal.
- June 24, 2022 — Agri-Mek 3.5 fl oz/acre (abamectin 0.0191 lb ai/acre) + Persist Ultra 0.25% v/v (methyl esters of canola oil 85% + alkyl phenol ethoxylate 12%) + BB5 NC 4.25 fl oz/acre.
- July 1, 2022 — Agri-Mek 3.5 fl oz/acre (abamectin 0.0191 lb ai/acre) + Persist Ultra 0.25% v/v (methyl esters of canola oil 85% + alkyl phenol ethoxylate 12%) + BB5 NC 4.25 fl oz/acre.
- July 12, 2022 — Radiant 20 fl oz/acre + Persist Ultra 0.25% v/v (methyl esters of canola oil 85% + alkyl phenol ethoxylate 12%) + BB5 NC 1 fl oz/100 gal.
- July 19, 2022 — Radiant 20 fl oz/acre + Persist Ultra 0.25% v/v (methyl esters of canola oil 85% + alkyl phenol ethoxylate 12%) + BB5 NC 1 fl oz/100 gal.
- July 28, 2022 – Exirel 20 fl oz/acre (cyantraniliprole 0.13 lb ai/acre) + Persist Ultra 0.25% v/v (methyl esters of canola oil 85% + alkyl phenol ethoxylate 12%) + BB5 NC 4.25 fl oz/acre.
- August 2, 2022 – Exirel 20 fl oz/acre (cyantraniliprole 0.13 lb ai/acre) + Persist Ultra 0.25% v/v (methyl esters of canola oil 85% + alkyl phenol ethoxylate 12%) + BB5 NC 4.25 fl oz/acre.

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 herbicide treatments was assessed on May 19 and May 31, 2022 (Table 1). Plots were hand-weeded (except for untreated plots) on July 22, 2022, and grown to maturity to determine yield.

The field was drip irrigated from March 28 to August 22, 2022. Plant tops were flailed on August 30, and onion bulbs were lifted on September 6, 2022. Because of poor plant stand in this study, bulbs were hand harvested from 20 ft lengths of one bed in each plot on September 12, 2022, 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 October 3, 2022. 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 lower Treasure Valley was characterized by mild winter 2021 followed by warm and dry conditions during onion planting time in spring 2022. Therefore, the study area was irrigated within 5 days of seeding (March 28, 2022). Onion emergence was observed on April 19, 2022. Plant count on May 11, 2022, indicated reduced plant population density ranging from 59,850 to 93,060 plants/acre across herbicide treatments (Table 1). The stand was below the targeted plant stand of 125,000 plants/acre. The variability in plant stand could be attributed to dry soil conditions at seeding during spring 2022 or other unidentified factor, but not herbicide treatments.

Evaluation on May 19, 2022, (7 days after Moxy 2EC application to onion at the 1-leaf) indicated onion ≤5% visible injury (data not shown) across herbicide treatments. Onion injury on May 31, 2022, (19 days after 1-leaf application and 8 days after 2-leaf application timings) was <10% across herbicide treatments (data not shown). Warmer weather during spring 2022 may have aided in buildup of substantial leaf cuticle waxy layer that prevented injury from herbicides.

Evaluations on May 19 indicated improved control of common lambsquarters and hairy nightshade across herbicide treatments (Table 1). Control for common lambsquarters and hairy nightshade was ≥99%. Subsequent evaluation on May 31, 2022 indicated complete control for common lambsquarters and hairy nightshade for Moxy 2EC or GoalTender or Moxy 2EC + Nortron herbicides, which was similar to the grower standard which received Moxy 2EC + GoalTender starting when onions were at the 2-leaf stage (Table 1).

Onion yield reflected the level of plant stand (Table 2). The marketable yield, which is composed of medium, jumbo, colossal, and super colossal grades was generally higher for treatments that received low rates of Moxy 2EC or GoalTender or Moxy 2EC + GoalTender or Moxy2EC + Nortron starting when onions were at the 1-leaf stage (903.3 to 1,095.6 cwt/acre) comparable to the grower standard herbicide practice (901.5 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) ranged from 95 to 98% for plants that received reduced rates of Moxy 2EC or GoalTender or Moxy 2EC + GoalTender treatments, 87% to 97% for Moxy 2EC + Nortron at 1-leaf stage, compared to 97% for the grower standard (Table 3). It is not clear why the percentage of bulbs with single centers was reduced for the tank-mixture of Moxy 2EC at 2 fl oz/acre + Nortron at 4 fl oz/acre and not for the Mixture that included Nortron at 8 fl oz/acre.

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 the prevailing warm spring weather conditions 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 2023.

