Soil fertility management for forage crops

Pre-establishment

Soil fertility management for forage crops is a continuous process that begins well before the forage crop is established. In the pre-establishment phase the soil conditions are adjusted to provide optimum soil fertility when the crop is established. At establishment the fertility program should deal with any last-minute small adjustments in soil fertility and any requirements for getting the plants established, such as a starter fertilizer. Finally, once the crop is established the fertility program focuses on maintaining good soil fertility levels for the life of the forage stand. This soil fertility management time-line is illustrated in Figure 1.

This fact sheet deals with the pre-establishment phase of soil fertility management for forages. The goal should be to have the soil pH in the optimum range and the soil phosphorus and potassium levels in the optimum to high range, as indicated in Table 1.

Figure 1. Soil fertility management time-line for corn-forage rotation.

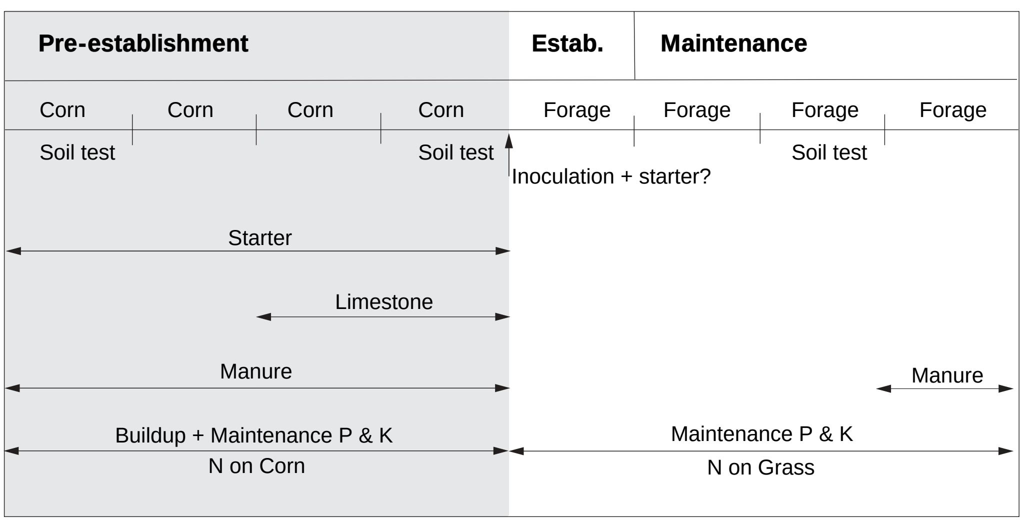

Table 1. Soil fertility goals at forage establishment.

Soil test	Range	Soil test level
pH (legumes)	6.5 - 7.0	Optimum
pH (grasses)	6.0 - 6.5	Optimum
P (ppm)	30 - 50	Opt. - High
K (ppm)	100 - 200	Opt. - High

SOIL PH AND NITROGEN NUTRITION OF LEGUMES

Crops vary in their sensitivity to soil pH. Generally, alfalfa is the most sensitive forage crop, followed by the other legumes and then by the grasses (Table 1). In legumes, pH sensitivity is related primarily to the nitrogen fixation process. At low soil pH, the bacteria responsible for nitrogen fixation are not very active and thus the crop can suffer from nitrogen deficiency. This effect on nitrogen is illustrated in Figure 2. With nitrogen fertilizer applied, soil pH has little or no effect on the yield of alfalfa. With no nitrogen applied, however, there is a very dramatic alfalfa yield increase as soil pH is increased. Thus, it boils down to adding lime to maintain the proper soil pH or adding nitrogen fertilizer. Applying limestone is much more economical than adding nitrogen fertilizer. A typical requirement of two tons of lime for 3 or 4 years would cost about $10 per year compared to 250 lbs. of nitrogen required every year, which would cost about $60 per year.

