Test Your Soil for Acidity

By C. M. Linsley and
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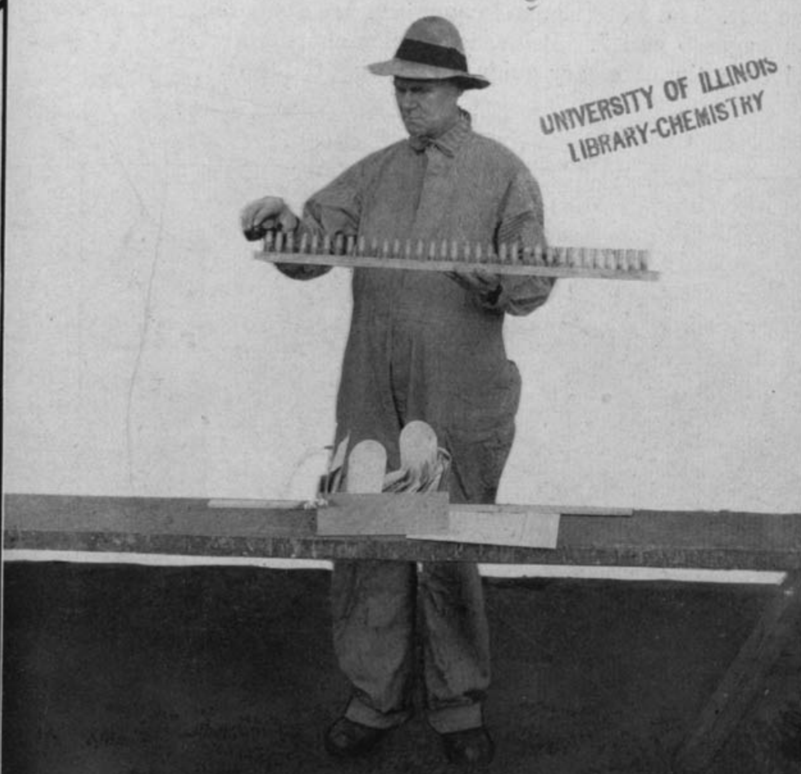

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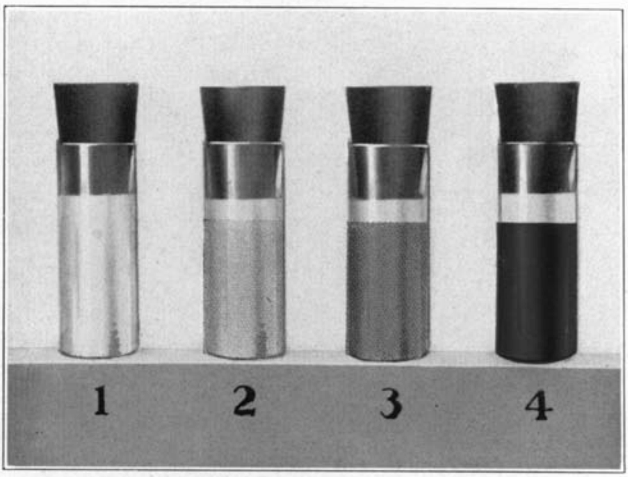
THE NEED for a method of testing and mapping soils for acidity that a farmer could use, has been evident for several years. The plan described in this circular has been designed to meet such a need. It has been used by many hundreds of Illinois farmers, who have found it both simple and practical and the means of saving many tons of limestone and many bushels of clover seed.

According to this plan, 23 *surface* samples, 5 *subsurface,* and 5 *subsoil* samples are collected from definite points in a 40-acre field. These are tested by means of the potassium thiocyanate method, and the result recorded on a map sheet. The completed map shows where limestone is needed and approximately how much should be applied to the acre.

This circular, together with the blank map forms (which can be obtained free of charge by addressing the Agronomy Department, University of Illinois, Urbana), gives complete directions for making the test. The materials and equipment are easily obtained, as described on pages 6 and 7. Below is a color chart, referred to on page 10, which is the necessary guide for reading the tests.



Color Chart for Reading Acidity Test

1—No acidity. No limestone needed.
2—Slightly acid. Needs 2 tons of limestone to acre.
3—Medium acid. Needs 3 tons of limestone to acre.
4—Strongly acid. Needs 4 tons of limestone to acre.

