over a period of 22 years had made the club an object of his affection and devotion.

To him golf was more than a game or a fleeting pastime. He appreciated the game in its finer aspects, knew it to be an opportunity for the close comradeship of the links, realized that the spirit of the rule was more often to be observed than the letter, and he believed that the honor of the game was not limited to the first shot at each tee, but extended from the first tee to the last hole. In his passing the game has lost one of its real leaders.

Appointment of Dr. John Montieth, Jr.

We are pleased to announce that Dr. John Montieth, Jr., who is well known to readers of THE BULLETIN as a result of his excellent work on turf grass diseases, has recently been employed by the United States Golf Association Green Section. He entered upon his new duties on April 1, and is to have charge of the research work. Dr. Monteith's past training and experience and his interest in turf grass problems fit him admirably for these investigations, and we confidently look forward to accomplishments that will be of great value to golf courses.

Effects of Individual Fertilizer Materials on Soil Reaction

By O. J. Noer, Madison, Wis.

Individual fertilizer materials affect soil reaction differently, some intensify and others reduce the acidity. In any program designed to modify soil reaction these specific effects must be considered.

The soluble acids dissolved in the soil water produce marked effects on vegetation, and the development of this acidity depends upon the presence in the soil of insoluble acids. It is the minute clay particles which become acid in character. In non-acid soils the clay is saturated with calcium, but additional calcium may be present in the form of lime carbonate. Until all the lime carbonate and appreciable amounts of the calcium saturating the clay are removed, soluble acidity will not develop. In humid regions the percolating waters, as they pass down through the soil, leach out calcium and the residual clay particles eventually become acid. Fortunately those materials which cause acidity accelerate the removal of calcium and thus hasten development of insoluble acids, the reservoir from which soluble acids are formed.

The insoluble clay is a complex salt exhibiting acid properties when its basic calcium is removed. Mineral fertilizers are also salts, containing an acidic and basic portion, and are usually water soluble. Those capable of yielding soluble acids contain a basic portion which the insoluble acid clay can absorb, leaving the soluble acid dissolved in the soil water. The basic material absorbed by the clay reduces its acid producing power, but re-solution usually takes place, especially if the basic portion is ammonia or potassium and leaves the clay unimpaired in acid properties.

The organic fertilizers have little effect on soil reaction until broken down into simpler substances by the soil micro-organisms, and any changes that do occur are therefore secondary, resulting from the interaction of these simpler materials with the soil constituents.

Acid soils contain iron and aluminum in combination (basic salts, hydroxides or oxides) capable of forming insoluble compounds with phosphoric acid, and thus nullify any effect the phosphoric acid might have on soil reaction.

The action of individual fertilizers is based on the above principles. Fertilizers are grouped according to the predominating plant food constituent, and may be further subdivided depending upon the chemical nature of the plant food element. In the main, members of each sub-group exert similar effects on soil reaction, differing only in degree.

The Nitrogenous Fertilizers

Fertilizer nitrogen exists in three main forms, either as ammonia, organic, or nitrate nitrogen. The ammonia fertilizers increase acidity, the organic carriers produce the same effects if free from basic materials, and the nitrates decrease acidity. The mechanism whereby these changes take place are best discussed for each important material.

Ammonium sulfate.—This fertilizer is the peer of all so far as increasing acidity is concerned. When applied to a soil already acid the ammonia is first taken up by the acid clay and sulfuric acid remains in solution. If the acid clay still contains calcium capable of being released it dissolves and then unites with the free sulfuric acid to form calcium sulfate (gypsum), a soluble, neutral salt which leaches out in the drainage waters. This leaves the clay more acid. The absorbed ammonia is gradually converted to nitric acid by soil micro-organisms, and either increases the soluble acidity or combines with more calcium. The net result is to markedly increase the acidity of the insoluble clay, and eventually a condition is reached where the clay becomes exhausted of all replaceable calcium. The peculiar effectiveness of ammonium sulfate results from the combined effect of the nitric and sulfuric acids.

Sulfate of ammonia accelerates the removal of lime carbonate from non-acid soil, calcium sulfate being formed and subsequently washed out in the drainage waters.

Ammonium phosphate.—This fertilizer increases soil acidity but is not as effective as sulfate of ammonia, because the phosphoric acid is precipitated in the soil as insoluble phosphate. If the soil is acid iron or aluminum phosphate is formed and in non-acid soil calcium phosphate is precipitated. Thus the sole effect on soil reaction depends upon the nitric acid formed from the ammonia by the soil organisms.

