MEASURE AND MANAGE

Liming of Agricultural Soils

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Why lime our soils? The addition of limestone properly applied to acidic soils contributes to higher crop yields and quality by correcting nutrient problems caused by the soil pH being too low. Liming decreases soil acidity (raises pH) and increases the availability of essential plant nutrients and decreases the phyto toxic effects of excessive aluminum, iron, and manganese on plant growth.

Acid soils can cause the precipitation of phosphorous (P) be combining with iron and aluminum. Reduced availability of P reduces crop growth and lowers nutrient use efficiencies of all plant nutrients. This will be an important factor in Nutrient Management Plans that factor in crop removal.

Maintenance of the soil pH at proper levels assures that the soil will always have an adequate supply of calcium and magnesium. We lose annually approximately 350- 500 pounds per acre of calcium, from crop removal, leaching, erosion, and from neutralizing N applications.

Acid Rain

Pure Water in equilibrium with normal atmospheric CO_2 has a pH of 5.6. Approximately 39 cm of rain, which is a normal supply in humid regions, can dissolve about 350 pounds per acre of $CaCO_3$ (Limestone). This is roughly the annual requirement to maintain the soil pH in agricultural soils in humid regions.
The burning of fossil fuels releases oxides of Sulfur and Nitrous compounds that end up in the precipitation. These compounds cause the rain to be less than 5.6 pH. The annual acid equivalent of rainfall has report to range from 28- 90 pounds per acre of calcium carbonate. In comparison to a normal farm practice of applying Nitrogen Fertilizer an application of 100 lbs. of N consumes 180 pounds of calcium carbonate. The N fixation of an alfalfa crop can consume 500 pounds of calcium carbonate when the N is mineralized to nitrate. Since only a portion of the rainfall is acid due to additional pollutants the effects on agricultural practices are minimal.

Liming Practices

Before lime applications can be considered a number of points need to be understood. Liming starts with a soil test that includes pH and when the pH is less than 6.2 a Buffer pH. Knowledge of the proper pH for the intended crop (target pH), crop rotation, calcium and magnesium levels in the soil, lime source calcitic or dolomitic, Ag-Index of the lime, tillage method and incorporation.

pH and Buffer pH

The best analogy to use is to view the soil sample as a cup. A low pH (5.9) is suggesting there is acid or hydrogen ions present (a measure of intensity). The Buffer pH measures how much acid is in the cup (quantity). The buffer pH determines the amount of lime needed to neutralize the soil acidity.

The buffer pH is used in pub 296 to determine the rate of lime to apply. From the soil report when the pH is less than 6.1 and a buffer pH is reported you will need to address the need for lime which will be dependant upon the desired pH for the next crop or crop rotation. A review of Pub 296 lime requirements would be the next step is to familiarize yourself with the target pHs and lime applications.

The buffer pH has a unique feature in that it automatically considers the different buffering capacities of soil textures. Example of 2 soils, one sand, one clay both with a pH of 5.5 can have different buffer pH values. The sand may have a BpH of 6.9 and the clay a BpH of 6.3. According to the table in pub 296 the recommended rate of lime to achieve a target pH of 6.5 would be 2 and 5 tonnes per ha. The clay soil has a higher buffering capacity, caused by the higher exchange capacity, which holds more H and requires a greater amount of lime to raise the pH from 5.5 to 6.5. Whereas the sandy soil with a lower buffering capacity, and a lower exchange capacity requires less lime to move the pH from 5.5 to 6.5.

Target pH

Knowledge of the desired pH for a particular crop is a must. As well an understanding of the crop rotation sequence needs to be known. Corn can grow well at a pH as low as 5.5 provided there is adequate calcium. However, if wheat is in the rotation a pH closer to 6.5 is needed therefore the over riding concern would be for the wheat since corn can also grow well at a pH of 6.5. Horticulture crops are more sensitive to pH changes potatoes do well at 5.5 and need lower pH for scab control whereas Cole crops may need a higher pH and high calcium saturations for club root control. Pub 296 lists the desired target pH by crop.

