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Project #: 3019-4387
Final Report
Title: Cultural Management of Soil Acidification and Aluminum Toxicity in Wheat-Based Systems of E. Washington
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Executive summary:

- Field trials with different rates (100-2000 lbs/ac of $CaCO_3$) of surface applied fluid (NuCal) and dry lime (sugarbeet lime source) were established in fall 2013 on prairie (Conservation Farm and private farm near Pullman, WA) and forest (private farm near Rockford, WA) soil in long-term continuous no-till sites. Crop and soil responses to treatments were monitored. 17 months after lime application the higher rates (2000 lbs CaCO3/ac) of lime had increased soil pH in the upper 2 inches by about ½ to 1 pH unit; however, treatments failed to address stratified soil acidity located at the 4 inch depth. The fluid and dry lime had similar effects on soil pH. We concluded that movement of these surface applied fluid or dry lime sources into the soil would be slow (years) and would fail to address stratified acidity in no-tillage operations in the short term if the stratified layer was deeper than the surface 2 inches. In addition, low rates of surface applied lime (100, 200 lbs/ac) had no statistically significant measureable effect on soil pH. Failure to address stratified soil pH with surface applied lime led to the development of a new fluid lime applicator that targets stratified soil acidity at the 3-4 inch depth. The applicator consists of 30 inch sweeps with 10 fluid lime injectors per sweep. A field trial in the spring of 2015 with the prototype applicator applied 103 gal/ac of fluid lime (about 1200 lbs/ac of CaCO3) and was successful at targeting stratified soil acidity at the 3 to 4 inch depth with minimal soil disturbance. We concluded that the fluid lime applicator had potential to rapidly address stratified soil pH in no-till situations where physical incorporation of lime with tillage operations was not preferred.
- No crop (wheat, chickpea, canola, lentil) yield differences were measured comparing control to the lime treatments during the study. However, as the lime treatments failed to address the acidity issue, our results are inconclusive as to any yield benefit the lime may have achieved if the treatments had successfully adjusted soil pH to agronomically favorable levels. Field trials were coordinated with Kurt Schroeder (Univ. of Idaho) and similar treatments were established in N. Idaho. Seed-placed lime was also evaluated for spring crops at the Cook Agronomy Farm, however, no yield responses were noted. Further investigations are required to identify situations where crop yield response to lime will occur or not occur. Furthermore, future investigations should also examine other potentially beneficial effects of lime application such as increases in nutrient use efficiency, changes in herbicide carry-over characteristics and influences on biological activity such as legume nodulation, earthworm activity and residue decomposition.

- Stratification of soil acidity in the surface six inches is one source of soil pH variability and requires that soil sampling depth-increment protocols are adjusted if the stratification is to be quantified. Sampling the surface 12 inches of soil will mask stratified soil pH issues and not identify potential problems. We recommend sampling the upper six inches or 0 to 3 and 3 to 6 inch increments to adequately measure soil acidification problems in no-till operations. Soil sampling protocols can now be found on the WSU dryland wheat extension website along with other current information on soil acidification (http://smallgrains.wsu.edu/soil-and-water-resources/soil-acidification-in-the-inland-northwest/). In addition to significant variability of soil pH with depth, there is often considerable spatial variability of soil pH across the field and to a lesser extent, from season to season. Spatially distributed soil samples at the Cook Agronomy Farm showed ranges of soil pH from 4.4 to 5.4 in surface 6 inch samples. Others have also measured considerable spatial variability of soil pH within fields ranging 2 or more soil pH units (e.g. soil pH of 4.5 to 7.0 in single field). Mapping spatial soil pH was conducted via grid sampling using Veris technology in combination with traditional soil sampling and testing protocols. Limitations of Veris technology used to map soil pH were identified (poor accuracy, limited field "windows" for operation). Lime requirements derived from the soil sampling indicated that rates of lime required to achieve a target soil pH could vary significantly across a given field. Preliminary conclusions are that these data support further investigations into exploring precision application strategies for lime where application rates target soil requirements and locations where crop response may occur.
- Currently regional soil testing laboratories use various buffer tests to determine the lime requirement. Common laboratory buffer tests are Adams and Evans and SMP buffer tests. These soil buffer tests, however, had not been tested for their suitability to a broad range of soils found in the Palouse region. As buffer tests are a fundamental test required to determine what lime rates are needed to change the soil pH from its current value to an identified target pH, we conducted laboratory incubation studies using 10 common Palouse soil types to further test and develop lime requirement determinations. The lime incubation investigation was successful and quantified how regional soils would respond with respect to pH to rates of lime ranging from 100 to 20,000 lbs/ac. These results were then combined with six different soil buffer tests (Shoemaker McLean and Pratt (SMP), Adams and Evans, Modified Mehlich, Sikora, Woodruff 7, and Woodruff 6) to determine which of these tests were most suitable to use for determining the lime requirement of Palouse soils. These results showed that the Adams and Evans and SMP buffer tests were not adequate as buffer tests. However, the modified Mehlich and Woodruff buffer tests were determined to be suitable for estimating the lime requirement for Palouse soils when correlated and calibrated. It is further recommended, however, that these laboratory based results are corroborated with field tests. These investigations are currently in place but require more time to assess.
- Research results have been presented at numerous (over 40) regional and national meetings during the course of the project. In addition, a multi-disciplinary soil acidification Extension team was organized to help coordinate the many disciplinary issues that soil acidification impacts and various Extension products that would be useful for producers (see: http://smallgrains.wsu.edu/soil-and-water-resources/soil-acidification-in-the-inland-northwest/). In addition, articles in Wheat life, Crop and Soils Magazine and The Furrow have highlighted research activities.

Impact:

- Our liming trials, using novel formulations and application techniques provided growers with immediate information about the efficacy of these methods under our conditions.
- Spatial characterization of soil pH and liming requirement will help target lime applications and lead to greater economic performance of crops.
- Soil buffer tests that are well suited for determining the lime requirement for Palouse soils were identified and should replace current buffer tests used by regional soil testing labs.
- New, multidisciplinary Extension products are now available for producer and other professionals to use with further offerings to be available in the coming year.