Functions of the Three Plant Food Elements

BY A. E. GRANTHAM, *Director*

Read at the Fourth Annual Convention of the National Association of Greenkeepers of America at Jefferson County Armory, Louisville, February 4-7, 1930

THE food of plants comes from three sources, water, air and soil. Those from the water and air are in such abundance that they are always present for the full needs of plants. The mineral elements, or those derived from the soil may be divided into three classes:

First, the non-essential, which, although they are absorbed by plants, are not considered to have a vital function, and has silicon, aluminum, sodium and possibly manganese:

Second, the essential and abundant—in this class are iron, calcium, magnesium and sulphur:

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Third, a class which may be considered critical, including nitrogen, phosphorus, potassium and possibly sulphur.

More recent investigations, however, lead us to believe that manganese and magnesium are deficient in some soils and are performing a more important function than was formerly considered. However, the purpose of this paper is to discuss the functions of the three principal ingredients of plant food; namely, nitrogen, phosphorus and potassium.

The use the plant makes of these elements has been carefully studied by chemists and physiologists for a number of years. The use of plant food by grass does not differ widely from other groups of plants, although little direct investigational work has been carried on along this line—the attention of the agricultural experiment stations in the past dealing largely with field-grown crops.

Plant Cell is Unit of Growth

THE plant cell is the unit of growth. The principle of life in the cell is protoplasm; it is the laboratory in which all the changes, which constitute the changes of the plant, take place. The vital processes of plants—assimilation, translocation, respiration and metabolism, are essentially chemical in character. Protoplasm is made up of complex compounds, which differ from non-living matter; first, in chemical composition; second its power of waste, repair and growth; and third, its reproductive power.

Living matter is constantly undergoing change—the result of the breaking down from its activities and by making good this loss by the manufacture of new protoplasm out of simple food materials. Here is where the elements of plant food play their part. With surplus protoplasm it makes new cells, more tissue and organisms. It produces new masses of living matter contained in the seed or fruit, which when deducted from the parent mass eventually begin a separate existence.

Let us consider the functions of each of these three elements. Nitrogen is a constituent of all proteins, compounds which are found as the active components of all protoplasm. Protein is from the Greek, meaning pre-eminence, or of first importance. The protoplasm of the green portions (leaves) of the plant permits protosynthesis of the carbohydrates, the synthesis of other tissue-building materials and the formation of reserve food substances.

What Nitrogen Does

THEREFORE, nitrogen is of the greatest importance to a plant. It promotes leaf and stem growth and gives the plant a dark green color and vigorous appearance. The lack of nitrogen is shown by pale green or yellowish leaves. Excess nitrogen gives rank growth and retards the ripening process. Excess nitrogen produces a soft plant tissue, due to the weak cell wall, which is in turn subject to plant diseases.

If we turn to field crops, on which most studies have been made with reference to nutrition, we find that wheat and oats, when supplied with heavy applications of nitrogen, have weak stalk growth, which makes the plants subject to lodging and to such diseases as rust and others. Wheat and oats belong to the grass family, although they are annuals. The same results are found with such crops as tobacco. While excess nitrogen produces large plants and abundant leafage, the tissues are not firm and fail to mature properly and the plant is much subject to disease. In the early growth of plants nitrogen is largely in the leaves—later it is transferred to the seed.

Phosphorus Stimulates Root Growth

THE second element, phosphorus, while directly essential to plant growth, the effect is not so visible in the general appearance or color. Available phosphorus in early growth stimulates root development, an important feature of grass growth. It hastens the development of adventitious buds or rootlets on plants that reproduce themselves by tillers, root-stalks or stolons. Most plants send out a secondary set of rootlets after those that have been produced directly with the seed. It is with these secondary rootlets that the phosphoric acid seems to have very active effect.

Farmers well know that wheat, seeded in the fall and fertilized with phosphates, makes a much better root system and is less subject to action of frost during the winter than wheat not so treated. This is evidence that more extensive root system is produced by the phosphates. Phosphorus hastens maturity. In other words, it acts in the opposite way from nitrogen and when applied with nitrogen tends to counteract the effects of over-feeding of nitrogen. Phosphorus is indispensable to plant growth, as it is the essential constituent of the nucleus of the cell. It is said to determine the rate of chemical changes in the cell.

