

2024 Report

Use of PRE- and POST-emergent Herbicide Admixtures to Optimizing Long-lasting Weed Control in Pear Orchards

Clebson Gonçalves¹ and Brad Hanson²

¹University of California Cooperative Extension, Lake and Mendocino Counties

²Professor of Cooperative Extension, Department of Plant Sciences, UC Davis

ABSTRACT

There is a growing demand for a broad-spectrum herbicide alternative to glyphosate and an adequate tank mixture with other PRE-emergent herbicides to improve efficiency and long-lasting weed control in pear orchard floors. To meet the practitioner's demand, the objective of these studies was to examine different PRE- and POST-emergent herbicide programs and application rates in the field to improve weed management on the pear orchard floor. We compared PRE- and POST-emergent herbicide programs for a broad spectrum of weed control. Two field trials were conducted during the 2024 growing seasons from May to September as randomized complete block designs with an existing stand of mixed grasses and broadleaf weeds. Treatments included PRE- and POST-emergent herbicide programs at different rates. In general, Glyphosate (Roundup PowerMAX[®]) or Glufosinate (Rely[®] 280) applied alone and in a tank mixture with indaziflam (Alion[®]), rimsulfuron (Matrix[®]), or pendimethalin (Prowl H2O[®]) within all different rates tested were safe for pear trees with no injury observed. Preliminary results showed that the POST-emergent herbicides Roundup PowerMAX[®] and Rely[®] 280 present similar efficacy for controlling a broad spectrum of weeds. However, due to year-round weed germination, most weeds will recover within four to six weeks after the initial application from only the POST-emergent herbicide application programs, requiring a sequential application to keep the orchard floors free of weeds during the growing season. The results showed that Roundup PowerMAX[®] or Rely[®] 280 tank mixture with the PRE-emergent herbicides Alion[®], Matrix[®], or Prowl H2O[®] improved efficiency and long-lasting weed control when compared to Roundup PowerMAX[®] or Rely[®] 280 applied alone. The preliminary results of this study strongly suggest that PRE- and POST-emergent herbicide programs may improve long-term weed control and reduce the total number of control operations required. These studies will be repeated in 2025.

INTRODUCTION

Glyphosate [N-(phosphonomethyl)glycine] is a non-selective herbicide registered to control annual and perennial weeds in agricultural, industrial, forestry, rights-of-way, and residential areas by inhibition of the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS). However, poor control of weeds such as ryegrass (*Lolium rigidum*), horseweed (*Conyza canadensis*), and hairy fleabane (*Conyza bonariensis*), with glyphosate application programs have been observed in orchards, vineyards, and noncrop areas (Bo et al. 2021; Moretti, 2016, 2021; Moretti and Hanson, 2017; Shrestha et al. 2008).

Beyond that, in recent years, litigation regarding glyphosate and its implication as a human carcinogen (Berry, 2020) has led to uncertainty in the agrochemical industry. Many distributors have pulled glyphosate products from their product lines. In some cases, communities and facilities are also preventing maintenance personnel from using glyphosate.

Practitioners are seeking broad-spectrum herbicide alternatives to glyphosate and adequate tank mixture with other PRE-emergent herbicides to improve efficiency and long-lasting weed control, but substitutes have scarcely been evaluated due to glyphosate's history of being effective and affordable. Although this doesn't seem imminent, if glyphosate were no longer available, Rely[®] 280 (glufosinate-ammonium) appears to be the most efficient and economical option.

Due to year-round weed problems in pear orchards, POST-only programs are not very economically or environmentally viable; thus, PRE herbicides may help improve weed control and reduce the total number of control operations required. The main objective of this study is to evaluate the advantages and disadvantages of (PRE and POST) herbicide programs in the field with different modes of action to improve weed management in pear orchards. Also, adopting spray programs with PRE-and POST-emergent herbicides may increase the time window between the last herbicide application and the harvest season and reduce the risk of herbicide residue in the crop.

OBJECTIVES:

The objective of these studies was to examine different PRE- and POST-emergent herbicide programs and application rates in the field to improve weed management on the pear orchard floor. We compared PRE- and POST-emergent herbicide programs for a broad spectrum of weed control.

