Soil
FACTSHEET

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Liming Acid Soils in Central B.C.

INTRODUCTION

The acidic nature of agricultural soils limits the productivity and range of crops that can be grown. Approximately 53% of the agricultural soils of Central B.C. are acidic. Soils near Prince George, Smithers and McBride tend to have a higher potential to be acid than soils near Vanderhoof, Quesnel or Williams Lake. There are exceptions, and acidic soils have been found on alluvial terraces along the Nechako River at Fort Fraser and on some terraces along the Quesnel River.

Currently, lime is not used in Central B.C. because of high costs and acid tolerant alternative crops. However, with time, soils will continue to acidify and the current crops may have their production potential reduced. There are some small areas where that has already occurred in the region. The alternative is to lime soils and grow crops with higher yield potentials.

SOIL pH and ACIDITY

Soil acidity is represented by the hydrogen (H) concentration of the soil water content. A scale has been developed to represent the relative degree of hydrogen concentration. The acidic end of the scale starts at pH 1.0, and ends at 14.0, the most alkaline level. Neutrality exists at the mid point value of 7.0.

Most crops will grow well over a broad pH range, but some crops are very sensitive to the soluble aluminum (Al), manganese (Mn) or iron (Fe) levels found in soils below pH 5.5. Low fertility may occur on very acidic soils, and is often due to low phosphorus availabilities. Crop sensitivity to high hydrogen levels are usually not found until the soil pH drops below 5.0.

The soil hydrogen levels affect **Rhizobium** bacteria, which fix atmospheric nitrogen for legumes. Differences exist among the various strains of **Rhizobium**, so that a moderately low (below 6.0) pH may affect the kind associated with alfalfa, but not those of alsike or red clover. Soil pH lower than5.5 will begin to affect the **Rhizobium** of most legumes.

Crops can be grown quite satisfactorily at lower pH levels on organic than mineral soils. Acidic organic soils do not have the potential for developing the elemental toxicities of acidic mineral soils. However, shallow organic deposits or muck soils that have a high mineral contents may have similar potentials for toxicities as acidic mineral soils.

The pH ranges which provide optimum growing conditions are:

1. Mineral soils - pH 5.5 to 8.0
2. Organic soils - pH 4.5 to 6.0

There are particular crop sensitivities even within these ranges, and some examples can be seen in **Table 1**.

TABLE 1 Crop Tolerance to Soil Acidity

pH 5.0*	pH 5.5	pH 6.0
Canola	Barley	Alfalfa
Oats	Bromegrass	Sweet Clover
Alsike clover	Russian Wild	
Red Clover	Ryegrass	
Orchardgrass		
Timothy		

**While crops may tolerate the soil acidity, nutrient deficiencies due to high soluble aluminum or iron may begin to occur which affects growth of all crops*.

ESTIMATING LIME REQUIREMENTS

Soil pH measures the degree of acidity, but cannot be used to estimate the lime needed to reduce the soils acidity. Soil test laboratories use special lime requirement test procedures to estimate the required lime rates needed to adjust soil pH. The goal is to raise soil pH beyond "target" pH levels. The most common target pH levels are 5.5, 6.0 and 6.5 for mineral soils and 4.5, 5.0 and 5.5 for organic soils. An example of using these target pH levels with appropriate crops can be seen in **Table 1**. The need to lime a crop will depend upon its lower pH limit beyond which the crop dies or drops in production.

Soil testing laboratories may differ in the depth of soil to which they are giving their recommendation. A lime recommendation made on the basis of an 8 inch soil depth will be 30% higher than if it was made for a 6 inch depth. Adjustments can be made to the lime rate once it is understood what the test laboratory recommendation depth is, and what depth the lime will actually be worked into the soil. The lime requirement is affected by the soils "buffering capacity", which is its ability to resist radical changes in pH. Particular soil components have a major impact on the degree of buffering capacity.

High clay or organic matter contents increase the soils buffering capacity. While clay or peat soils will not acidify as quickly as silt or sandy soils, it takes more lime to raise the pH of clay or peat.

