2022 - Ohio Vegetable & Small Fruit Research & Development Program

Herbicides for the Control of Smartweed (Ladysthumb) and Common Purslane in Muck Soils

Final Report

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Overall Objective: To evaluate ladysthumb and purslane response to currently registered herbicides applied at different rates and at different growth stages.

Overview

Ohio vegetable farmers struggle to control ladysthumb (*Polygonum persicaria*), a nonnative smartweed, and common purslane (*Portulaca oleracea*) in crops commonly grown in muck soils. In past smartweed trials (2020-2021) supported by OVSFRDP, we identified a few post-emergence (POST) herbicides for ladysthumb control, but no pre-emergence (PRE) options. With purslane, observations by farmers and our lab over the past few years suggest that purslane populations in Ohio's muck region are becoming harder to control with Roundup (glyphosate), potentially indicating development of resistance, and that alternative herbicides are needed.

In 2022, we conducted 5 trials (4 field and 1 greenhouse) that evaluated: 1. PRE control of ladysthumb and purslane using herbicides registered for muck soils; 2. POST control of ladysthumb and purslane using herbicides registered for muck soils; 3. Field response of ladysthumb and purslane to increasing rates of Roundup and the effect of surfactants on Roundup performance; and 4. Impact of Roundup rate and growth stage on POST control of muck-derived purslane in the greenhouse.

Take Home Messages

- <u>PRE Control of Ladysthumb and Purslane</u>: Too few ladysthumb emerged to differentiate herbicide effectiveness. Sharpen, Fierce and Reflex herbicides provided good (80-90%) PRE control of summer-germinating purslane.

- <u>Ladysthumb POST Control & Response to Roundup Rate</u>: Roundup at the 1X rate (32 fl oz/A) provided good (90%) control of emerged ladysthumb, and the 2X to 4X rates provided excellent (98-99%) control. For Roundup-alternatives, Sharpen, Basagran and Moxy 2E provided excellent (98-100%) POST control for emerged ladysthumb.

- <u>Purslane POST Control & Response to Roundup Rate</u>: The best control for emerged purslane was observed with the Roundup-alternative, Moccasin II Plus + Tricor (95% control), followed by Sharpen, Goaltender and Venue (88-91% control). While Roundup at the 3X and 4X rates provided 85% control, these rates are not realistic. The 1X and 2X rates of Roundup provided only marginal control (66 and 69%, respectively), consistent with past observations that Roundup is not adequately controlling purslane in the muck region of Ohio.

- <u>Impact of Adjuvants on Roundup Performance</u>: The addition of non-ionic surfactant (NIS), crop oil concentrate (COC) or methylated seed oil (MSO) to the 1X rate of Roundup did not appear to impact

its performance on ladysthumb and purslane, suggesting that including Roundup in tank mixes that incorporate adjuvants would not significantly increase or decrease Roundup performance.

- Response of Early- & Later-Stage Purslane to Roundup Rate in the Greenhouse: Purslane growth stage was an important factor in determining purslane survival to Roundup at increasing rates. While all smaller-diameter purslane treated with Roundup (1X to 4X rates) were dead at 4 WAT, only the larger-diameter purslane treated with the 4X rate had 100% mortality. For the larger purslane treated with the 1X to 3X rates, one to two plants in each treatment remained alive 4 WAT.

- Preliminary Conclusions on the Ability of Roundup to Control Purslane in the Muck Region of Ohio: Results from these field trials provided consistent evidence that Roundup is not adequately controlling muck populations of purslane when treated at the 1-3 inch-diameter growth stage. However, the 1-3-inch-diameter purslane grown in the greenhouse were completely controlled by all tested rates of Roundup. Interestingly, the 4-6-inch-diameter purslane were controlled only by the highest (4X) rate, consistent with the rule of thumb that larger plants are harder to kill. So why were we not able to control purslane in the field? While the majority of purslane in plots was 1-to-3-inches in diameter at the time of application, it is possible that larger plants were present. Also, plants in the field often develop a thicker outer leaf surface (cuticle) than those grown in the greenhouse, which may make it more difficult for Roundup to penetrate.

- Future Research: Further field testing that includes different growth stages of purslane along with the 1X to 4X rates of Roundup is recommended to determine if the current lack of adequate purslane control in muck soil is due to plant size or the actual development of glyphosate resistance.

Methods

All field research was located in muck soils at the OSU Muck Crops Agricultural Research Station (Willard, OH) and herbicide applications were made using a backpack CO_2 sprayer with a 4-nozzle boom calibrated to deliver 25 GPA using XR 11003 VS nozzles. Greenhouse research was conducted at the OSU CFAES Wooster Campus (OARDC) (Wooster, OH) and herbicide applications were made in a spray chamber with a 1-nozzle boom calibrated to deliver 20 GPA using a XR 11003 VS nozzle.

