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When to Apply Lime and Fertilizer

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Nearly half of all the fertilizer used in Kentucky each year is bought by farmers during the rush of the spring planting season. As a result, it is often difficult for the fertilizer industry to meet customer demands during this 6 to 8 week period.

Much of the fertilizer now used during the spring rush season could be applied during other seasons of the year. If farmers scheduled fertilizer applications more evenly throughout the year, dealers would be in a much better position to provide them with the kinds and amounts of fertilizer they desire. Custom application services could be improved. In many instances, off-season discounts could be obtained. Other services provided by dealers could be provided more efficiently because the dealers would not be in such a rush.

In addition, more even applications throughout the year would mean that much of the fertilizer necessary for spring planting would already be on the field. This would save valuable time during spring planting and eliminate the risk of not being able to apply fertilizer because of wet land in the spring. Fertilizing in the fall would also ease problems of soil compaction caused by spreading equipment since the soil would have time to mellow over winter.

Chemical Reactions of Lime and Fertilizer in Soil

When lime and fertilizers are applied to soils, many chemical reactions take place — some immediately, and some over long periods of time. These reactions have a great influence on when lime and fertilizer can be applied and how efficiently fertilizer is taken up by growing crops, and this influences the economic returns from lime and fertilizer use.

To better understand the nature of the chemical reactions taking place between soils and lime and fertilizer, we should first examine the soil.

The amount of surface area exposed in soil with which lime and fertilizer come in contact is extremely important. This factor is related to the amount of clay present in the soil, since most of the soil's potentially reactive surface area is made of clay particles and since, per given volume, there is more surface area in clay than in sand or silt.

The mineral form of individual soil particles and the extent to which these mineral soil particles have been coated with layers of oxides and organic materials also affect the total soil reaction.

All clay particles in soil have a net negative (-) electrical charge. Because of this negative charge, clay particles will react with components of lime and fertilizer which dissolve as positively (+) charged particles (cations) when added to soil. Lime materials dissolve to release positively charged calcium (Ca^{++}) and/or magnesium (Mg^{++}) particles, and some fertilizers dissolve to form positively charged particles (ammonium nitrogen (NH_4^+)) and potassium (K^+). Such positively charged particles (cations) are attracted to the negatively charged components of soils.

Lime

Materials commonly used as lime are either ground-up limestone rock, ground-up marl or products of limestone which have been altered by burning to make them more water soluble than the ground-up rock itself. By far the most common liming material in Kentucky is ground limestone (aglime), most of which is calcium carbonate. In some instances, there is enough magnesium carbonate present for the lime to be termed "dolomitic."

When applied to soil, the liming material reacts with soil moisture to release particles of calcium or, in the case of dolomitic lime, magnesium. The rate at which the lime material dissolves to release these particles is largely controlled by how finely it is ground and the chemical form of the material (carbonate, oxide or hydroxide). The finer the material, the more rapidly it dissolves. Oxides (burned lime) and hydroxides (hydrated lime) are more soluble in water and react much more quickly than carbonate forms of lime (calcitic aglime or dolomitic aglime).

Calcium or magnesium particles are attracted to and are held by clay particles in soils after the liming material dissolves. This neutralizes soil acidity, increasing soil pH readings. It also means that lime does not move very fast downward through soil. With the exception of extremely sandy soils, there is no concern in Kentucky over leaching losses of lime. For this reason, lime can be applied whenever practical, although it should be applied far enough before planting to allow time for adequately reacting with the soil and neutralizing acidity.

Nitrogen (N)

It is important to have enough available nitrogen in the soil at the time when the crop's growth is most rapid. Basically, we use two types of nitrogen: 1) ammonium or ammonium formers (urea, anhydrous ammonia); and 2) nitrate forms. In aerated soils, ammonium nitrogen is changed in the soil to the nitrate form. The nitrate form is completely soluble in soil water and therefore moves in the direction of soil water movement.

Soil temperature influences the rate at which ammonium nitrogen is changed to nitrate. It is generally considered that the rate at which this change takes place is negligible at freezing or below, while at soil temperatures above 50°F, the conversion rate is rapid. In Kentucky, soil temperatures during the winter generally do not stay cold enough to completely prevent conversion of ammonium nitrogen to nitrate nitrogen. This means that fall or winter application of anhydrous ammonia, urea, or other ammonium forms of nitrogen fertilizers to fallow land is not a sound practice.

Since nitrate nitrogen moves with soil water, it is subject to loss from the plant rooting zone by leaching during periods of high rainfall which results in a net percolation of water through the soil profile. If percolating water moves deeply enough to reach the water table, nitrate is then lost through groundwater to streams. An excess of water usually occurs in Kentucky during the months of December to April. On the other hand, if moisture percolating downward through soil does not reach the water table, nitrate nitrogen may move upward again as net movement of soil water shifts upward toward the surface because of evaporation and transpiration.

Since nitrate contains oxygen in its structure, losses of nitrogen fertilizer from water-logged soils can also be quite severe for another reason. Soil bacteria that require air will rob nitrate nitrogen of its oxygen if there is not enough free oxygen in the soil to meet their demands. In this process, nitrate nitrogen is converted to gaseous forms of nitrogen, which then escape from the soil surface. The presence of undecomposed organic residues intensifies such losses in water-logged soils simply because such residues cause soil bacteria to be more active and use more oxygen.

In regard to these nitrogen reactions, two points need emphasizing: 1) Although the first reaction of ammonium nitrogen is to be adsorbed onto the surface of clay and organic matter, it does not remain in the ammonium form very long under Kentucky's climatic conditions. It is transformed to nitrate nitrogen. 2) Nitrate nitrogen is subject to rapid loss from soil, either from leaching or from loss as a gas. However, there is some indication that leaching of nitrate nitrogen is not as rapid in red soils as it is in browner soils.

