Grant Code: AP6291

Title: Weed seedbank control in rotational crops as a proactive herbicide resistance management strategy

Personnel: Albert Adjesiwor, University of Idaho

Address: Albert Adjesiwor; Kimberly Research & Extension Center; 3806 N 3600 E; Kimberly, ID 83341; Office: 208-423-6616; Email: aadjesiwor@uidaho.edu

Justification/Rationale: Herbicide-resistant weed populations are evolving rapidly and threatening the sustainability of crop production. In Idaho, there are 11 documented cases of herbicide resistance in seven common weed species. These resistant cases encompass at least seven herbicide sites of action, which are among herbicides commonly used in economically important crops such as wheat. Herbicide-resistant weeds can impact the economics of wheat production by reducing crop yield and contaminating the harvested grain. In a bid to manage the current threat of herbicide-resistant weeds, weed scientists continue to recommend crop rotations that include competitive crops like wheat and alfalfa.

It is known that crop rotations do not eliminate weeds but can be used to reduce the build-up of weed populations, especially herbicide-resistant weeds. Idaho has a wide variety of crops which offers more options for crop rotation sequences. Nevertheless, for crop rotations to be effective weed management tools, the selection of crops must take into account the type of weeds present. This proposed work seeks to answer the following questions: (1) what happens to the weed seeds in the soil when wheat is planted in rotation with alfalfa? (2) is it better to rotate wheat with alfalfa or other annual crops to manage troublesome weed seeds in the soil? (3) are there effective residual herbicides to manage weed seeds in the soil during the alfalfa crop before rotating back to wheat? Answering these questions would provide the necessary information to growers wishing to diversify their weed management program and reduce the selection or build-up of herbicide-resistant weeds.

Objectives:

The goal of this research is to provide the foundational knowledge needed by stakeholders to adopt and integrate effective residual herbicide programs for weed control in wheat-alfalfa rotations. Specifically, we are proposing to:

1. Compare weed seedbank densities in wheat-alfalfa and wheat-corn/dry bean rotations
2. Evaluate residual herbicide programs for effective weed seedbank management within wheat-alfalfa rotations
3. Assess the economic impact of using herbicide mixtures and crop rotations for proactive herbicide resistance management

Methods/Plan of Work:

The field study was established under sprinkler irrigation at the University of Idaho Kimberly Research and Extension Center, Kimberly, ID. Before seeding weeds and crops in spring 2021, soil samples were collected across the research field to determine the weed seed bank composition.

This experiment was laid out as a split-plot randomized complete block design with four replications.

Main plot (Crop rotation): Main plots are 45 ft wide by 30 ft long and consist of four crop rotations ranging in diversity and complexity (Figure 1).

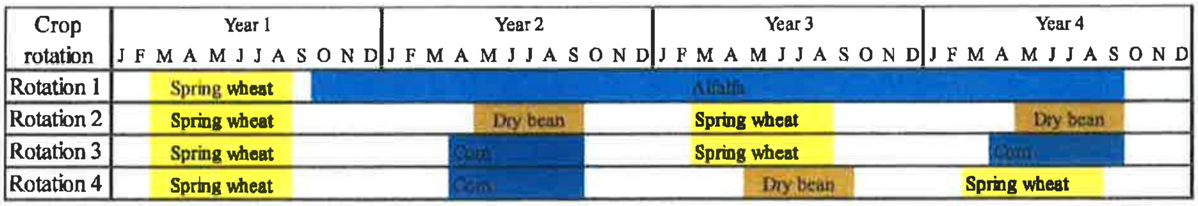

Figure 1. Temporal depiction of the proposed four-year crop rotation

Split-plot (herbicide): Split-plots measuring about 15 ft wide by 30 ft long were established within each crop rotation (main plot). The first herbicide treatment will rely on a combination of preemergence and postemergence herbicides that would provide the greatest weed control and allow rotation to the next crop. This will enable us to determine the effect of herbicide mixtures on weed management. The second treatment will utilize only a postemergence herbicide program to mimic what most growers would do. The third treatment will be no herbicide treatment that will allow us to determine the sole effect of crop rotation on weed management.

