Soil Nutrients and Soil Acidity

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PLANTS take up from the water in the soil all the nutrients they use, except carbon and oxygen which come from the air. Eight elements thus come from the soil. If any of these ten elements is missing plant growth will not be normal. Some elements seem to be more important than others, judging by the effect on the plant.

The eight elements coming from the soil are: nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, and hydrogen. In order to grow plants successfully, therefore, the supply of these eight elements must be kept adequate. Hydrogen is so common in water that it is never lacking in soil. Iron is another element about which we need not worry, except when there is too much iron present as in certain acid soils.

Sulphur is present in sufficient quantities except in the drier regions of the country. Superphosphate carries enough sulphur to meet any shortage. Magnesium has come in for much discussion and experimental work very recently. A shortage usually exists in acid soils. If pulverized limestone is used as a source of lime the chances are that the material will carry all the magnesium needed.

In the average soil then, nitrogen, phosphorus, potassium, and calcium (lime) are most often absent or not available. Nitrogen is limited in amount, since it is directly proportional to the amount of organic matter. Phosphorus is also limited in amount, and is not soluble in acid soils. Potassium is not plentiful in sandy soils, but clay soils contain large amounts. A neutral clay usually has but little soluble potassium, however. Calcium washes out of the soil so easily that there is usually a shortage of that element.

Nitrogen, phosphorus, potassium, and calcium have the following effects of plant growth:

NITROGEN—Dark green leaves, rapid growth of a succulent nature.

PHOSPHORUS—Lighter green leaves, sturdy growth, serves as a balancer for nitrogen by preventing too rapid growth, very favorable to root development.

POTASSIUM—Serves as a tonic to plants, strengthens the general make-up of the plant, and has been said to help the plant keep a stiff upper lip.

CALCIUM—Plants without calcium are very short and underdeveloped. Helps the plant to absorb potassium, phosphorus, and nitrogen.

SOIL ACIDITY

ACID soils are the rule instead of the exception in all regions of the country where rainfall amounts to more than 20 inches per year. Even where the soil has come from limestone the surface soil is usually acid and benefits from additions of lime. The reason for this situation is found in the fact that water dissolves out the basic material more rapidly than it does the acid material making up soils.

Soil that has been exposed to rain for thousands of years has lost nearly all the soluble or fairly soluble materials, and all that is left is made up of insoluble or inert substances. Many of the acid soils do not grow satisfactory crops without the addition of some basic material like limestone. Indeed, lime has come to mean a fundamental for soil treatment to allow practically any crop to grow normally. Any case of poor crop growth is usually laid to acid soil. Since many times the failure is due to other things than mere acidity, it is necessary to examine into all the other conditions in an acid soil. Acidity may be important (harmful) in soils for the following reasons:

1. Reduces the growth of clover*.
2. Makes nitrogen slowly available.
3. Makes potassium soluble.
4. Makes phosphorus unavailable.
5. Prevents the proper absorption of plant food by plants.
6. Soluble iron and aluminum appear in acid soils as toxic agents, causing weak plants.

*Not as much as desirable.

7. An acid soil is the most favorable medium for molds and fungi to develop in. Fungi are the organisms which cause most of the plant diseases.
8. Acidity may or may not keep out weeds.
9. Absence of calcium prevents length growth of stems.
10. Causes manganese to be soluble (usually beneficial).
11. May keep earthworms out.

ACIDITY AND THE GROWTH OF CLOVER

It is common knowledge that potassium (potash in everyday usage) is largely responsible for the growth and encouragement of clover in greens. Four per cent potash is considered a maximum in fertilizer mixtures for greens, and some mixtures carry only a trace or none at all.

Too little attention has been given by those in charge of greens to the amounts of available potash in the soil. (There is no quick, easy test for available potash.) The old story of plenty of sulphate of ammonia appeared to satisfy nearly everybody. But in numerous cases the continued use of sulphate of ammonia has failed and is failing to prevent the growth of clover. There is no question of the acidity developed by sulphate of ammonia. Why, then, does clover continue to grow under acid soil conditions?

