The Effect of Acidity on Turf and the Chemistry of Acid Soils

By O. J. NOER

THE FIRST fertilizer plats on this continent devoted to lawn grasses were started by the Rhode Island Agricultural Experiment Station. Sulphate of ammonia and nitrate of soda, alone and in combination, were used as the source of nitrogen. Superphosphate and muriate of potash were added to make a complete fertilizer.

The plats were laid down in 1907 and were fertilized continuously until 1942, when the experiment was concluded. The 55th annual report of the station summarizes the results in an interesting manner.

Turf on the nitrate of soda was unsightly because of its non-uniform character and invasion of weeds. The ones fertilized with a combination of nitrate of soda and ammonium sulphate were very slightly acid, and the turf was satisfactory.

There was considerable "winter kill" or dying out on the sulphate of ammonia plats. The soil was strongly acid, pH 4.0. The winter kill was first noticed in the spring of 1938. Very severe raking to remove the dead grass helped restore the turf so there were few vacant spaces by the end of the growing season. Without raking in June and September the turf on the acid plats would have died and disappeared. But recovery of the injured areas was very slow in 1939-1940 and 1941.

Raking showed that three times more clippings and dead grass accumulated on the acid soils (pH 4.0) than on the alkaline ones (pH 7 to 8). The slightly acid plats (pH 5 to 6) produced twice as much undecomposed grass as the alkaline ones. The accumulation of dead stems and roots produced a "sod bound" condition of the turf.

The action of sodium arsenite and lead arsenate, used for weed and worm control, showed that the grass on the acid plats was in a weakened condition. The turf on the sulphate of ammonia plats was damaged severely by both materials. Little or no injury occurred on the alkaline or slightly acid soils.

The concluding statements about these "old classic" plats, which were plowed under in 1942, are illuminating:

> "The plats that received sulphate of ammonia continuously as the source of nitrogen rather than nitrate of soda remained free of weeds and it was from the results of these tests that the "weedless lawn" dream was realized by the discovery of a long sought fertilizer that would grow grass and kill weeds. This gave rise to the 'sulphate of ammonia era' in turf culture. But as more research was undertaken and further observations were made, it was found that continuous applications of either sulphate of ammonia or nitrate of soda were inadvisable, due to the high acidity produced by the sulphate of ammonia, and the alkalinity produced by the nitrate of soda. However, sulphate of ammonia, when mixed with an equal weight of limestone to prevent the soil from becoming more acid, proved very satisfactory, and was also superior to nitrate of soda in maintaining desirable turf."

Passing of "Acid Era"

The "acid era" in turf maintenance on golf courses died along with the grass in the disastrous season of 1928. During that memorable hot wet and humid summer wholesale loss of the bent grass on greens occurred throughout the North. On many courses the turf on all the greens disappeared almost overnight. When reason finally prevailed, it was realized that soil can become too acid even for the supposedly tolerant bent grasses. Lime was restored to favor. Slight acidity may be desirable, but all turf authorities concede that the maintenance of a dense turf is even more important in the control of clover, weeds, and poa annua than an acid soil.

Moss and a damp location are synonymous with sourness to most laymen. Both are associated with unfavorable conditions for turf growth but not necessarily indicative of a sour or acid soil.

The chemist separates all matters into three groups based on their chemical reaction. Substances may be acid, alkaline, or neutral. Vinegar, muriatic, and sulphuric acids are examples of true acids. Quick and hydrated lime, soda and lye are alkaline reacting substances, which are called bases by the chemist.

Salts are formed when an acid and a base react chemically. Muriatic acid and soda react to form sodium chloride. It is the salt used to season food. Muriate of potash, commonly used as a fertilizer, is formed when potassium hydroxide and muriatic acid react with each other. Many salts are neutral in reaction, but some are acid and others are alkaline. Aluminum and iron sulphate are acid in reaction, while calcium carbonate (limestone) and sodium acetate are alkaline.

The different behavior of salts in respect to reaction is due to the fact that acids and alkalis differ in strength, or in degree of acidity or alkalinity. Muriatic and sulphuric acid are strong, but acetic acid (the acid in vinegar) and carbonic acid, which is an important constituent of the soil solution, are weak ones. Sodium and potassium hydroxides are strong bases, but iron and aluminum hydroxides are only feebly basic. Salts formed when a strong acid and a strong base combine (for example, sodium chloride) are neutral. The salt resulting from the combination of a strong acid and a weak base (iron and aluminum sulphate, for example) is acid in reaction, and one formed from a strong base and a weak acid is alkaline. Cardonic acid is a very weak acid, so calcium carbonate is alkaline in reaction (pH 8.0 to 8.5)

Chemical Reaction in Soils

The solid silt and clay portions of the soil consists of complicated mineral salts, the alumino-silicates. These soil contituents have acidic and basic properties. Although relatively insoluble in water, they are capable of reacting with the soluble salts in the soil solution and with lime. They are the reservoir from which the "active" or soluble acidity is derived.

To illustrate the type of transformations which occur in soils, the alumino-silicates can be represented by X. In an acid soil the mineral fraction can be called Acid X, and in a neutral or alkaline soil it becomes Calcium X, Potassium X, Sodium X, etc.

When ammonium sulphate is added to an acid soil, the following reaction occurs:

Acid X + Ammonium Sulphate ⇄ Ammonium X + Sulphuric Acid.

The active acidity of the soil is increased because sulphuric acid is a strong acid and extremely soluble. Additional acidity results as the soil micro-organisms transform the ammonium radicle to nitric acid, another strong water soluble acid. Ammonium sulphate has more power to create acidity than any other fertilizer material. Ammonium nitrate, ammonium phosphate, and urea are acid forming also.