Data collection: Weed density by species will be measured in each plot by counting all weeds in 2 randomly placed ~11 ft^2 quadrats. Crop density will also be measured in each plot. Crop yields will be determined by harvesting the center rows each year. Alfalfa will be harvested 3 to 4 times a year at approximately 10 to 30% bloom stage, dried, and weighed to determine forage yield. Dried alfalfa samples will be ground analyzed for nutritional composition. Crop yield and all inputs (fertilizer, fuel, herbicide, labor, seed, etc.) will be recorded and used in the economic analysis.

In late fall each year (after the last harvest), approximately 10 soil samples will be collected from each plot to a depth of 6 inches, and samples from each plot will be bulked. The soil will be frozen immediately to prevent seeds from germinating. The soil samples will be thawed in the spring and spread thinly (~ ½ inch) in flats filled with potting soil for exhaustive germination in the greenhouse to estimate weed seedbank density. Results will be analyzed following standard statistical procedures.

Duration: This is the ***third year*** of a 4-year study.

Cooperation/Complementation: One MS student (Chandra Maki) has been recruited to work on this project as part of her MS thesis. University of Idaho Kimberly Research and Extension will provide land space and assist with planting and management of research plots.

Anticipated Benefits/Expected Outcomes/Tranfer of Information/Technology: Because wheat growers cannot control prices, the only option to remain competitive is to reduce production costs and/or increase yield. The information generated from this project will aid Idaho wheat growers to reduce the impact of weeds on wheat yields through effective residual weed control in crop rotations. Also, this work will evaluate the economic impact of best management practices for weed seeds in the soil to reduce the selection or build-up of herbicide-resistant weeds. This project will be shown at field days in Kimberly ID and results will also be discussed at the Cereal Schools. Chandra Maki will use this data for her MS thesis. Results will be published on the UI Weed Science website and also presented at professional meetings. Final results will be published in Weed Science journal.

Literature Review:

Crop rotation for weed management: Crop rotations have long been recognized as one of the most effective practices for weed management (Pavlychenko and Harrington, 1934). Diverse crop rotations provide some flexibility in the use of different weed control practices (Goplen et al., 2017). A four-year crop rotation study has shown that a diverse crop rotation that included small grains reduced herbicide-resistant kochia seed population in the soil by 34 to 68%, compared to continuous corn and less diverse rotations (Mosqueda, 2019). Aside from the competitiveness of small grains against most annual weeds, small grains are often harvested earlier in the summer before annual weed seed production (Goplen et al., 2016). This reduces the chances of weed escapes and enrichment of the seedbank. Including perennial forage crops like alfalfa in rotations also allow for the elimination of annual weed seed production through multiple crop harvest (Goplen et al., 2017; Meiss et al., 2010). Thus, a crop rotation program that includes competitive small grain crops, perennial forage, and residual herbicide programs has the potential to deplete the sandbank of herbicide-resistant annual weeds.

Economics of proactive herbicide resistance management: The economic impact of herbicide resistance management has gained interest among scientists and farmers. A benchmark study has found that weed control costs were about 31% higher for best management practices recommended by academics compared to standard practices used by farmers (Edwards et al., 2014). However, crop yields tended to be greater in academic best management practices, thereby offsetting the additional cost incurred (Edwards et al., 2014). Using a bioeconomic model, Livingston et al. (2016) showed that although herbicide resistance management reduced first-year farm profits, net farm returns increased from the second year and subsequent 18 years. Thus, if implemented effectively, gains from herbicide resistance management would outweigh the short-term cost of resistance management.