Acknowledgements

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Table 1. Onion plant stand and 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 2022.

					Percent weed control[2]			
				5/11/2022	5/19/2022		5/31/2022	
Treatment[1]	Rate fl oz/acre	Growth stage	Application date	Plant population	Common lambsquarters	Hairy nightshade	Common lambsquarters	Hairy nightshade
Untreated								
Moxy 2EC	2	1-Leaf	May 5	72,820 ab	99 b	99 a	100 a	100 a
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
Moxy 2EC	4	1-Leaf	May 5	92,840 a	99 a	98 a	100 a	100 a
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
Moxy 2EC	6	1-Leaf	May 5	87,670 a	99 a	99 a	100 a	100 a
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
GoalTender	1	1-Leaf	May 5	93,060 a	99 a	99 a	100 a	100 a
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
GoalTender	2	1-Leaf	May 5	81,730 ab	99 a	99 a	100 a	100 a
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
GoalTender	4	1-Leaf	May 5	80,630 ab	99 a	99 a	100 a	100 a
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
Moxy 2EC	2	1-Leaf	May 5	89,100 a	99 a	99 a	100 a	100 a
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	72,600 ab	99 a	99 a	100 a	100 a
GoalTender	1	1-Leaf	May 5					
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
Moxy 2EC	2	1-Leaf	May 13	76,670 ab	99 a	98 a	100 a	100 a
Nortron	4	1-Leaf	May 13					
Moxy 2EC	2	1-Leaf	May 13	59,840 b	99 a	99 a	100 a	100 a
Nortron	8	1-Leaf	May 13					
Prowl H2O	32	LPRE	LPRE	82,500 ab	99 a	99 a	99 a	99 a
Moxy 2EC	12	2-Leaf	May 13					
GoalTender	4	2-Leaf	May 13					
LSD (P = 0.05)				27,819	NS	NS	NS	NS

[1]All treatments (except the untreated control) received a delayed-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.

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

Table 2. Onion yield (cwt/acre) in response to application of bromoxynil (Moxy 2EC) and/or Goal tender (oxyfluorfen) and/or Nortron (ethofumesate) at various rates and onion growth stages to manage weeds in onion variety 'Vaquero' at the Malheur Experiment Station, Oregon State University, Ontario, OR 2022.

							Marketable yield by grade[2]					
Treatment[1]	Rate	Growth stage	Application date	Rot	US No. 2	Small	2¼-3 in	3-4 in	4-4¼ in	>4¼ in	Total	Total Yield
	fl oz/acre				cwt/acre							
Untreated				0.0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -
Moxy 2EC	2	1-Leaf	May 12	0.0 a	0.0 b	2.8 b	42.2 ab	464.9 a	331.4 abc	175.9 a	1,014.4 ab	1,017.2 ab
Moxy 2EC	12	2-Leaf	May 23									
GoalTender	4	2-Leaf	May 23									
Moxy 2EC	4	1-Leaf	May 12	3.7 a	2.7 ab	5.5 b	92.1 a	440.8 a	245.3 cd	167.8 a	946.0 ab	957.9 ab
Moxy 2EC	12	2-Leaf	May 23									
GoalTender	4	2-Leaf	May 23									
Moxy 2EC	6	1-Leaf	May 12	2.7 a	3.1 ab	5.3 b	45.0 ab	575.3 a	281.5 a-d	109.2 a	1,011.0 ab	1,022.1 ab
Moxy 2EC	12	2-Leaf	May 23									
GoalTender	4	2-Leaf	May 23									
GoalTender	1	1-Leaf	May 12	4.1 a	0.0 b	11.6 ab	52.1 ab	572.3 a	286.4 a-d	93.3 a	1,004.1 ab	1,019.8 ab
Moxy 2EC	12	2-Leaf	May 23									
GoalTender	4	2-Leaf	May 23									
GoalTender	2	1-Leaf	May 12	0.0 a	10.6 a	6.4 ab	53.5 ab	540.9 a	201.9 d	130.2 a	926.6 ab	943.6 ab
Moxy 2EC	12	2-Leaf	May 23									
GoalTender	4	2-Leaf	May 23									
GoalTender	4	1-Leaf	May 12	0.0 a	0.0 b	5.7 b	30.2 b	462.3 a	385.5 a	217.6 a	1,095.6 a	1,101.3 a
Moxy 2EC	12	2-Leaf	May 23									
GoalTender	4	2-Leaf	May 23									
Moxy 2EC	2	1-Leaf	May 12	0.0 a	0.0 b	6.3 ab	69.6 ab	416.5 a	311.5 a-d	105.4 a	903.0 b	909.3 b
GoalTender	1	1-Leaf	May 12									
Moxy 2EC	12	2-Leaf	May 23									
GoalTender	4	2-Leaf	May 23									
Moxy 2EC	4	1-Leaf	May 12	0.0 a	0.0 b	5.8 b	47.8 ab	458.0 a	283.4 a-d	135.7 a	924.9 ab	930.7 ab
GoalTender	1	1-Leaf	May 12									
Moxy 2EC	12	2-Leaf	May 23									
GoalTender	4	2-Leaf	May 23									
Moxy 2EC	2	1-Leaf	May 12	9.0 a	0.0 b	3.4 b	35.8 b	401.0 a	365.3 ab	191.8 a	993.9 ab	1,006.3 ab
Nortron	4	1-Leaf	May 12									
Moxy 2EC	2	1-Leaf	May 12	6.1 a	0.0 b	23.5 a	27.2 b	483.4 a	317.8 abc	166.5 a	994.9 ab	1,024.4 ab
Nortron	8	1-Leaf	May 12									
Prowl H2O	32	LPRE	April 7	0.0 a	0.0 b	8.3 ab	43.1 ab	475.0 a	272.9 bcd	110.2 a	901.2 b	909.5 b
Moxy 2EC	12	2-Leaf	May 23									
GoalTender	4	2-Leaf	May 23									
LSD (P=0.05)				NS	10.1	17.5	55.2	NS	109.8	NS	183.5	176.7

