Grant code:	New
Title:	Impact of soil pH and liming on weeds and crop competition in wheat-based cropping systems
Personnel:	Dr. Kurtis Schroeder, Associate Professor of Cropping Systems Agronomy Joan Campbell, Principal Researcher of Weed Science
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Justification/rationale:
Soil pH has been on the decline in northern Idaho for decades. This decline is due to the long-term use of ammonium-based nitrogen fertilizers, and the fact that some northern Idaho soils are forest-derived, giving the soils a lower buffering capacity and making them more vulnerable to changes in pH. A recent survey of soil pH in northern Idaho reveals that the majority of soils have declined to a pH of 5.2 or lower in the upper 6 inches. Approximately 26% of the soil in this survey had a pH below 5.0 which also had significant quantities of soluble aluminum. In conjunction with the declining soil pH, there are growing weed management issues that are partially associated with direct seeding and changes in rotational crops, and partly due to an increase in the number of herbicide-resistant weeds. While there is data on crop response to soil pH and liming, there is little to no information on how weeds tolerate low pH or how they would respond to liming. Furthermore, there is little known about how soil pH will influence crop competition with weeds. Information on crop competition following liming could aid as another tool for integrated weed management. With growing weed problems and increasing herbicide resistance, additional cultural tools would aid in management.

Objectives:
Our hypotheses are that some weed species that are thriving in north Idaho will be found to have tolerance to aluminum toxicity and that lime application will decrease their competitive advantage and increase the ability of crops to outcompete weed, aiding in weed management.

Specific objectives are to:
1) Examine the tolerance of important broadleaf and grassy weeds to aluminum toxicity under greenhouse conditions.
2) Explore the impact of liming on crop competition with weeds in field trials.

Methods/Plan of work:
1. *Weed tolerance to soil acidity.* Soil will be collected from the University of Idaho Parker Plant Science Farm in Moscow, ID. A field at this farm is well documented and has a pH of about 4.2 with greater than 300 ppm soluble aluminum. A portion of the soil from this field will be adjusted to a pH of 5.5 and 6.5. Soils will be placed in pots in the greenhouse where weeds will be screened for tolerance to aluminum. The weeds that will be screened will include at a minimum mayweed chamomile, prickly lettuce, lambsquarters, Italian ryegrass, jointed goatgrass, and wild oat. In addition to being important weeds in northern Idaho, lambsquarters and wild oat also are being screened in the southern Idaho soil pH project and will serve as useful controls between the two studies. Known susceptible and tolerant wheat varieties will be included as a control. The trial will be organized as a randomized complete block design with five replications and will be completed twice. Plant height and above ground biomass will be

assessed to determine tolerance. As appropriate, visual assessments will be made to determine tolerance to aluminum toxicity.

2. *Impact of soil pH on weed competition.* This portion of the project will rely on a combination of established and new trials as a minimum of three locations. This will include a Potlatch location that was originally limed with 0, 1, 2 and 3 ton/A ground limestone in the fall of 2016. This site was part of study funded by the Idaho Wheat Commission to explore using higher rates of lime to reduce the impact of aluminum toxicity on crop yield. Both mayweed chamomile and Italian ryegrass are naturally persistent at the site. A second site will be established in Latah County near Moscow, ID, with the criteria that the site has a pH of 5.0 or below and quantifiable soluble aluminum levels as well as known weed issues. The Moscow and Potlatch sites will both include the 0, 1, 2 and 3 ton/A lime rates in replicated trials with four replications and each plot measuring 8 ft wide by 100 ft long. A third site will be established on the University of Idaho Parker Plant Science Farm in the afore mentioned field that has a pH of approximately 4.2. Portions of this field were limed about six years ago with 3 ton/A AgriCal fluid lime. The Parker Farm trial will be laid out across either limed or non-limed plots but will allow us to infest the site with weed species of interest. The crop sequence at all sites will follow a "standard" rotation scheme for north Idaho of winter wheat – spring wheat – spring broadleaf.

