Wheat and pea response to lime source and rate in acidified soils of northern Idaho

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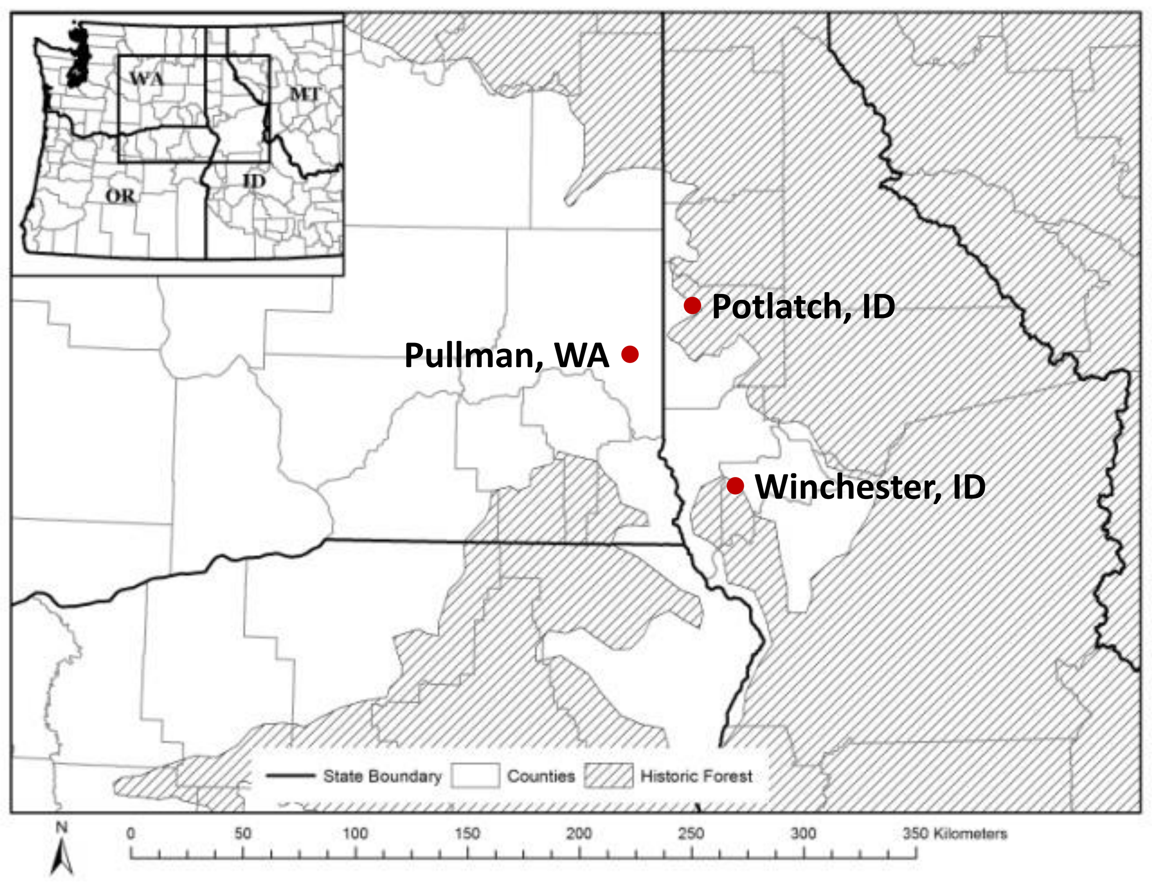
INTRODUCTION

Soil pH has been declining in northern Idaho and eastern Washington for decades, due primarily to the long term use of synthetic nitrogen fertilizer and a strong cereal-based cropping system. In some areas, plants grown in low pH soils are exhibiting aluminum toxicity, particularly in regions that were historically forested. Although tolerant and adapted wheat varieties have been identified for this region, these varieties will not perform well as soil becomes progressively more acidified, and similar tolerance is not available for susceptible rotation crops such as barley, cool season legumes and canola. To maintain or improve productivity, these fields will eventually require applications of lime to increase soil pH. There are few local sources of high quality calcium carbonate, making lime application costly. In addition, not all soils in northern Idaho are in need of lime application, necessitating additional information on regional soil pH and other soil factors that are influenced by soil acidity. The goal of this study was to examine the ability of low to moderate rates of lime to improve the soil pH and subsequently crop health and yield.