M-Obj1: PRE Control Alternatives for Ladysthumb and Purslane (2 Field Trials)

We established two field trials to compare PRE herbicides for control of ladysthumb and purslane. Treatments included Spartan 4F tested in 2021 plus 6 additional herbicides, using the recommended rate of each (Table 1). The ladysthumb PRE trial was conducted earlier in the season and the purslane PRE trial in new plots a month later to separate the workload. The design of each trial was a randomized complete block (RCB) with 4 replications. Plots measuring 20 ft long by 6 ft wide were established on 6-ft wide beds, with two observation quadrats (¼ m^2) per plot (Figure 1).

Ladysthumb Trial: Plots were sprayed on 6/29/22 (treatment was originally planned for June 14, but a June 13 Derecho flooded the plots, delaying the trial), and emergence counts done in quadrats approximately 1, 2, 3, 4 and 6 weeks after treatment (WAT). Plots were irrigated 0.5" immediately after treatment application to activate the herbicides, and on 7/13/22 to stimulate ladysthumb germination.

Purslane Trial: Plots were sprayed on 8/4/22, and percent control evaluated approximately 2 WAT, after which time, plots became overrun with weed growth and the trial ended.

Table 1. Herbicides and rates tested for 2022 ladysthumb and purslane PRE and POST control field trials.

PRE Control Alternatives				POST Control Alternatives			
Trt	**Herbicide**	**AI**	**Rate**	**Trt**	**Herbicide**	**AI**	**Rate**
1	Untreated	.	.	1	Untreated	.	.
2	Spartan 4F	Sulfentrazone	9 fl oz/A	2	Roundup	Glyphosate	32 fl oz/A
3	Sharpen + NIS[1]	Saflufenacil	2.5 fl oz/A	3	Linex 4L + COC[2]	Linuron	1.5 pt/A
4	Fierce	Flumioxazin + Pyroxasulfone	9 fl oz/A	4	Sharpen + MSO[3] + AMS[4]	Saflufenacil	2.5 fl oz/A
5	Reflex	Fomesafen	1.5 pt/A	5	Goaltender	Oxyfluorfen	1 pt/A
6	Sandea	Halosulfuron	2 oz/A	6	Basagran + COC	Bentazon	2 pt/A
7	Pursuit	Imazethapyr	6 fl oz/A	7	Moxy 2E + NIS	Bromoxynil	2 pt/A
8	Stinger	Cloryralid	4 fl oz/A	8	Venue + COC	Pyraflufen	4 fl oz/A
.	.	.	.	9	Aim + NIS	Carfentrazone	2 fl oz/A
.	.	.	.	10	Relfex + NIS	Fomesafen	1.5 pt/A

[1] Non-ionic surfactant (0.25% v/v). [2] Crop oil concentrate (1 gal/100 gal and 2 pt/A). [3] Methylated seed oil (1 gal/100 gal). [4] Ammonium sulfate (3 qt/100 gal).

