Soil Nutrient Analysis Laboratory

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Liming and Fertilizing Forage Crops in Connecticut

The Need for Lime in Connecticut
Nearly all naturally occurring Connecticut soils are very strongly to strongly acid (pH 4.5-5.5). Only a few of our soils are of limestone origin and not strongly acid. To produce crops efficiently, limestone must be applied to correct existing soil acidity. Subsequently, enough must be added to maintain a soil condition slightly acid to neutral in reaction.

Soil acidity occurs both naturally and as a result of cropping practices. Soil acidity is reduced naturally when rainfall leaches calcium and magnesium from the soil. Connecticut receives about 48 inches of rainfall annually, which is sufficient to lower pH considerably over a few years. The main cropping practice that lowers the pH of the soil is the application of nitrogen (N) fertilizer in the form of urea or fertilizers containing ammonium. These fertilizers reduce the pH of soils when soil microorganisms convert the urea or ammonium to nitrate and release hydrogen, which lowers pH. Harvesting forage, whether by machine, or through grazing, also removes large amounts of calcium and magnesium. Admittedly, grazing results in the subsequent re-deposition of nutrients – but the nutrients usually are not well distributed across the field.

Weeds are another reason to pay attention to the pH of the soil. Whenever soil pH is out of the optimum range for forages, certain weedy species may become more prevalent because they are more tolerant of soil acidity (or alkalinity) than the desired forages. Under these conditions, certain indicator weedy plants may give an early warning that soil pH needs to be adjusted (see OH 81 Using Plants as "Indicators" for Diagnosing Turf Problems by Sid Bosworth, University of Vermont Extension Agronomist http://www.uvm.edu/extension/yard/oh81.pdf).

In the absence of additional limestone as a routine maintenance practice, the soil pH starts trending down after a few years due to the processes discussed above. Then the weeds that can tolerate lower soil pH start to take over.

How Much Lime is Needed?
The desirable pH range for our forage legumes is 6.8 -7.0. A pH above 6.0 is satisfactory for grasses. Because a mixed stand of both makes desirable hay or pasture, the goal is to lime to the need of the more sensitive legume crop (6.8-7.0).

The amount of limestone necessary to obtain the desired pH varies with soil texture, organic matter content, and previous liming practice. A soil nutrient analysis, conducted on soil samples collected before limestone and fertilizer are applied, is the best guide to determine the quantity of ground limestone needed to adjust the soil pH into the optimum range for crop production. Adjusting the soil to an optimum pH is especially critical before establishing a new seeding because high soil acidity (low soil pH) can impair seedling development resulting in reduced or failed stands.

Once soil acidity has been corrected, one ton of ground limestone should be applied per acre every two to three years to maintain soil pH at that same level.

Placement of Limestone
Limestone moves downward only about an inch per year in most of our Connecticut soils. Therefore, the amount of limestone applied, the placement of the limestone, and the type of tillage used control how fast soil acidity is corrected. For hay and pasture stands that are to be improved without plowing and reseeding, limestone is topdressed at one to two tons per acre according to soil test. When more than two tons are needed, another one or two tons is then broadcast a year later followed by a ton per acre every three years thereafter.

Where hay or pasture crops are to be seeded, it is recommended that the required limestone, up to 2 tons per acre, be applied after plowing and harrowed in by using a disk. This practice provides optimum correction of acidity in the root zone of the establishing seedlings. If heavy application rates are required, plowing under a part of the limestone and disking in the remainder after plowing is the most desirable way to correct soil acidity.

Uniform spreading of limestone is essential because little lateral movement of limestone occurs in the soil.

When to Apply Limestone

Maintenance applications of limestone may be applied at any time of the year that soil conditions are suitable to bear the weight of the spreading equipment. Limestone could be applied to frozen ground that is free of snow although it is preferable to apply to unfrozen ground. Applications to the surface of snow should be avoided, because the likelihood of loss during runoff in the spring is higher.

With our most acid-sensitive forage crop, alfalfa, the timing of limestone application before planting can be critical. Limestone is slowly soluble in the soil, and several months to a year may be needed to raise the pH high enough for the alfalfa to establish and grow well. Other legumes are less sensitive, but the greater the progress in correcting acidity, the easier the establishment of the new crop, the faster it becomes a productive stand and the less weed pressure you will have.