The effective period of liming a soil depends on the climate, soil type and the amount of crop growth. In the Central region, the effective period may range from 5 to 10 years, depending upon whether dry or wet seasons are encountered. When the soil pH begins to drop several years after liming, a smaller amount may be applied to raise it up the target pH level. **Figure 1** presents a generalized picture of the rise and fall of soil pH over time.

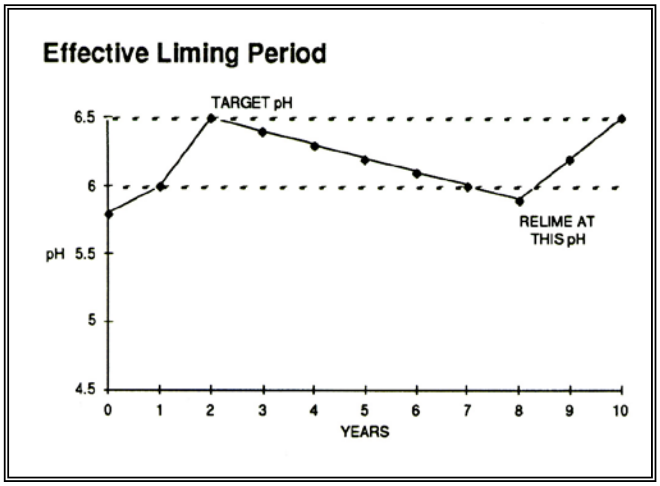

Figure 1

EFFECTS OF LIMING

Liming changes the biological, structural and chemical components of soils. How these changes improve plant growth conditions is explained in the following sections.

1. Soil Organisms

Organic matter decay is slow in acid soils, due to the low activity levels of soil organisms. Liming soils improves the environmental conditions for these soil organisms and results in an improved nutrient release for plants.

Plant disease organisms are affected by liming. The club root disease organism (**Plasmodiophora brassicae**) affects cabbages, turnips, broccoli, etc. and thrive under acid soil conditions. Liming has been recommended as a disease control method. Currently, the lime recommendation to control club root disease should raise soil pH to 7.0, or above. This requires a considerable amount of lime if pH levels are low, or if soils have high buffering capacities.

The other crop disease affected by liming is common scab of potatoes (**Streptomyces scabies**). Unlike the club root organism, the incidence of potato scab is increased with liming. It is advisable not to lime soils where potatoes are to be grown unless the pH is below 4.0–4.5.

2. Soil Structure

There is a widely held belief that liming clay soils improves the structure, or simply “breaks it up”. While there is limited research that shows reduced soil crusting, improved soil aggregate stability and improved surface water infiltration after liming soils does occur, it is not clear that it is a direct chemical effect. Liming accelerates organic matter decomposition which produces by-products which improve soil structure. It is likely that the main effect on soil structure is due to the development of humus in the soil.

3. Nitrogen & Sulphur

Nitrogen and sulphur are found in the organic matter portion of soils and must be converted to mineral forms through microbial decay to become available for plant growth. This process is slow in highly acidic soils, but can be improved by liming.

Liming stimulates the biological activity of a soil and part of the crop response that results is due to the increased mineral nitrogen and sulphur.

Raising the soil pH above 6.0 favours the atmospheric nitrogen fixation ability of legumes, especially alfalfa or sweet clover. Some legumes such as red or alsike clover can adequately fix nitrogen down to pHs as low as 5.0.

4. Phosphorus

Under acid soils, soluble compounds of aluminum (Al) and iron (Fe) combine with phosphorus into insoluble compounds, thus making phosphorus unavailable to crops. Liming will precipitate aluminum and iron in their hydroxyl forms ($Al(OH)_3$), enhancing the efficiency of phosphorus fertilizer uptake.

5. Calcium & Magnesium

Agricultural lime contains calcium and some magnesium. Liming supplies these elements for plant uptake. Dolomitic limestones contain more magnesium than calcitic limestones and can be used in situations where soil magnesium levels are low.

6. Aluminum & Manganese

These elements are toxic at low pH levels. Some crops are very sensitive to soluble aluminum and manganese. Currently, the toxic soluble aluminum level extracted with .02 M $CaC1_2$ is set at 1-2 ppm (parts per million). These levels are not common when soil pH is above 5.5. This value should be used as a guide only, as the tolerance to aluminum can vary even between varieties of barley which is generally considered to be an aluminum sensitive crop.

