The A B C of Turf Culture

The Nature of Soil Acidity and Effect of Fertilizer Materials on Soil Reaction

By O. J. NOER

SOILS in regions of moderate to heavy rainfall gradually tend to become acid in character. Rain water as it passes down through the soil slowly removes basic or alkaline material and leaves an acid soil residue. The rate of change varies and depends principally upon the amount of rainfall and character of the material from which the soil was derived. In regions of limited rainfall soils rarely become acid. Very little water percolates down through the soil, and soluble alkaline materials are not washed out. In fact these materials accumulate at the surface due to upward movement of water and evaporation at the soil surface.

Most of the golf courses in the United States are located in areas where acid soils develop. Since clover and weeds can be controlled by regulating soil acidity, a clear understanding of how it is produced and measured is of vital importance in turf maintenance on golf courses. During recent years soil chemists have obtained a clearer picture of soil acidity and devised simple accurate methods for its determination.

O. J. Noer

Editor's Note: For the past four years Mr. Noer has investigated the value of various fertilizers in relation to golf turf at the Soils Department, University of Wisconsin, under a fellowship established by the City of Milwaukee.

How Soils Become Acid

The chemist groups chemical compounds into three classes. They may be acids, bases or salts. Acids and bases have opposite chemical properties, and may be commonly distinguished by their different behavior towards an indicator such as litmus. An acid turns blue litmus red and a base turns the red paper blue. Muriatic and sulphuric acid are common acids of commerce. Vinegar contains acetic acid. Lye and quick lime are basic substances.

When an acid and base are allowed to react together, they are said to neutralize each other. Each loses its distinctive properties and a salt is produced. Generally salts are neutral substances. However, some have acid properties and others are basic. Soils consist of complex and simpler organic and mineral salts. These may be acidic, basic or neutral in character and the soil reaction depends upon which predominates.

A simple example probably best explains how soils become acid. If a fragment of granite rock reduced to a fine powder, is placed in a vessel and agitated with pure water for a time, the water will change in reaction becoming basic. It turns red litmus blue. The granite powder is no longer neutral but acid in character. This same phenomenon takes place in the soil as water percolates through it. Basic material passes into solution and is washed out leaving an insoluble acid residue.

If the acid granite powder is suspended in water containing a little salt, the water soon becomes acid, and the powder loses its acidic properties. The basic part of the salt has been taken up by the insoluble rock powder and soluble acid released. This is what takes place when ammonium sulphate or potash salts are applied to the soil.

The soil contains two kinds of acids, insoluble and soluble, sometimes referred to as potential and active acidity. The insoluble or potential acidity is the reservoir from which the soluble or active acidity is produced. It is this latter which controls clover and weeds. Soils containing large amounts of insoluble acidity are capable of yielding much soluble active acidity.

Methods of Determining Soil Acidity

A large number of methods for the determination of soil acidity have been devised. Most of the older methods measure the insoluble or potential acidity and serve as criteria of the amount of lime required to neutralize the acids. The newer methods determine the active acidity and measure its intensity. The use of these methods enables the greenkeeper to follow the soil reaction and eventually obtain a condition unfavorable to clovers.

The term Ph is arbitrarily used to express active acidity. A neutral substance, that is one which is neither acid or basic, has a Ph of 7. Figures less than seven represent increasing degrees of acidity and those greater than seven, increasing degrees of basicity. A soil of Ph 6 is ten times more acid than one of 7, and one of Ph 5, one hundred times. Thus it is evident that small differences in Ph represent large differences in soil reaction. Most plants grow best in the range of Ph 6 to 8.

When extreme accuracy is demanded Ph determination must be made in the laboratory with elaborate apparatus. Portable sets now on the market are sufficiently accurate for field use, and can be employed as a guide in attempts to modify soil reaction. In principle the method depends upon the fact that certain color indicators develop characteristic colors at different Ph values. In operation the soil is allowed to come in contact with the proper indicator and the color developed is compared with those on an accompanying chart. Ordinary water should never be used in making the test. It often contains sufficient lime to give erroneous results. Rain water serves as the best substitute for distilled water. Obviously the indicator solution must remain in intimate contact with the soil sufficiently long to permit maximum development of color.