[1]All 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. All treatments (except untreated) were sprayed with Moxy 2EC 12 fl oz/acre + GoalTender 4 fl oz/acre at 4-6 leaf stage.

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.

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

Table 3. 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 2022.

				Multiple centers[2,3]			Single center[2,3]	
Treatment[1]	Rate	Growth stage	Application date	Large	Medium	Small	Bullet	Functional[4]
Untreated	fl oz/acre			---	---	---	---	---
Moxy 2EC	2	1-Leaf	May 12	2.0 ab	3.0 a	21.0 a	74.0 b	95.0 ab
Moxy 2EC	12	2-Leaf	May 23					
GoalTender	4	2-Leaf	May 23					
Moxy 2EC	4	1-Leaf	May 12	0.0 b	5.0 a	14.0 ab	81.0 ab	95.0 ab
Moxy 2EC	12	2-Leaf	May 23					
GoalTender	4	2-Leaf	May 23					
Moxy 2EC	6	1-Leaf	May 12	0.0 b	4.0 a	17.0 ab	79.0 ab	96.0 ab
Moxy 2EC	12	2-Leaf	May 23					
GoalTender	4	2-Leaf	May 23					
GoalTender	1	1-Leaf	May 12	4.0 ab	1.0 a	20.0 ab	75.0 b	95.0 ab
Moxy 2EC	12	2-Leaf	May 23					
GoalTender	4	2-Leaf	May 23					
GoalTender	2	1-Leaf	May 12	0.0 b	5.0 a	14.0 ab	81.0 ab	95.0 ab
Moxy 2EC	12	2-Leaf	May 23					
GoalTender	4	2-Leaf	May 23					
GoalTender	4	1-Leaf	May 12	0.0 b	4.0 a	19.0 ab	77.0 ab	96.0 ab
Moxy 2EC	12	2-Leaf	May 23					
GoalTender	4	2-Leaf	May 23					
Moxy 2EC	2	1-Leaf	May 12	1.0 b	1.0 a	9.0 b	89.0 a	98.0 a
GoalTender	1	1-Leaf	May 12					
Moxy 2EC	12	2-Leaf	May 23					
GoalTender	4	2-Leaf	May 23					
Moxy 2EC	4	1-Leaf	May 12	1.0 b	6.0 a	15.0 ab	78.0 ab	93.0 ab
GoalTender	1	1-Leaf	May 12					
Moxy 2EC	12	2-Leaf	May 23					
GoalTender	4	2-Leaf	May 23					
Moxy 2EC	2	1-Leaf	May 12	8.9 a	3.6 a	13.3 ab	74.3 b	87.6 b
Nortron	4	1-Leaf	May 12					
Moxy 2EC	2	1-Leaf	May 12	1.0 b	2.0 a	14.0 ab	83.0 ab	97.0 a
Nortron	8	1-Leaf	May 12					
Prowl H2O (Grower std)	32	LPRE	May 12	0.0 b	3.0 a	15.0 ab	82.0 ab	97.0 a
Moxy 2EC	12	2-Leaf	May 23					
GoalTender	4	2-Leaf	May 23					
LSD (P=0.05)				7.3	NS	11.9	13.1	8.6

[1]All 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.

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

[3]Multiple-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.