Volunteer buckwheat control in irrigated spring wheat

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Buckwheat seed contamination in wheat is a concern for exports to Asia because it is considered an allergen risk in some countries, similar to the allergen risk of peanuts in the United States (NRCS bulletin, NB 190-16-8 ECS). Buckwheat is double-cropped or planted as a cover crop in the Columbia Basin irrigated agricultural region. It is normally planted in early summer following harvest of the previous crop and then harvested later in autumn. Buckwheat seed lost at harvest or plowed under with the cover crop can persist in the soil seedbank and become a weed in spring wheat grown the following year contaminating the harvested grain. We conducted a field trial to evaluate postemergence herbicide applications at two different stages of spring wheat growth on the eventual number of volunteer buckwheat seed contaminating harvested spring wheat grain.

The field site was located in Pasco, WA on land being farmed by WSU Franklin County Extension for agricultural research. During November 2015, a 150-foot^2 area was broadcast seeded with commercial buckwheat seed to simulate buckwheat crop harvest seed rain. The area was then disk-harrowed, irrigated, and seeded to a wheat cover crop. The site was sprayed with glyphosate in early February 2016 to kill the cover crop. On February 25, 2016, a dry granular fertilizer was spread over the plot site and the site was disk-harrowed 4 inches deep to break up the sod and incorporate the fertilizer. Buckwheat seed was re-broadcasted over the plot site and the site was disk-harrowed a second time and packed with a roller pulled behind the harrow. The field was seeded to 'Expresso' hard-red spring wheat at 160 lb/A using a 42-inch wide double disk drill with 6 openers on 6-inch spacing. Soil temperature averaged 40° F in the top 6 inches. Each plot consisted of 3 drill passes wide by 25 feet long; however, only the center drill pass was used for evaluation. The field site was sprinkler irrigated starting in April and received one application of a pyrethroid insecticide in April to control a cereal leaf beetle infestation.

Early postemergence herbicide treatments were applied on April 11 when the majority of the spring wheat had 4-5 leaves and the canopy was 4-9 inches in height. Volunteer buckwheat plants had 3 leaves and were 2-6 inches tall. Buckwheat density was variable and averaged 1-6

plants m^{-2}. The early treatments were broadcast applied with a CO_2 pressurized backpack sprayer and 10-foot spray boom at 3 mph. Application rate was 15 gal/A at 30 psi. Late postemergence herbicide treatments were applied with a tractor-pulled applicator that simulated center-pivot chemigation. The treatments were applied on April 29 when the majority of spring wheat was in the boot stage with a flag leaf showing. Volunteer buckwheat in the cotyledon stage was present in all plots but flowering plants were present only in plots with no early herbicide application. Herbicides were metered into a stream of water on the applicator and into an 11.7-foot spray boom with HH Fulljet nozzles. Volume output was 2700 gal/A at 66 psi moving 1 mph to simulate a 0.1-inch irrigation rate.

Herbicide efficacy was evaluated visually on April 26, two weeks following early treatments, and included buckwheat control and crop herbicide injury and the number of flowering buckwheat plants per plot. These evaluations were repeated on May 11, two weeks following late treatments and four weeks following the early treatment, and repeated again on June 23, one week prior to harvest. Plots were harvested on June 30 with a Kincaid plot combine and the grain was bagged individually from each 3.5 by 25-foot center drill pass per plot. The grain samples were cleaned with a Clipper seed cleaner, evaluated for moisture content with a Foss grain analyzer, and then hand-screened to determine number of buckwheat seeds in each sample. Crop yield was converted to bu/A and reported on a 12% moisture basis.

Both Huskie® and GoldSky® applied as an early postemergence treatment controlled volunteer buckwheat plants that established early with the crop (Table 1). Densities were not different from zero and were less than non-treated plots; however, Huskie was visually more effective than GoldSky at the April 29 evaluation as GoldSky treated plants were slower to show injury with some green stems and leaves remaining. By May 11, two weeks following the chemigation treatments, control of buckwheat was not different from zero with all treatments except Huskie/Brox® 2EC (early/late), None/Brox 2EC, and None/None (Table 1). Furthermore, densities in plots only treated late with Maestro® Advanced or Starane® NXT had near to complete control.

Episodic periods of drought between watering up until the May 11 evaluation reduced buckwheat density in the non-treated check and likely affected density and germination in all plots. Irrigation following May 11 was more frequent and densities of flowering buckwheat plant increased in all plots by the June 23 pre-harvest evaluation (Table 2). The only exception was with None/Brox 2EC. The chemigation application of Brox 2EC initially controlled most of the pre-existing buckwheat but poorly controlled (15%) all other weeds present, including Russian thistle, common lambsquarters, kochia, and tumble mustard. Competition from these weeds likely kept the buckwheat density low (1.1 plants/plot) until harvest. GoldSky/None also gave poor control (31%) of the other weeds, but the early GoldSky application likely controlled some of the other weeds, which opened a window for buckwheat to re-establish by harvest.