Large amounts of phosphates are taken up by the plant in its early stages of growth. Later it is translocated to the seed or grain, which contains large amounts of phosphorus. Since phosphorus is a constituent of every plant cell, and cells form the tissues of the plant, it must be looked upon as one of the very important elements of plant food. It has been remarked that since grass on the golf course or green is not grown for its seed, then why use phosphorus. It should be kept in mind that phosphates are necessary to the growth of all plants and whether the plant is deprived of the opportunity to produce seed or not, the living tissues (the blade of the grass) must have phosphorus.

Potash Forms Sugars and Starches

IT is generally stated that potash forms the sugars and starch in plants. We know that potatoes, beets and sugar cane require and use large amounts of potash. However, all plants require potassium, as it is needed in the cell sap to effect necessary changes in translocation of plant food. Plumpness and size in tubers and grains are dependent on plenty of available potassium. Potash hungry plants are more subject to disease. This is particularly noted in corn, tobacco and cotton, all of which are subject to particular diseases when the soil does not furnish enough potash.

The fact is well known that in general crops, excess potash retards maturity. This point may be of value in the maintenance and keeping of grass more luxuriant during the season. This is probably due to the fact that potash maintains the tone and vigor of the plant. The scarcity of potash is not shown so markedly in the case of plants, except by rather retarded growth and the tendency to be more susceptible to disease.

Each of the three elements, therefore, plays a special part in the growth of all plant life. While it is true some plants use more of one element than another, nevertheless nitrogen, phosphorus and potassium are found as a constituent of all living plant tissues.

The growing of grass under golf conditions, particularly on greens, presents a problem unlike most in the agricultural field. Until very recently little experimental work bearing directly on the fertilizer practice for greens has been conducted. Of course, for many years the agricultural experiment stations and the U. S. Department of Agriculture have carefully tested out the fertilizer requirements, particularly the functions of the various plant food

elements, nitrogen, phosphorus and potassium in producing the various crops. Under such conditions it is now pretty well known how each of these react in the growing of the crop, and particularly the part they seem to play under various conditions of soil and at various stages of plant growth.

Golf Course Has Artificial Conditions

ON the golf course we have very artificial conditions. The plant cannot be cultivated and on greens it is cut close, perhaps every day in the growing season. It is heavily watered and, to maintain the proper physical condition on the surface, repeated additions of compost and sand are made.

Heavy watering almost daily in hot weather produces a condition of soil tilth or structure that may be favorable or not to the best growth of grass, particularly since this greatly depends on the drainage and aeration of the soil. Therefore, there are no other conditions quite comparable. It is true with pasture environment, where cattle graze regularly, we have a condition more or less similar. However, the trampling action of cattle on grass is far different from the effect of footprints made by human beings. Further, the treading of the grass while the soil is quite wet furnishes another factor that is not at all favorable. These are some of the conditions confronting the greenkeeper.

At the same time the continued clipping of the grass removes plant food and in time the soil is bound to be depleted of one or more elements. The practice in many quarters has been based on the idea that grass needs nitrogen chiefly, if not entirely. This has resulted in repeated applications of nitrogen in the form of sulphate of ammonia or other quickly assimilable nitrogen carriers. This has resulted in forcing the grass, and without question results in a weaker and less resistant turf.

The prevalence of brown patch during the past few seasons seems to be somewhat associated with the practice of excessive applications of nitrogen. While this has not been definitely proved, there is such a close correlation between the practice and the prevalence of this fungus that the relation is hardly to be questioned. Then too, the soil on greens particularly is being constantly modified, due to the additions of sand, compost, etc.

Most Soils Need Phosphorus

MOST soils in the United States are deficient in phosphorus. In other words, under normal field conditions there is not enough available phosphorus to give a full growth to many crops. This should be borne in mind in building greens, that sufficient fertilizer, carrying all three elements of plant food, particularly phosphates and potash, should be applied to the soil before the greens are seeded. The same applies to fairways. The reason for the objection to the use of phosphates and potash in fertilizer often lies in the idea that these ingredients of plant food promote the growth of clover. It is probably true on soils hungry for these elements that clover will come in to some extent. However, the association of clovers with blue grass is one that is constantly changing.

Where land is made suitable to grow clover, blue grass is likely to follow rather than the reverse. The best blue grass lands of Kentucky contain many times as much phosphorus as they do nitrogen and these are almost pure blue grass lands. In other parts of the country, western Virginia, southern Wisconsin and northern Illinois, we find some of the most typical blue grass, but it is noticeable that they are on soils that are rich in phosphates and potash. It is a noticeable fact that stands of legumes, such as sweet clover, alfalfa and even Japanese clover, are followed by blue grass, which tends eventually to crowd them out. The nitrogen gathered by the legumes seems to favor the spreading of the true grasses.