Lime Type	Source of Lime	Dry Matter %	$CaCO_3$ Equiv.	Fineness Factor	Lime Score
Moses Lake Sugar Lime	Cascade Agronomics	92	84	85 to 98	65 to 75
Limestone (ground)	Pioneer Enterprises	99	95	80	75 to 89
NuCal (fluid lime)	Columbia River Carbonates	99	98	100	97

MATERIALS AND METHODS

Field trials were established at three locations in northern Idaho and eastern Washington to evaluate sources and rates of lime to increase soil pH. The sources of lime include ground limestone (Pioneer Enterprises), sugar beet lime (Moses Lake) and NuCal fluid lime (Columbia River Carbonates). The lime was applied to 4.9 m by 12.2 m plots at rates of 560, 1121 or 2242 kg calcium carbonate/ha in October of 2013 and immediately incorporated by to a depth of about 10 to 15 cm. An eleventh treatment consisted of 560 kg of NuCal and 1680 kg of ground limestone/ha. Winter wheat cv Madsen and spring pea cv Banner were seeded into replicated trials at all three locations. Soil samples were collected in May 2014 and 2015 to assess soil pH and other soil chemical properties. While soil pH was determined for all plots at 7.5 cm increments down to 30 cm, the soil chemical properties were measured only for the non-limed control and all plots receiving 2242 kg of calcium carbonate/ha. At the end of the growing season, the grain was harvested using a Wintersteiger plot combine.