Legumes are much more deeply rooted than grasses. Therefore legumes need to have the pH adjusted to a deeper depth. Since legume roots penetrate deeper than the traditional plow depth, additional time may be needed in fields with an extremely low pH to allow the limestone to move below the plow layer into deeper soil layers to increase the pH of the deeper soil, which often has a pH of 4.5 to 4.8. This phenomenon is most clearly seen in newly cleared forest lands. Legume stands in these fields usually do not last 5 or more years, which is typical in better soils. The short duration of legume stands on newly cleared land is due to the inability of the roots of the legumes to grow into the lower soil depths because of the low pH in the lower depths. The shallow rooting depth reduces nutrient and water uptake and stresses the plants, which reduces the longevity of the stand. Legumes also have a symbiotic relationship with mycorrhizial bacteria that live in the root nodules and fix nitrogen. The growth of these bacteria is inhibited by low soil pH and their declining populations further weakens legumes being grown in low pH soils.

In soils that have recently been cleared, it is beneficial to grow more acid tolerant plants for a few years while applications of limestone and the passing of time can work together to reduce the soil acidity in the deeper soil depths to a level that will allow a legume crop to succeed.

What Kind of Limestone Should be Used?

Ground limestone, commonly known as agricultural limestone is the most readily available and economical liming material. Historically there are records that refer to the use of "burned or quick" lime and hydrated lime during various time periods. Quicklime is made by heating limestone ($CaCO_3$) in an oven or kiln and creating CaO. This type of lime is still made but the cost prohibits its use in general agricultural practice. Hydrated lime ($Ca(OH)_2$), sometimes referred to as "slaked" or pickling" lime, is formed by mixing or "slaking" quicklime with water, resulting in a more expensive product that is extremely reactive and caustic. The cost generally restricts its use to specialty applications.

The agricultural limestone produced in Connecticut is dolomitic limestone that contains higher levels of magnesium than calcitic limestone that is mined in other parts of the country. This magnesium is desirable for the production of forage crops because both the plants and the animals need magnesium. Since it already is a component of the limestone, one does not need to purchase magnesium separately as is necessary for some areas of the country.

Agricultural limestone (aglime) is marketed in two forms, powdered or pelleted. Pelletizing adds an additional cost to the limestone, which is usually not warranted for agricultural use. That said, however, there is a relatively large market for pelletized limestone in the landscape industry. The pelletizing process involves mixing regular ground aglime with some type of binder that serves to hold the limestone together. This process eliminates the dust, allowing the limestone to be applied with standard rotary fertilizer spreading equipment and making the use of limestone in a residential area easier and cleaner. Typical agricultural lime is ground limestone with varying degrees of fineness depending on the use and the application equipment. More finely ground limestone reacts more quickly in the soil to reduce acidity – but it costs more and the application creates more dust.

Farmers usually have their limestone applied by a custom applicator because aglime is dusty, used at high rates, and requires the use of specialized equipment. These commercial applicators usually have rotary spreaders that spin the limestone onto the field in 20 to 40-feet wide swathes. Limestone used by these trucks is usually more coarsely ground to reduce the cloud of dust associated with this high powered equipment. Due to the large size of this equipment it is unable to be used in small fields. In these cases there are spreaders available usually 3 to 8-feet wide that can be towed behind small tractors or even ATVs to spread smaller fields by dropping the lime directly onto the soil surface. These spreaders are priced in the one to three thousand dollar range but can be worth the investment due to the continual need to apply limestone over the years.

Liquid or fluid lime is an aglime suspension in water. This form of lime is a relatively new product. Liquid lime permits more uniform application and eliminates the dust problems of spreading dry forms of limestone. To achieve suspension, the aglime is very finely ground; hence it reacts slightly faster than most dry forms to correct acidity. This type of lime is not used by farmers, but the landscape industry has adopted its use almost exclusively. Hydro seeding of limestone, seed, fertilizer and mulch in one application is now standard practice.

Fertilizers

Soil fertility largely determines the forage crop yield that can be achieved. If soils are deficient in nutrients, only small crop yields will be realized. The goal of any fertilization program is to produce the maximum economic yield for the crop whether harvested as hay, haylage, or as pasture. A fertility program based on the soil nutrient analysis is the best guide to the amounts of fertilizer or manure to apply.

Table 1, Nutrient Value of Fertilizers, lists the fertilizers commonly available in Connecticut and the amount of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) provided. The values on the soil test report are in pounds per acre. Fertilizer bag labels list percentages. To calculate how much fertilizer is needed to provide a given nutrient, divide the pounds per acre number by the percent on the bag (as a decimal). The result will be the pounds of fertilizer to apply per acre to obtain the needed nutrient.