PROCEDURES:

Two field trials were conducted during the 2024 growing seasons from May to September as randomized complete block designs with four replications (one pear orchard in Mendocino County and one pear orchard in Lake County) with an existing stand of mixed grasses and broadleaf weeds. The treatments included an untreated control, as well as glyphosate, and glufosinate applied alone and in a tank mixture with indaziflam, rimsulfuron, or Pendimethalin at two different rates, totaling 15 treatments (Table 1).

The treatments were applied in a water carrier volume of 30 gallons per acre using a CO₂ pressurized backpack sprayer equipped with 11003 VS flat-fan spray nozzles at 19-inch spacing (TeeJet, Spraying Systems Co, Glendale Heights, Illinois, USA). Grass and broadleaf weed control were assessed at 2, 4, 6, 8, 10, and 14 weeks after treatment (WAT) using visual weed control estimations and digital images.

Statistical analysis

Data was tested for normality and homogeneity of variance and subjected to ANOVA in R version 4.4.2 (R Core Team 2024). Appropriate nontransformed means of weed control was separated by Fisher's Protected LSD at $P = .05$. Graphs were plotted with Sigma Plot 11.0 (Systat Software Inc.).

RESULTS AND DISCUSSION

In general, Glyphosate (Roundup PowerMAX[®]) or Glufosinate (Rely[®] 280) applied alone and in a tank mixture with indaziflam (Alion[®]), rimsulfuron (Matrix[®]), or pendimethalin (Prowl H2O[®]) at all different rates were safe for pear trees with no injury observed (data not shown).

Preliminary results showed that Roundup PowerMAX[®] or Rely[®] 280 applied alone and in a tank mixture with Alion[®], Matrix[®], or Prowl H2O[®] at all rates, provided excellent weed control for most weeds present in the orchard at 2 and 4 WAT (Table 2, 3, and 4).

Rely[®] 280 proved to be a broad-spectrum herbicide with equivalent grass and broadleaf weed control similar to Roundup PowerMAX[®] for all dates assessed in this study. However, for both Roundup PowerMAX[®] or Rely[®] 280 applied alone at 6 WAT, jungle rice, field bindweed, and yellow nutsedge began to germinate or regrow as a result of regenerative underground propagules; via roots, rhizomes, or tubers, indicating the need

for sequential application around 5 to 6 weeks after initial application for effective long-term (Table 2, 3, and 4).

Roundup PowerMAX® or Rely® 280 tank mixture with the PRE-emergent herbicides Alion®, Matrix®, or Prowl H2O® improved efficiency and long-lasting weed control when compared to Roundup PowerMAX® or Rely® 280 applied alone (Table 1, 2, and 3).

The results showed that for all PRE-emergent herbicides used in this study, PRE-emergent herbicide-by-rates interaction was nonsignificant ($P > 0.05$) for weed control; thus, data were pooled over (Table 2, 3, and 4).

The PRE-emergent herbicides Alion® and Prowl H2O® provided better long-term control of jungle rice than Matrix®. On the other hand, all PRE-emergent herbicides showed similar control of field bindweed.

The results indicated that the Roundup PowerMAX® or Rely® 280 applied in a tank mixture with Prowl H2O® provides better control of yellow nutsedge compared to Roundup PowerMAX® or Rely® 280 applied alone. However, yellow nutsedge control was inferior for Prowl H2O® tank mix compared to Alion® or Matrix® tank mix.

FINAL CONSIDERATIONS AND FUTURE RESEARCH

Preliminary results showed that the POST-emergent herbicides Roundup PowerMAX® and Rely® 280 present similar efficacy for controlling a broad spectrum of weeds. However, due to year-round weed germination, most weeds will recover within four to six weeks after the initial application from only POST-emergent herbicide application programs, requiring a sequential application to keep the orchard floors free of weeds during the growing season.

The results of this study strongly suggest that PRE- and POST-emergent herbicide programs may improve long-term weed control and reduce the total number of control operations required.

