ANNUAL REPORT

Grant Code: AP6314
Title: Liming for Improved Nutrient Utilization and Weed Management in Wheat
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Abstract:

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 agricultural production accelerates acidification when ammonium-containing fertilizers are applied and as cations are removed at harvest. While most southern Idaho soils are above these thresholds, soil acidity is becoming increasingly problematic from Ashton to Driggs, Swan Valley/Antelope Flats, and Soda Springs. Sugar beet lime is a readily available amendment, but the 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. The objectives of this study are to evaluate the effect of liming on soil nutrient availability, plant nutrient uptake, grain quality and yield, and weed pressure. An additional objective is to conduct a lime requirement incubation study to determine how acidic Idaho soils respond to liming.

Background / Objectives:
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. 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, potatoes, wheat, and barley are 6.0, 5.5, 5.4, and 5.2, 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, Swan Valley/Antelope Flats, and Soda Springs. Sugar beet lime is a readily available amendment, but the 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.

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Results / Accomplishments :
Three on-farm field experiments were established in the fall of 2021 in Ashton and one at Swan Valley. Four replications of four sugar beet lime rates were applied at rates of 0, 2, 4, and 6 tons per acre on 50'x100' plots. Other than liming, the plots were managed according to the grower practices. During the 2022 growing season, irrigated spring wheat was grown at the Ashton sites and dryland barley was grown at the Swan Valley location. The centers of each plot were geo-referenced. Soil samples were collected at the 0-2, 2-4, 4-6, 6-8, and 8-12" depths in the spring and after grain harvest in 2022. These samples were dried and ground and are in the process of being analyzed for soil pH (1:1 soil: water, 1:2 soil: water, 1:1 soil:0.01 M calcium chloride), electrical conductivity, and free lime. Additional soil samples were collected at 0-6 and 6-12" depths and are awaiting analysis by Agvise Laboratories for extractable aluminum (a source of soil acidity and root toxicity). At grain maturity, grain yield, yield components (test weight, grain protein), aboveground biomass, weed biomass, and weed density were measured from a 5x5' section of each plot. My graduate student is in the final stages of preparing straw and grain samples to be sent for a complete nutrient analysis at Brookside Laboratories.

For the incubated lime requirement study, we collected 10 gallons of acidic soils from 16 field sites in southern (10) and northern Idaho (6) from Ashton, Swan Valley, Soda Springs, Moscow, and Potlatch. For this study, my graduate student (Kaone Mookodi) dried, ground, and homogenized each soil. The soil was then subdivided into 32 containers and treated with 0, 0.5, 1, 2, 4, 6, 8, and 10 tons per acre of calcium carbonate (lime). Water was added to each pot to bring the soil moisture content to 80% and then the pots were incubated for 90 days. The soils were dried and are in the process of being ground. Each soil will be analyzed for soil pH, electrical conductivity, free carbonate, and nitrate and ammonium content. We will then analyze the soils for lime requirement using the Sikora buffer, the modified Mehlich buffer, single addition calcium hydroxide, and sequential addition of calcium hydroxide methods.

At the end of the incubation, each pot will be subdivided into 3 or 4 smaller pots and planted to either wild oat, Kochia, cheatgrass, common lambsquarters, or redroot pigweed seeds. Germination and seedling vigor will be assessed for five weeks at the Kimberly R&E Center.