Table 1. Nutrient Value of Fertilizers (Guaranteed analysis -percent by dry weight)

Fertilizer	N %	P_2O_5%	K_2O %
Ammonium Polyphosphate	10	34	0
Ammonium Sulfate	21	0	0
Ammonium Nitrate	34	0	0
Diammonium Phosphate	20	50	0
Monoammonium Phosphate	12	50	0
Muriate of Potash	0	0	61
Potassium Hydroxide	0	0	70
Potassium Nitrate	13	0	45
Potassium Sulfate	0	0	50
Sulfate of Potash Magnesia (Sul-Po-Mag)	0	0	22
Triple Superphosphate	0	46	0
Urea	46	0	0

When to Fertilize

Fertilizers, by definition, are natural or synthetic substances that supply nutrients to plants. Therefore, it makes sense to apply fertilizers when the plant is actively growing so it can use the nutrients to support its growth and development. In Connecticut, the growing season is traditionally considered to be May through October. In some years the season may extend earlier into April or later into November or December but even when it does, not many nutrients are taken up during these periods. Ideally plant nutrients should be available when the plants can use them most effectively. Because it is difficult to predict this exact moment, we tend to fertilize early and let the plant absorb nutrients at its own pace. Unfortunately, this introduces some inefficiencies and the potential for nutrient losses.

Established Stands

Maintenance applications of fertilizer phosphorus (P_2O_5) or potassium (K_2O) can be made at any time during the growing season with little risk of loss to the environment. Nutrients applied late in the season will not be available to support crop yields in the year of application, but the fertilizer will stay in the soil through the winter and be there for uptake during the next growing season. Nitrogen (N), on the other hand, is different. Nitrogen is both volatile and soluble, and requires special consideration.

Urea is the most common form of nitrogen fertilizer available in Connecticut and it is highly soluble in water. Once in solution, the urease enzyme hydrolyzes the urea, breaking it down into ammonia and carbon dioxide. The ammonia can then dissipate into the air and be lost. This process is known as volatilization. Volatilization can cause the loss of up to 60% of the N applied as urea or as ammonium forms of N. The conditions that increase the chance of losing N to volatilization are application to the soil surface, rainfall or dew sufficient to dissolve the fertilizer granules but not sufficient to wash into the soil, plant material on the soil surface, and windy or humid conditions. Because N is usually applied to the soil surface of hay and pasture crops, it is best to apply urea and ammonium fertilizers before a prediction of at least a half inch of rainfall. This amount of rainfall is sufficient to wash the fertilizer into the soil where the ammonia gas produced will be captured by the water in the soil pores instead of lost to the atmosphere.

Some forms of nitrogen are very soluble and will readily dissolve in water. As the water flows down through the soil profile, it can carry, or leach, the nitrogen through and out of the root zone. Once out of the plants root zone, the nutrient is unavailable for plant uptake. The nitrogen may enter and contaminate ground water supplies and can also make its way into nearby surface waters resulting in eutrophication, which is the undesired stimulation of vegetative growth in lakes, ponds and other water sources.

Nitrogen fertilizer, therefore, should be applied to minimize volatilization and leaching losses. Too much rainfall can leach N from the soil, but too little rainfall immediately after application can cause large volatilization losses of N. Because no one can accurately predict the weather, it is recommended that nitrogen fertilizer be applied to fields in smaller amounts at several times during the growing season. For grass (legumes do not need N fertilizer due to the nitrogen-fixing bacteria) divide the annual maintenance amount of nitrogen needed (100 lbs per acre) by the number of cuttings obtained in a normal year, and then apply this amount during stages of active growth. For example, a grower that normally harvests 3 cuttings a year should apply about 33 pounds of nitrogen per acre, 3 times per year. The first as early in the spring as it is possible to get equipment into the field without damaging the grass, and then immediately following the first and second cuttings. This schedule minimizes the losses due to leaching because the plants are actively growing and needs the nutrients. Volatilization losses are also minimized because the amount of fertilizer per application is lower, and chances are that conditions will not be favorable for losses at all of the applications.

New Seedings

For new seedings, apply suggested fertilizers after plowing and incorporate fertilizers, along with any recommended limestone by disk-harrowing. For operations with smaller equipment, attempting to spread across freshly plowed fields can be a challenge. In this case, a light disk harrowing might be needed to create a smoother driving surface prior to fertilizer application. Most fertilizer dealers will arrange for custom application whether fertilizers are applied at seedbed preparation or as topdressing.

Manure

Manure can be beneficial for crop production in multiple ways. First and foremost, the manure contains nutrients. The amount of nutrients in manure varies depending on: the species of livestock; whether the manure is handled as a liquid or a solid; how much bedding is mixed in with the manure; and how the manure is handled and stored. Manure adds organic matter to the soil which increases the water holding capacity of the soil, increases the air space in the soil – making it easier for water to infiltrate. It also adds micronutrients to the soil. Micronutrients are nutrients that plants need, but in very small quantities. While these nutrients are essential, they are also very expensive, so it makes good economic sense to apply manure at least every few years to provide these nutrients.