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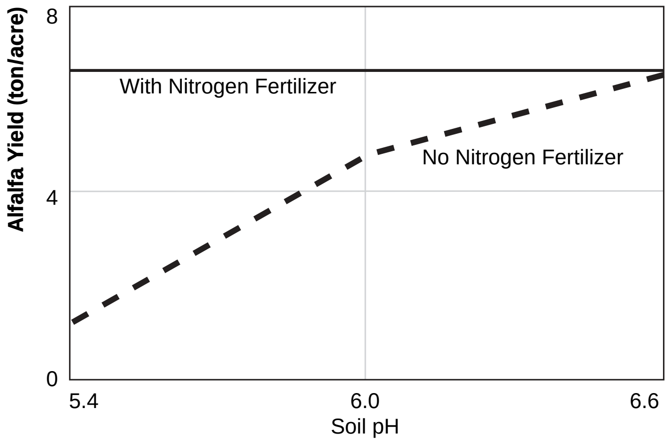
Figure 2. Relationship between soil pH and nitrogen response by alfalfa.



SOIL PH AND HERBICIDES

Soil pH also has an impact on herbicide residues, which can affect the forage seeding. Low soil pH causes the triazine herbicides to be bound to the soil. This has several important implications. First, when triazine herbicides are bound this way they are not effective in controlling weeds in the corn. Often this results in higher and higher rates of herbicides being used to get adequate weed control. These higher rates mean a greater probability of residual herbicide in the soil when the forage is seeded. Also, these bound herbicides are released when the soil is limed. If liming is postponed until just before seeding, this release of bound herbicide can have serious detrimental effects on the forage seeding. This result is aggravated by the use of EPTC (Eptam) when the forage is seeded.

The best way to avoid these problems is to maintain the soil pH above 6.2 throughout the crop rotation. This will minimize the adsorption of the herbicide to the soil and result in maximum effectiveness at minimum herbicide rates in the corn. This, in turn, will reduce the residual herbicide in the soil and avoid large release of bound herbicide just prior to seeding.

LIMING PRACTICES

There are several important considerations for liming practices. The rate of limestone required must be determined by a soil test that includes both a soil pH and a lime requirement test. Limestone should be applied at least six months to a year ahead of seeding. If the test calls for more than 4 tons of limestone per acre, the application should be split—with half of the limestone plowed in and the rest worked into the surface with secondary tillage. For low rates of limestone or if a split application is not possible, the limestone should be worked into the surface rather than plowed down. This ensures that the surface soil, where the seedling is developing and where the nodulation begins in legumes, has the proper pH.

Not all limestone is equal. The rate of limestone application should be adjusted for the neutralizing ability of the limestone. The neutralizing ability is given as the calcium carbonate equivalent (CCE) of the limestone. All soil test recommendations are made on the basis of 100 percent CCE. This does not mean that only 100 percent CCE limestone should be used. The rate of application for any limestone with a CCE higher or lower than 100 must be adjusted. The formula for making the adjustment is as follows:

Adj. Limestone Rec. = 100 x Limestone Rec. , CCE

An explanation of how to make this adjustment and a table for making the adjustment are provided in ST-2, “Fertilizer Recommendation Table,” sent out with each soil test run by Penn State and printed in the *Penn State Agronomy Guide*.

The fineness of the limestone is also an important quality consideration. The finer the limestone is ground, the more rapidly it reacts in the soil to neutralize the acidity. To be effective a minimum of 95 percent of the limestone should pass a 20-mesh screen, 60 percent should pass a 60-mesh screen, and 50 percent should pass a 100-mesh screen. Generally, there is little practical advantage in using a liming material that exceeds these fineness standards. It will probably only be advantageous to pay more for a finer limestone in an emergency where the pH is very low and rapid neutralization is required.

CALCIUM AND MAGNESIUM

Calcium and magnesium are essential secondary nutrients required by crops. Legumes in particular have a high demand for calcium and magnesium. A soil test is the best guide for determining the calcium and magnesium needs of a soil. Almost all calcium and magnesium are supplied to crops in limestone. Generally, in Pennsylvania soils, if the soil pH is in the optimum range there will be adequate calcium for the crop. Depending on the soil origin and the source of limestone that has been used in the past, however, magnesium may not be adequate. A soil test level of less than 5 percent saturation of the soil CEC or less than about 60 ppm is usually considered deficient in magnesium. When this occurs, a limestone should be used that contains magnesium to build the magnesium level in the soil into the optimum range. The amount of magnesium required depends on the CEC of the soil and the soil magnesium level.