7. Boron, Cobalt, Copper, Iron & Zinc

Boron, cobalt, copper, iron and zinc (B, Co, Cu, Fe, Zn) are micronutrients which are most available for plant uptake under acidic soil conditions. Liming to recommended pH levels will not affect the availability of these nutrients appreciably. High lime rates may temporarily induce micronutrient deficiencies. Many soils have low soil boron contents and liming may induce a deficiency. Fertilizing with boron at recommended rates will avoid an induced deficiency.

8. Molybdenum

Molybdenum (Mo) is a micronutrient which plays an important role in legume nitrogen fixation. Molybdenum availability is improved by liming soils. High molybdenum levels in forages may interfere with copper availability. If land is to be limed, the copper and molybdenum levels should be monitored in feeds to avoid problems in livestock nutrition.

SOURCES OF LIMING MATERIALS

1. Limestone

Central B.C. has many sources of limestone deposits and some marl deposits. Currently, most deposits are being used for industrial purposes, such as in the pulp and paper industry. Limestone deposits are concentrated along the Rocky Mountains east and north of Prince George, with smaller deposits near Vanderhoof and Smithers.

A limestone deposit with calcium carbonate value of 90-100% indicates that the material will make a good liming agent. Results of testing local limestone in Central B.C. have shown that there are deposits with high calcium carbonate levels. Limestone requires crushing and passing through a series of screens to achieve the right particle size to be graded as agricultural lime.

2. Marl

Marl is the mixture of clay and calcium carbonate. It is found where many small water animals deposited their shells in shallow lakes, or in natural seepage areas. The value of marl is that it does not have to be highly processed to use it as a liming material. However, marls are highly variable in their calcium content and their high clay and silt contents make marl difficult to reduce it to a form that can be spread evenly across a field.

3. Hydrated Lime

Hydrated lime, or calcium hydroxide ($Ca(OH)_2$) is available in bagged form. It is slightly caustic and extremely powdery making handling unpleasant. It provides a slightly faster reaction in the soil, but is as effective as limestone. The problem with this material is its expense and its associated handling qualities.

4. Waste Lime

There are a variety of waste lime products. The production of acetylene gas produces a waste lime product that is primarily $Ca(OH)_2$. Some pulp and paper mills produce waste lime, usually $Ca(OH)_2$. The calcium values of these products are usually high if they have not been contaminated with other materials. They are often stored outdoors and their moisture content may be high. One possible way to apply these kinds of materials is to suspend the lime in water through agitation and then apply the liquid to the land.

FIELD MANAGEMENT OF LIME

Ground limestone is a very unreactive material and is quite insoluble in water. In order to react completely with the acid soil, lime particles must be brought into close contact with the soil particles. The lime must have a high amount of fine powdered material that becomes well mixed into the soil. Crop seeding can follow after 4-6 weeks. If cultivations are kept to a minimum, then it is preferable to apply the lime in the fall before seeding, allowing the lime to react with the soil.

1. Application

To apply lime evenly, large specially adapted field spreaders are required. Normal bulk fertilizer spreaders are not adequately designed to handle ground limestone, having inadequate chain drives, small gates and light duty spinners.
Even with adequate field spreading equipment, the variability can be high. Low wind speeds may blow the fine portions of the lime. Some wind spreaders use skirting to reduce the movement of the lime fines. Wet limestone may tunnel over chain drivers in the spreader box and not flow at even rates to the spinners. Poor driving patterns may also result in overlaps or gaps in the spreading of lime.

2. Incorporation & Rates

Rototilling lime into soil achieves the best possible incorporation. Other cultivations which churn the soil over time are also recommended. Cultivating and disking are procedures which will incorporate lime. Several operations may be needed to ensure that full incorporation to 6-8 inches occurs. Moldboard plows tend to bury lime which then has to be incorporated with secondary tillage to spread the lime through the plow layer.

Broadcasting lime onto sod is an inefficient method of reducing soil acidity. The applied lime should be calculated on the basis of correcting acidity in the top 10 cm (4 inches) rather than 15 or 20 cm. Thus rates for liming sod should be reduced in relation to cultivated crops, or when lime is applied prior to seeding a grass or legume crop. The surface application of lime may result in higher loss of nitrogen from broadcast area fertilizers.