The literature review and the preliminary results of this study strongly suggest that developing more efficient herbicide application programs or alternatives to glyphosate by use of herbicides with different modes of action helps to reduce potentially resistant weeds. Also, adopting spray programs with PRE-and POST-emergent herbicides promotes longer-lasting weed control, reducing the number of herbicide applications,

increasing the time window between the last herbicide application and the harvest season, and reducing the risk of herbicide residue in the crop.

These studies may contribute to growers and PCA developing a more complete integrated weed management program in conventional pear orchard systems and potentially resulting in savings of [\\$ 65 per acre](#) by not adopting pre-harvest strip spray. To reduce costs, growers may also consider using generic herbicides rather than their brand-name counterparts. In many cases, generic herbicides may have the same effectiveness as brand-name counterparts at a lower cost (consult your UCCE Farm Advisor or your PCA).

These studies will be repeated in 2025 to confirm preliminary data assessed in 2024.

ACKNOWLEDGEMENTS

We would like to thank the California Pear Advisory Board for funding the studies. We thank grower cooperators Terry Rosetti (Mendocino County) and Andy Scully (Lake County). We thank Wilfredo Bello (Lake County Agricultural Technician) and Taylor Delbar (Mendocino County Agricultural Technician) for field trial assistance.

REFERENCES

- Bo et al. (2021). Mechanisms of glyphosate-resistant horseweed (*Conyza canadensis*) collected from tangerine orchards in Korea. *Horticulture, Environment, and Biotechnology*, 62, 995-1002.
- Berry, C. (2020). Glyphosate and cancer: the importance of the whole picture. *Pest Management Science*, 76(9), 2874-2877.
- Moretti, M. L., Sosnoskie, L. M., Shrestha, A., Wright, S. D., Hembree, K. J., Jasieniuk, M., & Hanson, B. D. (2016). Distribution of *Conyza* sp. in orchards of California and response to glyphosate and paraquat. *Weed Science*, 64(2), 339-347.
- Moretti, M. L., & Hanson, B. D. (2017). Reduced translocation is involved in resistance to glyphosate and paraquat in *Conyza bonariensis* and *Conyza canadensis* from California. *Weed Research*, 57(1), 25-34.
- Moretti, M. L. (2021). POST control of Italian ryegrass in hazelnut orchards. *Weed Technology*, 35, 638-643.
- Shrestha, A., Hanson, B., & Hembree, K. (2008). Glyphosate-resistant hairy fleabane documented in the Central Valley. *California Agriculture*, 62(3), 116-119.

Tables and Figures

Table 1. Trade names, active ingredients, and applications rates suggested for this study.

No.	*Treatment	Active ingredient	Rate (fl oz/ac)
1	Untreated	-	-
2	Roundup PowerMAX®	Glyphosate	64
3	Rely® 280	Glufosinate	56
4	Roundup PowerMAX® + Alion®	Glyphosate + Indaziflam	64 + 3.5
5	Roundup PowerMAX® + Alion®	Glyphosate + Indaziflam	64 + 4.5
6	Rely® 280 + Alion®	Glufosinate + Indaziflam	56 + 3.5
7	Rely® 280 + Alion®	Glufosinate + Indaziflam	56 + 4.5
8	Roundup PowerMAX® + Matrix®	Glyphosate + Rimsulfuron	64 + 3.0
9	Roundup PowerMAX® + Matrix®	Glyphosate + Rimsulfuron	64 + 4.0
10	Rely® 280 + Matrix®	Glufosinate + Rimsulfuron	56 + 3.0
11	Rely® 280 + Matrix®	Glufosinate + Rimsulfuron	56 + 4.0
12	Roundup PowerMAX® + Prowl H2O®	Glyphosate + Pendimethalin	64 + 70.4
13	Roundup PowerMAX® + Prowl H2O®	Glyphosate + Pendimethalin	64 + 102.4
14	Rely® 280 + Prowl H2O®	Glufosinate + Pendimethalin	56 + 70.4
15	Rely® 280 + Prowl H2O®	Glufosinate + Pendimethalin	56 + 102.4

*Ammonium sulfate (AMS) at 1% and nonionic surfactant was added to all treatments.