References:

1. Edwards CB, Jordan DL, Owen MD, Dixon PM, Young BG, Wilson RG, Weller SC, Shaw DR (2014) Benchmark study on glyphosate-resistant crop systems in the United States. Economics of herbicide resistance management practices in a 5 year field-scale study. Pest Management Science 70:1924-1929
2. Goplen JJ, Sheaffer CC, Becker RL, Coulter JA, Breitenbach FR, Behnken LM, Johnson GA, Gunsolus JL (2016) Giant ragweed (Ambrosia trifida) seed production and retention in soybean and field margins. Weed Technology 30:246-253
3. Goplen JJ, Sheaffer CC, Becker RL, Coulter JA, Breitenbach FR, Behnken LM, Johnson GA, Gunsolus JL (2017) Seedbank depletion and emergence patterns of giant ragweed (Ambrosia trifida) in Minnesota cropping systems. Weed Science 65:52-60

4. Livingston M, Fernandez-Cornejo J, Frisvold GB (2016) Economic returns to herbicide resistance management in the short and long run: the role of neighbor effects. Weed Science 64:595-608
5. Meiss H, Médiène S, Waldhardt R, Caneill J, Munier-Jolain N (2010) Contrasting weed species composition in perennial alfalfas and six annual crops: implications for integrated weed management. Agronomy for sustainable development 30:657-666
6. Mosqueda EG (2019) Efficacy and economics of cultural and mechanical weed control practices for herbicide-resistant weed management. Ph.D. Dissertations. Laramie WY: University of Wyoming. 111p.
7. Norsworthy JK, Ward SM, Shaw DR, Llewellyn RS, Nichols RL, Webster TM, Bradley KW, Frisvold G, Powles SB, Burgos NR (2012) Reducing the risks of herbicide resistance: best management practices and recommendations. Weed Science 60:31-62
8. Pavlychenko T, Harrington J (1934) Competitive efficiency of weeds and cereal crops. Canadian Journal of Research 10:77-94

FY2024

COMMODITY COMMISSION BUDGET

Principal Investigator: ***Adjesiwor***

Allocated by **Idaho Wheat Commission** *(Commission/Organization)*	during FY2022	$	19,228
Allocated by **Idaho Wheat Commission** *(Commission/Organization)*	during FY2023	$	19,448

REQUESTED SUPPORT: Budget Categories	*Awarded for FY2023*	*Requested for FY2024*
(10) Salary *(staff, post-docs, et NOTE: Faculty salary/fringe not allowed*	$ 11,205	$ 11,205
(12) Temporary Help/IH	$ -	$ -
(11) Fringe Benefits	$ 336	$ 403
(20) Travel	$ 800	$ 800
(30) Other Expenses	$ 1,554	$ 1,554
(40) Capital Outlay >$5k	$ -	$ -
(45) Capital Outlay <$5k	$ -	$ -
(70) Graduate Student Tuition/Fees	$ 5,553	$ 5,664
TOTALS	$ 19,448	$ 19,626

TOTAL BUDGET REQUESTED FOR FY2024: $ 19,626

BREAKDOWN FOR MULTIPLE INDEXES: Budget Categories	*(Insert Lead PI name)*	*(Insert Co-PI Name)*	*(Insert Co-PI Name)*	*(Insert Co-PI Name)*
(10) Salary *(staff, post-docs, et*	$ -	$ -	$ -	$ -
(12) Temporary Help	$ -	$ -	$ -	$ -
(11) Fringe Benefits	$ -	$ -	$ -	$ -
(20) Travel	$ -	$ -	$ -	$ -
(30) Other Expenses	$ -	$ -	$ -	$ -
(40) Capital Outlay >$5k	$ -	$ -	$ -	$ -
(45) Capital Outlay <$5k	$ -	$ -	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -	$ -	$ -
TOTALS	$ -	$ -	$ -	$ -
			Total Sub-budgets	$ -

Budget Justification

$	11,205	Graduate Student, $18.46/hr for 607 hrs
$	403	Student @ 3.6% = $403
$	800	Transportation and accomodation to present results at 2024 Western Weed Sicne Annual Meeting
$	1,554	Plot charges, seeds, stakes, sampling bags, flats for seedbank analysis
$	5,664	Graduate student tuition is $9,968/yr and mandatory student health insurace is $2,082/yr for a total cost of $12,050. Based upon 47% graduate student effort, requesting $5,664 in graduate student fees.

