Atlantic Soils Need Lime

Most agricultural soils in the Atlantic Region are naturally acidic and liming is essential if they are to be productive. Inadequate use of limestone has been a major limiting factor in crop production in this region since farming began. Failure to lime acid soils reduces crop yields and wastes much of the farmers' fertilizer investment. Relatively large applications of limestone are required to initially correct soil acidity and subsequently, smaller applications are required to maintain the soil pH in a desirable range for optimum production for most crops.

What is soil acidity?

Soil acidity is caused by the presence of hydrogen (H+) ions and the two types of acid that supply the hydrogen ions to the exchange complex of the soil are inorganic and organic. Soil acidity increases as soil nutrients such as calcium (Ca), magnesium (Mg) and potassium (K) are leached from a soil and replaced by H ions. Some of the acidity of soils in the Atlantic Region results from: (1) insufficient natural lime in the soil; (2) the use of fertilizers; (3) leaching due to rainfall and (4) crop removal. The hydrogen ions which are present in soil solution represent active acidity and those attached to clay particles and organic matter are called reserve acidity. The pH of a soil is a measure of the active acidity only, yet most of the acidity is held in the reserve form in most soils. In liming a soil, enough limestone must be applied for the calcium and magnesium in the limestone to replace both the active and reserve acidity in the soil. The amount of limestone required depends on the soil pH, organic matter content and the amount and type of clay present in the soil. If the amount of clay and organic matter is high (heavy soil), the soil has a high cation exchange capacity (CEC), and thus a large ability to hold nutrients (calcium, magnesium, potassium and micronutrients). Sandy soils have a low cation exchange capacity and low reserve acidity. This is why different amounts of limestone are required to raise different soils from one pH level to another. Soil testing takes into account both forms of acidity in determining the lime requirement.

Alkaline soils have pH values greater than 7.0 and require no limestone additions. Very few soils in the Atlantic region are alkaline. Acid soils have pH values below 7.0. A soil with a pH of 6.0 is mildly acidic, while one with a pH of 5.0 is ten times more acidic and a soil with a pH of 4.0 is one hundred times more acidic than a soil with a pH of 6.0. Soils below a pH of 5.0 usually contain levels of plant available aluminum and manganese which are toxic to plant growth.

Some aspects of the cation exchange capacity concept follow:

Soils with high clay content

- High CEC
- More lime required to correct acidity
- Greater capacity to hold nutrients in a given soil depth
- Hard to work
- Tillage costs increase
- High water-holding capacity-, drainage may be a problem

Soils with high sand content

- Low CEC
- Nitrogen and potassium leaching more likely
- Easily worked
- Tillage costs relatively low
- Low water-holding capacity; irrigation frequently necessary

What are the benefits of liming?

1. Very acid soils contain soluble aluminum and manganese at toxic levels. Liming thesoil changesthe aluminum (Al) and manganese (Mn) to less soluble chemical forms, thus greatly reducing their availability to the plant roots.

2. Liming increases the plant availability of phosphorus (P), and molybdenum (Mo) from the soil.

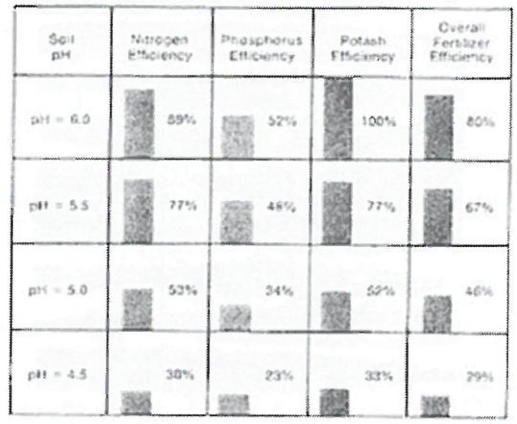
3. All liming materials supply calcium and reduce acidity. Dolomitic limestone supplies both calcium and magnesium.