Organic nitrogen fertilizers.—The effect on soil reaction depends upon the nitrogen content and the amount of extraneous basic materials. In the soil the organic nitrogen is ultimately converted into nitric acid by the soil organisms, and this tends to make the soil acid. Naturally the effect is most pronounced with those materials having a high nitrogen content, such as dried blood, and least with materials of low nitrogen content, such as the animal manures. Any basic substances are finally converted into carbonates which have alkaline properties. This occurs to the lime contained in manure, and if the amount is sufficient this lime may overcome the acid producing power of the nitric acid formed from the nitrogen. Bone meal and tankage usually contain sufficient lime to overshadow the nitrogen. It is doubtful if organic fertilizers ever markedly increase acidity.

Urea is usually classed as an organic fertilizer. Unlike the majority of organic materials it is completely water soluble. Plants are said to be able to take up urea direct, and where this occurs there can be no change in soil reaction. However, the nitrogen of urea is easily transformed to ammonia in the soil, and this in turn to nitric acid, so the tendency is to increase soil acidity whenever the urea is not taken up direct.

Nitrate fertilizers.—There are two nitrate fertilizers on the market, namely, nitrate of soda and calcium nitrate. They differ solely in the basic portion of the salt. In nitrate of soda the element sodium is the base, and in calcium nitrate it is calcium. Nitrate of soda is refined from natural deposits in Chile, and calcium nitrate is produced synthetically in Germany. Both materials tend to decrease soil acidity. Nitrate nitrogen is the form preferred by most plants, and when the nitrogen is taken up the basic portion, either sodium or calcium, remains and combines with the insoluble acid clay, thus neutralizing some of its acid and reducing its power to liberate soluble acids.

Phosphatic Fertilizers

There are three principle sources of phosphoric acid, namely acid phosphate, ammonium phosphate and bone meal. While other materials frequently contain some phosphoric acid, they are usually used primarily to supply other plant food elements. Excepting ammonium phosphate, they all reduce soil acidity.

Acid phosphate.—This is the most widely used source of phosphoric acid. The name refers to the process of manufacture and not its effect upon soil reaction. It is produced by treating raw rock phosphate, mined in Florida, Tennessee and the Carolinas, with sulfuric acid. This converts the insoluble calcium phosphate into a soluble phosphate. A portion of the calcium from the original rock is converted into calcium sulfate, a neutral salt, and the resulting soluble phosphate contains less calcium per unit of phosphoric acid than the original rock. When applied to the soil acid phosphate tends to make the soil less acid. On acid soils the phosphoric acid combines with iron and aluminum to form insoluble phosphates, and the calcium is released in a form capable of uniting with the acid clay and reducing its acid properties. The effect is slight since the amounts of phosphate ordinarily used are small, so for all practical purposes the reduction is slight.

Ammonium phosphate.—As explained above, the effect on soil reaction is due solely to the nitrogen, since the phosphoric acid is precipitated in the soil as an insoluble phosphate and thus removed from the soil solution. Ammonium phosphate is less effective than ammonium sulfate in increasing soil acidity.

Bone meal.—There are two principle grades of bone meal, steamed and raw bone. The steamed meal contains about 2½ per cent nitrogen and 27 per cent phosphoric acid, while the raw bone contains approximately 4 per cent nitrogen and a little more than 20 per cent phosphoric acid. Besides the insoluble calcium phosphate, bone also contains some lime carbonate. As soil processes convert the insoluble calcium to soluble phosphate, a portion of the calcium is released as lime carbonate, which with the lime carbonate naturally in the bone, reduces soil acidity by reacting with the acid clay.

Basic slag.—This is a commonly used phosphatic fertilizer in Europe but is rarely used in America. It contains free lime carbonate, and insoluble calcium phosphate, and hence reduces soil acidity.

Potash Fertilizers

The potash-containing fertilizers are imported from Germany and France. Muriate and sulfate of potash are the common carriers, both water soluble and containing 50 per cent potash. They are salts, the potash being the basic portion and muriatic (hydrochloric) or sulfuric acid constitute the acid portion. When applied to the soil they increase soluble acidity. The basic potash is taken up and held by the acid clay and the acid, either muriatic or sulfuric, remains in the soil solution. While the absorbed potash reduces the acid producing power of the clay, as soluble potash is withdrawn from the soil solution by the grass roots the absorbed potash gradually dissolves and the acid producing power of the clay is slowly restored.