It is difficult and inefficient to incorporate lime at rates in excess of 3 tons/acre (6.7 tonnes/ha). When lime recommendations are in excess of 3 tons/acre, applications should be split, and each application worked well into the soil.

CROPPING STRATEGIES FOR ACID SOILS

The main crops affected by soil acidity in Central B.C. are alfalfa, sweet clover and barley when pH’s are in the 5.0 to 6.0 pH range. Alternative acid tolerant crops are recommended when liming is prohibitively high. The alternatives to alfalfa at pHs below 5.8 are alsike, red clover and birdsfoot trefoil.

Oats are acid tolerant and can be used in place of barley when appropriate. Bromegrass and orchardgrass may be replaced with timothy and reed canarygrass when the pH drops below 5.5.

Nitrogen and sulphur fertilizers are acidifying agents. The conversion of ammonium to nitrate is a very acidifying process, while adding sulphates is akin to adding sulphuric acid to soils. Achieving good crop yields should override concerns about increasing good soil acidity with fertilizers.

CENTRAL INTERIOR LIMING TRIALS

Liming trials were conducted by the B.C. Ministry of Agriculture and Food, Resource Management Branch from 1983 to 1986. The objectives were to:

- Collect crop response data to liming on major agricultural soils in Central B.C.
- Evaluate the newly introduced Shoemaker McLean-Pratt (SMP) buffer-pH lime requirement test.

The trials were conducted on a small plot basis with calcium hydroxide $Ca(OH)_2$ rototilled into an approximate depth of 10 cm (4 inches). The soils were chosen for their differences in texture and acidity levels. Barley was the first crop for 1983, followed by Peace alfalfa for 1984 to 1986.

The information in **Table 2** indicates the variability of lime required to achieve target pH levels (pH 6.0 and 6.5) between the sites selected for these trials. This is due to the difference in texture, organic matter, soil acidity level and the buffering capacity of the soils.

TABLE 2 Variable Lime Rates Required to Reach Target pH

	Estimated Lime Requirement (Tons/acre)		
Soil Type	**Average pH**	**Target pH 6.0**	**Target pH 6.5**
Bednesti-silt loan	5.9	0.0	2.0
Driftwood – loam	5.8	2.0	3.0
Pineview-clay	5.5	5.4	6.7
Saxton-sandy loam	5.6	1.3	1.8

The information in **Table 3** shows that 3 years after the initial liming, the actual pH levels achieved varied from the target pH levels. Fluctuations in soil pH occur seasonally, and it is quite normal for a 0.3 unit variance to exist. The SMP buffer-pH method came close to predicting the correct lime rates necessary to achieve the target pH levels. From a field management perspective, raising the soil pH within the 6.0 to 6.5 range is the prime objective for alfalfa production. As long as the variation in soil pH falls within the range of 6.0 to 6.5, then the objective of liming has been reached.

TABLE 3 Soil pH Variation with Liming

Soil Type	**Original pH**	**Target pH 6.0**	**Target pH 6.5**
Bednesti	5.9	---	6.2
Driftwood	5.8	6.5	6.8
Pineview	5.5	6.1	6.4
Saxton	5.6	5.8	6.3

Alfalfa yields averaged a 0.5 ton/acre increase on the limed versus unlimed plots (see **Table 4**). This is somewhat misleading as the unlimed plots quickly filled in with acid tolerant grasses and clovers. The limed plots had a much higher alfalfa content than the unlimed plots, and had a higher protein value. The actual yield increases on a pure alfalfa only basis were more in the order of a 1 ton/acre increase.

TABLE 4 Yield Increase of Alfalfa on Limed Soils

Target	**Soil pH**	**Average Yield Increase Over Unlimed Alfalfa** T/ac
Bednesti	6.5	0.5◆
Driftwood	6.0	0.7◆
	6.5	0.4
Pineview	6.0	0.3✵
	6.5	0.5
	Average	0.5

◆ Average of two production years

✵ Average of three production years

NOTE Data for the Saxton site was not included due to only 1 year of data collection.