4. Liming promotes increased activity of soil micro-organisms which can result in faster decomposition of added organic matter and increased availability of organic nitrogen (N), and sulfur (S) and phosphorus to plants.

5. Liming improves efficiency of fertilizer use. (see Figure 1)

6. Liming improves soil structure by stabilizing soil aggregates, thus reducing soil erosion.

Figure 1. Fertilizer Efficiency at Various Soil pH Values.



How much lime is needed?

Results of soil tests in the Atlantic region show that approximately 70% of the soils need from 2 to 8 tonnes of limestone per hectare to correct present acid soil conditions. In extreme cases 16 tonnes or even more may be required per hectare. Periodic maintenance applications equivalent to approximately 0.5 tonnes per hectare per year are required to maintain a given pH.

The following factors determine the amount and type of limestone needs of a given soil:

1. Soil pH

2. Amount of reserve acidity in the soil 3. Depth of plowing

4. Magnesium level in soil

5. pH requirement of the crop under consideration

6. Soil texture (content of sand, silt and clay)

7. Fertilizer used

These factors must be considered collectively. Therefore, limestone recommendations should be made by the soils advisory laboratory on the basis of a truly representative soil sample. Table 1 indicates the effect of some of these factors on the lime requirement of soils.

Table 1 - Limestone Required (tonnes/ha)* to Change the pH of the Plow Layer (18 cm**) of various soils.

Texture of Plow Layer	Desired pH	Soil pH (in water) before Liming 4.5	5.0	5.5	6.0
		tonnes/ha ***			
Clay loam	6.5	13	11	8	4
	6.0	11	8	4	0
	5.5	8	4	0	0
Loam	6.5	11	9	7	4
	6.0	9	7	4	0
	5.5	7	4	0	0
Fine Sandy loam	6.5	9	7	4	2
	6.0	7	4	2	0
	5.5	4	2	0	0
Sandy loam	6.5	7	5	3	2
	6.0	5	3	2	0
	5.5	3	2	0	0

* Values should be adjusted for different depths of plowing.
** 1 cm = 0.394 inches
*** 1 tonne/ha = 0.446 tons/acre

Limestone - kind and quality

Liming materials differ in their chemical composition, neutralizing value, fineness of grind and speed of reaction with the soil. Choice of a liming material should not be made on the basis of cost alone because **The Cheapest Limestone may not be the most satisfactory for your particular soil requirements.** The limestone chosen should raise the pH to the required level as well as provide a proper balance of calcium and magnesium in the soil. Agricultural limestones are composed of either calcium carbonate called calcite limestone or a natural calcium magnesium carbonate combination called dolomitic limestone. Because agricultural limestone contains impurities, pure calcium carbonate, with a neutralizing value of 100, is used as a "standard" to compare the effectiveness of liming materials. Table 2 gives some common limestone analysis.

Table II. - Sensitivity of Crops to Boron.

Very Sensitive (up to ½ kg B per ha Broadcast)	**Sensitive** (Up to 1 kg B per ha Broadcast or 0.5 kg in Drills)	**Tolerant** (Up to 2 kg B per ha Broadcast or 1 kg in Drills)	**Very Tolerant** (Up to 4 kg B per ha Broadcast or 2 kg in Drills)
Cucumbers Snap Beans Strawberries	Barley Lima Beans Oats Potatoes Rye Squash Timothy Wheat	Carrots Celery Corn Clover Lettuce Onions Peas Peppers Spinach Tomatoes	Alfalfa Apples Beets Broccoli Brussels Sprouts Cabbage Cauliflower Radish Rutabaga Turnips

Fineness of grind is a very important factor that influences the rate of reaction of a limestone in the soil. The finer a limestone is ground the more quickly it will react when thoroughly mixed with soil. This is due to the increase in surface area of the limestone particles caused by finer grinding as illustrated in Figure 3.