Soil Amendments

These are substances added to the soil, not primarily as sources of plant food, but to modify soil reaction or physical soil conditions. Three materials, namely, lime, gypsum and sulfur, deserve consideration.

Lime.—Agricultural lime is commonly crushed limestone or lime carbonate, although hydrated lime or quick lime are occasionally used. When limestone is burned in a kiln, carbon dioxide escapes and quick lime is formed. Hydrated lime results when quick lime "slacks" with water. Approximately 56 pounds quick lime and 74 pounds hydrated lime are equivalent in neutralizing power to 100 pounds crushed limestone.

When any of the above forms of lime are applied to acid soils, marked reduction of acidity takes place. Hydrated and quick lime due to their greater solubility act much more quickly than the insoluble crushed limestone. The lime supplies basic calcium which completely neutralizes the soluble and insoluble acids if applications are sufficiently heavy. The by-products of the neutralizing action are water in the case of hydrated and quick lime, and carbonic acid (carbon dioxide) with the crushed limestone. Carbonic acid is a gas which escapes into the air and since water is neutral the net result is marked decrease in soil acidity.

Gypsum.—In times past gypsum was commonly used by agriculturists, but is now rarely applied to soils. Gypsum, also known as calcium sulfate, is a neutral salt consisting of calcium combined with sulfuric acid. When applied to very acid soils the first effect should be to increase soluble acidity. The acid clay absorbs the calcium and leaves the sulfuric acid dissolved in the soil water. If the gypsum applications are heavy, after the soluble acid leaches out in the drainage waters, the clay gradually releases calcium to the soil water and soluble acidity is reduced until marked removal of calcium takes place. Gypsum is sometimes used in attempts to flocculate heavy clay soils.

Sulfur.—There are specific micro-organisms in the soil capable of converting sulfur into sulfuric acid. The presence of air to supply oxygen and moisture are essential. Sulfur in limited amounts, mixed with topdressing, should promote soil acidity, and its use may prove valuable in regions where conditions make it difficult to create acidity by the sole use of acid-producing fertilizers.

In the next article the possibilities of introducing lime and other basic substances in sand, and in other materials, in quantities sufficient to overcome the acid-producing powers of the fertilizers, will be discussed, and the lime content of a few typical sands from some localities will be included.

The Service Rendered by the United States Golf Association Green Section to the Golfers of America *

By William C. McKnight, President, Baltusrol Golf Club, Short Hills, N. J.

When I was asked to make a few remarks to you today and was told of the topic it created great surprise in me. I could not conceive why, from my own standpoint, and holding the opinion that I do with respect to the work of the Green Section, there could be the slightest doubt in the mind of anybody with respect to that Section and the splendid work that has been done by it. But it is often well to look back over work in a retrospective attitude and to take stock.

This is an age of experts and an age of very intensive scientific searching for facts. You all have in mind notable instances of that, but I may remind you of the research laboratory of the General Motors Company. It is very extensive. It is doing an enormous work. It is probably more directly responsible for the vast improvements in structure and operation of automotive engines and automobiles than any work that is going on in the country today. The research laboratory of the General Electric Company is vast, and its work is directly responsible for most of the modern improvements in electric devices. (The most notable instance, I suppose, with which you are all familiar is the development of the metal filament lamps which were perfected in the research laboratory of the General Electric Company.) The Bureau of Standards at Washington is doing a most gratifying work, the benefits of which are widespread throughout the entire country. I have no doubt that it was due to knowledge of such facts that Mr. Whitney and his associates in the management of the United States Golf Association in 1921 conceived and organized the Green Section. In his annual address in 1922, I learn from the reports that he stated to the meeting with respect to the Green Section: "Its object is to form a central distributing station in order to gather and send out to the golf clubs in the United States information of value relative to the upkeep and preservation of the finer grasses; also to advise the green committees of the golf clubs in this country on all matters that will be of benefit to them and thereby save a great deal of the money that has hitherto been wasted through lack of proper information."

That was very prophetic of what has happened. It was their idea to establish for golf a great research laboratory and to dissemi-

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*Address given at annual meeting of the United States Golf Association Green Section at New York City, January 6, 1928.