Soil test recommendations for magnesium are given in several ways. The recommendation is sometimes given as the amount of magnesium to apply, or the recommendation may be given as a minimum magnesium content in the recommended limestone. Recommendations on Penn State soil tests are given in both of these ways. Sometimes the recommendation is simply: “Use a dolomitic limestone.” This is less desirable because there is no set definition or minimum magnesium content for a limestone to be labeled as dolomitic. If the soil is optimum or high in magnesium, either a calcitic or dolomitic limestone can be used. The decision should be based on the availability and the cost of limestone.

High soil potassium can have a negative effect on the uptake of calcium and magnesium by crops. This antagonism does not usually affect the yield of the crop, but it can have a negative effect on crop quality. In particular, low magnesium in grasses, when they are the primary feed for cattle, can result in hypomagnesemia or grass tetany. This is mainly a problem in pasture systems where cattle get most of their forage from the pasture. Pastures that have not been limed with a dolomitic limestone and that have had potassium fertilizer applied are the most susceptible to this problem, particularly early in the spring.

PHOSPHORUS AND POTASSIUM

Forage crops have a high demand for phosphorus and potassium. Thus, it is critical that soil levels of these nutrients be built up in preparation for growing forage crops. Phosphorus and potassium are relatively immobile in the soil. For example, phosphorus moves less than one-eighth of an inch a year in soil. To bring the rooting zone of a soil into the optimum level for crops, the phosphorus and potassium must be thoroughly mixed with the soil. Therefore, it is very important that the soil levels be built up before the perennial forage crop is established, because once the crop is established there is no way to effectively mix the phosphorus and potassium with the soil in the rooting zone.

It is difficult to bring low fertility soils up to high fertility without some tillage to mix the nutrients and limestone throughout the primary rooting zone of the crop. In no-till cropping systems this is an especially difficult problem because there is no opportunity for mixing. If soil fertility is low in no-till, it is suggested that at some point in the crop rotation the recommended limestone, phosphorus, and potassium be applied and tilled into the soil to build the fertility levels. Once the soil levels are in the optimum to high range on the soil test, surface application of the limestone and the fertilizer phosphorus and potassium in a no-till system can maintain these levels.

MANURE

On farms with livestock, the manure applied to corn is a major contributor to meeting the phosphorus and potassium goals at establishment. When manure is applied to corn to meet corn's nitrogen needs, excess phosphorus and potassium are also applied (Figure 3). This excess phosphorus and potassium builds soil levels, often into the high range, and can be used by a forage crop later in the rotation. When manure is not available, fertilizer must be applied to the corn to replace the nutrients removed in the corn crop and if necessary to build the soil levels into the optimum to high range before forage establishment.

Keeping records and following soil test trends can be very helpful in fine tuning the fertility program for a corn-forage rotation. This is illustrated in Figure 4. Notice the buildup during the corn part of the rotation when manure is being applied to meet a significant proportion of the corn's nitrogen needs and a draw-down of the soil nutrient levels in the forage part of the rotation. Also notice that over time the trend in soil test levels should be relatively constant and maintained in the optimum to low end of the high range.

Figure 3. Nutrient removal by corn as compared to the nutrients applied in dairy manure, when the manure is applied to meet the nitrogen needs of the corn.