Test Your Soil For Acidity

Systematic Testing Saves Clover Seed and Limestone

By C. M. LINSLEY, Assistant Chief in Soils Extension and
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Failure to test their soils for acidity is costing Illinois farmers many thousands of dollars every year in both clover seed and limestone. Many farmers sow at least 40 acres of red clover or sweet clover each year on land that is too acid to grow these crops successfully. This is an expensive practice. It means throwing away fifty to one hundred dollars in seed each year for every 40 acres seeded. If this money had been used to buy limestone, many farmers by this time would have all the acid land on their farms limed. A systematic test of the soil, which any farmer can make, will indicate where limestone will be needed in order to grow clovers successfully.

Not All Soils Need Limestone

Farmers who apply limestone without first testing their soil to determine whether or not limestone is needed and, if it is needed, how much is required to the acre to correct this acidity, are taking up their liming program blindly. Some will be throwing away high-priced clover seed by their failure to apply sufficient limestone, others will be wasting limestone by applying it to land that already contains plenty. Much of the land in Illinois, it is true, is acid, but there is nevertheless a large acreage that still contains plenty of limestone from the native supply. The soils of this state, often within a single field, vary widely in their need for limestone. Areas of sweet soil, slightly acid, medium acid, and strongly acid soil may all be present in the same field. It is important, therefore, that a systematic and detailed test be made of the field so that limestone may be applied according to the need for it.

The experience of a farmer in one of the northern Illinois counties is typical of many. This man had ordered 120 tons of limestone for a 40-acre field. While the shipment of limestone was on the road, he became interested in soil testing thru the farm bureau. When he collected samples from the field according to directions, he found that only about 60 tons of limestone were needed to correct the acidity of the field. This meant a saving of 60 tons of limestone, worth $120. Instead of wasting the limestone on land that already contained a supply, he had it for use on another field.

What is Soil Acidity?

The waste of clover seed is often due to lack of a clear understanding of what soil acidity is. For a practical working basis, it is sufficient to say that an "acid" soil is one that does not contain

FIG. 1.—HERE LIMESTONE HAS MADE THE DIFFERENCE BETWEEN A CROP OF SWEET CLOVER AND NO CROP

Left, no limestone; right, limestone. Sweet clover is one of the most sensitive crops to soil acidity. This crop will not grow on acid soils until limestone has been applied.

enough lime for the successful growth of our common legumes, particularly clovers and alfalfa. A "sweet" soil on the other hand is one that does contain sufficient lime for the vigorous growth of these crops.

Soils Become Acid From Cropping and Leaching

Because sweet clover grows luxuriantly along the roadside, a farmer often concludes that it should grow in the field across the fence. Accordingly, he may seed sweet clover year after year in a field that is too acid to grow this crop successfully and wonder why he never gets a stand. A test of the roadside soil where these patches of sweet clover are found will almost invariably show that it is sweet, even tho the soil in the cultivated field may test distinctly acid.

The reason for the above difference is that lime has been removed more rapidly from the cultivated field than from the sod along the roadside. The crops harvested during fifty to seventy-five years of farming and the more rapid leaching in the cultivated field have reduced the lime supply. The lime removed in crops, however, probably accounts for only a small part of the total loss; the greater loss has resulted from leaching. Rains seeping down thru the soil dissolve a large amount of the lime in the soil, and it is then carried away in the drainage water. As much as 500 pounds, it has been estimated, may be leached from an acre of cultivated land each year. The lime under sod dissolves much less rapidly and hence the loss is not so great.

Sweet Clover More Sensitive to Acid Soil Than Red Clover

Land that will grow a fair crop of red clover during favorable years, it has been assumed, should also grow sweet clover. This is not a sound assumption, for sweet clover is much more sensitive to soil acidity than is red clover. Altho red clover often grows fairly well on soils that are slightly to medium acid, especially if the soil is fertile and the season favorable, sweet clover will seldom grow on soils that are even slightly acid.

Soil, Not Unfavorable Seasons, Usual Cause of Clover Failures

Unfavorable weather is often blamed for clover failures. The remark is frequently heard, "It is not the soil but the unfavorable seasons that cause my clover failures. The clover always comes up a good stand but it burns out during the hot, dry spell after harvest or freezes out during the winter."

Altho weather conditions have much to do with the failure of the clover crop, the condition of the soil is more often the direct cause of failure. It is not unusual to see a field of clover killed by hot, dry weather while another field across the road will come thru these same hardships in good condition. The difference in soil conditions will often explain why the clover holds on one field and not on the other. One field is "sweet"—in other words, contains plenty of lime—while the other field is "acid." The acid soil does not produce a strong, vigorous plant, and such plants are less able to withstand the hardships of unfavorable weather.