Lime Source (type)

There are 2 basic types of lime one containing calcium carbonate referred to, as calcite and the other containing both calcium and magnesium carbonates called dolomitic. Calcitic lime usually has a calcium level around 39% and dolomitic has a calcium level 22-25% and magnesium from 9-14%. Both limes are effective in neutralizing acidity. Dolomitic lime is a logical source when soil magnesium levels are low, less than 50 ppm this is usually associated with sandy soil conditions.

Agricultural Index (Ag-Index)

The Ag-index is a laboratory test that can be performed on a limestone sample to determine how effective the lime will be in neutralizing soil acidity. The Ag-Index considers the neutralizing value or effective calcium carbonate level and factors in the fineness of the sample. All lime recommendations produced by Agri-Food Laboratories assumes a lime with an Ag-Index of 75 will be used.

The Ag-Index allows for a fair comparison of different lime sources to determine their effectiveness in neutralizing acidity. If a lime was available and only had an Ag-Index of 25 and the recommendation called for 2 te/ha. An application of 6 te/ ha of this lime would be needed in order to be as effective as 2 te of 75 Ag-Index lime.

There are various ranges in lime quality and price. The Ag-Index is the only way to determine the best option. If a lime was available with an index of 100 then only 1.5 te of this lime would be needed to be as effective as 2 te of an Index 75 lime.

Lime fineness is an important factor in the rate of reaction not in the neutralizing value. Fine lime with a mesh size of 100 will react within 20 days a lime with a particle size of 25 mesh will take 3-5 years to react and can be considered rather useless. In the Ag-Index calculation a mesh size of 60 is given a maximum value anything smaller is given the same rating a 100 mesh or 200 mesh lime has no more value than a 60 mesh lime. The only difference is the rate of reaction with fine particles having a greater surface area reacting quickly. Particle size may be an issue in short rotations or limited land tenure fine lime is more expensive. A well planned crop and lime rotation may allow for a more coarse lime (cheaper) to used as long as sufficient lead time is considered for application timing and reaction.

Incorporation of Lime Applications

Thorough incorporation of lime will speed up the reaction and affect the pH change quickly. In conventional primary/ secondary tillage practices it is easy to incorporate the lime.
In reduced till or no-till operations lime incorporation is limited. This is an important factor since lime recommendations assume lime will be incorporate into the top 6 inches. Therefore in reduced till it is necessary to reduce the single application rate. Current wisdom suggests half the amount twice as often.

With the current no- till soybeans, wheat, and plough for corn scenario the best time to apply lime would be in the corn year. Soil test and plan ahead.

In addition to the impact lime has on soil nutrients it has a profound effect on soil Microbiology. Soil is healthier when proper pH is maintained as a host of beneficial bacteria, flora and fauna can flourish. The nitrogen and sulfur cycle, and organic matter production are enhanced at proper pH. The following table illustrates the effect pH has on microbial activity.

Relationship of Soil pH to Soil Microbial Activity

pH	Reaction	Microbial Activity
<5.0	strongly acid	low primarily fungi
5.0-6.0	moderate acidic	low
6.0-6.6	slightly acidic	moderate
6.6-7.4	neutral	high
7.4-8.0	slightly alkaline	moderate
8.0-9.0	alkaline	low

Microbes are more active at neutral pH, in breaking down pesticides, decomposing organic matter and releasing nutrients.

Summary

Soil Acidity causes a number of problems on our agricultural fields.

1) Reduced availability of some essential nutrients.
2) Increased solubility of certain micronutrients sometimes to toxic levels.
3) Reduced microbial activity of beneficial organisms and enhancement of harmful ones.
4) Impact on some herbicide performance and yield loss from crop damage and weed infestations.

By measuring and managing with soil tests and following the appropriate steps for determining lime application rates we can easily fix problems associated with soil acidity.