The answer appears to be that potash is much more soluble in acid than in neutral soils. Tests made in various states on the effects of acid-producing nitrogen fertilizers on solubility of potash all showed that the more acid the soil becomes the more soluble the potash. Soluble potash is usually available, and therefore clover gets the tonic it needs.

Loam or clay soils, and heavy soils in general, contain large amounts of total potash. Attempting to keep out clover from such soils with sulphate of ammonia, is like trying to put out a fire with gasolene. Perhaps when you are trying to get rid of clover by using sulphate of ammonia you are actually giving the clover more encouragement than the grass.

ACIDITY MAKES NITROGEN SLOWLY SOLUBLE

The bacteria that change nitrogen from ammonia to nitrite and nitrate work best in soil that is nearly neutral. When soil acidity is strong the work of these bacteria practically stops. So when you add sulphate of ammonia to an acid soil and fail to get the results expected, perhaps the acidity is so great as to prevent the growth of essential bacteria. A pH value of 5 or less is very apt to cause a serious shortage of nitrate nitrogen. It is a condition which should be carefully checked and observed.

ACIDITY AND SOLUBLE POTASH

Experiments have shown that more potash is soluble in acid soils than in neutral soils. This is a perfectly natural consequence. Remember that potassium is a base, and that acids unite with bases very easily. If no acids were present the potash would be much less soluble. Most plants are able to get potash rather freely from a neutral soil because of the help calcium gives in the absorption of potash.

ACIDITY AND SOLUBLE PHOSPHORUS

Phosphorus behaves directly opposite to potassium. It is an acid-forming substance, therefore is not made soluble by acids in the soil. Bases are required to make phosphorus soluble and available. Attempts to make soil strongly acid must therefore be undesirable because of the phosphorus behavior.

ACIDITY AND ABSORPTION OF PLANT FOOD

The element calcium does much to help plants take up other elements. For instance, potassium is taken into the plant only with difficulty when no calcium is present. Just how much it helps the other elements, directly at least, has not been fully worked out. Indirectly it is most important. Calcium is absolutely necessary for the change from ammonia to nitrate nitrogen, and for making phosphorus soluble.

Soil acidity has come to mean practically a lack of calcium, because of the pronounced effects of calcium on various elements. In other words, none of the effects of an acid soil are noticed when the element calcium is added to the soil. We call potassium a tonic to plants, but it can only be a tonic when it is within the plant, and there is little hope of it being taken up by the plant in usable quantities when no calcium is present in soil.

ACIDITY AND GROWTH OF ORGANISMS

The small organisms in the soil are very important. They take care of rough organic matter and reduce it to a condition in which it can be at least partly used by plants. Most of the organisms belong to the plant kingdom. There are a few small animals in soil, but we may practically forget them in this discussion. They are active only in soils that are too wet for good crop production.

Water-logged soils, ones that are unsanitary and unhealthy, are favorable to the growth and activity of small animals called protozoa. Much discussion and many experiments have failed to give us a sound conclusion regarding the work of these organisms. They have no economic value which anyone has discovered in soils properly handled.

The organisms which belong to the plant kingdom are divided into two general groups, bacteria and fungi. Fungi (molds) are less desirable than bacteria because so many of them are the causes of diseases which weaken both tops and roots of plants. Many of the fungi work on organic matter and break it up. In that respect they are as valuable as bacteria.

Fungi, and especially the less desirable sorts, are more abundant in acid and wet soils than in other soils. In wet soils fungi are probably the main cause of unsanitary conditions that develop in such soils, because the products they form are poisonous to plants.

Brown patch is caused by a fungus. Therefore, the more acid the greens become, the more susceptible the grass is to attacks of brown patch, and the more vigorous the brown patch itself.