FIG. 2.—EFFECT OF SOIL TREATMENT ON RED CLOVER

A fair stand of red clover is often secured on acid soils when the season is favorable, but the crop usually is light. The heavy crop at the right was grown on the same soil and under the same weather conditions as that on the left, but soil treatment, including limestone, was applied.

How Is a Farmer to Know Whether His Land Needs Limestone?

It is possible, of course, to test soils for acidity by sowing sweet clover. Growth or lack of growth will indicate where the soil is sweet and where acid, for sweet clover seldom will grow on a soil that is acid. This, however, is an expensive kind of test.

Fortunately there is a simple and inexpensive method for determining whether or not a soil is acid and, consequently, whether or not it needs limestone. This is known as the Comber, or potassium thiocyanate, test. The material used in making the test is a solution of potassium thiocyanate in alcohol, or some other suitable solvent. A 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol[1]—is satisfactory.

The test is made by placing a small amount of soil in a test tube or small glass vial and adding some of the testing solution. The soil and testing solution are then thoroly mixed by shaking. After allowing the soil to settle, the color of the solution indicates whether or not the soil is acid. If the solution remains colorless, the soil is "sweet," in other words, it already contains plenty of limestone. If the solution turns red, the soil is acid and the degree of acidity is indicated approximately by the degree of redness.

Equipment for Making Test

The following equipment is used in carrying out the above test:

1. A bottle of testing solution.

2. A set of vials or bottles of 1- or 2-dram capacity and corks. Thirty-three of these bottles are necessary for making the test in a 40-acre field. These bottles can usually be purchased thru a local drug store (Fig. 3).

3. A rack for holding bottles. A convenient rack can be made from a stick of wood measuring about 1 by 1½ by 34 inches. Bore part way thru the stick 33 holes on inch centers. Make holes of such a size that the bottles will fit them snugly. A thin strip of wood of the same length and width as the rack can be used to hold the bottles in place while shaking them.

4. Envelopes or small paper sacks for collecting samples. These may be found more convenient than bottles for this purpose. The ad-

[1]Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. formula No. 1 and No. 4 has been found satisfactory. For the information of the reader it may be stated that a satisfactory solution ready for use may now be purchased commercially. So far as is known the only source of such a solution in Illinois is the Urbana Laboratories, Urbana, Illinois. It is manufactured under the trade name of "Richorpoor."

vantage in envelopes is that the samples will dry more thoroly in them than in the bottles if the samples happen to be frozen or wet when collected. However, the bottles will usually be found satisfactory.

Number of Samples to Collect

Twenty-three surface samples collected from a 40-acre field according to the systematic plan described below and 5 subsurface and 5 subsoil samples should locate the areas of sweet and acid soil fairly

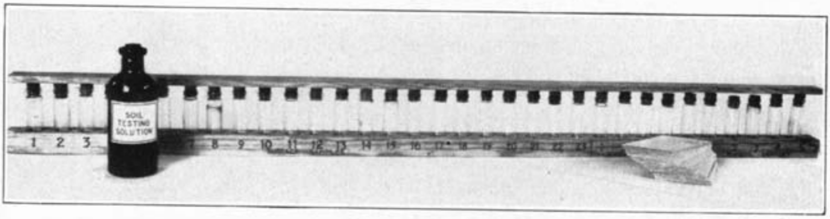


FIG. 3.—EQUIPMENT FOR MAKING SYSTEMATIC TEST OF SOIL FOR ACIDITY

Thirty-three small bottles are necessary in making the systematic test of a 40-acre field. A rack for holding the bottles will keep the samples in order. A thin strip of wood can be used over the tops of the bottles to hold them in place while shaking. Envelopes or small paper sacks are convenient for collecting samples, or the rack of bottles may be taken to the field and the soil samples placed in them as they are collected.

accurately. One or two samples will not usually give accurate information; in fact, they may often be misleading because of wide variations within a field.

How the acidity may vary in a 40-acre field of the corn belt is shown in Fig. 10. If only one sample had been collected from this field, it might have been taken from the sweet soil, in which case it would have been assumed that the entire field was sweet and did not need limestone. On the other hand, a sample from the strongly acid area would have indicated that the entire field needed 4 tons of limestone to the acre. Systematic testing prevents these mistakes.