Table 2. Jungle rice (*Echinochloa colona*) control following Glyphosate (Roundup PowerMAX®) or Glufosinate (Rely® 280) application alone or admixture with indaziflam (Alion®), rimsulfuron (Matrix®), or pendimethalin (Prowl H2O®) at two different rates (Trials started on May 30, 2024).

TREATMENT Active ingredient	Rate (fl oz/ac)	Jungle rice Control (%)							
		2 WAT	4 WAT	6 WAT	8 WAT	10 WAT	14 WAT		
Roundup PowerMAX®	64	97 ab	86 b	48 b	31 c	11 c	10 d		
Rely® 280	56	94 b	87 b	52 b	25 c	0 d	0 d		
Roundup PowerMAX® + Alion®	64 + 3.5	98 ab	97 a	89 a	84 ab	81 a	68 ab		
Roundup PowerMAX® + Alion®	64 + 4.5	97 ab	98 a	93 a	88 ab	83 a	72 a		
Rely® 280 + Alion®	56 + 3.5	97 ab	97 a	89 a	86 ab	82 a	68 ab		
Rely® 280 + Alion®	56 + 4.5	99 a	96 a	88 a	87 ab	82 a	67 ab		
Roundup PowerMAX® + Matrix®	64 + 3	99 a	98 a	83 a	78 b	70 ab	48 bc		
Roundup PowerMAX® + Matrix®	64 + 4	98 ab	98 a	85 a	81 ab	70 ab	46 bc		
Rely® 280 + Matrix®	56 + 3	98 ab	97 a	84 a	78 b	67 b	46 bc		
Rely® 280 + Matrix®	56 + 4	98 a	96 a	83 a	80 ab	72 ab	41 c		
Roundup PowerMAX® + Prowl H2O®	64 + 70	96 ab	96 a	85 a	87 ab	80 a	60 abc		
Roundup PowerMAX® + Prowl H2O®	64 + 102	98 ab	97 a	92 a	90 a	83 a	66 ab		
Rely® 280 + Prowl H2O®	56 + 70	97 ab	97 a	89 a	85 ab	80 a	58 abc		
Rely® 280 + Prowl H2O®	56 + 102	98 a	97 a	91 a	87 ab	83 a	66 ab		
LSD (P=.05)		2.7	4.2	7	6.4	8.3	15.1		

*Ammonium sulfate (AMS) at 1% and nonionic surfactant was added to all treatments.

Table 3. Field bindweed (*Convolvulus arvensis*) control following Glyphosate (Roundup PowerMAX®) or Glufosinate (Rely® 280) application alone or admixture with indaziflam (Alion®), rimsulfuron (Matrix®), or pendimethalin (Prowl H2O®) at two different rates (Trials started on May 30, 2024).

TREATMENT Active ingredient	Rate (fl oz/ac)	Field bindweed Control (%)											
		2 WAT		4 WAT		6 WAT		8 WAT		10 WAT		14 WAT	
Roundup PowerMAX®	64	93	a	89	ab	63	b	46	b	29	b	14	b
Rely® 280	56	91	a	85	b	61	b	49	b	26	b	10	b
Roundup PowerMAX® + Alion®	64 + 3.5	92	a	91	ab	88	a	86	a	82	a	66	a
Roundup PowerMAX® + Alion®	64 + 4.5	96	a	96	a	93	a	88	a	85	a	74	a
Rely® 280 + Alion®	56 + 3.5	96	a	92	ab	89	a	85	a	80	a	70	a
Rely® 280 + Alion®	56 + 4.5	95	a	92	ab	90	a	86	a	80	a	69	a
Roundup PowerMAX® + Matrix®	64 + 3	97	a	97	a	91	a	87	a	84	a	62	a
Roundup PowerMAX® + Matrix®	64 + 4	96	a	92	ab	88	a	85	a	80	a	61	a
Rely® 280 + Matrix®	56 + 3	95	a	93	ab	85	a	81	a	75	a	56	a
Rely® 280 + Matrix®	56 + 4	96	a	93	a	86	a	81	a	76	a	53	a
Roundup PowerMAX® + Prowl H2O®	64 + 70	91	a	90	ab	87	a	85	a	81	a	69	a
Roundup PowerMAX® + Prowl H2O®	64 + 102	94	a	95	a	91	a	85	a	80	a	64	a
Rely® 280 + Prowl H2O®	56 + 70	93	a	91	ab	83	a	78	a	72	a	52	a
Rely® 280 + Prowl H2O®	56 + 102	96	a	94	a	86	a	82	a	80	a	68	a
LSD (P=.05)		3.4		5.3		6.7		7.1		10.3		15.9	

