Ground Lime for Soil Amendment

by Padraic McGrath B.Eng, R&D Manager, McGrath's Limestone Quarries Ltd

The application of lime is one of the oldest and most important methods of improving the condition of soils. The main reason for applying ground lime to soils is to increase the pH of an acidic soil. Soil pH, is a measure of the amount of hydrogen ions in the soil solution.

Soils tend to be naturally acidic in areas where rainfall is sufficient to cause substantial leaching of basic ions (such as calcium and magnesium), which are replaced by hydrogen ions. It is essential that the pH of a soil is monitored and adjusted to ensure that vital plant nutrients are made available for uptake by the roots of plants. Fourteen of the seventeen essential plant nutrients are obtained from the soil and most of these nutrients which plants require for healthy growth can dissolve easily when the pH of the soil ranges from 6 to 7.5. Below pH 6.0, some nutrients, such as nitrogen, phosphorus, and potassium, become less available for uptake.

The table below shows how soil pH effects the availability of Nitrogen (N), Phosphorus (P), and Potassium (K).

	pH 4.5	pH 5.0	pH 5.5	pH 6.0	pH 7.0
Nitrogen(N)	30%	43%	77%	89%	100%
Phosphorous(P)	23%	31%	48%	52%	100%
Potassium(K)	33%	52%	77%	100%	100%

Table 1:

Effect of soil pH on the availability (%) of N, P and K (Source: MEAC)

Other benefits of adding lime to a soil include:

- Improve drainage and soil aeration as lime causes small particles of soil to stick together into larger particles.
- Better microbial activity in the soil. Earthworms are more active in a neutral (i.e. 6.0 – 7.0 pH) environment.
- Lime can also be a source of valuable calcium and magnesium for the soil.

Types of liming materials available

There is a wide range of materials available which can be used to improve the pH of a soil but the most common materials used are calcium lime and magnesium lime.

Calcium lime is produced from high purity calcitic limestone deposits which are predominantly made up of calcium carbonate, CaCO3 (greater than 99% in some deposits). Magnesium lime is produced from dolomitic limestone deposits which contains calcium magnesium carbonate MgCa(CO3)2. Dolomitic lime should only be applied if the soil also has a magnesium deficiency. Production of agricultural lime from these minerals is relatively straight forward but the quality of agricultural lime depends on the purity of the mineral deposit and the production method used. The rock is extracted from the ground by blasting and then crushed/grinded down to the required fineness for use as agricultural lime.

Granulated or Prilled lime is limestone or dolomite which has been grinded down so that 100% of the particles are finer than 0.15mm. The powder mineral is then granulated/ agglomerated using a binder material to form pellets or granules which are 2-4mm in size. These pellets/granules are easily spread onto the soil using a conventional fertilizer spreader. Once they come in contact with moisture the binder breaks down quickly and the powdered material is released into the soil and starts to neutralise the acid immediately. It is very effective at increasing soil pH quickly but it is much more expensive than standard agricultural lime.

Determining the quality of liming materials

The quality of agricultural can be determined by two factors; the neutralizing ability of the material and the rate at which the liming material neutralises the soil.

Values used to display the neutralising value of a liming material include:

- Total Neutralizing Value (TNV). This is the percentage of the material that can neutralize acid expressed as the calcium carbonate equivalence (CCE) of the product.
- Calcium Carbonate Equivalence (CCE). This standard compares the liming material to pure calcium carbonate (CaCO3). Some materials such as hydrated lime and burned lime will have a CCE higher than 100%. Pure magnesium carbonate (MgCO3) will neutralize about 1.2 times more acidity than CaCO3 so dolomitic limestone will have a higher CCE than calcitic limestone. The CCE value also identifies the purity of the deposit as a high purity deposit will have a high CCE value. This important as some deposits may contain high levels of toxic heavy metals which could potentially be spread onto a soil and taken up by plant roots causing further problems along the food chain.

These values give the user an idea of the quality of the liming material and it is important to understand how these values are presented. For example 1 tonne of a liming material with a TNV of 85% will neutralise the same amount of acid in the soil as 0.85 tonnes of a