Points at Which Samples Should Be Collected

The points on a 40-acre field from which the samples should be collected are indicated in Fig. 4. Envelopes or testing bottles marked "surface" and numbered from 1 to 23 should be taken to the field for use as containers for the surface samples. In the same manner a set of containers marked "subsurface" and numbered from 1 to 5, and a set marked "subsoil" and numbered from 1 to 5, should be prepared for collecting the samples from the lower depths.

In taking samples, follow the lines in the direction indicated by the arrows on the soil sampling diagram. The numbers along the lines indicate the number of 3-foot paces to take in locating the points where the soil samples are to be collected.

To collect samples, start in the northwest corner of the field. Locate the first point by walking 8 rods (or 44 three-foot paces) east and an equal distance south. At this point take sample number 1 of the surface and place in the container marked number 1. Walk south 44 more paces to locate the point where subsurface and subsoil sample number 1 is to be collected. Continue sampling around the field, following the lines indicated in the diagram and placing each sample in the properly marked envelope.

Be sure the samples are collected approximately at the points indicated in order that the map to be made from the diagram will represent the true condition of the field.

Collecting the Samples

In taking samples the following details should be observed:

1. Collect about 1 tablespoonful of soil if the samples are collected in envelopes or in small paper sacks. If collected in the testing bottles, fill the bottles full.

2. Take the *surface* samples from a depth of 1 to 2 inches using a knife if the soil is not loose.

3. Take the *subsurface* samples from a depth of 12 inches.

4. Take the *subsoil* samples from a depth of 20 inches. A soil auger, post-hole digger, or spade can be used for taking subsoil samples.

5. Be careful to have each sample representative of the depth at which it is taken and free from a mixture of soil lying above. If a spade is used, this may best be done by digging a hole, one side of which is vertical. A thin slice may be cut from the vertical side of the hole and the samples taken from it.

6. See that the samples are dry when tested. Soil that is in good working condition can be considered dry enough. If samples are collected when wet or frozen, they should be allowed to become air-dry before testing. An excessively wet soil interferes with the formation of the red color developed by an acid soil, and as a result the test will show less acidity than it would if the soil were dry. The samples should not be allowed to become excessively dry by too long exposure to the heat of stoves, furnaces, or the sun.

Making the Test

Having collected the samples, proceed with the test as follows:

1. Fill testing bottle one-third full of soil.

2. Place the 33 samples in the rack and add enough testing solution to fill the testing bottles about two-thirds full. *It is important to have equal volumes of soil and solution.*

3. Place corks in bottles.

4. Hold strip of wood over corks of bottles to keep bottles in place, and shake them thoroly.

5. Allow samples to stand for ten minutes.

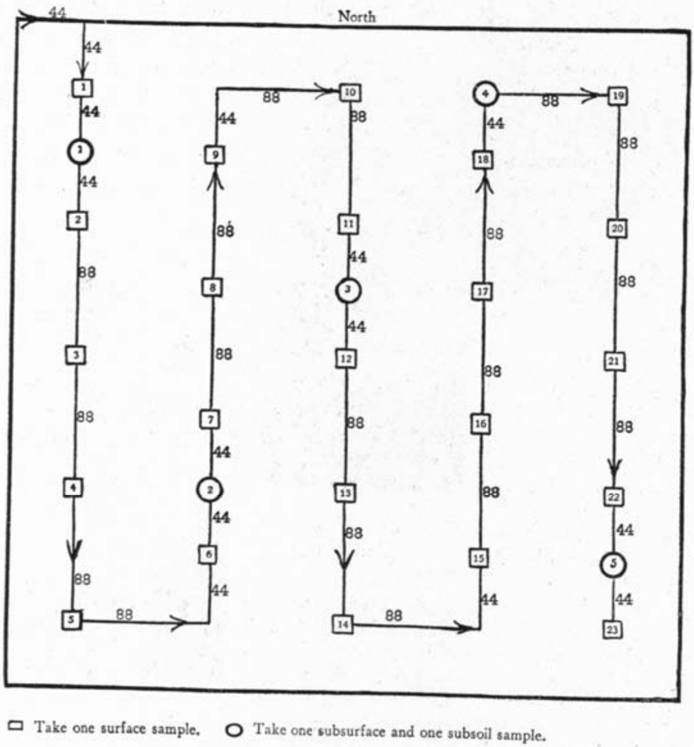


FIG. 4.—SOIL SAMPLING DIAGRAM FOR 40-ACRE FIELD

In taking samples, follow the lines in the direction of the arrows. The larger numbers along the lines indicate the number of 3-foot paces to take in locating the points where the samples are to be collected. The numbers in squares indicate where the 23 surface samples are taken, and the numbers in circles where the 5 subsurface and subsoil samples should be taken.