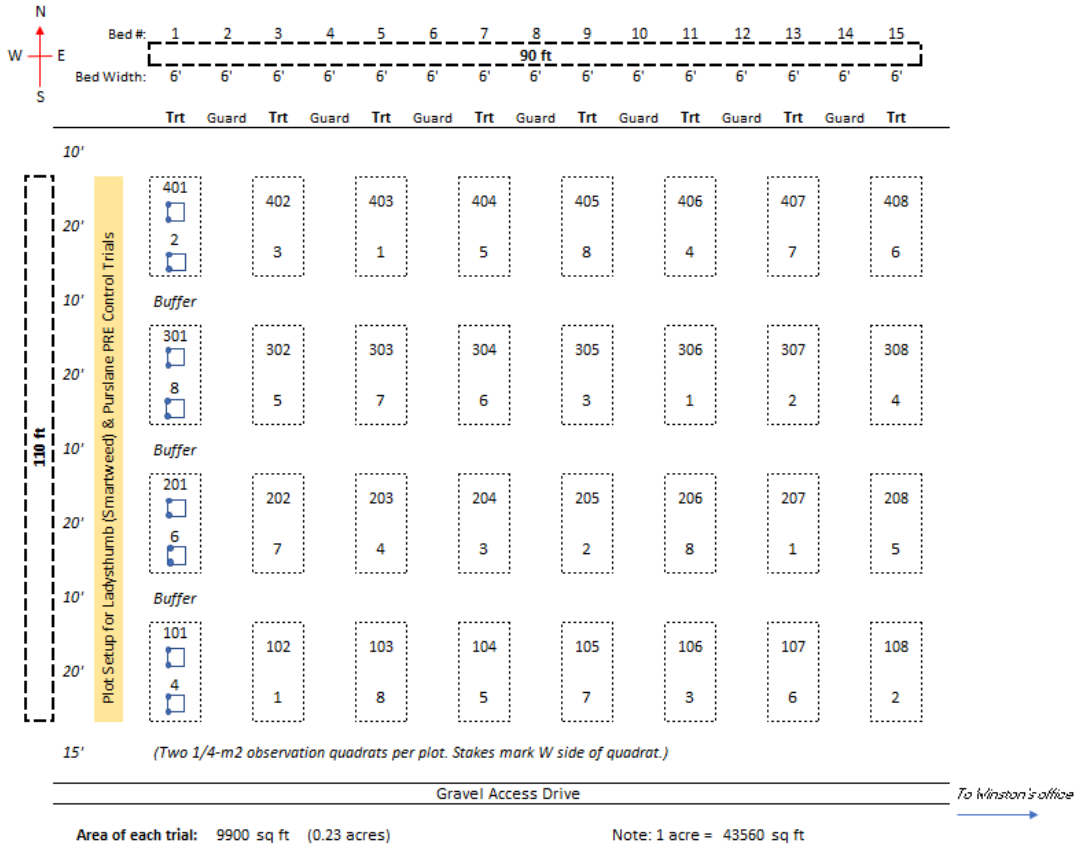

Figure 1. Layout of ladysthumb and purslane PRE control trials (two ¼ m² observation quadrats per plot).

M-Obj2: POST Control Alternatives for Ladysthumb and Purslane (1 Field Trial)

We established a field trial to compare POST herbicides for control of ladysthumb and purslane. The POST treatments included Roundup, 4 products identified as effective in 2021 trials (Moxy 2E, Basagran, Reflex and Sharen), and 4 additional herbicides, using the recommended rate of each (Table 1). The design was a RCB with 4 replications. Plots measuring 20 ft long by 6 ft wide were established on 6-ft wide beds, with two observation quadrats (¼ m²) per plot (Figure 2, orange plots).

Plots were sprayed on 6/19/22 when the majority of ladysthumb plants ranged from 1-7 leaves and 1 to 3 inches tall and the majority of purslane ranged from ½ to 3 inches in diameter and ½ to 2 inches tall. Percent control (0-100% scale, with 0% control for untreated plots) was evaluated at the plot level approximately 1, 2 and 4 WAT. No supplementary irrigation was needed during the trial period.

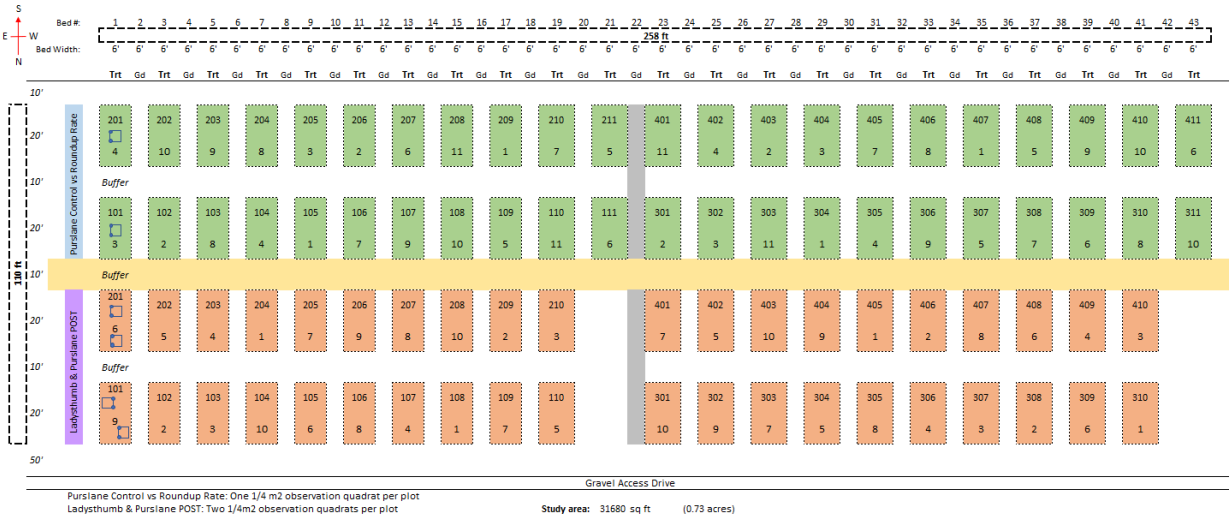

Figure 2. Layout of the ladysthumb and purslane POST control trial (orange plots) (two ¼-m² observation quadrats per plot), and layout of the trial to evaluate ladysthumb and purslane response to increasing Roundup rates (green plots) (one ¼-m² observation quadrat per plot).

M-Obj3: Ladysthumb and Purslane Response to Increasing Roundup Rates and the Effect of Surfactants on Roundup Performance (1 Field Trial)

The trial was conducted to determine the POST response of ladsythumb and purslane to increasing rates of Roundup (1X, 2X, 3X and 4X) and determine the impact of different adjuvants on 1X Roundup effectiveness. The trial included 3 additional herbicides as potential Roundup alternatives, using the recommended rate of each (Table 2). The design was a RCB with 4 replications. Plots measuring 20 ft long by 6 ft wide were established on 6-ft wide beds, with one observation quadrat (¼ m²) per plot (Figure 2, green plots).