*Ammonium sulfate (AMS) at 1% and nonionic surfactant was added to all treatments.

Table 4. Yellow nutsedge (*Cyperus esculentus* var. *leptostachyus*) control following Glyphosate (Roundup PowerMAX®) or Glufosinate (Rely® 280) application alone or admixture with indaziflam (Alion®), rimsulfuron (Matrix®), or pendimethalin (Prowl H2O®) at two different rates (Trials started on May 30, 2024).

TREATMENT Active ingredient	Rate (fl oz/ac)	Yellow nutsedge Control (%)											
		2 WAT		4 WAT		6 WAT		8 WAT		10 WAT		14 WAT	
Roundup PowerMAX®	64	88	ab	81	ab	45	cd	30	cd	6	d	0	c
Rely® 280	56	83	ab	78	b	35	d	26	d	6	d	1	c
Roundup PowerMAX® + Alion®	64 + 3.5	85	ab	82	ab	71	ab	63	ab	53	abc	44	ab
Roundup PowerMAX® + Alion®	64 + 4.5	88	ab	86	ab	74	a	71	ab	64	a	51	a
Rely® 280 + Alion®	56 + 3.5	90	ab	86	ab	75	a	70	ab	60	ab	50	a
Rely® 280 + Alion®	56 + 4.5	86	ab	81	ab	63	abc	57	abc	52	abc	33	ab
Roundup PowerMAX® + Matrix®	64 + 3	93	a	88	ab	78	a	69	ab	64	a	50	a
Roundup PowerMAX® + Matrix®	64 + 4	90	ab	89	ab	78	a	75	a	68	a	50	a
Rely® 280 + Matrix®	56 + 3	90	ab	85	ab	77	a	71	ab	65	a	38	ab
Rely® 280 + Matrix®	56 + 4	94	a	93	a	79	a	73	a	66	a	46	ab
Roundup PowerMAX® + Prowl H2O®	64 + 70	80	b	78	b	51	bcd	40	bcd	30	c	18	bc
Roundup PowerMAX® + Prowl H2O®	64 + 102	83	ab	80	ab	66	abc	55	abc	42	abc	31	ab
Rely® 280 + Prowl H2O®	56 + 70	83	ab	80	ab	59	abc	45	a-d	35	bc	27	ab
Rely® 280 + Prowl H2O®	56 + 102	89	ab	86	ab	60	abc	52	a-d	40	abc	31	ab
LSD (P=.05)		7.2		7.7		14.6		19.1		17.6		19.1	

*Ammonium sulfate (AMS) at 1% and nonionic surfactant was added to all treatments.