Recording the Results

1. Read and record the results for each *surface* sample on a diagram similar to Fig. 8, using the following symbols:

0 for sweet (neutral or basic)
— for slightly acid
═ for medium acid
≡ for strongly acid

The color chart on page 2 of this circular, will be of assistance in reading the results.

2. Record results of *subsurface* and *subsoil* tests as shown in Fig. 8.

3. If subsurface and subsoil samples do not show acidity, they may be tested for carbonates (limestone) with hydrochloric acid and the results recorded in the blank spaces provided at the bottom of the map diagram. If carbonates are present, bubbling or effervescence will take place.

FIG. 5.—COLLECTING SAMPLES

If the envelopes or paper sacks are used, 1 tablespoonful of soil should be collected. If testing bottles are used, the bottles should be filled full. Surface samples should be collected from a depth of 1 to 2 inches, subsurface samples from a depth of 12 inches, and subsoil samples from 20 inches.

FIG. 6.—ADDING SOLUTION

When making the test the bottles should be filled one-third full of soil and enough testing solution added to fill the bottles two-thirds full. It is important to have equal volumes of soil and solution.

FIG. 7.—MAKING THE TEST

The soil and solution should be mixed by shaking the bottles vigorously for 2 or 3 minutes. The samples should then be allowed to stand for 10 minutes, after which they should be read.

CAUTION: Do not handle hydrochloric acid or make any tests with it until all samples have first been tested for acidity with potassium thiocyanate solution. Contamination with the acid may give an acid reaction to soil samples that might not otherwise be acid.

4. Make a soil acidity map for the surface samples. Trace in with lead pencil the areas of equal acidity. This is done by assuming that the gradation is uniform from one area to another. Thus a neutral area cannot be adjacent to an area of strong acidity. Lines represent-

ing slight and medium areas of acidity should be placed between neutral areas and areas of strong acidity. In drawing these lines, therefore, no one line should meet or touch another line. The map will be more interesting and better understood if the different areas are colored with various shades of red, which can be easily done with a red pencil.

The various steps in making an acidity map are illustrated in Figs. 8 to 10, pages 12 to 14.

Completed Map Shows Where and How Much Limestone Is Needed

The field map, developed from the tests described above, will show where the acid areas are located and the intensity of the acidity. This information will be useful both in choosing the legumes to be grown and in determining the amounts of limestone needed to grow such legumes as sweet clover. The following table indicates what can be done with the various areas, assuming that the subsurface and subsoil are not acid. Note modifications with respect to limestone applications that are necessary when these strata contain limestone or are acid.

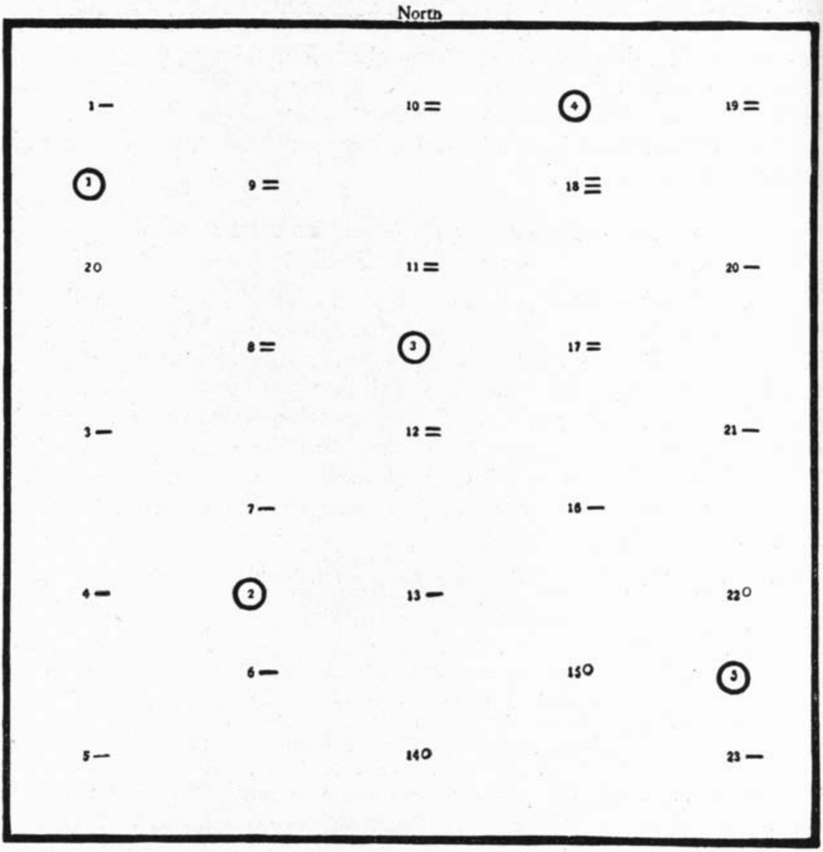
Degree of acidity in surface soil	*Possibilities of cropping without the use of lime*	*Tons of limestone needed per acre*
Sweet	Will grow alfalfa and sweet clover	0
Slight	Will grow red clover, alsike, soybeans, etc., but only poor alfalfa and probably no sweet clover	2
Medium	May grow alsike, soybeans, etc., but will probably not grow a good crop of red clover	3
Strong	Will not produce good crops of any of the commonly grown legumes	4

