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LIMING PRACTICES

NORTH CAROLINA STATE COLLEGE OF AGRICULTURE AND ENGINEERING
OF THE
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AND
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N. C. AGRICULTURAL EXTENSION SERVICE
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Liming Practices*

PURPOSE OF LIMING

1. *Corrects or Adjusts Soil Acidity:* Plants differ in their tolerance of acidity or their requirements for a basic medium for growth. Applications of lime or limestone neutralizes the soil acids because of the basic nature of the materials. (See Table on Liming Materials.)
2. *Supplies Calcium and/or Magnesium:* Lime or limestone is the cheapest source of supply for calcium which is required by all plants. Magnesium is an important part of the green coloring matter (chlorophyll) of the plant. A deficiency is indicated by "sand drown" in tobacco, red leaves in cotton, etc. Magnesium is also important as a carrier of phosphorous within the plant, regulating the uptake of other elements, etc. Lime or limestones containing magnesium have the added advantage of supplying magnesium in the most economical form.
3. *Prevents Fixation of Phosphates Applied as Fertilizers:* Acid soils contain soluble iron and aluminum which fixes applied and soil phosphates in a form unavailable to plants. Neutralizing the soil acids with lime or limestone removes the iron and aluminum from the soil solution so that applied phosphates remain available to the plant for a longer period.
4. *Makes Conditions More Favorable for Growth of Legumes:* Provides a more favorable soil medium for growth of nitrogen fixing bacteria. Fixation of nitrogen from the air in the nodules of most legumes may be very low under excessive acid soil conditions or at very low calcium levels.
5. *Stimulates Decomposition of Organic Material:* The decomposition of crop residues, and the conversion of organic nitrogen to nitrates are increased in the presence of lime, accompanied by a proper pH level.
6. *May Indirectly Improve Physical Condition of Soil:* The use of lime or limestone alone may not improve the physical condition of the soil. However, lime or limestone usually makes growth conditions more favorable for most plants, especially legumes. Where legumes make greater growth and this greater amount of vegetation is returned to the land, the clays and silts have a tendency to be bound together by the organic matter to form larger particles or granules. These granules permit better areation and moisture relationships and facilitate root development.
7. *Increases the Yields of Most Crops:*

A. Lespedeza (N. C. Experiment Station Bulletin)

CROP	POUNDS OF HAY PER ACRE				
	Original pH	No Treatment	Phosphates	Lime	Phosphate and Lime
Lespedeza and Bluegrass	5.5	1420	1730	....	2530
Lespedeza (Eroded soil)	5.0	1320	1210	1510	2700
Lespedeza (Poor soil)	5.0	1800	2240	2520	3000

* This circular was prepared by E. R. Collins, In Charge, Agronomy Extension, with suggestions from and approval by, the members of the Agronomy Department of the N. C. Experiment Station.

B. **Corn, Wheat, Red Clover, and Cotton:**

Corn, cotton, wheat, etc., grown in rotation with a legume, usually shows increased yields from applications of limestone. These increased yields usually follow a better growth of the legume, more vegetation turned under, and improved soil fertility. Continuous corn without lime on a Cecil clay loam averaged 15 bushels per acre, while corn in a three year rotation of red clover, corn and cowpeas averaged 37 bushels per acres where lime was applied.

Similar results are shown in a four year rotation of corn, wheat (red clover), red clover, and cotton (rye) on a Cecil clay loam soil pH 5.1 (N. C. Expt. Sta. Bul. 331).

CROP	YIELD		
	No Lime	2800 Lbs. Limestone Once in Rotation	Increase Due to Lime
Corn	19.4 bu.	32.7 bu.	13.3 bu.
Wheat	14.4 bu.	20.7 bu.	6.3 bu.
Red Clover	617 lbs.	2737 lbs.	2120 lbs.
Seed Cotton	909 lbs.	1055 lbs.	146 lbs.

C. **Peanuts (N. C. Expt. Sta. Bull. 330)**

No. of Fields	Period	Increase for 400 lbs. Dolomitic Limestone in Row	Net Profit Above Cost of Limestone*
21	3 yrs.	83 pounds per acre	$3.58 per acre

* Peanuts valued at six cents per pound and ground dolomitic limestone at $7.00 per ton.