Plots were sprayed on 6/19/22 (see POST Control Alternatives for Ladysthumb and Purslane above for plant size at application). Percent control (0-100% scale, with 0% control for untreated plots) was evaluated at the plot level at approximately 1, 2 and 4 WAT. No supplementary irrigation was needed during the trial period.

Table 2. Herbicides and rates tested for the 2022 field trial to evaluate ladysthumb and purslane response to increasing rates of Roundup and the addition of surfactants.

Response to Roundup Rates & Surfactants				
Trt	**Herbicide**	**AI**	**Rate**	
1	Untreated	.	.	.
2	Roundup 1X	Glyphosate	32	fl oz/A
3	Roundup 2X	Glyphosate	64	fl oz/A
4	Roundup 3X	Glyphosate	96	fl oz/A
5	Roundup 4X	Glyphosate	128	fl oz/A
6	Roundup 1X + NIS[1]	Glyphosate	32	fl oz/A
7	Roundup 1X + COC[2]	Glyphosate	32	fl oz/A
8	Roundup 1X + MSO[3]	Glyphosate	32	fl oz/A
9	Basagran + COC	Bentazon	2	pt/A
10	Moxy 2E + NIS	Bromoxynil	2	pt/A
11	Moccasin II Plus + Tricor	S-metolachlor	1.5 + 1	pt/A

[1] Non-ionic surfactant (0.25% v/v). [2] Crop oil concentrate (2 pt/A). [3] Methylated seed oil (1 gal/100 gal).

M-Obj4: Impact of Roundup Rate and Growth Stage on Control of Purslane (1 Greenhouse Trial)

A greenhouse study was conducted to evaluate the dose response of purslane derived from muck soils to Roundup at 1x, 2x, 3x and 4x rates at two different growth stages (early, 1-3 inches diameter; later, 4-6 inches diameter). The design was a RCB with 6-7 replications.

The intent was to complete this research before the 2022 growing season and soil samples were collected in late January 2022 from the Muck Crops Station; however, purslane seeds remained dormant, so no plants could be grown. A second set of soil samples were collected in early fall 2022 and placed in a 40 F cooler for 6 weeks. Soils were sieved and placed in trays in a greenhouse set at 78/70 F for 14/10 hr day/night to encourage purslane germination. At the 2- to 4-leaf stage, purslane seedlings were transplanted into 6"-pots (1 seedling/pot) filled with Pro-Mix soilless medium. When plants reached the designated growth stages, treatments were applied in a spray chamber, and percent injury ratings and plant size (height, length and width) measurements were taken at 1, 2 and 4 WAT. An approximate plant volume (height x length x width) was calculated for each plant at each evaluation.

Data Analysis

Data were analyzed using analysis of variance (ANOVA) (Proc GLM in SAS 9.4). For significant models ($p<0.05$), mean separation was determined using the LSMEANS statement with 'PDIFF' and 'ADJUST=Tukey' options. Data were transformed when necessary to meet model assumptions.

Results & Discussion

R&D-Obj1: PRE Control Alternatives for Ladysthumb and Purslane (Figure 3)

Ladysthumb Trial: Very few ladysthumb plants emerged in plots after treatment (average total number per treatment ranged from 1.5 to 4 seedlings), so differences could not be detected among the PRE herbicides tested (data not shown). Unfortunately, a huge storm flooded the plots the night before the intended application date on June 14.

Purslane Trial: Three of the PRE-applied herbicides, Sharpen, Fierce and Reflex, provided good (80-90%) control of summer-emerging purslane 2 WAT (Figure 3).