Annual Report

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Abstract:
Herbicide-resistant weed populations are evolving rapidly and threatening the sustainability of crop production In Idaho. A 4-year crop rotation study was initiated in 2021 at the University of Idaho Kimberly Research and Extension Center to evaluate weed control and seedbank dynamics in wheat-alfalfa vs wheat-annual crop (corn and dry bean) rotations. There were three herbicide treatments: untreated, postemergence (POST) only, and preemergence (PRE) + POST. It was observed that weed seedbank density was reduced from 1734 to as low as 578 to seeds per 10 square ft in some treatments. Weed seedbank density tended to be higher in the untreated checks and there was a trend of preemergence (PRE) + postemergence (POST) treatments slightly reducing weed seedbank density compared to POST only treatment. Weed density within the crops during the growing season was influenced by the type of crop as well as the herbicide treatment. Both POST only and PRE + POST treatments reduced weed density compared to the untreated and the PRE + POST treatments reduced weed density in each crop compared to the POST only treatment.Weed control treatments had no effect on alfalfa yield. However, herbicide application (POST only and PRE + POST) improved corn and dry bean yield. The combinantion of fewer weeds and greater crop yield in the PRE + POST treatments holds promise for reducing weed seedbank and potentially improving crop productivity and economics.

Background/Objectives: Herbicide-resistant weed populations are evolving rapidly and threatening the sustainability of crop production. In a bid to manage the current threat of herbicide-resistant weeds, weed scientists continue to recommend crop rotations that include competitive crops like wheat and alfalfa. This research project seeks to answer the following questions: (1) what happens to the weed seeds in the soil when wheat is planted in rotation with alfalfa? (2) is it better to rotate wheat with alfalfa or other annual crops to manage troublesome weed seeds in the soil?

The objectives of this study were to:

1. Compare weed seedbank densities in wheat-alfalfa and wheat-corn/dry bean rotations
2. Evaluate residual herbicide programs for effective weed seedbank management within wheat-alfalfa rotations
3. Assess the economic impact of using herbicide mixtures and crop rotations for proactive herbicide resistance management

Results/Accomplishments:

2022 field trial and weed seedbank density:

The soil samples collected from fall 2021 were thawed in spring 2022 for exhaustive germination in the greenhouse to estimate weed seedbank density. Seed density was counted weekly throughout the summer until there was no weed emergence. It was observed that weed seedbank density ranged from 578 to 1734 seeds per 10 square ft (Figure 1). Weed seedbank density tended to be higher in the untreated checks and there was a trend of preemergence (PRE) + postemergence (POST) treatments slightly reducing weed seedbank density (Figure 1).

Weed density within the crops during the growing season was influenced by the type of crop as well as the herbicide treatment (Figure 2). Both POST only and PRE + POST treatments reduced weed density compared to the untreated. In addition, PRE + POST treatments reduced weed density in each crop compared to the POST only treatment. This has implications for the number of weeds that will go to seed at the end of the growing season.

Weed control treatments had no effect on alfalfa yield (Figure 3). However, herbicide application (POST only and PRE + POST) improved corn and dry bean yield. The combinantion of fewer weeds and greater crop yield in the PRE + POST treatments holds promise for reducing weed seedbank and potentially improving crop productivity and economics.

Next Steps/Projections: This study will be continued in 2023 and results will be made available to the Idaho Wheat Commission and Idaho wheat growers. Results from this study will be presented at the 2023 Weed Tour at Kimberly and the 2023 Western Society of Weed Science Conference.

Publication/Presentations/Popular Articles/News Releases/Variety Releases: This study was showcased at the the 2022 Weed Tour at Kimberly.

