Liming to Improve Nutrient Availability and Potato Yield

On-Farm Demonstration Research Manual

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British Columbia Ministry of Agriculture and Food

March 10, 2023

(Updated fall 2024)

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Acknowledgement:

Funding is provided by the Canadian Agricultural Partnership a five-year, $3 billion investment to strengthen the agriculture, agri-food and agri-based products sector, ensuring continued innovation, growth and prosperity.

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Background

Soils in Pemberton, British Columbia (BC) are typically acidic and low in phosphorus. Lime access on a large scale can be difficult in some areas of BC. Low soil pH has the potential to affect potato yield based on the effects it has on nutrient availability. Nitrate is more easily taken up by plants and sulfur is better retained in acidic soils (Miller 2021). Micronutrients including boron, zinc, manganese, iron and copper are more available in acidic soil compared to alkaline soil (Miller 2021). When soil pH drops below 5.5, aluminum becomes soluble and can cause toxicity, affecting plant roots (Miller 2021). The optimum pH range for phosphorus availability is 6-7. Below this range, phosphorus becomes insoluble as it binds with aluminum and iron and becomes inaccessible to plants; therefore the application of lime to increase soil pH may have a positive effect on phosphorus availability in the soil (Cifu *et al.* 2004; Jasim *et al.* 2020; Miller 2021). Cifu *et al.* (2004) conducted a 15-year study looking at the effects of soil pH and yield in potatoes based on three different rates of lime that were applied on acidic red soils in China. They found that lime application significantly increased soil pH and yield in potatoes, with the maximum yield increase by liming being 44.1%. The authors also noted that an increase in yield may continue for several years after lime application based on the rate that was applied. Hamilton and Bernier (1973) assessed the effect of limestone application on Kennebec potatoes in southwest Quebec and observed an increase in yield with limestone application. The increase in yield was similar to other studies however they also observed a decrease in water soluble phosphorus. A long-term study on the effects of lime application in potatoes in the UK also resulted in a significant increase in yield for most years of study as well as a significant positive correlation between phosphorus and yield in potatoes (Holland *et al*. 2019). Access to lime in certain areas of BC can be difficult and costly, but could lead to enhanced nutrient availability and increased yield. On-farm demonstration research is a way to evaluate the cost and benefits for individual farmers. Demonstration research can be replicated over a few years to gain confidence in the results.

Objective & Research Questions

The objective of this on-farm demonstration research is to evaluate the effect of liming of acidic soils on nutrient availability and potato yield.

The research questions that this project will be addressing are:

1. Does liming one year prior to growing potatoes increase potato yield?
2. Does liming allow for reduced inputs of phosphorus?

Trial Design

In order to evaluate the effect of liming, this demonstration trial will consist of one 5-acre area (Control) that will be farmed using normal grower practices, compared to a 5-acre area (Lime) that will receive the lime (Fig. 1). Each treatment area will be approximately 450 m long by 45 m (about 48 rows of potatoes) wide.

Figure 1. Trial layout consisting of two treatments - a control area and a limed area.

⇨ Represents trial area

Materials List

- 10-20 tons of lime
- Lime spreader
- Gem Star seed (for 10 acres)
- Stakes
- Marker
- Soil probe and bucket
- Plastic bags for soil samples
- Scale
- Potato size profile board
- Datasheet
- Camera

Methodology

Liming

Lime will be applied at a rate of 2-4 t/ac based on Terralink recommendations following soil testing in spring 2023. The lime will be applied in 2023 on an established hay field. Lime may be applied anytime during the summer 2023. Possible timings include early spring, after 1st cut, or in late summer before major rain events. Timing will not impact the performance of the lime; lime will start reacting in the soil only once incorporated. Lime will be applied using a spreader with an approximate 10-meter width spreading capacity. To cover the 45 m wide area, 4-5 spreader passes along the south edge of the field will be required. Lime will be incorporated in fall 2023 or spring 2024 to a depth of at least 10 cm.

Planting

Gem Star russet potato variety will be planted in spring 2024. A total of 10 acres will be planted with this variety to cover both the lime and control treatments.

Fertilizer rate

Depending on soil phosphorus levels, two rates of phosphorus (standard and reduced), may be tested the year potatoes are planted. With historically low phosphorus levels in the soils in Pemberton, a reduced phosphorus input may not be recommended. If a reduced rate is tested, a portion of the potatoes planted in both the lime and control area (e.g., four rows in each treatment) would receive the reduced rate and the rest would receive the standard phosphorus rate.