   Prior to standard herbicide application and two weeks after herbicide application, weed species will be identified and counted within a quadrat (0.5 by 0.5 m). Plant samples will also be collected to determine the biomass of each species present in addition to the crop. At the end of the growing season, the plots will be assessed for number of tillers per unit area and harvested to determine grain yield and quality such as test weight, 1,000 kernel weight and grain protein. Soil samples will be collected in May to a depth of 12 inches (0 to 3, 3 to 6 and 6 to 12-inch segments) from all locations to determine soil pH, calcium saturation, base saturation, and KCl extractable aluminum.

Duration:
This project is anticipated to be a two- to three-year project with field trials being initiated in the summer of 2023 and greenhouse studies occurring during the winter of 2023-2024 and 2024-2025.

Cooperation/Collaboration:
Research plots will be conducted in cooperation with local growers in Potlatch and Moscow. Efforts are being coordinated with Drs. Jared Spackman and Albert Adjesiwor who have a similar project in progress in southern Idaho. Funding for a graduate student who will work on this project will be provided via an assistantship from Limagrain Cereal Seeds.

Anticipated Benefits/Expected:
Results of this study will complement both previous work on the benefits of liming as well as regionally coordinated efforts to manage herbicide resistant weeds. Information on the relative tolerance of important weed species will be determined as well as the effectiveness of crop competition with weeds in limed soils. This information will be beneficial for growers making the decision to start liming fields and will potentially provide another tool for integrated management of weeds.

Transfer of Information/Technology:
The results of this study will be shared at field days and winter cereal schools. Data summaries will also be published in the annual "Dryland Field Day Abstracts" book co-published between the University of Idaho, Oregon State University and Washington State University. Completed

study results will be summarized for an Idaho Grain magazine article and results will be published in a peer-reviewed journal article.

Literature Review:

Issues with low soil pH were traditionally associated with the southeast and central regions in the United States. However, observations of declining soil pH are becoming more common in the semi-arid regions of the northwestern region of the United States including Idaho, Washington, and Montana (Koenig et al., 2011; Jones et al., 2019). The impact of low soil pH on the persistence of herbicides is well known and has even resulted in the herbicide labels being modified to change plant back restrictions in acidic soils (Raeder et al., 2015). In addition to the negative impact on crop performance, a concern with herbicide persistence is that the reduced rate of decomposition increases the exposure of weeds to sublethal doses of herbicides and could increase the risk of developing herbicide resistance. Aside from the impact of soil pH on herbicide decomposition, some weed species can tolerate aluminum toxicity and thrive in low pH soils (Bilski and Foy, 1988). Weed species that are tolerant of aluminum toxicity and hence acid soils are likely to be more challenging to control. This can be further exacerbated if the crops being grown in the region are sensitive to low pH. Previous work has demonstrated that plant growth and yield is negatively impacted by soil pH at or below 5.2 to 5.6 for pea, lentil, barley and wheat (Mahler and McDole, 1987). The combination of persistent weeds in low pH soils and reduced competitiveness from crops can result in greater weed pressure in acidic soils. There is very little research that has been conducted on the impact of lime on crop competition with weeds, and aside from the work currently being conducted in southern Idaho, there is no information on this topic in the Pacific Northwest. However, data from other regions of the world indicates that liming can influence crop competition. A long-term study conducted in Lithuania to explore the impact of liming on weed competition demonstrated that the number of weeds was 4.1 times lower in limed soils (6.4 to 6.8) compared to an acid soil (4.0 to 4.1) (Skuodiene et al., 2020). In Australia, researchers discovered that within 2 years after lime application, populations of rigid ryegrass (annual ryegrass) seeds were reduced by 70% in a wheat crop (Borger et al., 2020). While there is limited data, literature does suggest that liming acid soils can have a tremendous impact on weed populations and crop competition. While it is known that crop competition is integral for weed control, the response of weed species in the Pacific Northwest to soil pH is unknown.