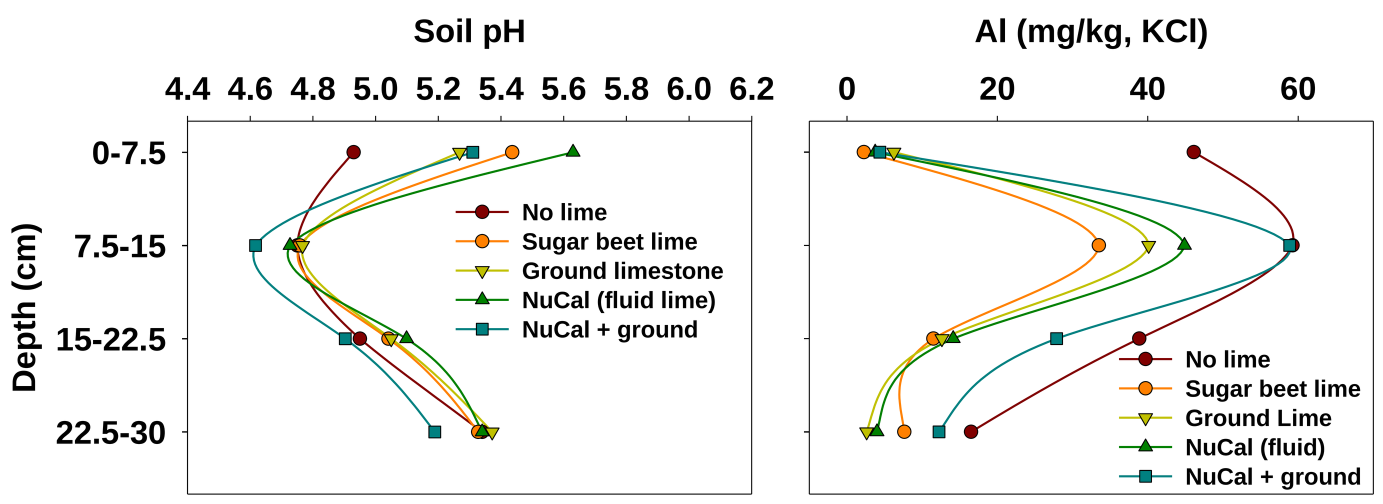


RESULTS

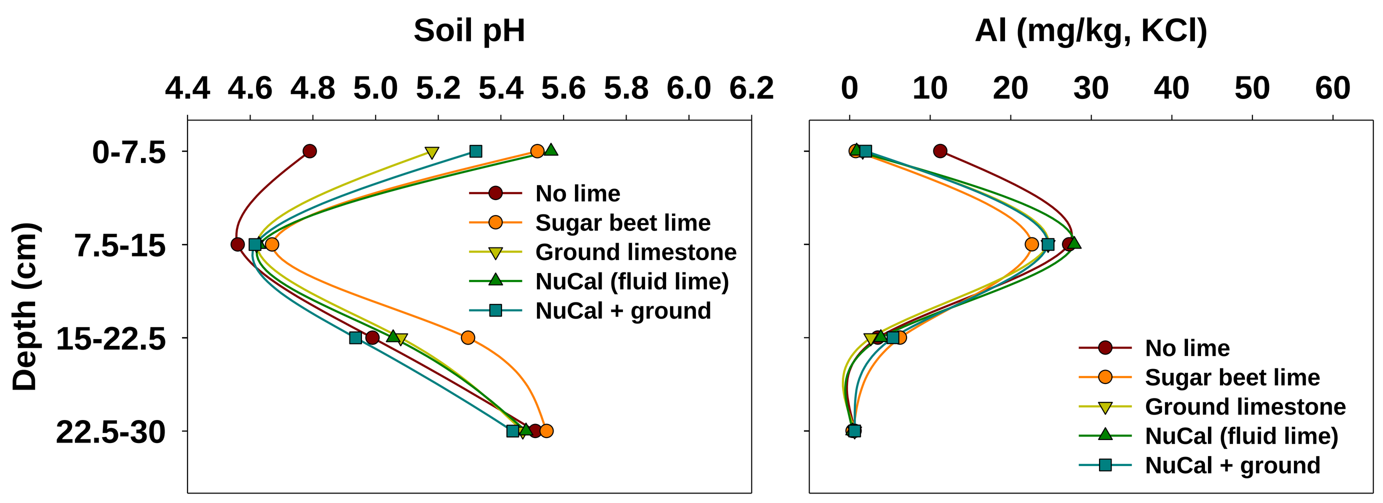
Eight months after lime application, the soil pH in the upper 7.5 cm of the non-limed soil ranged from 4.8 at Pullman and Winchester to 4.9 at Potlatch. Soil from the 7.5 to 15 cm layer tended to be slightly more acidic at all locations and then increased up to 5.3 at Potlatch to 5.7 at Winchester in the deepest sample (22.5 to 30 cm). All plots limed with 2242 kg calcium carbonate/ha improved the soil pH in the upper 7.5 cm of soil by 0.3 (NuCal + ground at Winchester) to 0.8 units (NuCal alone). The greatest increase in soil pH tended to be with either sugar beet lime or NuCal fluid lime. At this eight month sampling, very little change in the soil pH below the 7.5 cm depth was observed in limed plots.

KCl extractable aluminum (Al) was measured at all three locations, being more abundant in the upper 15 cm of soil. In the non-limed controls, Potlatch was observed to have the highest quantity of Al (46 to 59 mg/kg in upper 15 cm), while Pullman and Winchester had similar quantities (11 to 29 mg/kg in upper 15 cm). Lime application always resulted in substantially less Al in the upper 7.5 cm of soil at all three locations (0.8 to 6.3 mg/kg). At all locations sugar beet lime and NuCal fluid lime consistently resulted in the lowest quantities of Al. Below 7.5 cm, the change in Al concentrations was less obvious and in many cases, no different from the non-limed control.