Timing and application of manure is basically the same as nitrogen fertilizer. Because manure contains nitrogen, one needs to take the same precautions with manure as with nitrogen fertilizers to prevent both volatilization and leaching of nutrients. Manure is a little more environmentally risky to apply compared to nitrogen fertilizer because the manure also contains soluble forms of phosphorus. This soluble phosphorus can move with water through the soil and also can be lost by surface erosion of soil particles. Like nitrogen, it can cause the degradation of water resources by promoting algae blooms and eutrophication in fresh water systems.

Due to the variation in the nutrient content of manure discussed above, it is recommended that specific manures be analyzed for nutrient content, but even a manure analysis will provide only a rough estimate of the nutrient content of manure because of the difficulty of obtaining a sample that accurately represents the nutrient concentration of the manure. A number of laboratories in the Northeast will analyze the nutrient content of manure for a small charge.

Table 2. Nutrient credits for various types of manures.

	Pounds per ton manure		
Manure	**N**	**P_2O_5**	**K_2O**
Beef	11	9	10
Dairy – solid	5	3	6
Goat	8	10	2
Horse	12	4	9
Poultry – solid	16	20	12
Sheep	11	8	19
Swine	14	11	11

Crop Nutrient Needs

Anyone involved in growing a crop asks the same question "How much fertilizer or manure should I apply to a given crop?" Unfortunately, the answer is "It depends!" It depends on a number of factors: the crop, the fertility level already in the soil, the yield goal desired, the soil temperature, rainfall and other factors too numerous to mention. The best way to estimate nutrient needs is to have the soil analyzed for the availability of nutrients. The University of Connecticut Soil Nutrient Analysis Laboratory will analyze the soil for a small fee and provide a fertilizer recommendation based on the crop desired.

If time constraints or other circumstances are such that you are unable to analyze your soil before applying fertilizer or manure you may refer to Table 3. Maintenance Fertilizer Recommendations for Perennial Crops, or Table 4. Fertilizer Recommendations for Seeding an Annual or Perennial Crop for generic recommendations as appropriate to your needs.

Table 3. Maintenance Fertilizer Recommendations for Perennial Crops

Crop	N	P_2O_5	K_2O
	—— lbs/acre ——		
Alfalfa	0	48	214
Alfalfa, grass mix	0	13	71
Clover, Alsike	0	33	154
Clover, Crimson	0	33	154
Clover, grass mix	0	13	71
Clover, Ladino	0	33	154
Clover, Red	0	33	154
Grass	100	23	31
Orchardgrass	100	23	31
Pasture, grass	100	34	31
Pasture, legume & grass mix	0	13	71
Reed Canarygrass	100	23	31
Rye, cereal	40	34	0
Ryegrass	100	23	31
Ryegrass, Tetraploid	100	23	31
Tall Fescue	100	23	31
Timothy	100	23	31
Trefoil	0	33	154
Trefoil, Birdsfoot	0	33	154
Trefoil, grass mix	0	13	71

Table 4. Fertilizer Recommendations for Seeding Forage Crops

Crop	N	P_2O_5	K_2O
	—— lbs/acre ——		
Alfalfa	40	78	49
Alfalfa, grass mix	40	78	49
Barley	40	27	19
Buckwheat	30	20	45
Clover, Alsike	40	78	49
Clover, Crimson	40	78	49
Clover, grass mix	40	78	49
Clover, Ladino	40	78	49
Clover, Red	40	78	49
Corn, BMR	140	46	72
Corn, Field	140	46	72
Grass	40	44	0
Kale	160	130	125
Oats	40	27	19
Orchardgrass	40	34	0
Pasture, grass	40	44	0
Pasture, legume/grass	40	78	49
Reed Canarygrass	40	27	19
Rye	40	34	0
Ryegrass	100	23	31
Ryegrass, Tetraploid	40	34	31
Small Grains	40	27	19
Sorghum	100	39	49
Sorghum/SudanGrass	100	39	49
Soybeans	40	27	19
Sunflower	80	25	50
Tall Fescue	40	34	0
Timothy	40	34	0
Trefoil	40	64	29
Trefoil, Birdsfoot	40	101	9
Trefoil, grass mix	40	101	9
Triticale	40	27	24
Turnip	50	50	50
Wheat	40	27	19

University of Connecticut

COOPERATIVE EXTENSION SYSTEM

College of Agriculture and Natural Resources

W.W. Washko and G.F. Griffin. 1982. University of Connecticut Cooperative Extension System

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