Bacteria do best in slightly acid to basic soils. Any condition which makes the soil approximately neutral in reaction is a great aid to the growth of bacteria. Nearly all of the desirable sorts of bacteria are killed if a soil remains acid for any length of time.

ACIDITY AND WEEDS

MANY experiments have shown that weeds are fewer in number on acid than on neutral or basic soils. Unfortunately, the reverse of this has often proved to be the case. That does not help the people who want to sell fertilizer.

Why does the difference exist? One guess is as good as another. Here are two possible answers to account for more weeds on neutral soil: First—growing conditions are so much better under neutral than under acid soil conditions that weeds can crowd out the grass. Certain types of weeds require more phosphorus than others, or than grass. These weeds will therefore do best on neutral soil. Second—and probably more important, the bent grasses grow enough better on acid soil to make a solid turf in which there is no room for weeds.

ABSENCE OF CALCIUM PREVENTS LENGTH GROWTH

WHERE calcium is a limiting factor, plants are very stunted in appearance and character. A grass plant will never grow tall in the absence of calcium. But nobody wants the grass on a green to grow tall. That is beautiful theory, yet how does it work?

Short grass plants provide a less desirable putting surface than do longer plants, cut to the same height, of course. In short grass all the plant characters are present just as much as in tall grass. The two most important of these characters are the nodes (joints) and internodes (stem between the joints). When calcium is limited the internodes simply forget to lengthen. But the nodes are there just the same and a squatty plant is the result. The grass blades from such plants tend to grow more horizontally than straight up. In other words there is nothing to make the grass stand up as it should.

ACIDITY AND MANGANESE SOLUBILITY

MANGANESE is one of the recent additions to the list of necessary plant nutrient elements. It was overlooked for a long time because extremely small amounts are sufficient to produce normal growth. Acid soils have enough soluble manganese for good plant growth, hence the average greenkeeper need have no fear of a shortage.

When soils are neutral, or are limed until they are nearly neutral, especially sandy soils, there is often difficulty from a lack of manganese. Manganese simply becomes insoluble in neutral soils. This is one case where acid soils have a distinct advantage.

ACIDITY AND CONTROL OF EARTHWORMS

A FEW years ago most people thought that earthworms did not work in acid soils. One or two experiments showed this to be the case in soils used for general farming purposes. Experience with acid soil in greens has been far from similar. Here are soils plenty acid and becoming more so every year, yet worms are much too plentiful and active.

There must be a reason. In fact, there are at least two reasons why worms are so active in acid greens. First—the soil in greens is kept (usually) moist enough to be a real treat to worms. Second—there is plenty of food for them to work on in greens, much composted material and organic matter on which they especially thrive. What a contrast with the acid soil used for general crops. Such soils are often too poor to grow any organic matter, hence there is nothing for the worms to live on. No organic matter is added, either, in many cases.

HOW TO CORRECT SOIL ACIDITY

PRACTICALLY all the troubles for which acid soils are responsible, either directly or indirectly, are eliminated when lime (calcium) is added to the soil. For that reason lime has come to be the only material used to make soils neutral. Of all materials which might be used as neutralizers, lime is cheapest and best in all respects.

Lime is sold or offered for sale in three forms. The natural limestone is quarried and pulverized to a fine powder. This is the material most people mean when they say lime. One hundred pounds of limestone will neutralize the acidity from one hundred thirty-two pounds of sulphate of ammonia. It will neither burn the grass nor the skin of persons handling it, and is the most desirable form of lime to use on grass.

The limestone may be burned without grinding to form lump or builders' lime. This material is highly caustic and will burn grass severely when applied during the growing season. Burned lime is more concentrated than pulverized limestone because the burning process drives off some of the unnecessary substances that simply dilute the calcium. Fifty-six pounds of pure burned lime will neutralize one hundred thirty-two pounds of sulphate of ammonia.