Effect of Fertilizers on Soil Reaction

The different fertilizer materials affect soil reaction. They either increase or decrease soil acidity. Soils have a remarkable power of resisting change so it is difficult to demonstrate the effect of single applications. It is only when applications are continued over an extended period that marked changes occur. Sandy soils are more easily changed than loam and clay soils.

The continued use of ammonium sulphate increases soil acidity. If the soil contains limestone particles, the ammonium sulphate reacts with it forming calcium sulphate and carbon dioxide. The calcium sulphate is washed out in the drainage water and the carbon dioxide escapes into the air as a gas. The ammonia in ammonium sulphate is also capable of displacing basic calcium contained in the mineral soil particles. This calcium disappears in the drainage water as calcium sulphate.

The ammonia taken up by the soil particles is gradually released and converted into nitric acid by the nitrifying bacteria of the soil, and combines with more calcium. The resulting compound is either taken up by the plants or leached from the soil.

Ammonium phosphate also tends to make the soil more acid but is not as effective as ammonium sulphate. Acid soils always contain iron and aluminum oxides, materials which have but little effect upon soil reaction. So long as either exists in the soil the phosphoric acid combines with them forming insoluble iron and aluminum phosphates. Consequently, lime or other basic material is not leached from the soil. The nitric acid formed by the action of the nitrifying bacteria on the ammonia is capable of removing basic material from the soil, and it is this action that increases acidity.

Sodium nitrate tends to make the soil less acid. The sodium is basic in character and is left to neutralize soil acids when the nitrate portion is taken up by the plant.

The effect of organic nitrogenous fertilizers depends upon the amount and character of the mineral materials they contain.

Acid phosphate decreases soil acidity. When applied to an acid soil insoluble iron and aluminum phosphate are produced and its lime released. The term acid phosphate is a misnomer so far as effect in soil reaction is concerned. Bone meal has the same effect only more marked because it contains more lime.

Potash fertilizers increase soil acidity. The potassium is taken up and held by the soil particles and an acid residue is left in the soil solution.

Extreme Acidity Associated With Low Fertility

Very acid soils are often low in fertility. Extreme acidity retards conversion of soil nitrogen to nitrates by depressing the activity of the soil nitrifying bacteria and other beneficial soil bacteria. Nitrate nitrogen is the form preferred by most plants. The growth of molds and fungi is often favored by acidity. These organisms require nitrogen and may deprive the turf of its limited supply. In acid soils phosphoric acid is held as insoluble iron and aluminum phosphate, and solution may not occur rapidly enough to satisfy the entire demand of the turf for phosphoric acid. Hence it is probably unwise to create greater acidity than is required to discourage clover and weeds.

Acidity at Which Clover Fails

Agricultural workers have investigated the effect of acidity on the growth of clover. It makes its best growth at Ph 6 to 8. At Ph 5 growth ceases. At Ph 5.5 it is very doubtful if clovers can survive, especially if the grasses are growing vigorously, and there is probably no advantage in attempting to increase soil acidity beyond that point.

The ball is held up best in turf composed entirely of grasses. Poor "lies" are obtained on turf containing clover. Hence soil conditions favorable to the growth of grasses but unfavorable to clover, must be maintained. Regulating soil reaction helps discourage clover. Sufficient acidity is most easily obtained in regions where soils are normally slightly acid, but the persistent use of acid producing fertilizers will eventually prove effective even on non-acid soils. When a point is once reached where clovers fail, the soil should be maintained at that reaction, so as to make other conditions for growth as favorable as possible.

(Note: Illustration of practical soil tester will be found on page 24.)

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