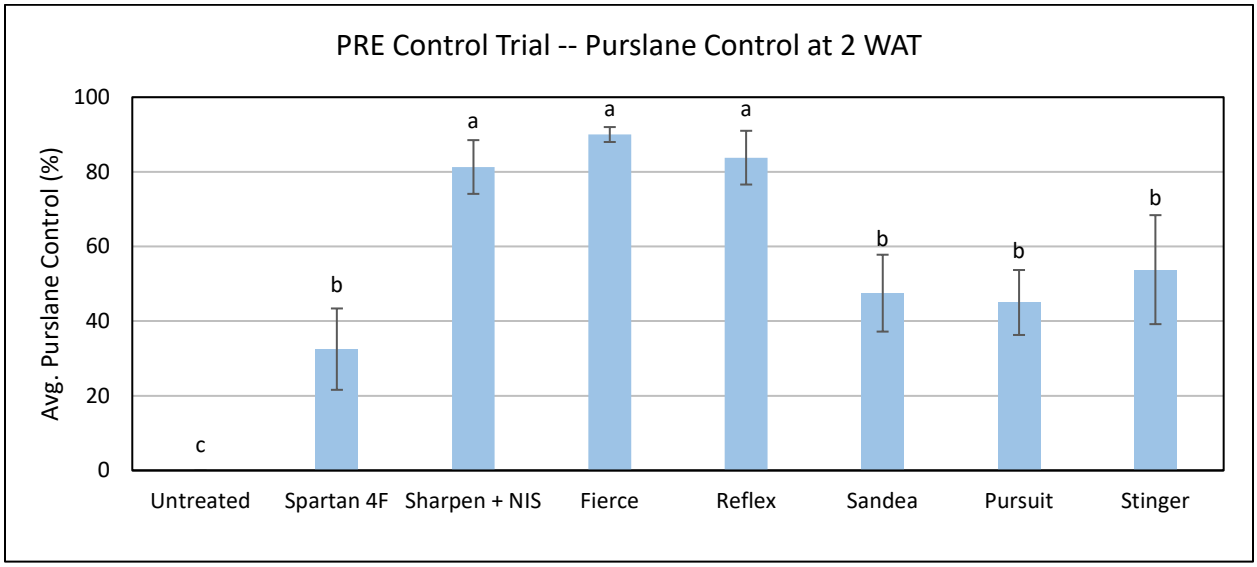

Figure 3. Percent control of purslane at 2 WAT) with PRE applied herbicides. Treatments with the same letter are not significantly different from each other at p<0.05. Error bars represent standard error.

R&D-Obj2: POST Control Alternatives for Ladysthumb and Purslane (Figure 4)

Ladysthumb: Sharpen, Basagran and Moxy 2E provided 98-100% control of emerged ladysthumb plants 4 WAT, followed closely by Roundup at 90% control (Figure 4A).

Purslane: Sharpen, Goaltender, Venue, provided good (91, 91, and 88%, respectively) control of emerged purslane plant 4 WAT (Figure 4B). Roundup (field rate) provided only marginal (63%) purslane control by the final evaluation, supporting past observations that glyphosate is not controlling this weed.