1. When only the *subsoil* is *sweet*, reduce above amounts ¼.
2. When both the *subsurface* and *subsoil* are sweet, reduce above amounts ½.
3. When the *subsurface* is medium to strongly acid, add ¼ to above amounts.
4. When both the *subsurface* and *subsoil* are medium to strongly acid, add ⅓ to above amounts.

The above recommendations are made on the basis of the average agricultural limestone now on the market, which contains considerable fine material. If the stone is of poor quality and somewhat coarse, more will have to be used.

How Often Should Limed Field Be Tested?

Where enough limestone has been applied to correct the acidity, another application may not be necessary for ten to fifteen years. A number of fields where limestone was applied from ten to fifteen years ago still contain enough limestone to grow good crops of sweet clover. However, it would be a good plan to test the field after six years. If the soil tests sweet, then the farmer is assured that limestone is not

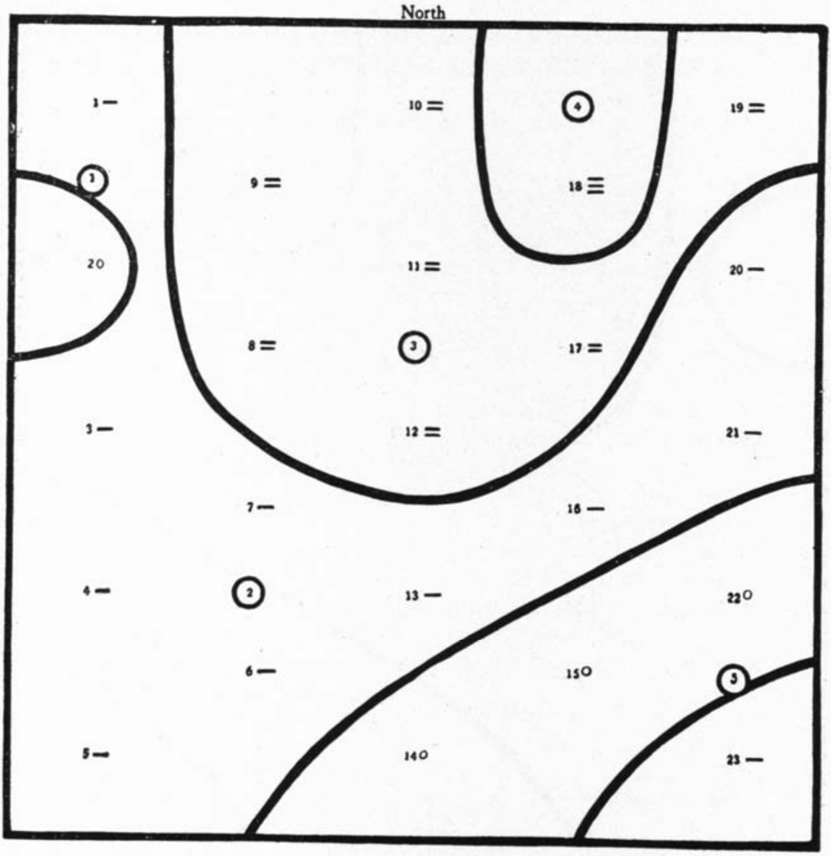


No.	Acidity		Carbonate	
	Subsurface	Subsoil	Subsurface	Subsoil
1	—	—		
2	—	—		
3	=	=		
4	=	=		
5	—	—		

Record subsurface and subsoil tests for both acidity and carbonates as indicated by symbols or names.

