The A B C of Turf Culture

Soil Characteristics and How Plant Food Becomes Available

By O. J. NOER

FERTILIZERS are only effective when climatic and soil conditions are favorable for the growth of turf grasses. Frequently the distracted green chairman or greenkeeper attributes poor turf to a lack of plant food, where other unfavorable conditions are equally important, and when fertilizer applications result in failure may unjustly condemn the fertilizer. Sometimes poor growth on newly planted greens is traceable to the use of too heavy soil construction. The puddled soil becomes hard and the roots fail to obtain much needed oxygen. Fertilizers will not overcome the bad effects of faulty drainage. Turf on coarse sandy soil, or thin soils covering gravel knolls rarely obtains sufficient water. The wise greenkeeper corrects or modifies these conditons before making large expenditures for fertilizer and is well repaid for the greater effectiveness of the fertilizer.

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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.

Great care must be exercised in the selection of fertilizers, because it takes time to correct the effects produced by the injudicious use of some materials. The amount and availability of the plant food constituents is of first importance. Leather is high in nitrogen, but of little value because decay does not take place in the soil. The nitrogen of sulphate of ammonium is ordinarily immediately available. Between these extremes materials of varying degrees of availability can be chosen. Acid phosphate is a far better source of phosphoric acid than bone meal for new seedings because of its greater availability. Certain plant food elements must be used with caution because they unduly encourage clover. The secondary effects produced in the soil are also important. Some materials increase while others decrease soil acidity and thus affect clover growth. All these factors must be considered in choosing fertilizers.

The particular plant food elements and amounts which should be used depend upon local soil conditions, and satisfactory results are obtained only when the soil conditions are taken into consideration.

Soils differ greatly in their power to sustain turf growth partly as a result of plant food deficiencies. Certain soil types are notoriously high in some elements and low in others. Some are likely to be low in all plant elements. Naturally soils which have been heavily cropped need more fertilizer than those which have been carefully handled and frequently manured. Black soils, while often superior to the light colored soils may have been so badly depleted of plant food that new seeding fails to produce desirable turf. Had deficiencies been recognized prior to seeding, time and money could have been saved and good turf obtained.

Soil Deficiencies Confined to Three Plant Food Elements

Turf depends upon the soil to supply seven of the ten necessary plant food elements. All soils contain abundant supplies of four of these, so only one or more of the three elements, nitrogen, phosphorus and potassium, need be added in fertilizers. These are usually referred to as ammonium, phosphoric acid and potash.

Total Amount of Plant Food in Various Soils

Soils consist of a mixture of humus and organic matter and solid mineral particles. Practically all of the nitrogen exists in the humus and the elements phosphorus and potassium occur principally in the mineral portion, although the humus also contains limited amounts of both. Sand particles consist of silica mainly, and hence are low in plant food elements. It is in the silt and clay particles that phosphorus and potassium are most abundant.

Peats and mucks, consisting mainly of partially decayed plant residues, are high in nitrogen and often low in phosphorus and potassium. Sand usually contains very little humus and the finer mineral particles, and is low in all plant food elements, especially if derived from sand stone, but may contain sufficient potash if derived from granite rocks. Sandy loams, loams, and clays vary in their humus content and are low in available nitrogen if low in humus. They are usually well supplied with potassium, but may need additional phosphorus, particularly on new seedings.

The plow layer of an acre of good loam soil contains roughly about 2500 to 3500 pounds nitrogen, 1000 to 1400 pounds phosphorus and about 40,000 pounds potassium. Sands usually contain less than one-third to one-half as much nitrogen and phosphorus, and may be low in potassium. While peats and mucks may contain eight to ten times as much nitrogen, they are low in phosphorus and potassium.

The roots of closely clipped turf rarely extend beyond several inches and obtain most of their plant food from this shallow layer of soil.

Even the sandy soils contain a sufficient total plant food to support growth over a number of years, if the turf could draw upon the entire supply, but only materials dissolved in the soil water are available, and frequently solution from the insoluble soil materials does not take place rapidly enough to satisfy the demands of the turf. Actively growing turf requires a uniform and continuous supply of soluble food, and unless such conditions are maintained in the soil, poor growth results. In a general way, soils highly charged with plant food yield soluble material more rapidly than those of lower content. Solution takes place more rapidly in sandy soils than heavy soils, so it would be folly to attempt to raise the total plant food content of sands to equal that of heavy soils.

Amounts of Soluble Plant Food in Soil Solution

During the growing season, only small amounts of dissolved plant food are found in the soil under turf grasses. These amounts are so small that only exact chemical methods are required for their determination. Soluble nitrogen is rarely found. Just as soon as solution occurs the nitrogen is taken up by the turf roots. A million pounds of soil water, under these conditions, rarely contains more than several pounds of soluble nitrogen. In fallow cultivated soil as much as 30 to 50 pounds of soluble nitrogen may be present. The dissolved potassium is never very high, and the soil water may contain less than a pound of dissolved phosphorus. These amounts are never sufficient to maintain growth over extended periods. Conditions favoring rapid replenishment of the soil solution as the turf roots remove food must be maintained if normal growth is to take place.