Control Full Fert. (44 rows)
Control reduced Fert. (4 rows)
Lime Full Fert. (44 rows)
Lime reduced Fert. (4 rows)

⇨ Trial design if reduced fertilizer rate is tested

Data Collection and Evaluation

Soil sampling

Soil samples will be taken three times: 1) In spring 2023 to establish a baseline 2) In spring 2024 prior to planting and 3) Post-harvest of potatoes in 2024.
Samples will be collected using a soil core (2.5 cm diameter) from 15 random locations in each treatment (Fig. 2). Samples will be taken to a depth of 15 cm. Soil from all cores will be mixed together to obtain one composite sample for each treatment. Laboratory analysis of soil samples will be completed by the Terralink Plant Science Lab in Abbotsford, BC.

Figure 2. Soil pH and phosphorus levels to be evaluated from soil testing.

The specific parameters that will be evaluated will be 1) Soil pH levels prior to liming compared to levels the following year and 2) phosphorus level to inform on appropriate fertilization to match crop needs.

Figure 3. Yield will be evaluated from 7' 3" length of rows which is directly transferable to ton/acre.

Yield and tuber size profile

Yield will be assessed from four locations in each treatment. In each location, assessment will be made from plants harvested from a randomly selected 7' 3" length of row (Fig. 3). The number of plants will be recorded. Yield will be assessed by counting the number of tubers from three tuber size categories, small (2" diameter and smaller), medium (2" to 3.5") and large (over 3.5"), and by recording the weight (lbs) of the unwashed (see below) potatoes from each of the three categories (Fig. 4). Mean total yield and mean yield per size category will be compared between treatments.

Figure 4. Yield for three tuber size categories will be recorded.

Record-keeping

The following information should be recorded for future referral (see attached datasheet):

Dates: lime application, lime/hay cultivation, potato planting, harvest assessment, soil sampling (spring 2023 and fall 2024).

Data collected: Soil pH, soil phosphorus levels, yield, number of tubers and yield per size category.

Photos: Lime application, potato plant vigor in control and lime area, yield and tuber profile.

Trial Schedule	
Date	**Description of Activities**
Spring 2023	Take baseline soil sample
Summer 2023	Apply lime to hay field
Fall 2023 or spring 2024	Cultivate lime/hay
Spring 2024	Take soil sample prior to planting
Spring 2024	Plant Gem Star in trial area
Fall 2024	Conduct yield and tuber size profile assessments by hand
Fall 2024	Host a field day before full field harvested
Fall 2024	Take post-harvest soil test
Fall 2024	Analyse data and prepare a trial summary

Budget for Supplies (new)		
Item	**Description**	**Cost**
Lime	10-20 tons of lime; $90/ton	$900-1,800
Trucking	Trucking cost for lime; $50/ton	$500-1,000
Soil test (2023-2024)	Terralink Plant Science Lab fees: $92.50 per sample, 6-8 samples	$555-740
Plastic bags	Large plastic bags for soil sampling	$10

Labour (outside of normal farm practices)		
Item	**Description**	**Hours**
Lime	Equipment calibration and lime spreading	4
Soil sampling	Three samplings	6
Yield	Two people one day	16
Field day	Promo and hosting	8
Summary	Analyse data and prepare a trial summary	8

Potential Funding Options

1. BC Climate Agri-Solutions Fund (BCCAF) - Nitrogen Management.

Datasheet Template

Activity	**Date**
Spring 2023 soil sampling	
Lime application	
Cultivation of lime/hay	
Spring 2024 soil sampling	
Potato planting	
Harvest assessment	
Post-harvest soil sampling	

Soil sampling

Treatment	Timing	pH	Phosphorus
Control	Spring 2023		
Lime	Spring 2023		
Control	Spring 2024		
Lime	Spring 2024		
Control	Fall 2024		
Control Reduced Rate	Fall 2024		
Lime	Fall 2024		
Lime Reduced Rate	Fall 2024		

Yield and tuber size profile

Treatment	Sub-Sample #	# Plants	# Tubers	# Small	# Medium	# Large	Total Yield (lbs)	Lbs Small	Lbs Medium	Lbs Large
Control	1									
Control	2									
Control	3									
Control	4									
Control P Reduced Rate	1									
Control P Reduced Rate	2									
Control P Reduced Rate	3									
Control P Reduced Rate	4									
Lime	1									
Lime	2									
Lime	3									
Lime	4									
Lime P Reduced Rate	1									
Lime P Reduced Rate	2									
Lime P Reduced Rate	3									
Lime P Reduced Rate	4									

Note: If different phosphorus (P) fertilizer rates (full and reduced rates) are not tested, data in the grey cells would not be collected.

References

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