FIG. 8.—FIRST STEP IN MAKING AN ACIDITY MAP

The results of the test are recorded by means of symbols. Those for the surface are placed directly on the map, and those for the subsurface and subsoil are placed in the blanks at the bottom of the diagram. The numbers within circles indicate the five points on the field at which subsurface and subsoil samples were taken and the acidity at each point is recorded by the corresponding number in the table below the map. O means *no acidity*; — means *slight acidity*; = means *medium acidity*; and ≡ indicates *strong acidity*.

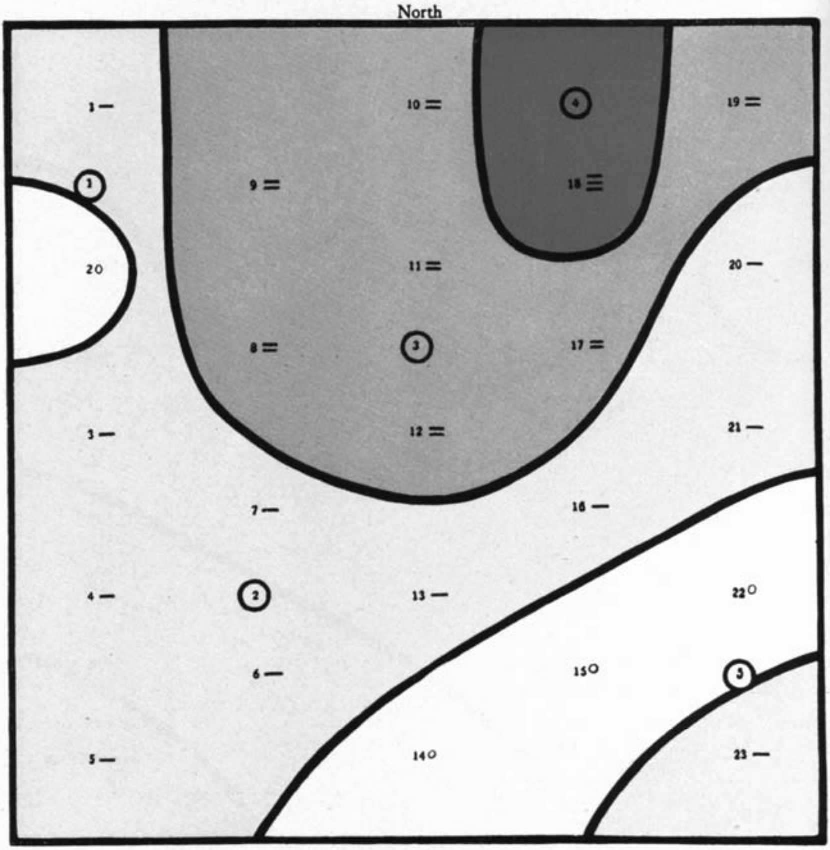


No.	Acidity		Carbonate	
	Subsurface	Subsoil	Subsurface	Subsoil
1	–	–		
2	–	–		
3	=	=		
4	=	=		
5	–	–		

Record subsurface and subsoil tests for both acidity and carbonates as indicated by symbols or names.

FIG. 9. LINES ARE DRAWN TO INDICATE THE AREAS OF ACIDITY IN THE SURFACE SOIL

The change in acidity from one area to another is gradual. A neutral area, for example, will never be adjacent to an area of strong acidity. Areas of slight and medium acidity will intervene between neutral areas and areas of strong acidity. With this point thoroly understood, it will be easy to see that the boundary lines of the different areas should be so drawn that no one line will meet or touch another at any point on the map.



No.	Acidity		Carbonate	
	Subsurface	Subsoil	Subsurface	Subsoil
1	–	–		
2	–	–		
3	=	=		
4	=	=		
5	–	–		

Record subsurface and subsoil tests for both acidity and carbonates as indicated by symbols or names.

FIG. 10.—THE COMPLETED MAP

The areas of acidity in the surface soil are colored with an ordinary red pencil. Those portions of the field left uncolored are *sweet* in this stratum. The area colored with the lightest shade of red is only *slightly acid* and needs 2 tons of limestone to the acre. The medium red area indicates a *medium acid* soil that needs 3 tons of limestone to the acre. The dark red area indicates a soil that is *strongly acid* and therefore needs 4 tons of limestone to the acre. Since the subsurface and subsoil of the medium and strongly acid areas are medium acid (see samples from areas 3 and 4), the limestone applications should be increased according to the suggestions on page 11.