At harvest, volunteer buckwheat densities were greatest in plots treated with Huskie/Brox 2EC, Huskie/None, GoldSky/Brox 2EC, GoldSky/None, and None/None (Table 2). The early postemergence treatments by themselves were not able to provide season-long control, and Brox 2EC was not effective in controlling later emerging buckwheat. Late postemergence treatments

by themselves did not completely control the other weeds present, but competition from these weeds may have helped to reduced buckwheat presence up until harvest. Disregarding these late-only treatments, combinations of early applied Huskie or GoldSky with late applications of Maestro Advanced or Starane NXT yielded the fewest flowering plants with Maestro Advanced providing more consistent control than Starane NXT. Fewer flowering buckwheat plants per plot also translated into fewer buckwheat seeds per harvest sample ($r=0.71$; $p\leq0.0001$). Maestro Advanced was most consistent in preventing grain contamination, averaging less than one buckwheat seed per sample in each of the three treatments where it was applied (Table 2). Only the None/Maestro Advanced treatment yielded 0% contamination, but this may have been in part due to competition by the other weeds where no early weed control treatment was applied.

Wheat yields were variable across the plots with averages ranging between 49 and 71 bu/A (Table 2); however, differences between treatments were not significant at $p\leq0.05$. Variability was likely due to periods of drought early in the crop growth cycle, as none of the herbicides caused any visually evident injury symptoms (data not shown).

Table 1. Density of flowering volunteer buckwheat plants, and visually-rated buckwheat control two weeks following early and late postemergence herbicide applications to irrigated spring wheat.[1]

	Herbicide applications per spring wheat stage		Buckwheat two weeks after early treatments[4]		Buckwheat two weeks after late treatments[5]	
Trt	Early[2]	Late[3]	Flowering	Control	Flowering	Control
	(spray)	(Chemigation)	(plants/plot)	(%)	(plants/plot)	(%)
1	Huskie	Brox 2EC	0.3 b	98 a	1.0 c	96 a-c
2	Huskie	Maestro Advanced	0.0 b	98 a	0.0 d	100 a
3	Huskie	Starane NXT	1.0 b	96 a	0.5 d	96 a-c
4	Huskie	None	0.3 b	93 a	0.3 d	95 a-c
5	GoldSky	Brox 2EC	0.8 b	80 b	0.0 d	93 bc
6	GoldSky	Maestro Advanced	1.0 b	81 b	0.0 d	100 a
7	GoldSky	Starane NXT	0.0 b	80 b	0.0 d	96 a-c
8	GoldSky	None	0.0 b	81 b	0.0 d	87 c
9	None	Brox 2EC	12.7 a	0 -	1.5 b	85 c
10	None	Maestro Advanced	9.0 a	0 -	0.0 d	100 ab
11	None	Starane NXT	5.2 a	0 -	0.0 d	100 a
12	None	None	20.7 a	0 -	14.2 a	0 -

[1]Means in each category followed by the same letter are not statistically significant at $p \leq 0.05$.

[2]Early herbicides were broadcast applied April 11 when spring wheat had 4-5 leaves. Huskie was applied at 13.5 oz/A with ammonium sulfate at 1 lb/A. GoldSky was applied at 16 oz/A with a non-ionic surfactant at 0.5% v/v.

[3]Late herbicides were applied through chemigation on April 29 when the spring wheat was at boot stage. Chemigation treatments were Brox 2EC at 32 oz/A, Maestro Advanced at 25.6 oz/A, and Starane NXT applied at 27.4 oz/A. Spray adjuvants were not added to the chemigation treatments.

[4]Early treatments were evaluated April 26, two weeks after applications and consisted of number of flowering buckwheat plants per plot and herbicide injury symptoms.

[5]Early and late treatments were evaluated on May 11, two weeks after chemigation and 4 weeks after early treatments.

Table 2. Harvest measurements of flowering buckwheat plant density, buckwheat seed in the harvest wheat sample, spring wheat yield, and control of weeds other than buckwheat.[1]

Trt	Herbicide applications[2] per spring wheat stage Early	Late	Other Weed Control[3]	Flowering Buckwheat Plants[4]	Buckwheat Seeds[5]	Wheat Yield[6]
	(spray)	(Chemigation)	(%)	(plants/plot)	(seed/plot)	(bu/ac)
1	Huskie	Brox 2EC	93 ab	10.1 bc	51.4 ab	67 a
2	Huskie	Maestro Advanced	100 a	1.7 e-g	0.9 e	66 a
3	Huskie	Starane NXT	78 b	3.2 de	9.1 bc	53 a
4	Huskie	None	80 b	12.5 ab	7.2 b-d	71 a
5	GoldSky	Brox 2EC	77 b	6.2 b-d	6.4 cd	71 a
6	GoldSky	Maestro Advanced	91 ab	2.4 d-f	0.6 e	71 a
7	GoldSky	Starane NXT	91 ab	3.6 c-e	0.2 e	69 a
8	GoldSky	None	31 cd	12.2 b	19.9 a-c	65 a
9	None	Brox 2EC	15 d	1.1 e-g	0.5 e	49 a
10	None	Maestro Advanced	66 bc	0.7 fg	0.0 e	55 a
11	None	Starane NXT	67 bc	0.2 g	1.3 de	54 a
12	None	None	0 -	30.3 a	70.5 a	60 a

[1]Means in each category followed by the same letter are not statistically significant at $p \leq 0.05$.
[2]See Table 1 for application rates.
[3]Herbicide efficacy in controlling weeds other than volunteer buckwheat was visually assessed June 23 and included Russian thistle, common lambsquarters, kochia, and tumble mustard.
[4]Flowering buckwheat plants were counted in each center drill pass per plot on June 23.
[5]Number of buckwheat seeds contaminating wheat harvested from each 3.5 by 25-ft plot. Means presented are estimated least squared means (LSMEANS) calculated by the GLIMMIX statistical procedure in SAS® statistical software.
[6]The center 3.5 by 25-foot drill pass of each plot was harvested for crop yield on June 30.