

Grant Code: NEW

Title: Liming for Improved Nutrient Utilization and Weed Management in Wheat

Personnel: Jared Spackman, Assistant Professor, UI Aberdeen; Albert Adjesiwor, Assistant Professor UI Kimberly; Jon Hogge, Area Extension Educator

Address: Jared Spackman 1693 S. 2700 W. Aberdeen, ID 83210; (208) 312-2454;
jspackman@uidaho.edu

Justification/Rationale: The optimal soil pH for most agronomic crops is 6.2 to 7.3 when nutrient availability is maximized. Most southern Idaho agricultural soils are neutral to alkaline (pH 7 to 8.5) but naturally slowly acidify due to precipitation. Agricultural production accelerates acidification when ammonium containing fertilizers are applied and as cations are removed at harvest (Hart et al., 2013). Because soil pH change is gradual, yield reductions are often not observed until a soil pH threshold is reached. The critical threshold for sugar beets, barley, potatoes, and wheat are 6.0, 5.8, 5.5, and 5.4, respectively. Below these thresholds, root growth is inhibited negatively impacting nutrient and water uptake. While most southern Idaho soils are above these thresholds, soil acidity is becoming increasingly problematic from Ashton to Driggs, as well as other pockets across southern Idaho. Sugar beet lime is a readily available amendment, but current University of Idaho and soil testing lab liming recommendations are based on other Midwest and Pacific Northwest states' recommendations that do not reflect southern Idaho soils' physical, chemical, and climatic properties.

In addition to improving nutrient availability and crop growth, scientific experiments have shown that lime applications can reduce weed seed germination and vigor and make crops more competitive. Liming acidic soils in Idaho could provide additional benefits of improving wheat competitiveness against weeds, reducing weed pressure, decreasing the overall impact of weeds on wheat yield, and reducing the number of weed seeds in the soil. Weed seeds in the soil remain the major source of weed infestation in crops. Thus, the best indication of the "next" weed problem is the composition of weed seeds in the soil. We are proposing a multi-disciplinary study that evaluates the effect of liming on nutrient availability, crop growth, weed density, and weed seed composition in the soil.

Objectives:

Hypothesis: Liming will improve soil nutrient availability, crop growth, and reduce weed pressure on agronomic crops.

Objective 1: Evaluate how liming modifies soil nutrient availability, plant nutrient uptake, and grain quality and yield.

Objective 2: Evaluate the effect of liming on weed pressure.

Objective 3: Perform a survey of southern Idaho acidic soils' physical and chemical properties and weed seed census.

Procedures/Plan of Work: Four on-farm field experiments will be conducted in the Ashton-Driggs area on an east-west transect from 2021 to 2024. Four replications of four sugar beet lime rates will consist of 0, 1, 2, and 4 tons per acre. Lime will be applied using a commercial

applicator's spreader to 50'x50' plots. Other than liming, the plots will be managed according to the grower practices. Sites will be characterized for micro and macronutrient content and soil physical properties by analyzing soil samples from the top foot of each plot. Additional soil samples will be collected at the 0-2, 2-4, 4-6, 6-8, and 8-12" depths in the fall of 2021 before liming; spring, summer, and fall of 2022; and each subsequent spring and fall until 2024. These samples will be analyzed for soil pH, electrical conductivity, and free lime. Each fall, additional soil samples will be collected at 0-6 and 6-12" depths and analyzed for extractable aluminum (a source of soil acidity and root toxicity). The 0-6" soil samples will also be analyzed for weed seed bank density, weed diversity, and resistance to at least five herbicide sites of action. At maturity, wheat yield, yield components (test weight, grain protein), aboveground biomass, weed biomass, and weed density will be measured from within each plot. The aboveground biomass will be analyzed for complete nutrient analysis.

Lime requirement recommendations for southern Idaho soils will be done by collecting one gallon of acidic soils (pH<6) from the 0-6" and 6-12" depth increments in Ashton, Driggs, Grace, Oakley, Lake Channel (west of American Falls), Carey, Jerome, and other sites identified by agronomists and soil testing labs. A 90-day lime incubation will be performed by adding calcium carbonate lime to each soil at rates of 0, 1, 2, 4, 6, and 8 ton per acre. Soil pH, electrical conductivity, free carbonate, and nitrate and ammonium content will be measured at the beginning and end of the incubation. The non-limed soils will be evaluated for lime requirement using the Sikora buffer, the modified Mehlich buffer, single addition calcium hydroxide, and sequential addition of calcium hydroxide methods.

Duration: Four years (2021, 2022, 2023, 2024).

Cooperation/Collaboration: Dr. Jared Spackman and Dr. Albert Adjesiwor's teams will work together to establish the on-farm trials, collect soil and tissue data, and collect acidic southern Idaho soils for the lime calibration study. Dr. Spackman's team will perform the soil pH, electrical conductivity, free lime, and extractable aluminum analyses while Dr. Adjesiwor's team will perform the weed seedbank and weed herbicide tolerance analysis. Mr. Jon Hogge will assist in identifying growers to participate in the study, identifying acidic soils for sampling, sample collection, and organizing grower field days.