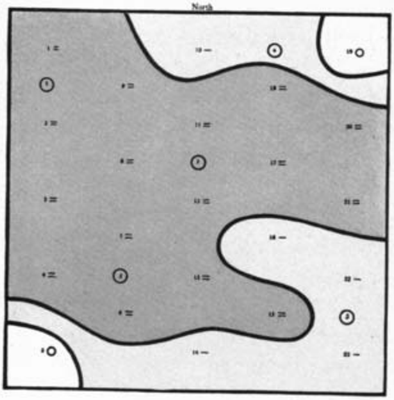


Fig. 11.—A Field on Which the Soil Was Practically All Acid

Altho the systematic test of such a field does not mean much saving in limestone, it does show how much limestone should be applied on the areas of various degrees of acidity.

needed for the present. However, an acid test on limed land does not always mean that more limestone is needed.

The systematic testing of a limed field will often show a number of acid samples. Altho this indicates that the limestone is getting low, it does not always mean that more limestone is needed. Often such a field will grow excellent sweet clover. This may be accounted for by the fact that the limestone has not yet become evenly distributed thru the soil or, if limestone has been on for some years, the finer particles may have been used up, leaving only the coarser particles. Each particle of limestone corrects the acidity in a thin zone of soil around it. Where the limestone has not become evenly distributed, or where the particles are few in number, as would be the case when the finer part of a limestone application has been used up, there will be zones of acid soil in between these zones of sweet soil surrounding each particle. Altho the extensive root system of the clover or alfalfa plant may be able to reach the sweet soil zones to secure enough lime, yet when samples are collected, soil may be taken from the acid zones between these particles. Where limed land shows a number of samples testing acid, the farmer can probably decide whether or not more limestone is needed by watching the clover growth.

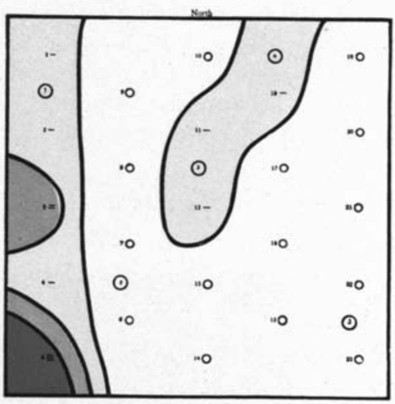


Fig. 12.—A Field on Which the Soil Test Saved 90 Tons of Limestone

The owner of this 40-acre field had planned to apply 3 tons of limestone to the acre. The systematic test showed that approximately 30 acres were sweet. This knowledge meant a saving of 90 tons of limestone.

Some Crops Less Sensitive to Soil Acidity Than Others

Sweet clover and alfalfa are the most sensitive of any of the commonly grown farm crops to soil acidity and seldom will grow successfully on acid soils. Red clover will often make a fair growth on soils of slight to medium acidity especially if the soil is fertile and the season favorable. Alsike is less sensitive to soil acidity than is red clover and consequently can be grown on soils that are too acid for red clover. Cowpeas and soybeans are the least sensitive of any of the legumes commonly grown in this state and will produce fair crop on medium to strongly acid soils. However, the yield of these so-called acid-tolerant legumes are usually increased appreciably by the use of limestone on soils that are medium to strongly acid.

The grain crops such as corn, oats, wheat, and barley are little affected directly by soil acidity. The benefit to grain crop from limestone comes thru the better legume crop. However, applications of limestone may increase corn yields by reducing some of the corn diseases.

This test should not be expected to tell positively whether red clover will or will not grow on a particular soil, but it does indicate fairly accurately where limestone can be used at a profit. Red clover can be grown with various degrees of success on soils that test acid according to this method. There is no sharp dividing line between a sweet and acid soil on one side of which red clover will make a maximum growth and on the other side of which it will not grow. The stand and growth will vary with the acidity. On sweet soils a maximum crop of red clover will be produced providing other conditions are favorable, while the stand and growth on acid soil will usually decrease with the increase in acidity. Altho good stands of clover may be obtained on acid soils, especially if the season is favorable, it usually pays to apply limestone because the yield will be increased from one-half to one ton to the acre, depending on the degree of acidity of the soil.

Don't Guess---TEST!

FIG. 13.—A GROUP OF FARMERS LEARNING TO TEST SOIL AT A FARM BUREAU TESTING MEETING