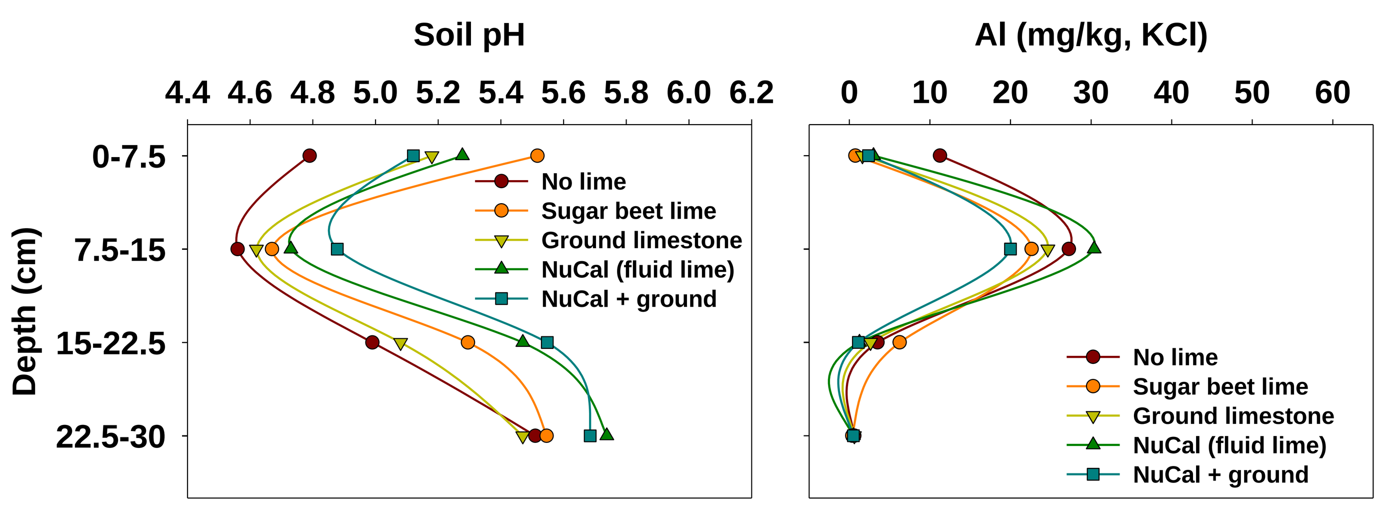
Potlatch, ID



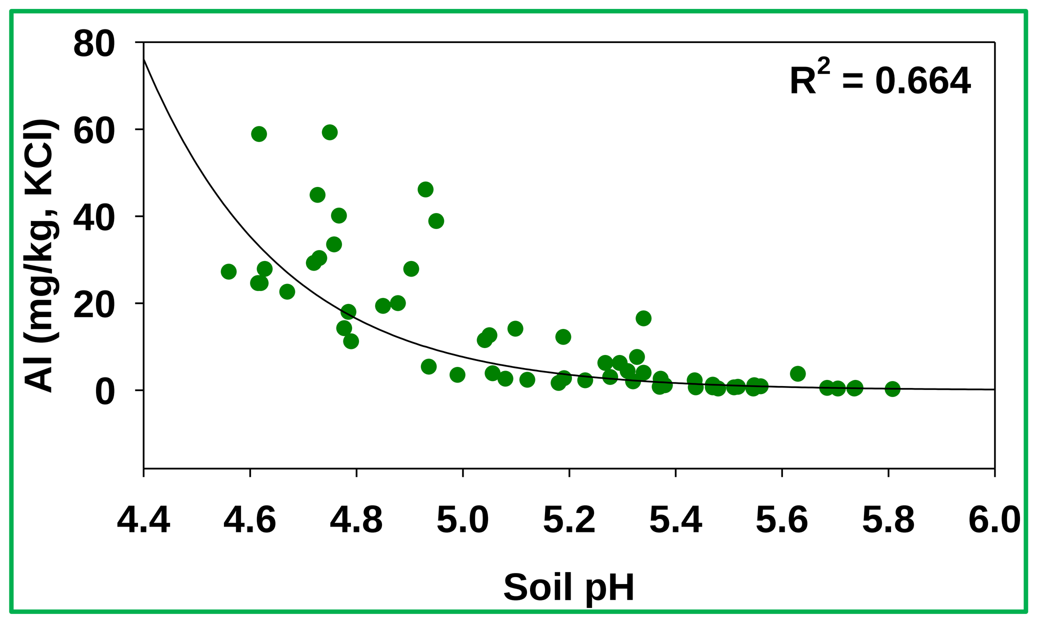
Pullman, WA



Winchester, ID



Soil pH from the limed and non-limed plots was correlated with the KCl extractable Al. As previously observed, the quantity of extractable aluminum is at or near 0 mg/kg in most samples with a pH of 5.2 or higher. However, at a pH of about 4.7 to 4.9, the quantity of Al increased substantially. Plants grown in fields that have a pH approaching this range may be at risk of developing aluminum toxicity and subsequent reductions in plant vigor and yield.



There was not a significant yield response to liming in either 2014 or 2015 for either winter wheat or spring pea. However, in 2014, there was an incremental increase in the pea yield at Potlatch with increasing lime concentration. In 2015, a significant heat event in late June resulted in abortion of most of the flowers in the spring pea, so yields were substantially reduced. In 2014, the wheat yield did not differ at either of the locations. However in 2015, the lowest yields at Potlatch and Pullman occurred in the non-limed plots and the highest yields tended to be observed in plots with the highest lime rates. No difference was found between the non-limed and limed plots at Winchester.

	Winter Wheat Yield (metric tons/ha)				
	2014		2015		
Treatments	Potlatch	Winchester	Potlatch	Pullman	Winchester
No lime control	2.82	2.82	4.78	6.26	4.71
Sugar beet 500	2.49	2.82	5.92	6.52	4.44
Sugar beet 1000	3.16	2.76	5.58	6.46	4.37
Sugar beet 2000	3.23	2.69	5.78	6.93	4.51
Camas 500	3.16	2.69	4.91	6.52	4.24
Camas 1000	2.96	2.96	5.25	6.86	4.71