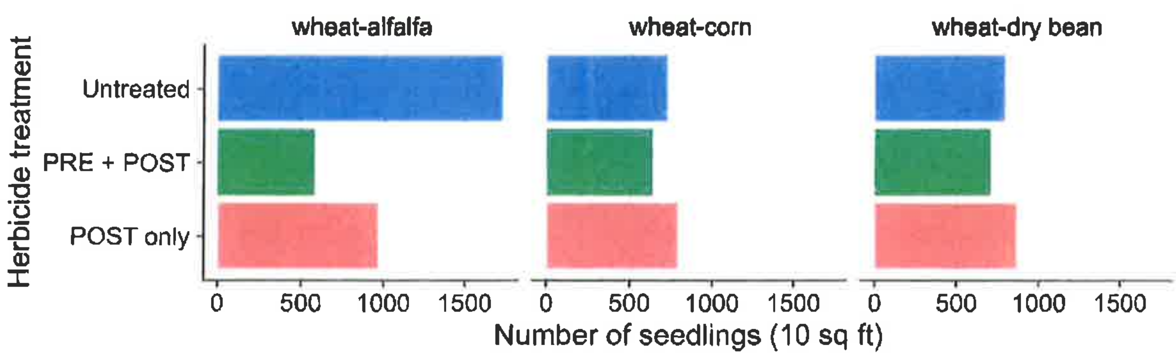

***Figure 1** Effect of postemergence (POST) and preemergence (PRE) + POST herbicide treatments on weed density in spring wheat rotations. Soils collecteсd from fall 2021 at Kimberly, Idaho.*

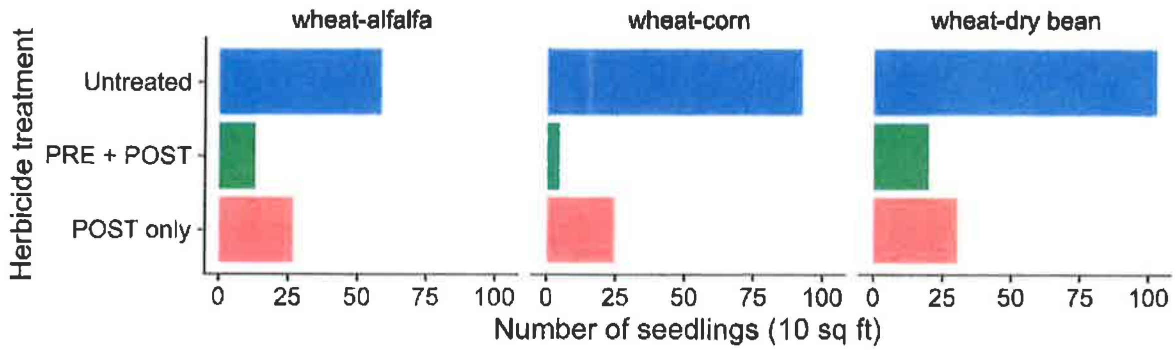

Figure 2 *Effect of postemergence (POST) and preemergence (PRE) + POST herbicide treatments on weed density in spring wheat rotations in 2022 at Kimberly, Idaho.*

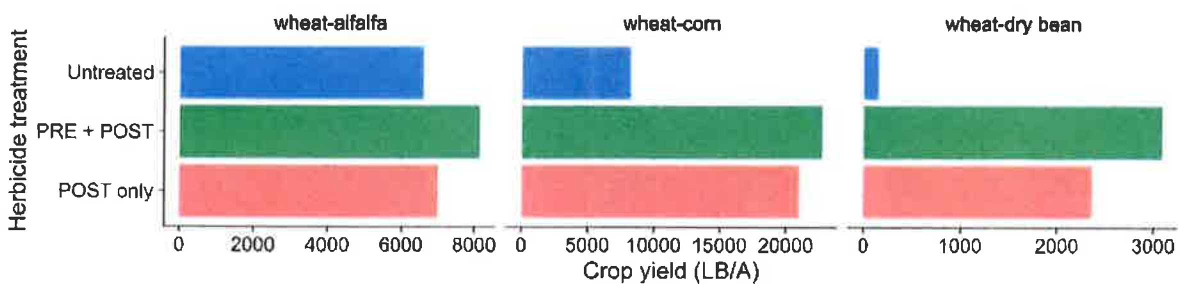

Figure 3 *Effect of postemergence (POST) and preemergence (PRE) + POST herbicide treatments on crop yield in spring wheat rotations in 2022 at Kimberly, Idaho.*