Anticipated Benefits, Expected Outcomes and Impacts, and Transfer of Information: The on-farm study will generate two peer-reviewed journal articles and two Extension bulletins. Both the on-farm and the lime recommendation studies will contribute data to Dr. Adjesiwor's database of herbicide-resistant weeds and weed seed bank density across southern Idaho. Because Idaho's lime guidelines were developed using research from other Pacific Northwest states' datasets, this lime recommendation study will be the only dataset to our knowledge that is specific to the lime requirements of southern Idaho soils. We anticipate two graduate students (one from each PI's program) will use this data as part of their theses. The results will be shared at professional meetings (e.g., Weed Science Society, Tri-Societies meetings, Western Nutrient Management Conference), Extension events (Cereal School, field days), and the PI's websites. The raw dataset will be published in a publicly available data repository to ensure the longevity of the dataset and its availability for future research applications. This project will be used to inform growers and crop advisors about the potential benefits of liming for a competitive

advantage over weed pressure, improved crop health, and nutrient availability and uptake.

Literature review

Soil acidification is an increasingly common problem for Idaho wheat producers. Formerly neutral to slightly alkaline agricultural soils in Montana, Idaho, Oregon, and Washington have acidified following repeated applications of ammonium containing fertilizers, cation leaching with irrigation water, and cation removal with harvest (Hart et al., 2013; Engel et al., 2020). Additionally, sandy soils acidify more rapidly than clayey soils due to less organic matter and cation exchange capacity. Acidic soils reduce soil nutrient availability to crops and increase aluminum and manganese solubility that reduces crop growth by killing the root tips (Hart et al., 2013). Lime is required to neutralize soil acidity and includes a variety of sources including limestone, sugar beet lime, and wood ash among others (Mahler and McDole, 1994). Sugar beet lime is a readily available source in southern Idaho and is commonly used on acidic soils in Ashton and other southern Idaho fields. In a Montana study, 2.5 tons ac^{-1} of sugar beet lime was required to raise soil pH from 4.7 to 6.0 in the top 4 inches of the soil profile (Engel et al., 2020). Most of the pH change occurred in the first year following tillage.

In addition to improving crop growth and nutrient availability, liming acidic soils increases the competitiveness of the crop against weeds (Lemerle et al. 1995; Li et al. 2019). Healthy crops effectively compete with weeds for water and nutrient resources reducing weed density and the number of weed seeds produced annually. This is especially important for managing herbicide-resistant weeds. A recent study demonstrated that lime application to an acidic soil increased tiller number in wheat and the overall competitiveness of wheat against rigid ryegrass (Borger et al. 2020). This reduced rigid ryegrass growth and weed seed produced. In the Ashton area, a local agronomist often observes reduced barnyard grass and corn spurry pressure following liming (Personal communication with Bryan Miller, 2020).

References

1. Borger CPD, Azam G, Gazey C, van Burgel A, Scanlan CA (2020) Ameliorating soil acidity–reduced growth of rigid ryegrass (*Lolium rigidum*) in wheat. *Weed Sci.* 68: 426–433. doi: 10.1017/wsc.2020.38
2. Engel, R., C. Jones, and R. Wallander. 2020. Soil acidification: Remediation with sugar beet lime. Montana State University–Extension.
3. Hart, J.M., D.M. Sullivan, N.P. Anderson et al. (2013). Soil acidity in Oregon: Understanding and using concepts for crop production. Oregon State Extension EM 9061.
4. Lemerle D, Verbeek B, Coombes N (1995) Losses in grain yield of winter crops from *Lolium rigidum* competition depend on crop species, cultivar and season. *Weed Res* 35:503–509
5. Li Y, Cui S, Chang SX, Zhang Q (2019) Liming effects on soil pH and crop yield depend on lime material type, application method and rate, and crop species: a global meta-analysis. *J Soil Sediment* 19:1393–1406
6. Mahler, RL, and RE McDole (1994). Liming materials. University of Idaho, Cooperative Extension Service, Agricultural Experiment Station, College of Agriculture.

FY2022

IDAHO WHEAT COMMISSION - BUDGET FORM

Principal Investigator: Jared Spackman

If applicable, Allocated by Idaho Wheat Commission during FY 2020 \$ -

If applicable, Allocated by Idaho Wheat Commission during FY 2021 \$ -

REQUESTED FY2022 SUPPORT:

Budget Categories	(10) Salaries (staff, post-docs, etc.)	(12) Temp Help	(11) Fringe	(20) Travel	(30) OE	(70) Graduate Tuition/ Fees	TOTALS
Idaho Wheat Commission	\$ 16,849		\$ 354	\$ 6,091	\$ 7,600	\$ -	\$ 30,894

TOTAL BUDGET REQUEST FOR FY 2022: \$ 30,894

BREAKDOWN FOR MULTIPLE SUB-BUDGETS:

Budget Categories	Jared Spackman	Albert Adjesiwor	(Insert CO-PI Name)	(Insert CO-PI Name)
(10) Salaries			\$ -	\$ -
(12) Temp Help	\$ 9,227	\$ 7,623	\$ -	\$ -
(11) Fringe Benefits	\$ 194	\$ 160	\$ -	\$ -
(20) Travel	\$ 3,004	\$ 3,087	\$ -	\$ -
(30) Other Expenses	\$ 6,129	\$ 1,471	\$ -	\$ -
(70) Graduate Student Tuition/Fees	\$ -	\$ -	\$ -	\$ -
TOTALS	\$ 18,553	\$ 12,341	\$ -	\$ -

Total Sub-budgets \$ 30,894

Brief Explanatory Comments: (see FY2022 RFP for guidance)

FY2022 Version