How Plant Food Becomes Soluble

Soluble nitrogen results from decay or decomposition of the humus or organic matter of the soil, by soil bacteria and fungi. The nitrogen existing even in soluble organic matter is not directly available to the plant, but must be resolved into simple forms. A host of bacteria and fungi attack the complicated organic compounds and release nitrogen in the form of ammonia. Then specific groups of organisms rapidly convert the ammonia nitrogen into nitrate nitrogen. This is the form preferred by most plants. During decay the carbon is converted into carbon dioxide, or carbonic acid, and any mineral plant food elements contained in the organic matter are released in forms available to the plant. Phosphorus and potassium are also dissolved by the soil water from the insoluble mineral soil constituents.

Factors Affecting Rate of Solution

Naturally the first essentials for an adequate supply of soluble nitrogen is in the supply of the various groups of organisms which bring about decay. Dark color in a soil is usually an indication of the presence of humus, and large nitrogen content. Yet if black soils have been under crop for a long period without additions of manure or green manure crops, soluble nitrogen may not be produced rapidly enough to satisfy the needs of the turf. The residual humus resists further decay and is of little value except as it improves the physical condition and water-holding capacity of the soil. This fact is frequently overlooked on new seedings. An established turf increases the humus content of the soil. As new roots are formed the old ones die and upon decay their nitrogen is again converted into forms suitable for use. It is necessary only to supply sufficient nitrogen to balance the losses due to baking and removal of clippings.

All well drained soils contain hosts of bacteria which multiply rapidly if conditions permit. The organisms which liberate available nitrogen require oxygen and water. They are most active when temperatures range from 70 to 90 degrees Fahrenheit, and in fact cease operations during the cold winter weather. Activity begins again with the advent of warmer weather in the spring. This is Nature's method of conserving nitrogen during the period when plants are dormant, because nitrate nitrogen leaches from the soil if not taken up by the plant roots. If the soil is too acid the activity of the organisms which convert ammonia to nitrate nitrogen is greatly retarded and in extreme cases ceases entirely.

Phosphorus exists in the soil as lime, iron or alumium phosphate. The two later predominate in acid soils. The rate of solution depends upon soil reaction, state of division of the phosphate, and presence of carbonic acid. Acid soils do not yield phosphorus as readily as non-acid soils because iron and alumium phosphates are less soluble than lime phosphate. For this reason phosphate applications for new seedings should be heavier on acid soils than on non-acid soils. The finer the individual units containing the phosphorus the more rapid does solution occur because of the larger surfaces exposed. The prin-

(*Continued on page* 35)

A B C of Turf Culture

(*Continued from page* 14)

ciple is universal. Granulated sugar dissolves more rapidly than lump sugar for the same reason. When soluble phosphates are added to the soil they are precipitated in a very fine state of division. This permits rapid solution when heavy demands for phosphorus are made.

Plant roots excrete carbonic acid, and it is also formed during decay of soil organic matter. Its presence in the soil water increases the rate of solution of phosphorus.

The soil supply of potassium exists in complicated mineral such as feldspar and mica. The soil water in contact with these minerals gradually dissolves potassium, and if charged with carbonic acid solution takes place more rapidly. Some of the minerals hold the potassium so tenaciously that solution is extremely slow. Finely divided minerals containing potash yield soluble potassium more rapidly than coarse particles. When heavy soils, containing large amounts of potassium respond to additions of potash fertilizers it is because the remaining potassium is held in combinations which resist the solvent action of the soil water. When soluble potassium fertilizers are added to the soil the fine clay particles retain the potassium, and yield it to the soil water when the plant takes up the potassium already in solution.

What Constitutes a Fertile Soil?

Productive soils are more than so much dirt. They are manufacturing plants, teeming with life, in which the raw plant food materials are converted with forms which the growing plants can utilize. The fertile soil is an efficient factory where a uniform and constant supply of plant food is produced to meet the demands of the growing turf. It is capable of speeding up to take care of any abnormal demands. To be effective it must be well drained, and yet well supplied with moisture to meet the demands of plants and bacteria. It must be well granulated and friable so plant roots and bacteria obtain needed nitrogen. This condition permits rapid extension of the roots which reach out in their search for food and water. Some readily decomposable organic matter is essential to the life of the soil organisms. It is a source of plant food and the resulting humus improves soil structure and increases the water holding capacity of the soil. After good turf is established the old roots as they decay increase the soil supply of organic matter. While acid soils are desirable in golf courses to discourage clover and weeds it must be recognized that too much acidity may reduce the efficiency of some soil processes. If the above conditions have been fulfilled, and climatic conditions are favorable, good turf growth depends upon the presence of sufficient plant foods. If not already present they can be added in fertilizers with full assur-