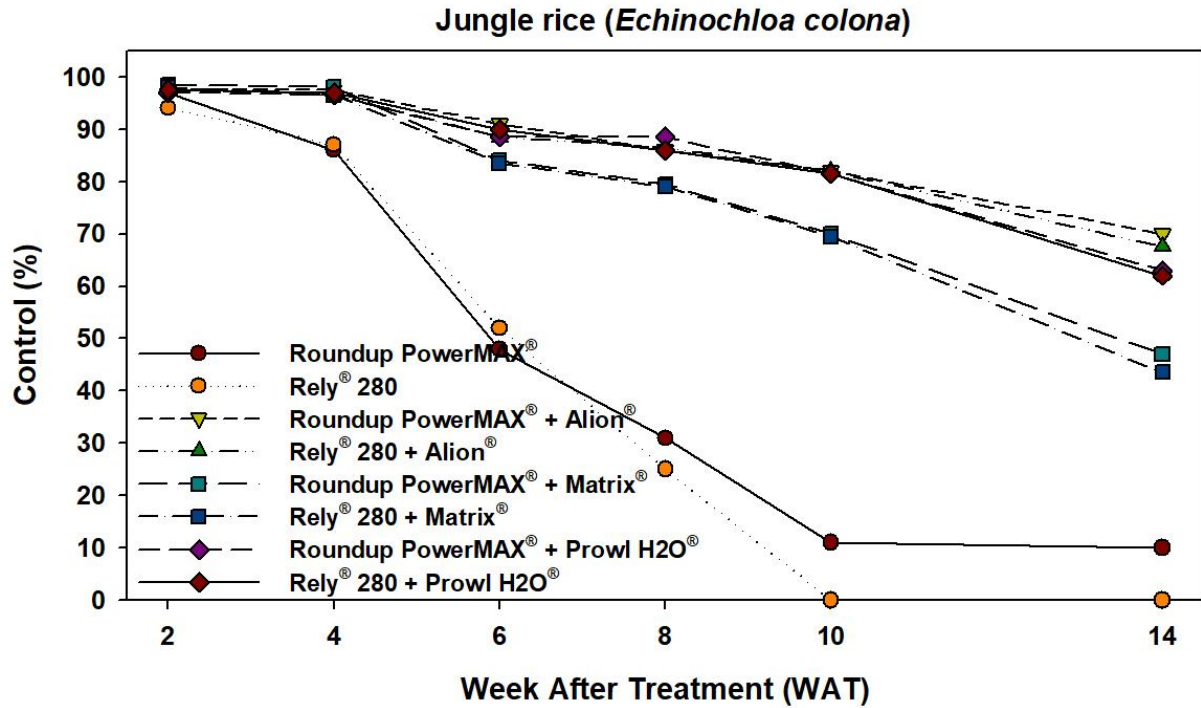


Figure 1. Jungle rice (*Echinochloa colona*) control following glyphosate or glufosinate application alone or admixture with indaziflam (Alion[®]), rimsulfuron (Matrix[®]), or pendimethalin (Prowl H2O[®]), rates data were pooled over.