D. **Strawberries (N. C. Expt. Sta. Bull. 332)**

Soil Type	Original pH	Rate of Application	Increase in yield Qts. per acre
1. Norfolk fine sandy loam	4.8	2400 lbs. broadcast	550
2 years		800 lbs. in furrow	900
2. Norfolk fine sandy loam	5.3	2400 lbs. broadcast	480
3 years		800 lbs. in furrow	470
3. Coxville fine sandy loam	4.6	6000 lbs. broadcast	1300
2 years		8000 lbs. broadcast	1700
4. Norfolk fine sandy loam 3 years	4.9	2000 lbs. broadcast	60

TIME AND METHOD OF APPLICATION

Liming materials may be applied at any time convenient to the farmer which is usually late fall and winter. Time is required for ground limestone to react and neutralize the soil acids. Reaction is hastened by thoroughly mixing the limestone with the soil by discing or harrowing. Hydrated and burned limes and basic slag react with the soil more rapidly than ground limestones and therefore can be applied nearer the time of seeding the crop which is to be benefitted by the limestone.

Legumes give a greater response to lime than corn, cotton, tobacco, etc., and therefore, it is advisable to apply the limestone in the fall or winter preceding the growing of the legume in the rotation.

Broadcast applications are advisable in most cases. Uniform distribution is imortant and the small cost of an inexpensive lime spreader is well justified. Where small applications are used it can be applied in the row in the same manner as a fertilizer. This is advisable with high lime requiring crops such as peanuts where it is recommended to apply 400 pounds of ground dolomitic limestone in the row before planting. This gives the row crop maximum benefit from the limestone applied. The following crop of cotton or corn does not need the high lime content that would be required by a broadcast application of lime for peanuts.

EVALUATION OF LIMING MATERIALS

1. *Speed of Reaction with Soil Acids:* Burned and hydrated limes react more quickly than ground oyster shells or ground limestones but their cost is considerably higher per unit of neutralizing value. They may be used to advantage when applied immediately before planting a legume on an acid soil but it is more economical to apply the limestone long enough before planting for neutralization of the soil acids.

   Ground limestones are sold with a guaranteed screen analysis (See information required by law). The finer the particles the more rapid the soil acids are neutralized. *For practical purposes a limestone ground so that 65-80 percent passes a 48 mesh screen is satisfactory providing the 100 mesh and finer materials have not been removed.* Forty to fifty percent should pass 100 mesh.

   The following table shows the screen analysis of five ground limestones that have been sold in North Carolina.

SCREEN SIZES FOUND IN GROUND DOLOMITIC LIMESTONE THAT WERE OFFERED FOR SALE IN NORTH CAROLINA

	No. 1	No. 2	No. 3	No. 4	No. 5
Passing 10 mesh screen	100%	100%	100%	100%	100%
Passing 40 mesh screen	90	97	61	62	51
Passing 60 mesh screen	71	74	36	48	42
Passing 80 mesh screen	62	62	35	44	40
Passing 100 mesh screen	54	46	29	40	38

From the above figures it would be expected that the speed of reaction of, or neutralization by, Nos. 1 and 2 would be superior to Nos. 3, 4 and 5 because of the larger percentage of fine material. Methods of comparing different liming materials are given under "neutralizing value" below.

2. *Neutralizing Value:* Limestones differ in their neutralizing value; therefore, it is necessary that they be classified on a common basis. Their neutralizing values are expressed as "calcium carbonate equivalent" or "neutralizing equivalents." Pure calcium carbonate is used as the standard and is considered to have a "neutralizing equivalent" or "calcium carbonate equivalent" of 100. Lime or limestone should be purchased on the basis of cost per unit of "calcium carbonate equivalent."

A. **Comparison of Liming Materials on the Basis of Neutralizing Value:**

One ton of ground dolomitic limestone with a neutralizing equivalent of 95, will have a neutralizing value equivalent to 1900 pounds of calcium carbonate (200 x 95% = 1900).

Marl, with a neutralizing equivalent of 60, would require 3167 pounds to be equivalent to one ton of ground dolomitic limestone with a neutralizing equivalent of 95. (1900 ÷ 60% = 3167).

With ground dolomitic limestone at $3.00 per ton, one could afford to pay $3.00 x 2000 ÷ 3167 or $1.89 per ton for marl on the basis of neutralizing value.