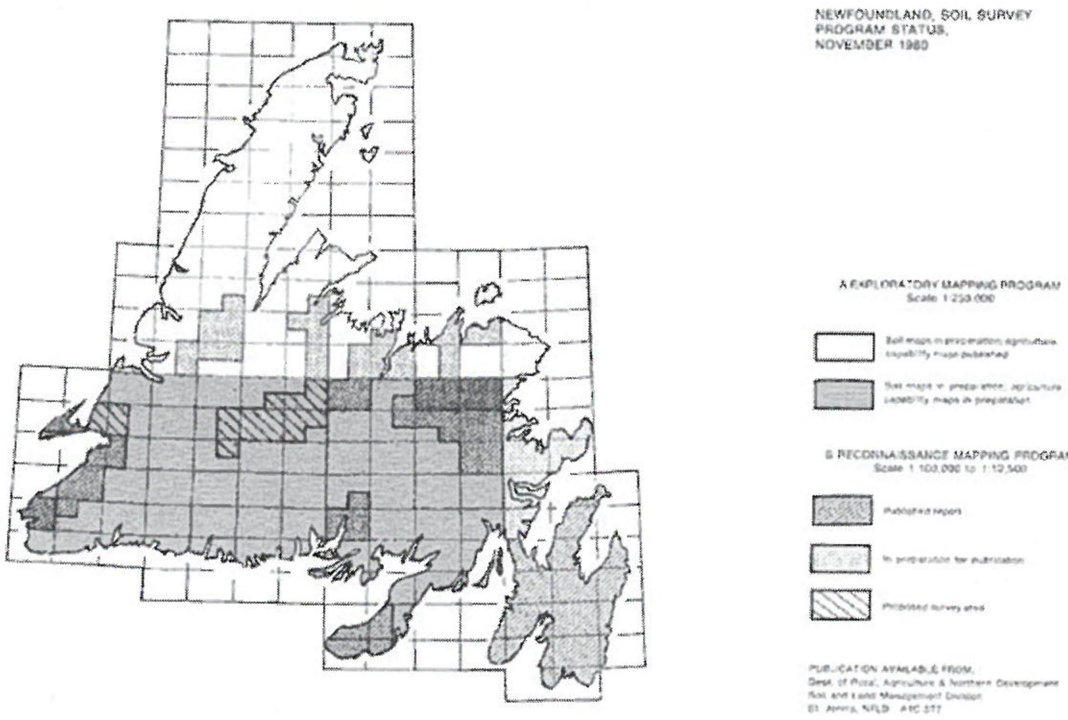


Figure 3 - Soil Survey Map of Newfoundland

The large number of very small particles in finely ground limestone allows the limestone to be more thoroughly distributed throughout the soil and in more direct contact with soil particles than would occur with coarsely ground limestone. Limestone particles larger than 2.00 mm (9 mesh TYLER) screen, such as grit fillers used in granular fertilizers, have very little effect on soil pH. The rate of limestone reaction increases with decreasing particle size. A finely ground limestone, all of which will pass through a 2.00 mm screen and 60% of which will pass a 0.15 mm (100 mesh TYLER) screen has sufficient fine particles to give quick results, yet has enough coarse particles to prolong its effect. (See Figure 4.)

When and how should limestone be applied?

The primary reason for applying lime is to adjust the pH rather than to supply plant nutrients.

Remember: it takes twice as much lime to correct the acidity of the cultivated layer of a soil plowed 20 centimeters deep as it takes to correct the acidity of the same soil plowed only 10 centimeters deep.

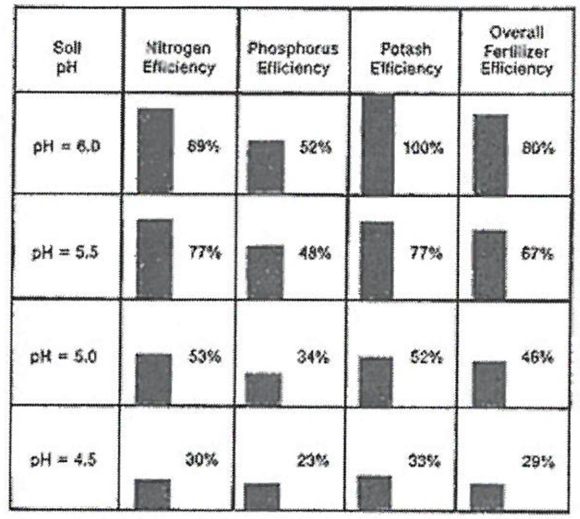


Figure 4 - Fertilizer Efficiency at Various Soil pH (water) Values. (Potato Councillor, September 1979, Page 8)