These reactions show that nitrogen can be used most efficiently by a crop if it is applied either while the crop is growing or just before it starts to grow. Even with these precautions, there will be occasions when split applications of nitrogen should be helpful. For example, heavy rains following applications of N can result in leaching losses from permeable soils or in denitrification losses in soils which tend to waterlog.

Phosphorus (P)

Phosphate fertilizer, when applied to soil, reacts very rapidly to form compounds that are less soluble than the form in which the fertilizer was added. This is due largely to the iron and aluminum oxides in the soil which rapidly react with applied phosphate, making it less soluble. For this reason, phosphates are not mobile in soil, and leaching losses of phosphate are insignificant in Kentucky soils. Erosion of surface soil containing applied phosphates is the most likely way in which phosphates would be lost from soils.

Since phosphates are relatively immobile in soil, it is not important that phosphate fertilizer be applied during the crop's growth cycle. The long residual value of phosphates in soil will make them available to crops over long periods of time. It is rare that more than 25 percent of phosphates applied to a crop is used in the first year after application.

Potassium (K)

Potassium dissolves from fertilizer in the soil, is attracted to clay particles, and is then held tightly enough that leaching losses are negligible. In sandy soils which have very little clay, leaching losses of potassium can be a problem. This is not of general concern in Kentucky, however, since only a small portion of agricultural land in Kentucky is of sandy texture. In most Kentucky soils, potassium is not likely to leach, and there should be no great practical concern over when it is applied to the soil. The most likely losses of potassium would be through sediment losses from erosion. It is unlikely that more than 40 percent of potassium applied in a given year would be used by crops during that year.

Fertilizer Requirements of Crops

There always should be enough available nitrogen, phosphorus and potassium present in soil during a crop's growth cycle so as not to limit growth. This can be accomplished by: 1) applying enough P and K to raise soil test levels to at least the "high-medium" level, and then making annual applications to maintain soil test values at that level, and by 2) applying N to match the growth cycle of the crop as closely as is practical. Remember that using lime to achieve acceptable soil pH levels is necessary for best fertilizer utilization by your crops.

Sod Crops (Hay and Pasture)

Legumes or Grass-Legume Mixtures

For establishment of a new stand, apply lime at least 6 months in advance of seeding. Then apply a small amount of N to stimulate initial seedling growth along with the necessary P and K at seeding.

Apply topdressings of P and K when convenient, preferably after herbage has recently been clipped or grazed. Nitrogen is not necessary where more than 25 percent of the stand is made up of a perennial legume. Apply boron (B) each year on all alfalfa fields and on clover fields to be harvested for seed.

Straight Grass

For new seedings of straight grasses, apply a moderate amount of N along with the necessary lime, P, and K at time of seeding.

For topdressing cool-season grasses, apply N in at least two split applications (late winter or early spring, and late summer). For warm season grasses, you can achieve greater efficiency by splitting applications to coincide with clippings or rotational grazing. Apply P and K anytime when convenient, preferably after herbage has been recently clipped or grazed.

Grass Seed

You can increase seed yields from grass fields to be harvested for seed by late fall and early spring topdressings with N. For bluegrass seed production, apply N between November 15 and December 15, and again between February 15 and March 15. For fescue seed production, an application of N between November 15 and December 15 is sufficient. For orchardgrass and timothy seed fields, apply N between February 15 and March 15.

Small Grains

Small grain crops usually are part of a cropping rotation system which includes another crop. Lime, P, and K can be applied anytime. It often is convenient to apply when seeding the small grain. Apply half the N at the time of seeding to stimulate fall growth of the small grain. Additional N should be top-dressed on the small grain between February 15 and March 15 for top production. When small grains are grown in a rotation or in a double cropping system, the P and K requirements for both crops (forage legumes, soybeans, corn, forage, or grain sorghum) can be applied at seeding of the small grain.

Corn or Grain Sorghum (single crop)

For single crops of corn or grain sorghum, apply lime, P, and K when convenient. This would usually be sometime between harvest in the fall and seeding the following spring. N should not be applied until planting or shortly after. On sandy soils where leaching during the growing season can be great, or on soils which tend to be waterlogged, more efficient use of N can be obtained by applying only a small portion at planting time and then sidedressing the remainder at about the knee-high stage of growth. Applying nitrogen in the fall on land to be fallow during the winter and planted to corn in the spring is not a sound practice. Under Kentucky climatic conditions, overwinter N losses from both leaching and denitrification are great. Research at the University of Kentucky indicates, however, that overwinter N losses from the red-colored soils are not as great as those from yellow and brown soils.

Soybeans

Apply lime, P, and K to soybeans when convenient, being sure that the lime is applied far enough in advance of the crop to adequately adjust pH. When double-cropping soybeans with small grain, you can apply the required P and K for both crops at seeding of the small grain in the fall.

Tobacco

For tobacco, apply lime, P, and K when convenient, preferably soon after harvest. If pH needs adjusting apply lime in the early fall. Apply N at the beginning of field preparation or just ahead of setting. Supplemental N applications after planting may be necessary if leaching or denitrification losses occur.

Summary

It is quite evident that much of the fertilizer added to Kentucky soils does not have to be applied during the spring planting season to be effective in soil improvement. Much of the fertilizer needed for profitable crop production can be applied during other seasons of the year without sacrificing yields. A shift away from traditional spring applications of fertilizer can help save valuable time and assure better service from the fertilizer industry.

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