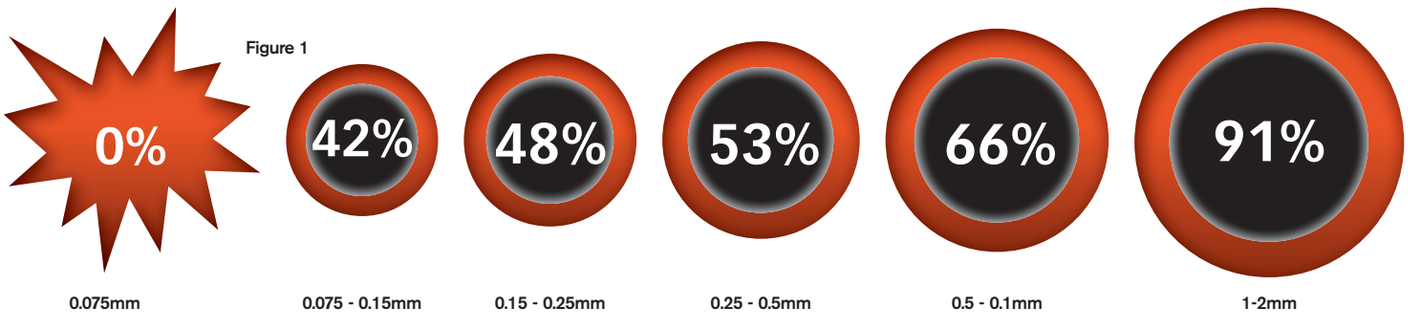

Figure 1

liming material with a TNV of 100%. Using a material with a high TNV will result in a large cost savings for the user as less material will be needed to adjust the soil pH as opposed to using a liming material with a low TNV.

Another important factor to consider is the rate at which a liming material reacts with the soil to increase its pH. This is determined by the particle size distribution of the liming material. Agricultural lime is more effective when the particles are very small because the limestone has a better chance to dissolve and to neutralize soil acidity. The particle size distribution is also critical as particles over 2mm are considered to have little or zero neutralising effects on a soil as it takes to much time for large particles to break down and neutralise the acid in a soil.

Figure 1.
Effect of lime particle size on the % of the lime particle that does not react with the soil after 3-6 months following lime application. (Source: The Importance of Liming and Soil pH; W.D. Brogden)

Laboratory Trails carried out at West Virginia University found that limestone particles react with soil at the following rates:

1. Particles that pass a 0.15mm sieve react 100 percent with the soil in six months or less;
2. Particles that pass a 0.25mm or finer sieve react 100 percent within the first year;
3. Particles that pass a 0.85mm but not a 0.25mm sieve react about 50 percent in the first year;
4. Particles not passing a 0.85mm sieve have little liming value and are not generally credited when evaluating lime materials.

Following these findings the researchers developed a value for accessing the quality of a ground limestone material for soil amendment. The Effective Neutralizing Value (ENV) combines TNV and fineness to estimate how much of a liming material will be available to change the soil pH within one year. This value has been adopted by many ground lime users around the world as a way of accurately determining the quality of a liming product. The % passing values are given a weighting figure depending on its availability within one year. A value of 1.0 is given to the % passing 0.25mm since 100% of this material reacts within one year; a value of 0.5 is given to the % passing 0.85mm but not passing 0.25mm since 50% of this material reacts within one year of being applied.

Table 2:
Calculation of ENV for a ground limestone sample. (Source: The Value of Agricultural Limestone, Edward B. Burton)

% Passing 0.85mm Sieve	100			
% Passing 0.25mm Sieve	85	X	1 =	85
% between 0.85 Sieve & 0.25mm Sieve	15	X	0.5 =	7.5
% Effectiveness of Liming Material	92.5			
CCE of limestone	95%			
ENV of Ground Limestone Sample	95 X 92.5/100 =		87.88%	
Tons of lime required per ton lime requirement = 1/87.88 X 100 = 1.14 tons of this lime needed to equal 1 ton of 100% ENV lime (%ENV)				

Industry Standards for Agricultural Lime

Currently the standard for ground limestone is set by the Department of Agriculture and for ground limestone to be certified as agricultural lime it must meet the following criteria set out in S.I. No.248 of 1978:

- 100% of the material must pass 3.35mm sieve
- Greater than 35% of the material must pass a 0.15mm sieve
- The total neutralising value shall not be less than 90%
- The moisture content shall not be more than 3%.

This standard has become somewhat outdated and doesn't pay enough attention to the importance of the particle size distribution of a ground lime product.

The above standard is expected to be replaced by a European regulation in the near future which divides natural liming materials into two different categories namely standard quality lime and fine quality lime with more emphasis of particle size distribution.

In Ireland the quality of ground lime for agricultural use can vary depending on the deposit from which it is extracted and the production method that is used to grind the lime down to the required fineness. Users of ground lime need to be made more aware of the roles that purity and particle size distribution of the ground lime have in the effectiveness of neutralising soils. It is important to remember that 1 tonne of poor quality ground lime does not equal 1 tonne of high quality ground lime. It may in fact be beneficial to spend extra on good quality lime as a lesser amount will be needed to neutralise a soil than if poor quality lime was used for the same application.

References

Edward B. Burton West Virginia University, Forage Management – The Value of Agricultural Limestone 1994.

W.D. Brogden, The Importance of Liming and Soil pH, THE FERTILIZER ASSOCIATION OF IRELAND

Proceedings of Spring Scientific Meeting 2011.

Donald Bickelhaupt, Soil pH: What It Means, www.esf.edu/pubprog/brochure/soilph/soilph.htm