A most important consideration is limestone incorporation into the soil. Unless the limestone is thoroughly mixed to full plow depth, only a part of the rooting zone will be favourable for plant growth. For Fall applied lime, the possibility of surface runoff is another good reason for incorporation of lime into the soil. Limestone applied on the surface, as in a pasture, penetrates very slowly and requires many years to correct the acidity to plow depth. For best results, land to be planted to pH-sensitive crops should be limed the previous Fall. Some benefit is derived from Spring application. On areas where a permanent sod is maintained, light applications are preferable to one heavy application.

If the recommendation is 6 or less tonnes per hectare, the limestone should be applied before or after plowing and be thoroughly worked into the seed bed. If the lime recommendation is greater than 6 tonnes per hectare, plow down one-half and work the other half into the surface before seeding. It is recommended that not more than 6 tonnes per hectare be applied in one application and for practical reasons, not more than 12 tonnes in one year. No more than 4 tonnes per hectare should be applied to permanent sod in one year. When there is a large lime requirement (in excess of 12 tonnes per hectare) the lime should be applied over several years.

Remember: the lime requirement (or "Required Application") is the amount of limestone needed to raise the soil pH to 6.5 (in most cases) as determined by soil tests. The lime recommendation is based on the lime requirement.

The equipment used for liming must spread limestone uniformly. The introduction of bulk spreading equipment by custom operators has provided an efficient means of spreading limestone on large areas of land in a minimum of time. Custom spreading equipment with floatation tires allows spreading when soil is too soft for conventional equipment. Custom spreading eliminates handling of the limestone by the farmer but attention to the uniformity of the spread must be maintained.

Lime losses from the soil

As calcium and magnesium are lost through leaching and crop removal, the acidity of the soil is increased and soil pH levels are lowered. It is advisable to retest soil 1 to 2 years after liming to measure changes in pH. With the high rates of fertilizer in use today, the soil pH may drop rapidly, thus requiring very close attention to the liming program.

Remember: Soils of the Atlantic region require at least 400 to 500 kg of limestone per hectare per year to maintain a constant pH. This need for maintenance cannot be stressed strongly enough.

Effect of acid rain on acidity

It is estimated that the plow layer in the Atlantic region requires only about 60 kg limestone per hectare per year to neutralize the acidity from acid rain. The acidity results from sulfuric and nitric acids formed through reactions between sulfur and nitrogen (released into the air from the combustion of fuels) and atmospheric moisture.

Effect of fertilizers on soil acidity

The nitrogen-supplying materials in essentially all commonly used fertilizers contribute acidity. Table 3 indicates the amount of limestone needed to counteract the acidity caused by various fertilizers. For example, an application of 100 kg of nitrogen per hectare per year (300 kg of ammonium nitrate) will require 180 kg of limestone per hectare to counteract the fertilizer acidity. If limestone is applied only every third year, 540 kg per hectare will be required for neutralization of fertilizer acidity. Similar calculations may be made for mixed fertilizers if the amounts and forms of nitrogen they contain are known.

Calcium and Magnesium Needs in the Atlantic Provinces

Calcium and magnesium are essential elements in the nutrition of plants.

Calcium deficiencies, though rare, may also be encountered Linder low pH conditions and are easily corrected by application of either limestone or gypsum (calcium sulphate).

The magnesium content of many Atlantic soils, while naturally low, can be easily corrected with either dolomitic limestone or the application of fertilizers containing magnesium. Apples, forages, oats, barley, corn, potatoes, and tobacco are sensitive to magnesium deficiency. Magnesium deficiency usually occurs in coarse-textured acid soils limed in the past with calcitic limestone, oyster shell, blast lime or marl. Magnesium deficiency may also be induced by heavy potassium fertilization on soils approaching a deficient Mg level.