When sodium nitrate is applied to an acid soil it reacts with the acid clay complex in the following manner:

Acid X + Sodium Nitrate ⇄ Sodium X + Nitric Acid.

There is a temporary increase in active acidity, but the ultimate effect is to reduce soil acidity because Acid X becomes Sodium X. The nitrate is absorbed and utilized by the plant. All other nitrate fertilizers tend to reduce soil acidity.

Cyanamid is the trade name for calcium cyanamid. The nitrogen is converted into urea by the soil, provided the soil is not strongly acid. The nitrogen ultimately goes to the nitrate form. The calcium becomes lime hydrate. Whenever 100 pounds of cyanamid is used, it is equivalent to applying 70 pounds of lime. So soil acidity is reduced by cyanamid.

Superphosphate is the principal phosphatic fertilizer used on turf. It is a soluble form of calcium phosphate. In practice superphosphate does not have a marked effect on soil reaction. The tendency is to reduce the acidity because the calcium combines with the acid clay fraction (Acid X) to form a calcium clay (Calcium X). The phosphate radicle is taken up by the plant or reacts with soluble aluminum or iron to form the corresponding phosphate. Both are much more

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Range Ball Retriever

Fonken Mfg. Co., Burbank, Calif., now is in production of its ball retriever sufficiently to serve the enlarging market for the device which has been used on California practice ranges for about 4 years with marked satisfaction. The Fonken machine uses revolving plastic discs to pick up balls.

Effect of Acidity

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insoluble, and less readily available, than any of the calcium phosphates. That is the reason acid soils reduce the efficiency of applied phosphates, other than organic forms such as bone meal.

Muriate and sulphate of potash are the sources of potash used as fertilizers. The muriate (called potassium chloride by the chemist) is slightly cheaper than the sulphate. It is the one used on grass and most crops. The effect of either one when used on an acid soil is to increase the active acidity temporarily, but the final effect is to reduce the acidity, as illustrated by the following chemical equation:

Acid X + Potassium Chloride ⇄
Potassium X + Hydrochloric Acid.

The hydrochloric acid (the chemical term for muriatic acid) is soluble and leaches out in the drainage water. So the final effect of the potash fertilizer is to change Acid X to Potassium X and thereby reduce soil acidity.

Lime and gypsum are commonly called soil amendments because they are not considered as essential plant nutrient materials. Their function is an indirect one, to make conditions favorable for growth. The mechanism involved when used on an acid soil, is not generally understood.

Ground limestone, hydrated lime, and quicklime are the three forms of lime which can be used to correct soil acidity. Calcium carbonate is the active ingredient in limestone. The other two forms of lime are derived from it. Quicklime (calcium oxide to the chemist) is formed when limestone is subjected to intense heat in a kiln. The residue is calcium oxide, or quicklime. It reacts with water to form hydrated lime or calcium hydroxide. Calcium Oxide + Water = Calcium Hydroxide.

When ground limestone is applied to an acid soil, it reacts with soil acids in the following manner:

Acid X + Calcium Carbonate ⇄
Calcium X + Carbonic Acid

The carbonic acid is a very feeble and unstable acid. It breaks down into water and carbon dioxide gas, which escapes into the air. Thus there is an immediate reduction in the active acidity.

Hydrated lime and quicklime are more soluble than limestone and act faster. Quicklime combines with water when added to a moist soil and becomes hydrate. The hydrate reacts with the acid clay complex according to the following equation:

Acid X + Calcium Sulphate ⇄
Calcium X + Water.

Since water is the by-product of the reaction, the reduction in active acidity begins promptly after hydrate or quicklime are applied.

Understanding Alters Use

Gypsum or calcium sulphate were used extensively as a soil amendment before the chemistry of acid soil was well understood. It is not a satisfactory material to use when the sole purpose is to reduce soil acidity. The first effect produced by it is to increase the active acidity. The after effect following the disappearance of the active acid, usually as a result of leaching, is to reduce the potential acidity because Acid X becomes Calcium X. The reaction is exactly similar to the one shown for potash fertilizer salts. The only difference is that a calcium clay is formed instead of potassium clay. The action of gypsum is illustrated in the following equation:

Acid X + Calcium Sulphate ⇄
Calcium X + Sulphuric Acid.

The mineral clay and silt complex is a great soil stablizer. Because it has acidic and basic properties, the tendency is for soils containing it to resist change. It is the principal reason why change in reaction is gradual following the use of acid-forming fertilizer or lime. This property is usually referred to as the "buffer" capacity of the soil by the chemist, and is a wise provision of nature. Except for this buffering capacity, plant and crop production would be a more trying and difficult task. Some of the soil fluctuations, either from natural forces or the foolhardiness of man, might be too violent for the plant to survive.

The soil humus, or organic matter has chemical and buffer properties from the reaction standpoint which are similar to those of the mineral fraction. This fact is often overlooked. Other effects on the physical condition and water-holding capacity of the soil are the ones usually stressed.

Modern practice is to express soil reaction in terms of pH. It is a measure of "active" acidity, but does not give a true picture of the quantity of lime needed to produce a given change in reaction. In the pH scale the figure 7 represents neutrality. Lower figures represent increasing acidity, and higher ones increasing alkalinity. Each figure differs by a multiple of 10, so pH 6 is 10 times, pH 5 is 100 times, and pH 4 is 1,000 times more acid than neutral. Similar differences apply in the alkaline range. Soils usually fall in the range of pH 4.0 to 8.5, but more commonly within the narrower limit pH 5.0 to 7.5.

Acid soils are confined to the humid regions, that is in areas where the annual rainfall is 20 inches or more. Lime is gradually leached out of the soil by the percolating water.

The practical aspects of lime and its use on golf course turf will be discussed later.