Besides being caustic, burned lime takes on water and in so doing may produce considerable heat. It is therefore dangerous to store burned lime inside a building where there is any chance of water leaking in and reaching the lime.

When burned lime is treated with water (slaked) it becomes fine in texture and is known as hydrated lime. Seventy-four pounds of hydrated lime will neutralize one hundred thirty-two pounds of sulphate of ammonia. It is thus about half way between burned lime and pulverized limestone in efficiency. Hydrated lime is caustic to grass and disagreeable to handle, although safe to store. In the table at the top of next column is a comparison of three common liming materials.

Agricultural lime means more commonly a mixture of hydrated lime and pulverized limestone, used for general application to soil on which plants are to be grown.

A good application of limestone is about 50 pounds per thousand square feet. Such an application should take care of all acidity from sulphate of ammonia for three to five seasons. Smaller amounts may, of course, be added, say every year. Fifty pounds of limestone are equal to thirty-seven pounds of hydrated lime and to twenty-eight pounds of burned lime. Limestone costs from $5 to $9 per ton. A pound of actual calcium costs about the same in limestone and in burned lime. The cost per pound of calcium in hydrated lime is considerably higher than in the other forms. When lime is purchased in carload lots considerable saving is made if the shipping and delivery points are on the same railroad.

Common name	*Other names by which it is known*	*Pounds needed to neutralize 100 lbs. sulphate of ammonia*	*Desirability for use on grass*
BURNED LIME	Builders', lump, stone, quick, or caustic lime.	42 pounds	Burns grass. Dangerous to store. Too lumpy to apply directly. More effective per lb. than any other.
HYDRATED LIME	White lime.	56 pounds	Burns grass. Fine and easy to apply. More effective per lb. than limestone. Safe to store. Burns hands somewhat.
GROUND OR PULVERIZED LIMESTONE	Lime. Agricultural lime.	76 pounds	Does not burn grass or skin. Safely stored at any time. Heavy to handle, and goes only half as far per lb. as burned lime.

Burned and hydrated limes can be used perfectly well when grass is dormant. This means late fall or early spring application. In normal conditions at least 40 pounds limestone per thousand square feet should be used every five years, unless calcium-carrying nitrogen fertilizers are used.

One of the peculiar things about lime is that it neutralizes only that layer of soil with which it comes in contact. Lime put on the surface of soil neutralizes only the top layer in spite of the fact that drainage water washes lime through the lower soil layers. A very small amount of the lime in drainage water is taken up by the lower soil layers, so small it can scarcely be measured.

This fact makes it possible to add lime to greens without having much influence on the clover growing there. The lime remains in the top layer where most of the grass roots are and does not get to the clover roots that are some distance down. Continued lime applications would be necessary to encourage growth of clover roots near the surface.

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Market Place *and* Buyers' Guide---

Putting Green Mowers

Toro Mfg. Company
Pennsylvania Lawn Mower Works
Worthington Mower Company
Cooper Mfg. Company
Ideal Power Lawn Mower Co.
Roseman Tractor Mower Co.
The F. & N. Lawn Mower Co.
Jacobsen Mfg. Company

Power Putting Green Mowers

Jacobsen Mfg. Company
Worthington Mower Company
Ideal Power Lawn Mower Co.

Rakes

Pennsylvania Lawn Mower Works

Rhode Island Bent Seed

A. N. Peckham

Rollers (Hand)

John H. Graham & Co., Inc.
Stumpp & Walter Company

Rollers (Fairway)

John H. Graham & Co., Inc.
Toro Mfg. Company
Worthington Mower Company

Rollers

Stumpp & Walter Company
Toro Mfg. Company
Worthington Mower Company

Rough Mowers

Toro Manufacturing Company
Pennsylvania Lawn Mower Works
Worthington Mower Company
Ideal Power Lawn Mower Co.
Roseman Tractor Mower Co.
Jacobsen Mfg. Company
Philadelphia Toro Company
International Harvester Co. of America
Gravely Mower & Cultivator Co.