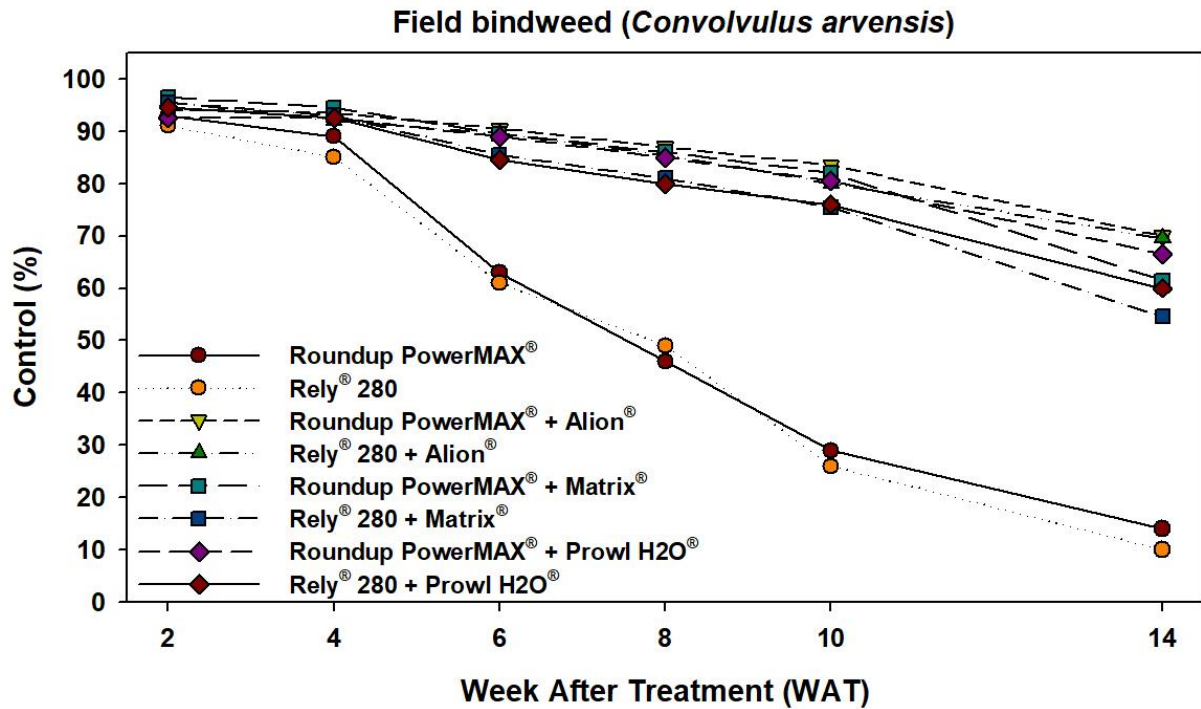


Figure 2. Field bindweed (*Convolvulus arvensis*) control following glyphosate or glufosinate application alone or admixture with indaziflam (Alion[®]), rimsulfuron (Matrix[®]), or pendimethalin (Prowl H2O[®]), rates data were pooled over.

Yellow nutsedge (*Cyperus esculentus* var. *leptostachyus*)

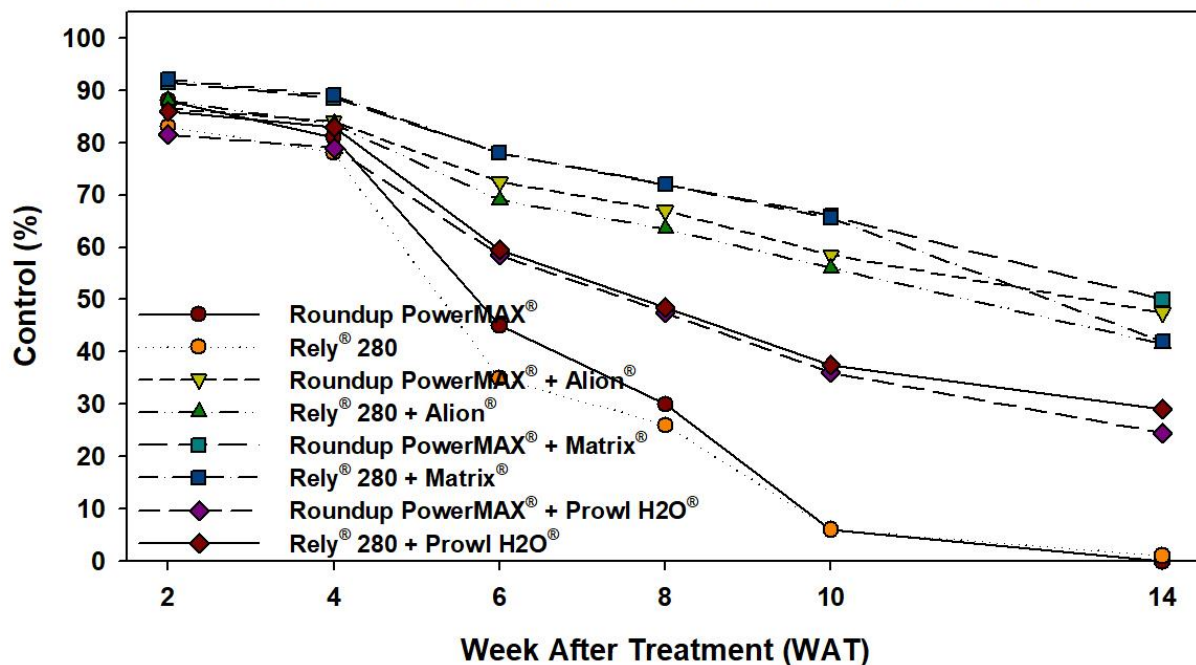


Figure 3. Yellow nutsedge (*Cyperus esculentus* var. *leptostachyus*) control following glyphosate or glufosinate application alone or admixture with indaziflam (Alion®), rimsulfuron (Matrix®), or pendimethalin (Prowl H2O®), rates data were pooled over.