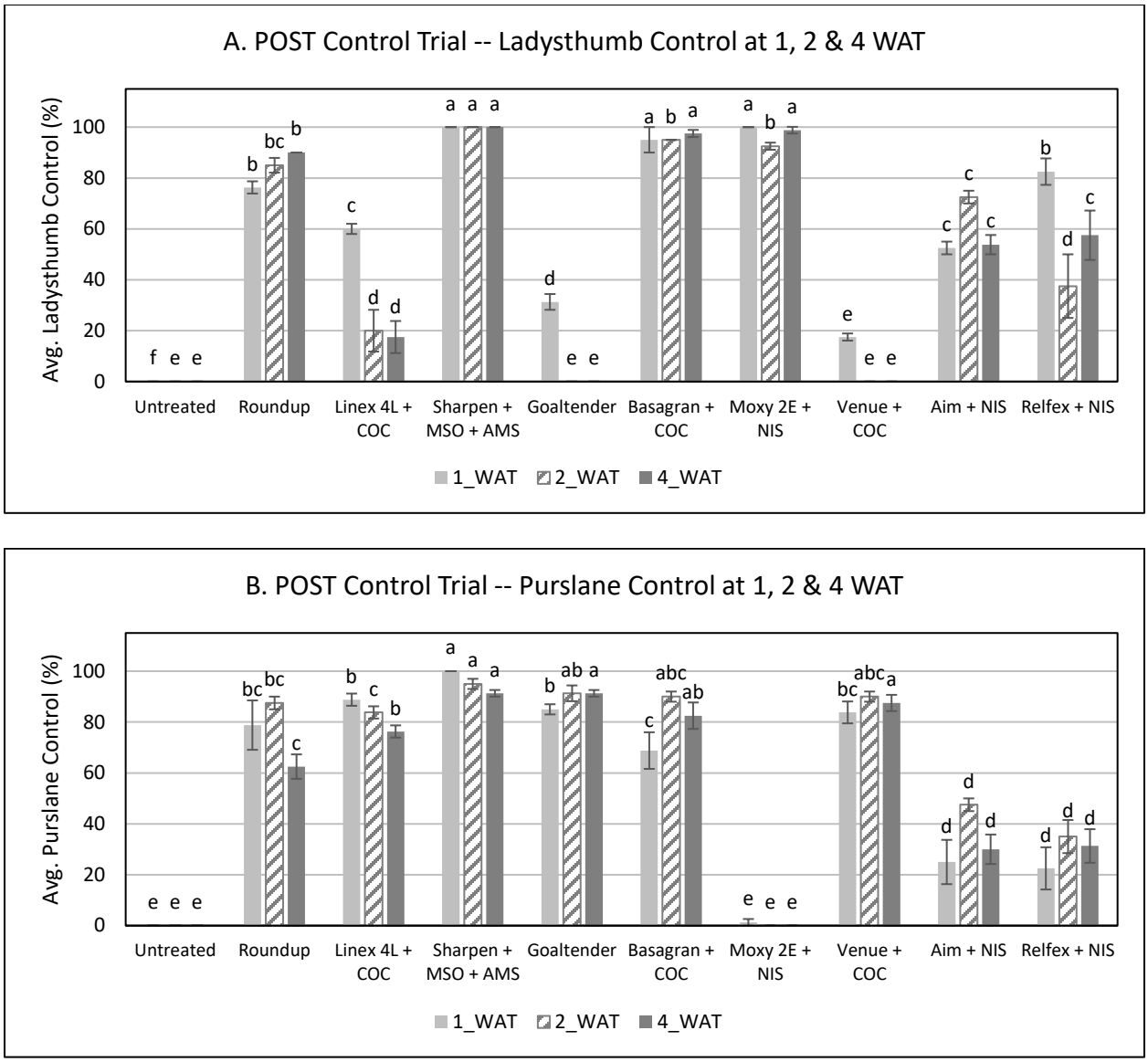

Figure 4. Percent control of (A) ladysthumb and (B) purslane 1, 2 and 4 WAT following field application of POST herbicides. For each evaluation, treatments with the same letter are not significantly different from each other at p<0.05. Error bars represent standard error.

R&D-Obj3: Ladysthumb and Purslane Response to Increasing Roundup Rates and Impact of Surfactants (Figure 5 & 6)

Ladysthumb: At 4 WAT, the 1X (field) rate of Roundup provided good (90%) control of emerged ladysthumb plants, and the 2X, 3X and 4X rates provided excellent (98-99%) control (Figure 5A). The addition of non-ionic surfactant (NIS), crop oil concentrate (COC) or methylated seed oil (MSO) to the 1X rate did not increase or decrease Roundup performance. Of the 3 Roundup-alternative herbicides, Moxy 2E provided excellent (94%) control, similar to the results of the POST Control Trial (R&D-Obj2 above), but Basagran provided less control than in the POST Control Trial (83% compared to 98%).

Purslane: At 4 WAT, the 1X and 2X rates of Roundup provided marginal control (66 and 69%, respectively) of emerged purslane plants (Figure 5B), consistent with that observed for 1X Roundup in the POST Control Trial (R&D-Obj2 above). Purslane control improved to 85% with the 3X and 4X rates of

Roundup, but some purslane plants remained alive and appeared to be recovering 4 WAT (Figure 6). The addition of NIS, COC and MSO to the 1X rate did not have a significant effect on Roundup performance. Of the 3 Roundup-alternatives, only Moccasin II Plus + Tricor provided excellent (95%) control.