Some of the best stands of blue grass I have ever seen followed, without seeding, fields of alfalfa where the alfalfa was gradually crowded out by the encroachment of the grass.

Recent experiments conducted at the New Jersey Experiment Station, and reported in the December issue of the **National Greenkeeper**, offer some very good evidence along this line. These tests have been running for several years. It was found there that the plats receiving a complete fertilizer showed the least amount of white clover, the most white clover appearing on the check plat. Likewise, tests

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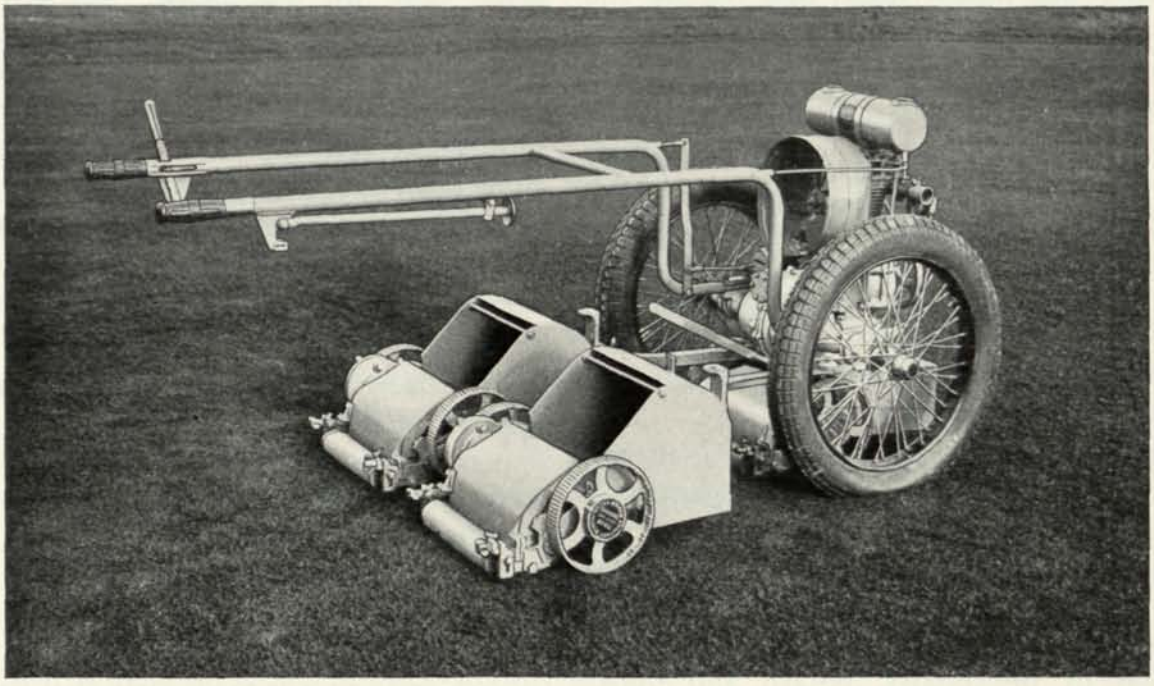

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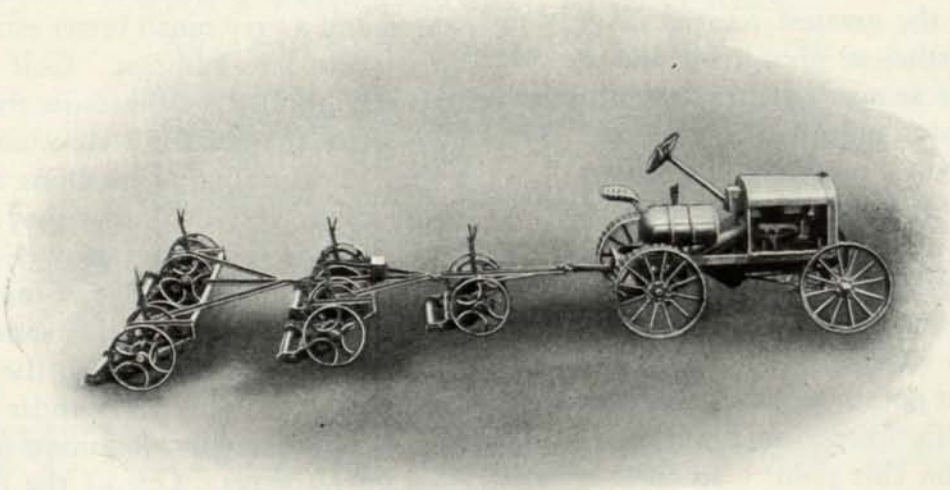

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with lime, against which considerable prejudice has been aroused in recent years, showed that lime did not increase weeds where ample plant food was added in addition, and it was also noted that lime plus fertilizer gave the best and most uniform growth.