Camas 2000	2.89	2.89	5.65	6.39	4.57
NuCal 500	3.16	2.76	5.58	6.32	4.51
NuCal 1000	2.96	2.56	5.72	6.52	4.24
NuCal 2000	2.49	2.96	5.45	6.86	4.64
NuCal + Camas 2000	3.09	2.69	5.58	6.46	4.57
Average	2.95	2.78	5.45	6.52	4.51
P-value	0.334	0.503	0.596	0.984	0.380
CV	15.5	9.2	13.8	12.7	6.6

	Spring Pea Yield (metric tons/ha)			
	2014		2015	
Treatments	Potlatch	Winchester	Potlatch	Winchester
No lime control	2.56	0.07	0.05	0.04
Sugar beet 500	2.55	0.08	0.05	0.04
Sugar beet 1000	2.72	0.05	0.05	0.05
Sugar beet 2000	2.95	0.06	0.06	0.04
Camas 500	2.51	0.05	0.05	0.04
Camas 1000	2.59	0.05	0.05	0.06
Camas 2000	2.70	0.05	0.05	0.04
NuCal 500	2.68	0.07	0.05	0.07
NuCal 1000	2.79	0.06	0.06	0.04
NuCal 2000	2.50	0.06	0.05	0.07
NuCal + Camas 2000	2.52	0.05	0.05	0.04
Average	2.64	0.06	0.05	0.04
P-value	0.847	0.298	0.967	0.812
CV	14.3	29.7	25.0	51.4

CONCLUSIONS

- Soil pH continues to be a concern in northern Idaho and eastern Washington. While plants grown in most fields do not show symptoms of Al toxicity, some fields may be nearing the tipping point in pH.
- Sources of lime were similar in response, but treatment with sugar beet lime or NuCal fluid lime tended to result in a greater increase in soil pH and decrease in Al concentrations.
- Small, non-significant yield responses were occasionally observed. Higher rates of lime may be required given the soil test results indicated a lime requirement of about 8200 to 11900 kg calcium carbonate/ha to reach a target pH of 6.0 in the top 15 cm.
- Rate and frequency of lime application will likely need to be tailored for each location to optimize crop yield.