Dolomitic limestone is the most economical source of magnesium available in this region for application to the soil. When liming soils low in magnesium, dolomitic limestone is highly recommended. If the soil pH is already high and magnesium is needed, it may be supplied for the current crop year as an additive in a blended fertilizer or as a foliar spray. Conversely, if the soil Mg level is adequate and lime is required, calcitic limestone may be used to raise the soil pH to the required level.

A dolomitic limestone containing 38% magnesium carbonate will supply 1 10 kg of magnesium per tonne. Most of this magnesium in finely ground limestone is available to plants. If the same limestone contains 53% calcium carbonate it will supply 212 kg of calcium per tonne. A calcitic limestone containing 88% calcium carbonate will supply 352 kg of calcium per tonne.

Gypsum is a source of calcium and sulfur. It has little if any effect on soil pH and can be used for crops grown on more acidic soils requiring improved Ca levels, (e.g. potatoes). **Gypsum is not a living material.**

Consequences of Overliming

Liming soils to pH 6.5 or higher restricts the availability of some micronutrients. For example, the availability of boron decreases above pH 6.5. Higher than normal amounts of boron fertilization may be needed for crops having a high boron requirement to overcome the effect of liming in excess of pH 6.5. Liming the

Table III - Approximate Reductions in Fertilizer Application where Manure is Applied

Solid Manure	**Liquid Manure**	**Subtract from Fertilizer Requirement**				
tonnes per hectare*	cubic metres per hectare**	Nitrogen N(kg/ha) F&W	Spr	SprC***	Phosphate P_2O_5(kg/ha)	Potash K_2O(kg/ha)
		Cattle or Mixed Livestock Manure				
20	50	25	50	60	20	90
30	75	40	75	90	30	135
40	100	50	100	125	40	180
		Swine Manure				
20	30	25	50	60	25	35
30	45	40	75	90	35	50
40	60	50	100	125	50	70
		Poultry Manure				
4	10	20	45	60	25	22
10	25	50	110	140	60	44

* 66 bu manure = 1 metric tonne approximately. 10 tonnes/ha = 4.5 ton/acre.

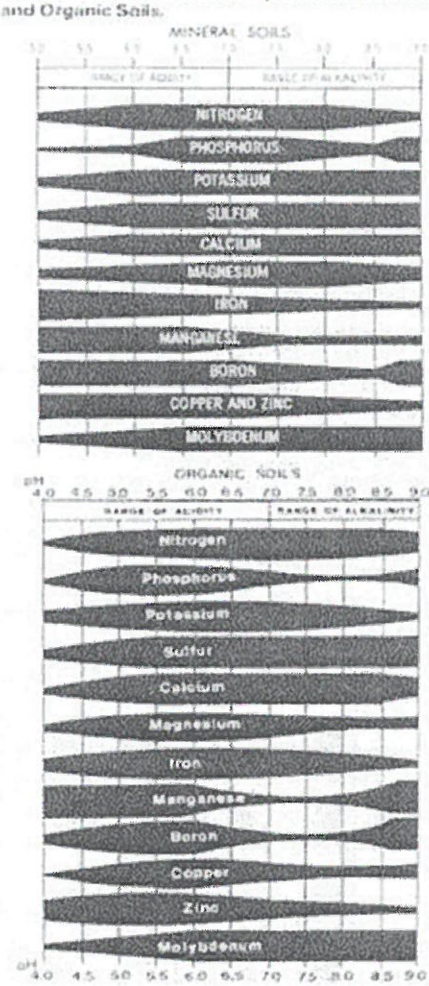
** One cubic metre = 220 imperial gallons. One cubic metre per hectare = 90 gallons per acre.

*** F & W denotes fall and winter applied manure.
Spr denotes spring applied and not covered immediately including surface applications after seeding.
SprC denotes spring applied manure covered immediately after application.