References:

1. Bilski, J.J., and Foy, C.D. 1988. Differential tolerances of weed species to aluminum, manganese and salinity. Journal of Plant Nutrition 11:93-105.
2. Borger, P.D., Azam, G., Gazey, C., van Burgel, A., and Scanlan, C. 2020. Ameliorating soil acidity-reduced growth of rigid ryegrass (*Lolium rigidum*) in wheat. Weed Science 68:426-433.
3. Jones, C., Engel, R., and Olson-Rutz, K. 2019. Soil acidification in the semiarid regions of North America's Great Plains. Crop & Soils magazine March-April, pp. 28-31, 56.
4. Koenig, R., Schroeder, K., Carter, A., Pumphrey, M., Paulitz, T., Campbell, K., and Huggins, D. 2011. Soil acidity and aluminum toxicity in the Palouse region of the Pacific Northwest. Washington State University, Extension Bulletin FS050E.
5. Mahler, R.L., and McDole, R.E. 1987. Effect of soil pH on crop yield in northern Idaho. Agronomy Journal 79:751-755.
6. Raeder, A.J., Lyon, D., Harsh, J., and Burke, I. 2015. How soil pH affects the activity and persistence of herbicides. Washington State University, Extension Bulletin FS189E.

7. Skuodiene, R., Karcauskiene, D., Feize, V., Feiziene, D., Repsiene, R., and Siaudinis, G. 2020. Changes in weed flora under the influence of long term application of liming and reduced soil tillage. Zemdirbyste-Agriculture 107:25-32.

FY2024

COMMODITY COMMISSION BUDGET

Principal Investigator: Kurt Schroeder

Allocated by _____ *(Commission/Organization)*	**during FY2022**	**$** -
Allocated by _____ *(Commission/Organization)*	**during FY2023**	**$** -

REQUESTED SUPPORT: **Budget Categories**	*Awarded for FY2023*	*Requested for FY2024*
(10) Salary (*staff, post-docs, et NOTE: Faculty salary/fringe not allowed*	$ -	$ -
(12) Temporary Help/IH	$ -	$ 2,880
(11) Fringe Benefits	$ -	$ 104
(20) Travel	$ -	$ 600
(30) Other Expenses	$ -	$ 8,530
(40) Capital Outlay >$5k	$ -	$ -
(45) Capital Outlay <$5k	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -
TOTALS	$ -	$ 12,114
TOTAL BUDGET REQUESTED FOR FY2024:		$ 12,114

BREAKDOWN FOR MULTIPLE INDEXES:

Budget Categories	*Schroeder*	*Campbell*	*(Insert Co-PI Name)*	*(Insert Co-PI Name)*
(10) Salary (*staff, post-docs, et*	$ -	$ -	$ -	$ -
(12) Temporary Help	$ -	$ 2,880	$ -	$ -
(11) Fringe Benefits	$ -	$ 104	$ -	$ -
(20) Travel	$ 400	$ 200	$ -	$ -
(30) Other Expenses	$ 7,565	$ 965	$ -	$ -
(40) Capital Outlay >$5k	$ -	$ -	$ -	$ -
(45) Capital Outlay <$5k	$ -	$ -	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -	$ -	$ -
TOTALS	$ 7,965	$ 4,149	$ -	$ -
			Total Sub-budgets	$ 12,114

Budget Justification

$	-	(10-Insert Personnel Type, Hourly Rate, Hours Anticpated and General Tasks
$	2,880	12-Temp help to count weeds, fille pots, plant, collect samples etc. for 4 weeks at $18.00 per hour **Fringe rates: Staff = 42%; IH= 8.7%; Student= 3.6%*
$	104	11-Temp student help at 3.6% fringe *Per Diem= $55/day In-State; Mileage= $0.655/mi*
$	600	20-Travel to plot sites, 18 trips per season (915 miles @ $0.655/mi)
$	8,530	30-Soil samples (144 at $35/sample), tissue tests (60 at $30/sample), combine rental (3 hr at $75/hr), land
$	-	(40-Insert Capital Equipment description)
$	-	(45-Insert Capital Equipment under $5K description)
$	-	((70- Insert tuition request) *$12,050/YR= Tuition, Fees and SHIP*