These points are merely brought out to show that perhaps there is not as much danger to be feared from the use of fertilizer carrying phosphates and potash, and perhaps the use of lime, as is generally considered. It is true that bent grass is largely used on greens proper. The bents in their native states grow on soils that have a good supply of potash—blue grass particularly where there are abundant phosphates.

Tests on Pasture Grasses

DURING the past two years The National Fertilizer Association has conducted a large number of tests on top-dressing pasture grasses in various parts of the eastern states and New England. These tests consisted of comparing results secured with the application of phosphates, potash and phosphates, and nitrogen, phosphates and potash. Most of these pastures had been down for years and many of them were on native foundation. It is interesting to note that while the complete fertilizer gave the greatest returns in growth of grass, nevertheless phosphate and potash combined made as much yield as the nitrogen. In other words, phosphates produced 341 pounds, potash 302 pounds and nitrogen alone 650 pounds. Of further interest was the fact that the plat receiving all three elements of plant food maintained a more vigorous growth during the hot summer weather than where single elements were used.

The fact that potash tends to delay maturity when applied in liberal amounts may have some bearing on this point. In these tests it was found that phosphates and potash did increase the amount of clover, but where nitrogen was applied in addition the grass was further stimulated and became a very strong competitor of the clover. Subsequently it may appear that, due to the greater growth of clover, the true grasses will grow more luxuriantly as has been observed elsewhere.

It is worth while remembering that other plants, such as lettuce, spinach and plants grown for their leafy tops are fertilized not only with nitrogen but with large amounts of phosphates and potash also. With grass, we have been trying to keep it growing in many cases by the use of nitrogen alone. Some greenkeepers have found already that they can well afford to apply some complete fertilizer to greens, even during the summer, if applied in very small quantities along with the compost that is usually put on. Of course, this has to be done with care, but where greens seem to be lacking vigor and tone undoubtedly fertilizer carrying phosphates and potash will be of much benefit.

Apply Fertilizers Early in Season

WHERE complete fertilizers are applied it seems from all evidence obtainable at present that it should be applied very early in the growing season, as soon as grass shows signs of renewed growth in the spring. The test conducted by The National Fertilizer Association, referred to above, showed that where the top-dressing was made early that there was twice as much grass produced as where it was applied 30 to 50 days later.

The early application of top-dressing means more vigorous and better turf earlier in the season and a very much better established grass during the late summer. Golf courses that formerly applied fertilizers in the usual manner—after the grass is well established—have found upon changing methods and applying the fertilizer very early that they have received a much more permanent growth of grass.

Much of our knowledge of growing grass is empirical. What we need is some definite experimental work to establish the factors most favorable to growing grass under the very artificial conditions now obtaining on greens and even on fairways. One of the lines of work that might be undertaken is a study of the root system development as effected by the repeated cutting.

Does frequent cutting weaken or tend to strengthen the root system?

Does the heavy watering during the summer keep the feeding roots near the surface or does it cause them to go down?

These factors have a definite relation to the

(*Continued on page* 50)

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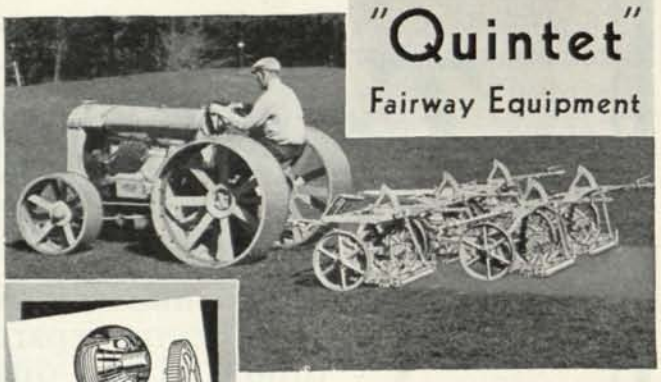

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Greenkeeping Problems in Canada

BY W. J. SANSOM, *Greenkeeper*
Toronto Golf Club, Long Branch, Ont.