Table taken from the Ontario Ministry of Agriculture and Food Publication 296, 1980 Field Crop Recommendations.

Figure 2 shows some of the benefits of liming mineral and organic soils.

Figure 2. Relative Availability of Elements Essential to Plant Growth at Different pH Levels for Mineral and Organic Soils.



soils to pH 6.5 or higher will decrease the availability of zinc, iron, manganese and copper The availability of molybdenum in- creases with liming to pH 5.5 or higher, but large in- creases in the availability of molybdenum occur only when soils are limed to pH 6.0 or higher. (See Figure 2).

Soil pH ranges required by crops

On mineral soils, most crops give optimum production if the pH is between 5.5 and 6.5. Blueberries and cranberries are exceptions as they grow best on very acid soils. Alfalfa and sweet clover growth is seriously reduced as the soil pH falls below 6. Cereals, corn and grasses grow satisfactorily between pH 5.5 and 6.0, but perform better if the soil pH is in the 6.0 to 6.5 range. The recommended pH ranges for a number of crops are presented in Figure 5. While potatoes grow well at pH levels above 5.4, scab susceptible varieties may be grown at soil pH levels of 5.0 to 5.4 to reduce the risk of scab infection. The scab organism does not thrive well in these low pH levels. Scab resistant varieties can be grown at soil pH levels around 6.0.

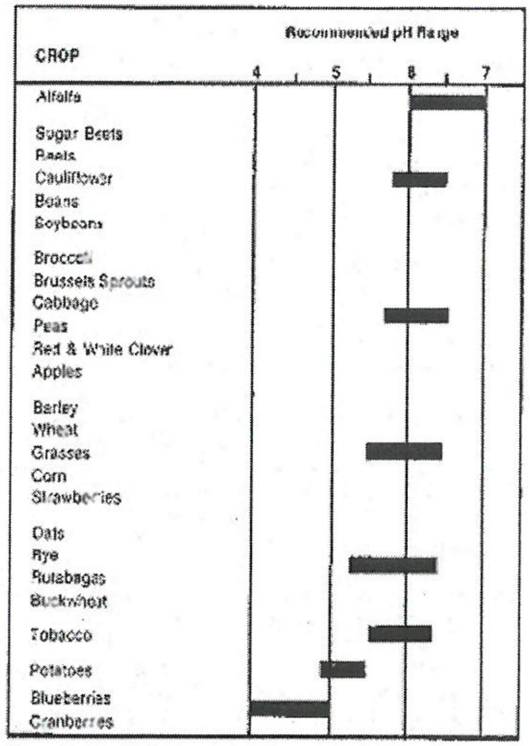


Figure 5 - Most Suitable pH (water) Ranges for Various Crops.

Liming does not replace other management practices. In addition to the use of limestone, productive soils also require adequate additions of crop nutrients through fertilizers, crop residues and manures. Timeliness of cultural operations remains important in order to make optimal use of soil, labor, and climatic resources and to produce crops of high yield and quality. Normal pest control practices and selection of recommended crop varieties are still requisites to successful production operations.

Advice on taking soil samples is available from your county or district agricultural office or from your provincial soils labratory

Send Soil Samples for analysis to-

1. Nova Scotia Dept. of Agriculture &
   Marketing Soils & Crops Branch Harlow
   Institute Box 550
   Truro, N.S. B2N 5E3
   Phone: 895-1571

2. Soil Laboratory
   New Brunswick Dept. of Agric. & Rural Dev.
   P.O. Box 6000
   Fredericton, N.B. E3B 5HI
   Phone: 453-2108

3. P.E.I. Soil & Feed Testing Lab.
   Agricultural Research & Extension Bldg.
   P.O. Box 1600
   Charlottetown, P.E.I. CIA 7N3
   Phone: 892-5465

4. Dept. of Forest Resources and Agrifoods
   Agrifoods Branch
   Soil and Plant Laboratory
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   Mt. Pearl, NL A1B 4J6
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