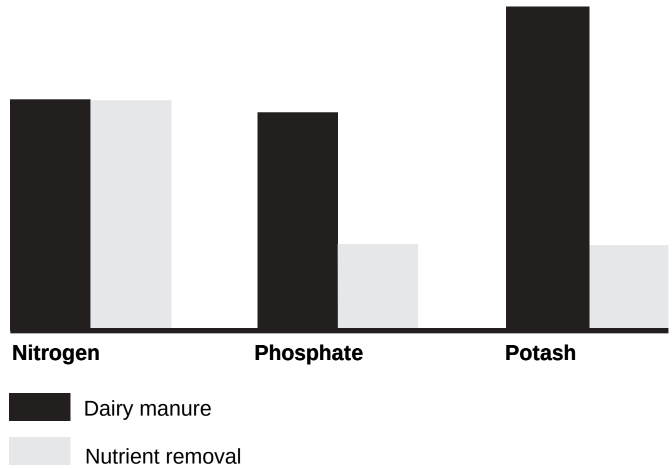
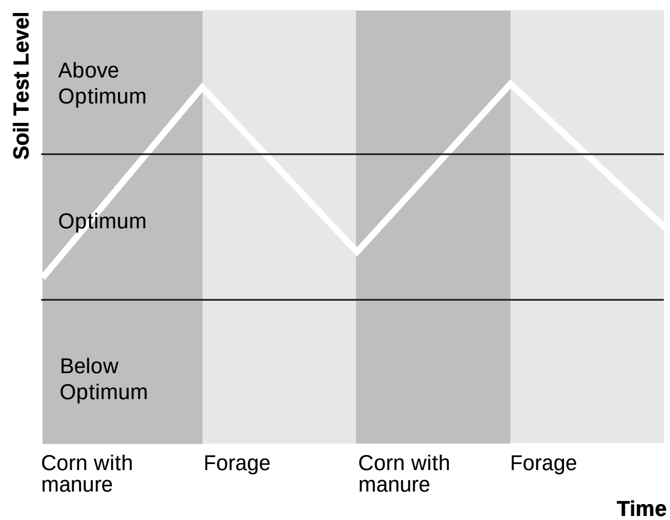


Figure 4. Soil test trends in a corn-forage crop rotation.



SOIL TESTING

Soil test recommendations from the Penn State soil testing program are designed to gradually build soil levels for phosphorus and potassium into the optimum range and then maintain them by replacing the nutrients that the crop removes. A regular soil testing program should be followed in fields sampled at least every three years or when the crop changes in the field. The soil test prior to establishment of a forage crop is especially important. A regular program like this along with application of the recommended nutrients as fertilizer or manure is critical in the crops prior to forage crop establishment and should result in meeting the pre-establishment soil fertility goals. Details on calculating soil test recommendations are provided in ST-4, "Interpreting Soil Tests for Agronomic Crops," or recommendations can be estimated from ST-2, "Fertilizer Recommendation Table," both sent out with each soil test run by Penn State. This information is also available in the *Penn State Agronomy Guide* and on the Agricultural Analytical Services Laboratory web site: www.aasl.psu.edu.

A crucial part of a good soil testing program is to take good soil samples. Table 2 gives the recommended guidelines for taking soil samples. Most of the errors associated with soil testing are a result of samples that are not representative of the fields being tested. Remember, the recommendations can only be as good as the sample and the information supplied to the lab.

Table 2. Guidelines for taking soil samples.

1. Sample at the right time. The best time to sample is in the fall.
2. Take cores from at least 15 to 20 spots randomly over the field to obtain a representative sample. One sample should not represent more than 10 to 20 acres.
3. Sample between rows. Avoid old fence rows, dead furrows, and other spots that are not representative of the whole field.
4. Take separate samples from problem areas.
5. Sample to plow depth in cultivated fields.
6. Take two samples from no-till fields: one to a 6-inch depth for lime and fertilizer recommendations, and one to a 2-inch depth to monitor surface acidity.
7. Sample permanent pastures to a 3- to 4-inch depth.
8. Collect the samples in a clean container.
9. Mix the core samplings, allow to air dry, and remove roots and stones.
10. Fill the soil test mailing container.
11. Complete the information sheet, giving *all* of the information requested.

SUMMARY

In the pre-establishment phase, the soil conditions must be adjusted to provide optimum soil fertility when the crop is established. Liming during the last year in corn and applying fertilizer and/or manure during the years preceding the forage seeding are important for building soil levels into the optimum to high range. A regular soil testing program plays a critical role in this process.

Prepared by Douglas Beegle, professor of agronomy

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