Read at the Fourth Annual Convention of the National Association of Greenkeepers of America at Jefferson County Armory, Louisville, February 4-7, 1930

WHEN asked by our worthy President, Mr. Morley, to give a paper titled "Greenkeeping Problems in Canada," I consented, fully aware of the fact that it would be impossible for me to do justice to the article covering the whole Dominion of Canada from coast to coast, with such a vast difference in climatic conditions, soil, etc.

In northern Ontario, and east of us to the Province of Quebec, the seasons are much shorter and winters more severe, so that their problems or at least some of them would be different than ours in Ontario. But leaving climatical conditions out of the picture for a while, the greenkeeper's problem would chiefly be grasses.

Grass—The Earth's Richest Garment

IT seems perfectly natural for a man to specialize in fruit, in rose culture, herbaceous and Alpine plants or in orchids, for it is so obvious that to excel in any of these popular and much patronized branches of the garden craft one requires to make it his main, if not his whole study.

W. J. SANSOM

But grass that is green only, and not of so many colors—grass that grows to be mown, and rolled, grass that grows so often where it is not wanted even in paths and roadside, what need indeed can there be to specialize in this? That indeed would be more apparent if a knowledge of grass were more prevalent with our club officials and green committees. For strangely enough many that possess good greens and fairways have very little knowledge of the fine grasses and their requirements so necessary to maintain a course in perfect condition. In the past many failures indicate a lack of essential knowledge and prove beyond doubt the urgent need of a close study of grass.

It is astonishing how many people have the idea that all grasses are practically alike, without giving the matter much real thought. They have a sort of notion that grass grows on lawns or any place under adverse circumstances and with little or no nourishment and other cultural aid. It would be quite unnecessary to look upon putting greens as requiring special cultural treatment. Herein lies the secret of many failures in the past, for the first essential to success is a close acquaintance with the many varieties of grass, their natural characteristics, the conditions under which they thrive and the amount of hard wear they are capable of enduring. Then can we arrive at a clear understanding of the kinds that can be expected to thrive in a particular soil or situation and to blend mixtures that will suit all particular purposes. There are fine mixtures that will produce a smooth sward to make a good bowling or putting green that would be totally unfit for the purpose of football or cricket.

The Greenkeeper's Task

QUITE naturally a man who has kept a plot of grass neat and tidy on a private estate and has mowed and rolled, weeded, patched in season, may consider himself qualified for the task of maintaining a golf course, arguing that it is precisely the same kind of work on a larger scale with only the difference of larger implements and labor to get over the work. That experience in the proper care of lawns will be of service to one who aspires to greenkeeping is not to be denied, but it will prove seriously inadequate if he should shoulder at once the full responsibility of the upkeep of a golf course. The task being as distinct from ordinary lawn work as the cropping of a kitchen garden is from the entire management of a farm.

The putting green is, of course, of paramount importance and it is here that the finest work is required. The turf must be ideal, or at any rate it must be the aim of the greenkeeper to make it so; an intimate knowledge of weeds, insects, and fungold pest and vermin, and the surest and cheapest methods of getting rid of them will be essential. He must also have a wide knowledge of feeding grasses which of necessity differ considerably where so large and varied an area is concerned from the ordinary method of nourishing a small lawn.

The Nourishment of Grasses

THE management of grass demands knowledge, experience and forethought, as well as manual labor. Mowing and rolling are essential, while other matters of fully equal importance are frequently neglected or otherwise ignored. It should be borne in mind that every time a green is mown a great deal of grass growth is cut and removed, the production of which helps to exhaust nourishment from the soil.

No farmer expects to grow crops continuously for a succession of years without changing crops and manuring the land, and it becomes equally futile to expect to maintain a golf course in fine condition without periodically replenishing the store of plant food upon which the roots of grass may feed. We cannot manure turf as we do a corn or potato patch. The feeding of green and fairways must be accomplished by fine methods. Whatever nourishment is to be applied must be given in the form of a top-dressing, and it is therefore desirable that highly concentrated plant food should be used, thus reducing bulk to a minimum. Further they shall be quickly soluble that they may be readily washed down to the roots of the turf by rain or watering, leaving the surface clean and playable. Upon the character of the soil depends to a large degree the nature of manure it requires to improve its productive power.

It would be ridiculous to suppose that one may write an article or a book laying down definite instructions on the planning and construction of a golf course that will serve as a faithful guide under all circumstances and conditions: not one volume, but a series of books