B. **Comparing the value of two ground dolomitic limestones from their guarantee of fineness.**

Guarantees of screen sizes have been changed recently to the mesh sizes shown below. Comparisons are made on the basis of screen sizes now required by law.

Fineness of Particles		Percent of each size particles	Pounds of each per ton	Percent estimated to be available 1-3 yrs.	Pounds available per ton
Limestone A					
Passing 10 mesh	100%	5% (100-95)	100	10%	10
Passing 20 mesh	95	15% (95-80)	300	40%	120
Passing 48 mesh	80	26% (80-54)	520	100%	520
Passing 100 mesh	54	54%	1080	100%	1080
			2000		1730
Limestone B					
Passing 10 mesh	100%	30% (100-70)	600	10%	60
Passing 20 mesh	70	25% (70-45)	500	40%	200
Passing 48 mesh	45	7% (45-38)	140	100%	140
Passing 100 mesh	38	38%	760	100%	760
			2000		1160

When limestone A above costs $3.00 per ton delivered, limestone B would be worth only $\frac{1160}{1730}$ x $3.00 or $2.02 per ton delivered on the basis of availability over a period of 1 to 3 years.

In the case of limestone B, the farmer would be required to buy, handle and apply 3000 pounds (2000 x $\frac{1730}{1160}$) to get the same neutralizing effect as 2000 pounds of limestone B. This comparison with the new screen sizes shows the same relative value as limestone numbers 1 and 5 given above.

3. *Magnesium Requirements of the Soil:* Dolomitic limestones contain magnesium (See Table of Liming Materials) and higher neutralizing equivalents than calcium limestones. Where magnesium deficiency exists this is the most economical method of supplying magnesium. The law

requires that the calcium and magnesium content of liming materials shall be guaranteed as shown. (See information required by law.) Magnesium deficiency is more common in the Coastal Plain and in the very sandy soils of the Piedmont.

INFORMATION REQUIRED BY LAW ON LIMING MATERIALS

In case of materials sold in bulk the information shown on the bags below shall be delivered to the purchaser either with the material or with the invoice therefor.

A. Ground limestone or mixtures of burned or unburned materials:

Example	Required by Law
100 pounds net	Net weight when sold in packages.
JOHN DOE'S GROUND DOLOMITIC LIMESTONE	A brand or trade name truly descriptive of the product.
Guaranteed Analysis Calcium Carbonate ($CaCO_3$) ..... 52% Magnesium Carbonate ($MgCO_3$) .. 42%	The minimum percent of calcium expressed as calcium carbonate ($CaCO_3$) and of magnesium expressed as magnesium carbonate ($MgCO_3$).
Neutralizing equivalent 95	Total neutralizing value expressed as "calcium carbonate equivalent" or "neutralizing equivalent."[1]
Screen Analysis 100% through 10 mesh 95% through 20 mesh 80% through 48 mesh 54% through 100 mesh	Fineness of the material as determined by screens complying with the specifications of the United States Bureau of Standards.
JOHN DOE CO., NORFOLK, VIRGINIA	

The name and address of the manufacturer or vendor guaranteeing the registration.

[1] Since calcium and magnesium are expressed in terms of carbonates, regardless of the actual form of occurrence, neutralizing equivalent is lower than that which is calculated from the Carbonate guarantee.

B. Burned materials. (The term "lime" can be used only with completely burned material).

Example[2]

100 pounds net

JOHN DOE'S BURNED OYSTER SHELL LIME

Guaranteed Analysis

Calcium Oxide (CaO)	55%
Magnesium Oxide (MgO)	0.5%
Neutralizing equivalent	100

JOHN DOE CO., NORFOLK, VIRGINIA

[2] Burned lime from calcium limestones will be higher as shown in the table below.

Required by Law

Net weight when sold in packages.

A brand or trade name truly descriptive of the product.

The minimum percent of calcium expressed as calcium oxide (CaO) and of magnesium as magnesium oxide (MgO).

Total neutralizing value expressed as "calcium carbonate equivalent" or "neutralizing equivalent."

The guarantee of screen analyses shall not be required for the products of completely burned limestones or shells.

The name and address of the manufacturer or vendor guaranteeing the registration.