Seaside Bent

Seaside Bent Company

Seed

Henry A. Dreer
O. M. Scott & Sons Co.
J. Oliver Johnson, Inc.
Stumpp & Walter Co.
A. N. Peckham
Peter Henderson & Co.
J. M. McCullough's Sons Co.
Illinois Grass Co.
Arthur D. Peterson
Henry A. Dreer
Philadelphia Seed Co.
Seaside Bent Company
Lyman Carrier

Signs

Standard Mfg. Company

Sod Cutters

J. Oliver Johnson, Inc.
Pacific Greenkepers' Appliance Co.

Sprayers

Hardie Mfg. Company
Friend Mfg. Company

Sprinklers

L. R. Nelson Mfg. Company
Buckner Mfg. Company
Economy Irrigation Company
Campbell Irrigation Company
Double Rotary Sprinkler Co.
Dan F. Ryan

Spuds

Diamond-Calk Horseshoe Company

Stolons

O. M. Scott & Sons Co.
Hubbard Nurseries
Lyman Carrier

Sulphate of Ammonia

Synthetic Nitrogen Products Corp.

Tee Markers

Standard Mfg. Company

Tee Mowers

Toro Manufacturing Company
Pennsylvania Lawn Mower Works
Worthington Mower Co.
Ideal Power Lawn Mower Co.
Jacobsen Mfg. Company

Tee Stands

Worthington Mower Co.

Tillage Implements

International Harvester Co. of America

Top Dressing

Hyper-Humus Company
The Ohio Humus Company
Atkins and Durbrow, Inc.

Tractors

E. G. Staude Mak-A-Tractor Co.
Toro Manufacturing Company
Worthington Mower Co.
International Harvester Co. of America
Ideal Power Lawn Mower Co.
Roseman Tractor Mower Co.
R. S. Horner
Gravely Mower & Cultivator Co.

Tractor Wheels and Spuds

R. S. Horner

Trees

Blue Ridge Evergreen Supply Co.

Turf Fertilizers

Armour Fertilizer Works

Urea

Synthetic Nitrogen Products Corp.

Water Pipe

McWane Cast Iron Pipe Co.

Worm Eradicators

Peter Henderson & Co.
C. B. Dolge Company
Reade Mfg. Company

Soils

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particles with abundant pore space to provide the best aeration and assure that excess of water will be removed rapidly, give or assist capillary action, and yet hold the moisture that is always necessary for the grass plants to thrive.

To modify a heavy clay soil will require a great deal of sand. Yet a sandy soil will not require nearly as much clay in proportion to make it a sandy loam. A sandy soil, before it can be called sandy, has to contain 80% or more of separate sand. The balance could be all clay. A clay soil on the other hand can contain 30% or more of the separate clay, the balance can be all sand; thus only by adding 10% of clay, a soil may be changed from one extreme to the other.

Soil Nutrients

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MAKING SOILS PURPOSELY ACID

THE best practical method for making soils purposely acid is to add sulphur. Crude sulphur flour is the material to use, at the rate of 7 to 15 pounds per thousand square feet. It has no burning effect on grass, and rather quickly changes to sulphuric acid in soil. All of the sulphur is changed to acid during one growing season.

A more rapid but expensive method is to add alum (aluminum sulphate) up to 6 pounds per thousand square feet. Alum is already acid and is at once effective. In buying this material, be sure to specify aluminum sulphate. The alum of trade contains potash, which ought to be left out of the picture. One might even use ammonium alum for the nitrogen contained. This would acidify soil just as much as ordinary alum.

Much the same condition applies in acidifying soil as in liming, namely that the acid-forming substance affects only that part of the soil with which it comes in contact. Such a condition no doubt accounts for the failure of continued sulphate of ammonia treatments to eliminate clover from greens. The acid has little or no effect on soil a few inches down where the clover roots thrive.