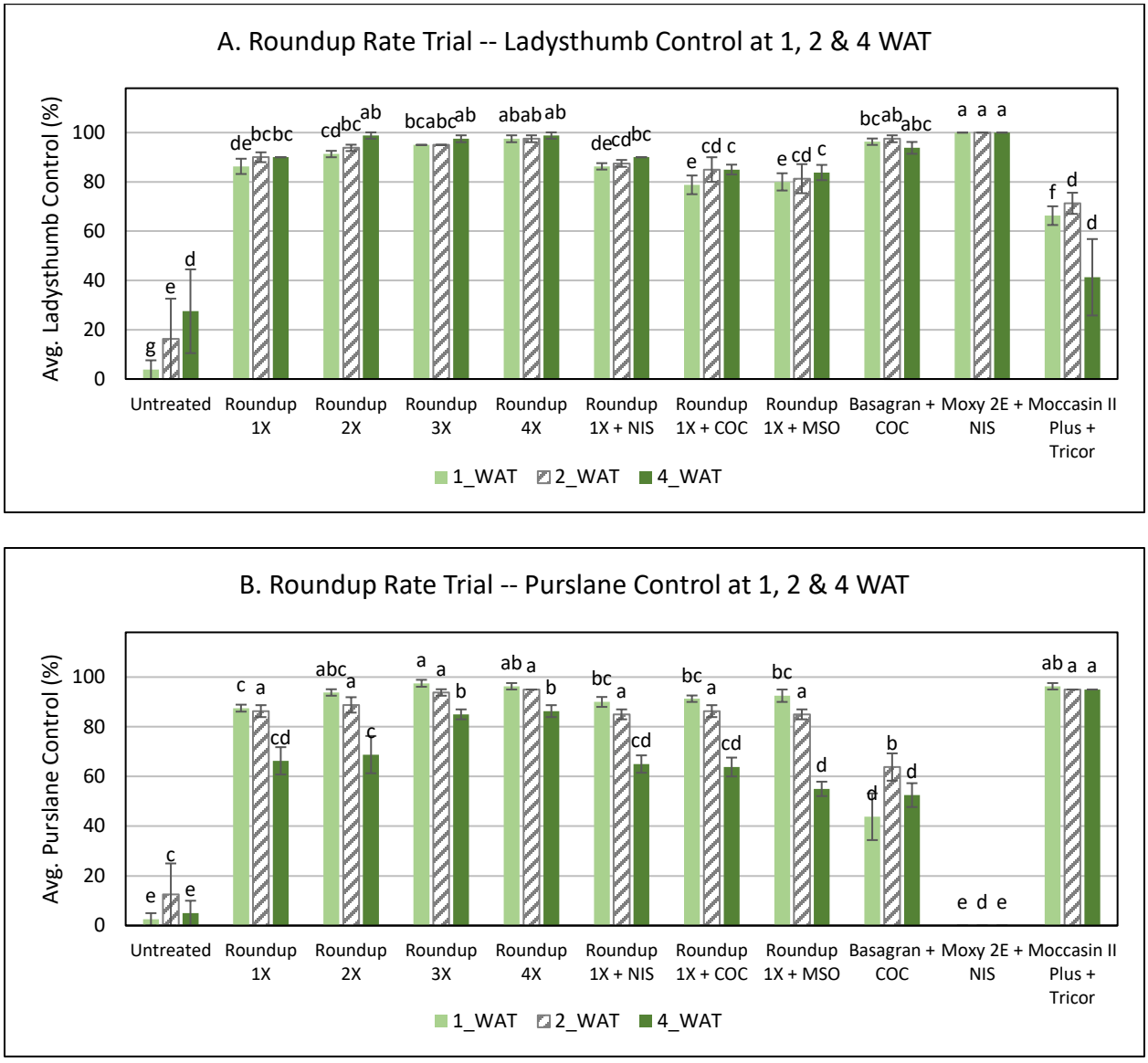

Figure 5. Percent control of (A) ladysthumb and (B) purslane 1, 2 and 4 WAT following field application of increasing rates of Roundup. For each evaluation, treatments with the same letter are not significantly different from each other at p<0.05. Error bars represent standard error.

Figure 6. Purslane plants recovering in plots 4 WAT following a Roundup application at the (A) 3X (plot 402) and (B) 4X (plot 211) rates.

R&D-Obj4: Impact of Roundup Rate and Growth Stage on Control of Greenhouse-Grown Purslane (Figures 7 & 8)

While untreated purslane thrived in the greenhouse over the course of 4 weeks, all early- and later-stage purslane treated with Roundup, regardless of rate, had similarly high plant injury at 4 WAT (Figure 7). However, growth stage did impact plant survival. While injury was 100% (indicating plant death) at 4 WAT for all the smaller-diameter purslane treated with any of the rates of Roundup (Figure 7A & 8A), only the larger-diameter purslane treated with 4X Roundup averaged 100% injury (Figure 7B & 8B). Later-stage plants treated with 1X, 2X and 3X Roundup averaged 78, 93 and 95% injury, respectively, indicating some plant survival. Most of the surviving plants showed signs of new leaf production (Figure 8B). Plant volume of purslane followed a similar pattern to treatments as plant injury (data not shown).

Important Note: While data are not presented here, we included purslane in the greenhouse trial that were derived from soils collected at the OARDC Wooster Horticulture Unit 1, and these plants were as hard or harder to kill with Roundup (compared to the muck-derived purslane). Most of the early-stage Wooster plants survived the 1X rate, along with one plant treated at 2X and one at 4X. However, it is important to note that we have not observed the same issue of purslane persistence in the field following Roundup treatment as we do in the muck region.