This example is about the average of burned oyster shell lime sold in North Carolina.

LIMING MATERIALS

	Common Names[1]	Calcium Carbonate Equivalent or Neutralizing Equivalent	Average Composition
Dolomitic Limestone	Agricultural limestone Ground dolomitic limestone	95 - 108%[2]	52% $CaCO_3$[2] 42% $MgCO_3$
High Calcic	Ground Limestone Air slacked lime Precipitated lime	85 - 100%	80 - 95% $CaCO_3$
Ground oyster shells	Baked lime	80 - 90%	85% $CaCO_3$
Marl		50 - 90%	60% $CaCO_3$
Burned Lime	Burned oyster shells Lump lime Builders lime Caustic lime	90 - 110%[2] 150 - 175%	55% CaO; 0.5% MgO[2] 85% CaO
Hydrated Lime	Water slacked lime	120 - 135%	65% CaO
Basic slag		25 - 35%	45 - 48% CaO; 5 - 7% MgO (also 8-10% available P_2O_5)
Wood ashes		40 - 50%	45% $CaCO_3$
Gypsum	Land plaster	0—Supplies calcium and sulfur but does not neutralize accidity	70 - 75% $CaSO_4$[2]

[1] These common names do not necessarily correspond to the terminology required by law in that lime refers to completely burned products.

[2] Bulletin N. C. Department of Agriculture, Spring 1941.

OVER LIMING INJURY

Excess applications of lime or failure to properly clean up the lime where piled in the field sometimes results in injury to plants.

This evidence of overliming injury is more easily observed than the poor growth of legumes existing on many farms due to insufficient lime. As a result overliming injury is frequently overemphasized and many fields go unlimed because of fear of applying too much. Following the procedure of submitting soil samples for lime recommendations and applying lime as recommended should overcome the danger of excess applications.

The cause of this injury varies with different soils but can usually be corrected when examined by men trained in this field. Manganese and boron deficiencies are probably the most common cause of excess lime injury. One of the explanations for these deficiencies is the fixation of these elements by the soil, the same as an acid soil fixes phosphates in a form unavailable to plants. Both of these deficiencies can usually be recognized from soil analyses and plant deficiency symptoms and corrected by applications of boron and manganese, and sometimes iron.

LIME IN RELATION TO DISEASES

The Plant Pathology Division advises that soil reaction has a definite effect on the growth and parasitism of certain soilborne organisms. Scab of Irish potatoes is most frequently serious when the crop is grown in soils having a reaction more alkaline than approximately pH 4.8 to 5.0. Applications of lime to scab-infested soils having this or a more alkaline reaction are likely to increase the severity of scab. Black root rot of tobacco is present in many North Carolina soils, but is most injurious in soils having a pH reacting greater than approximately 5.6 to 5.9. When liming soils, one should keep in mind the possible effect that the altered soil reaction will have on disease development in subsequent crops.

For further information contact the Plant Pathology Division.

HOW MUCH LIME OR LIMESTONE TO APPLY

It is impossible to determine the lime requirement of a soil by looking at it. Soil test kits are often unreliable in the hands of inexperienced operators. A free soil testing service is available to farmers of North Carolina where the best methods available are used under controlled laboratory conditions. If in doubt as to the lime requirements of your soil submit a sample for free test.

HOW TO GET SOIL TESTED

The North Carolina Department of Agriculture maintains a free soil testing service. Secure soil sample containers and instruction sheet for collecting the soil samples from the county agents, agricultural teachers, Farm Security supervisors, fertilizer dealers, or from the North Carolina Department of Agriculture, Raleigh, North Carolina.

LIME REQUIREMENTS OF CROPS

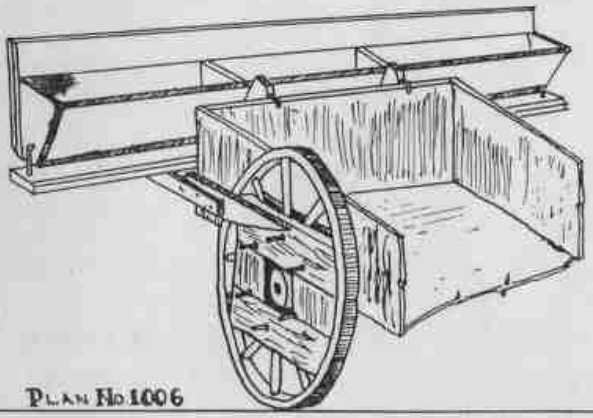
Plants differ in their lime requirements and the crops grown in the rotation should be considered in a lime recommendation.