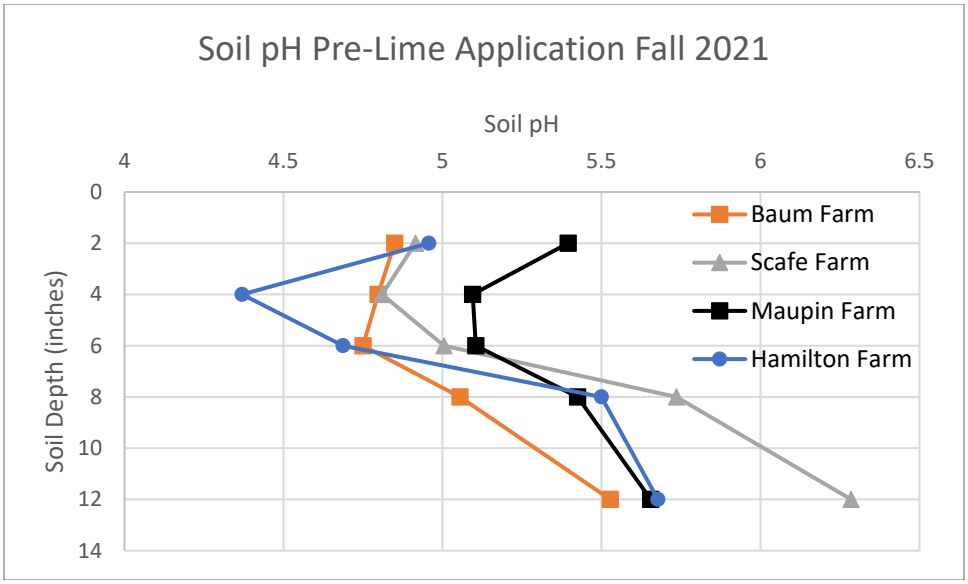

Figure 1: Soil pH changes by depth before lime application. Soil pH followed a pattern of decreasing from the 0-2" depth to the 2-4" and 4-6" depths and increasing in the 6-8" and 8-12" depths. Historically, these soils had more alkaline soils but over 100 years of farming, applying nitrogen fertilizers, and withdrawing base cations at harvest, the surface soil pH has declined while the deeper depths have greater soil pH values. Calcium carbonate deposits can still be found at deeper depths in these soils.

Outreach / Applications / Adoptions:
The on-farm study will generate two peer-reviewed journal articles and two Extension bulletins. In collaboration with Dr. Dave Tarkalson from USDA ARS in Kimberly, Dr. Spackman's graduate student, Kaone Mookodi, is working on a journal article to address how soil pH and liming impact small grain seedling vigor.

This study supports the research and trial and error testing done by Valley Wide Ag in Ashton over the last 20 years. The IWC study is a collaborative effort to provide research-based lime requirement recommendations to agronomists and the farmers they work with.

In September 2022, Dr. Spackman and Tom Jacobsen had an informal meeting with several small grain growers in Ashton and Soda Springs to talk about liming principles, nutrient management, and the current status of the IWC-funded liming study. These growers expressed interest in conducting additional lime research and are currently collaborating on a Western SARE grant that will supplement the IWC-funded study.

Dr. Spackman's lab is working with a national research group (Fertilizer Research Support Tool https://soiltestfrst.org/lime/) to reevaluate liming recommendations and practices. Drs. Spackman and Schroeder joined this research team in 2022. Dr. Spackman has submitted acidic soils from Ashton and Soda Springs for inclusion in a national lime incubation study.

Dr. Spackman's lab is working with Dr. Dave Tarkalson at USDA ARS in Kimberly and Amalgamated Sugar on ways to utilize precipitated calcium carbonate (spent sugar beet lime) as an agronomic amendment in both acidic and alkaline soils. Through this relationship, Dr.

Spackman will help convert some of Dr. Tarkalson's research articles into Extension bulletins.

Dr. Spackman is conducting a lime incubation study with undergraduate students at Brigham Young University – Idaho. These students are evaluating precipitated calcium carbonate, calcium hydroxide, and calcium carbonate as liming agents and determining how long it takes for these lime products to neutralize acidic soils. They are also examining the impact of soil moisture at the time of lime application on how readily soil pH is neutralized.

Next Steps/ Projections:

For the on-farm field trials, we will continue to monitor changes in soil pH in each plot over the next two years.

After Kaone finishes analyzing the lime incubation samples, we will use the modified soils to evaluate the effect of soil pH on weed vigor. We will likely evaluate red root pigweed, wild oat, Kochia, and/or corn spurry.

Kaone will continue to analyze the soil sample results and will write them up as part of her thesis.

Publications / Presentations / Popular articles / News Releases / Variety Releases:
We have presented information about the liming study at the University of Idaho Forage Schools held in March 2022 at Mudlake, Preston, and Idaho Falls and Cereal Schools in Soda Springs. Despite many of these locations having alkaline soils, the topic generated significant interest. Kaone will present a poster at the Western Nutrient Management Conference in March 2023. We also anticipate presenting the first year of data at the 2023 American Society of Agronomy-Crop Science Society of America-Soil Science Society of America annual conference.