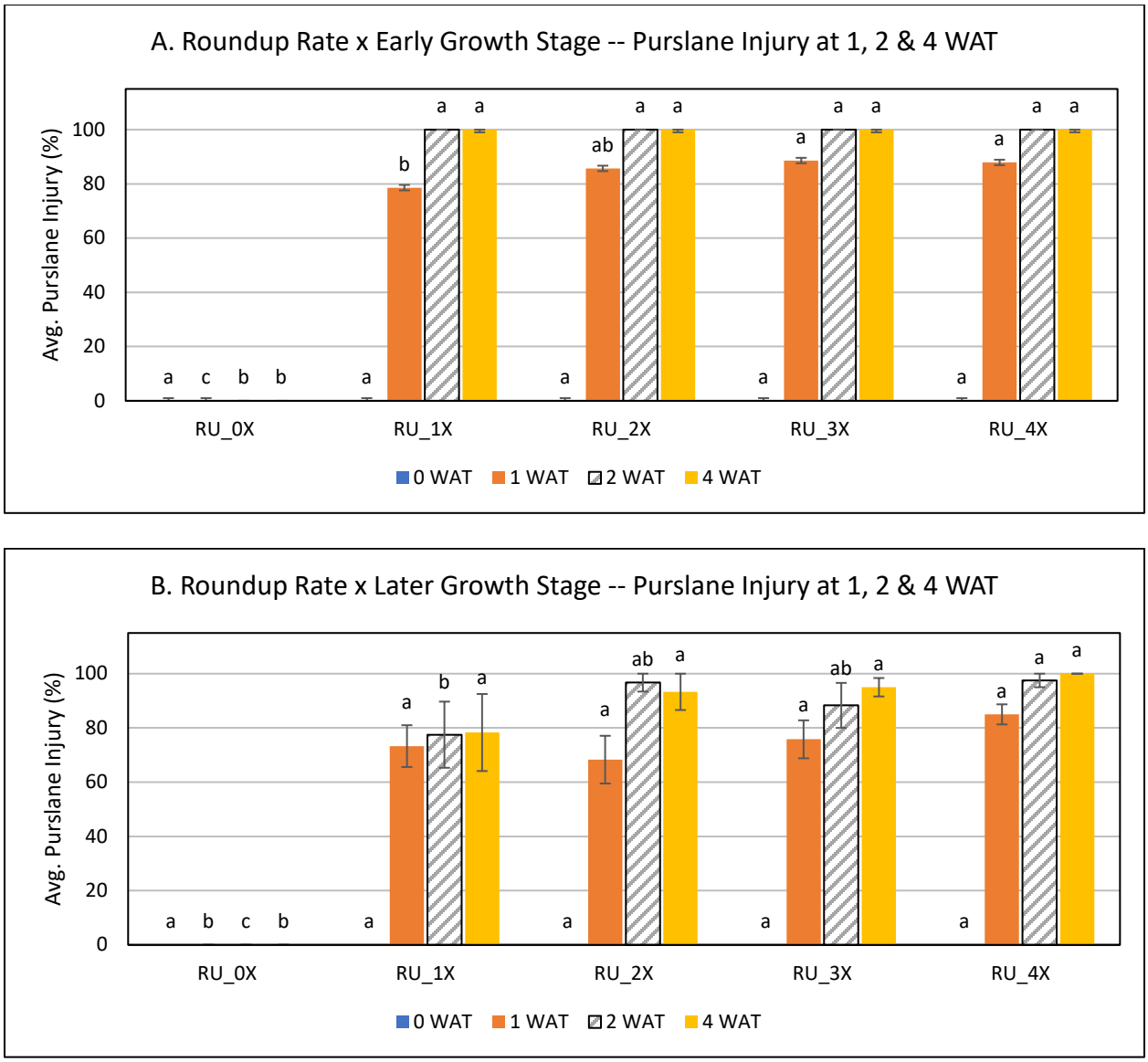

Figure 7. Percent injury of (A) early-stage (1-3-inch diam.) and (B) later-stage (4-6-inch diam.) purslane at 0, 1, 2 and 4 weeks after treatment with increasing Roundup rates. The trial was conducted in the greenhouse. For each plant growth stage and evaluation, treatments with the same letter are not significantly different from each other at $p<0.05$. Error bars represent standard error.

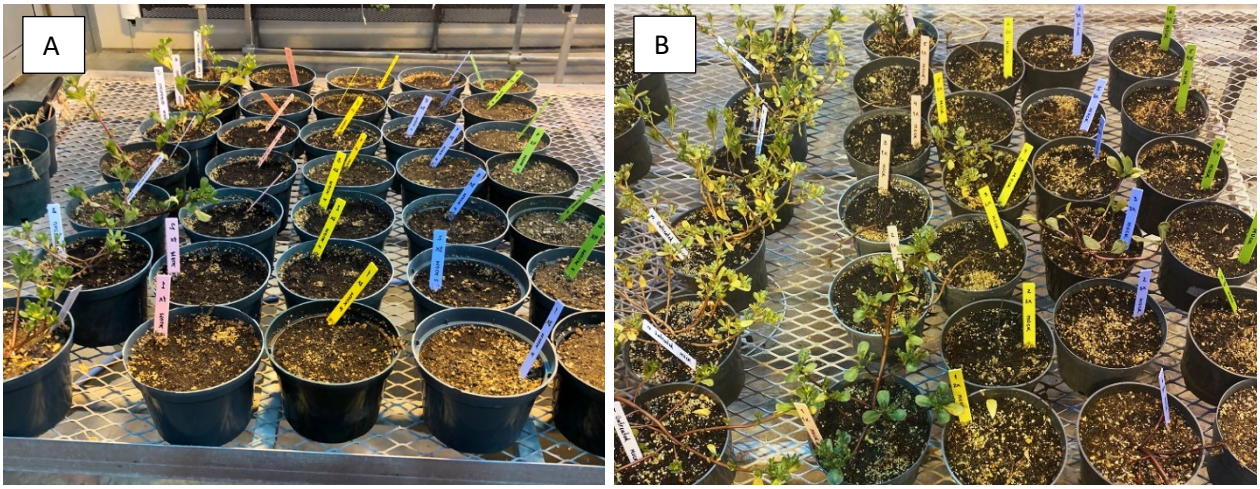

Figure 8. At 4 WAT, (A) early-stage and (B) later-stage purslane (derived from muck soils) used in the Roundup Rate greenhouse trial. For each stage, treatments are arranged in columns by Roundup treatment (left to right: 0X, 1X, 2X, 3X and 4X). Only the early-stage plants in the control group survived. All later-stage plants in the control group survived, along with two plants treated at 1X of Roundup, one plant treated at 2X and two plants treated at 3X.

Acknowledgements

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