SOIL REACTION (pH) PREFERENCES OF PLANTS

The following table is given as an indication of the general acidity tolerance of specific crops but it does not infer that these crops cannot be grown outside the range indicated under some conditions. The calcium and magnesium content of the soil may be a more important factor in plant growth than the pH of the soil within the limits indicated on the table. Many of the plants in the first and second columns are grown best in rotation with other crops having high lime requirements and are not themselves detrimentally affected by the higher lime level. See section 7B.

Plants tolerant of medium acidity (pH 5.0 - 5.5)	Plants tolerant of moderate acidity (pH 5.5 - 6.0)	Plants requiring higher pH levels (pH 6.0 - 6.8)
Apples	Barley	Alfalfa
Austrian winter peas*	Beans, snap	Asparagus
Bermuda grass	Beans, field	Beets
Blueberries	Bluegrass*	Brussel sprouts
Buckwheat	Cabbage	Cantaloupes
Carpet grass	Cantaloupes	Cauliflower
Clover, Alsike*	Carrot	Celery
Corn*	Clover, Crimson	Clover, Sweet
Cotton*	Clover, Hop	Lettuce
Cowpeas	Clover, Red*	Peanuts
Crotalaria	Clover, White*	Peas, English
Dallis grass	Collard	Spinach
Johnson grass	Cucumber	Swiss chard
Millet	Eggplant	
Oats	Kale	
Orchard grass	Mustard	
Potatoes	Onions	
Red Top	Peach	
Rye	Pepper	
Rye grass (Italian)	Pumpkin	
Sorghum	Radish	
Sudan grass	Soybean	
Sweet potatoes	Squash	
Tomatoes	Strawberry*	
Velvet beans	Tobacco	
Vetch, Hairy*		
Watermelon		
Wheat*		

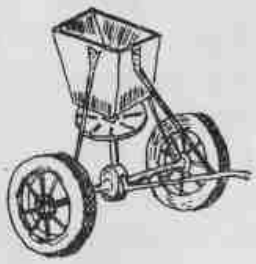
* This is a borderline case and some authorities put it in the group to the right.



LIME SPREADER

THIS PLAN GIVES DIMENSIONS AND BILL OF MATERIALS FOR BUILDING A LIME SPREADER, MADE OF WOOD, WHICH CLAMPS ON THE END GATE OF A WAGON.

PLAN No. 1006



LIME SPREADER

A SIMPLE, METAL HOPPER MOUNTED ABOVE A DISK DRIVEN BY THE REAR END ASSEMBLY OF A JUNKED CAR.

PLAN No. 254

FERTILIZER DISTRIBUTOR

PLAN SHOWS CONSTRUCTION DETAILS OF A DISTRIBUTOR MADE LARGELY OF METAL AND USING REAR AXLE ASSEMBLY OF A JUNKED AUTOMOBILE.

THESE PLANS CAN BE ORDERED BY NUMBER FROM DEPARTMENT OF AGRICULTURAL ENGINEERING.

PLAN No. 12.

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS STATE OF NORTH CAROLINA NORTH CAROLINA STATE COLLEGE AND U.S. DEPT. OF AGRICULTURE COOPERATING RAY AUS, ENGINEER, RALEIGH, N.C.		
HOME MADE DISTRIBUTORS		
N.C.	NO. 1005	SHEET 1 NO. 1
NOV. 1942		

The AGRICULTURAL EXTENSION SERVICE maintains a county farm agent in each of North Carolina's 100 counties and a home agent in 94 counties. They are assisted, in many of the counties, by assistant agents and by Negro farm and home agents. The Extension Service represents the United States Department of Agriculture, the North Carolina State College of Agriculture and Engineering, and the local county. Farmers or other members of the rural family may secure full information about the Nation's War program as it relates to the farm family by discussing the matter with these county agents. Bulletins, printed material and other information may be secured by writing to the Agricultural Extension Service, North Carolina State College, Raleigh, N. C.