Fertility and Fertilizers

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Less than ten years ago, many authorities recommended nitrogen in the form of sulphate of ammonia as the only fertilizer for use on golf courses. There have been many changes since that time in fertilizer recommendations by experts on turf culture.

In general agriculture, it has been recognized for years that many soils require other elements in addition to nitrogen to produce normal plant growth. Today we see no real reason why not so long ago it was assumed by some people that in some way grasses on golf courses had nutritional requirements different from other cultivated plants.

Why was sulphate of ammonia recommended to the exclusion of all other plant foods? The history of this movement, or may we say fad, is rather peculiar.

In 1917, the Rhode Island Agricultural Experiment station published in Bulletin 170, the results of a series of fertility experiments with several different varieties of grasses. Different fertilizer mixtures were used on plot tests which had been running for several years. Thus, it was found that a fertilizer mixture which tended to change the soil reaction to an alkaline condition increased both grass and weed growth.

A fertilizer which tends to change the soil reaction from an acid to an alkaline condition during the course of the growing season, is known to be "physiologically alkaline." In this particular case, the physiologically alkaline portion of the fertilizer consisted of nitrate of soda and basic slag. A potash salt was the third constituent of the mixture. The grass used in these tests made the best growth, but lime-loving weeds also grew well.

Another mixture used was composed of sulphate of ammonia, superphosphate, and muriate of potash. This fertilizer increased soil acidity and was "physiologically acid." In this particular case, grass made good growth, however, weeds did not grow as luxuriantly as was the case with the physiologically alkaline fertilizer.

In the experiments cited on plots receiving the nitrogen, phosphorus, potash, and calcium salts, the bulletin brought out the fact that with "complete" plant foods, physiologically acid reacting fertilizer was superior to physiologically alkaline fertilizer, only in regard to decrease in weed growth. From the standpoint of grass growth, however, the alkaline reacting fertilizer was best.

Unfortunately, the bulletin caused some people to draw wrong conclusions. On the basis of the experiments reported, sulphate of ammonia was recommended by a number of the authorities as the only element of plant food necessary to be applied to the soil. Somehow the importance of phosphorus and potash in plant nutrition was disregarded, perhaps unintentionally.

"Sulphate of Ammonia for Weedless Putting Greens, Fairways, and Lawns," became the slogan of interests selling this product. Writers and speakers used it as a subject for articles and talks. Although nitrogen in the form of sulphate of ammonia is a good source of this element as a plant food, it obviously cannot be used indefinitely to the exclusion of all other essential elements without disastrous results.

SOIL ACIDITY SOMETIMES LIMITS PLANT GROWTH

Sulphate of ammonia became popular because it made the soil acid. We know today that there is a certain range of soil acidity at which various grasses make optimum growth. Thus, Kentucky blue grass thrives at the neutral point and slightly on the acid side of this point, whereas, the bents and fescues do well at slightly higher soil acidity. Increase in soil acidity beyond certain limits, however, will have a decided detrimental effect on grass growth.

Where sulphate of ammonia alone has been applied for a number of years, a deficiency of potash and phosphorus limits grass growth, but the acidity produced in many cases may be the limiting factor.

If medium soil acidity is desirable, it does not follow that very strong acidity is better. Acidity must be controlled within reasonable limits otherwise increased acidity is not only detrimental to certain weeds, but to the grasses as well. As a matter of fact, beyond certain limits, increase in soil acidity

will make conditions favorable for growth of certain acid tolerant weeds because the grasses have given up the struggle.

Let us consider briefly some experiments that are classical in the history of agriculture. At the outset I will admit that the experiments to be cited were made under conditions which in many cases are not identical with those prevailing on the average golf course, nevertheless, the sum total of the effects fertilizers had on the soil and plant growth may be expected to be reproduced on many of our soils.

CLASSICAL GRASS PLOT TESTS OF THE ROTHAMSTED EXPERIMENT STATION, ENGLAND[1]

IN 1856, Sir John Lawes, a wealthy landowner, in conjunction with a young chemist, afterwards known as Sir Henry Gilbert, started some very important tests which are being continued today. A well established turf was subdivided into a number of plots. Each plot has received practically the same kind and amount of fertilizer ever since 1856. These grass plots today tell an interesting story as to what may be expected from various single and mixed fertilizer materials. The conclusions that may be drawn are useful information for greenkeepers, although the conditions of these experiments are not exactly those prevailing on golf courses.

Where sulphate of ammonia alone has been used, grasses have completely disappeared and only weeds are left. The surface of the soil has become extremely acid, and there is actually peat formation, three or four inches in thickness, on the surface. Very light annual applications of sulphate of ammonia have also caused very marked decrease in grass production. Weeds have crowded out desirable grasses.

Straight nitrate of soda applied year after year has gradually but definitely reduced the amount of grass cut annually. Weeds have crowded out most of the desirable grasses.

It seems needless to point out that the check plots which received no fertilizer of any kind are doing poorly. Plots receiving straight superphosphate at the rate of 350 pounds per acre are, after all these years, badly run down; however, they are much better than the check plots as should be expected.

A combination of 350 pounds of straight superphosphate plus 412 pounds of sulphate of ammonia per acre first gave increased yields. Gradually but very definitely, the yields decreased to such an extent that today the combination of two elements of plant food only gives no better results than straight sulphate of ammonia alone.

When, however, potash is mixed with the superphosphate and sulphate of ammonia, exceptionally high yields have been maintained until to date.

LIME AND SULPHATE WORK WELL TOGETHER

THE whole series of tests as outlined has been duplicated with the exception that in this series, lime has been supplied as an additional constituent. It is significant that where complete plant foods were used and sulphate of ammonia was the source of nitrogen, the addition of lime gave the highest results. This is very interesting, and yet, in the light of present-day knowledge, it is exactly what we should expect.

In conjunction with these tests, it should be mentioned that when fourteen tons of well-rotted manure per acre were applied, alternating with 600 pounds of fish meal, the results of these large applications of organic materials were by no means as good as those obtained with the purely inorganic forms of plant food. Here we have tests that have run sixty-six years. The time interval is long enough for anyone to draw some conclusions. A summary of these classical tests is as follows:

In order to obtain best results, a suitable combination of nitrogen, phosphorus, and potash must be present in adequate amounts. Each element is important. Not one of these three can be omitted without limiting grass growth.

Large quantities of sulphate of ammonia alone used over a number of years also makes the soil so acid that normal grass growth is no longer possible. The neutralizing action of lime on plots receiving sulphate of ammonia only does not make up for the lack of phosphorus and potash.

Complete inorganic plant foods have definitely proven superior to organic forms. Relatively high percentages of phosphorus and potash in complete fertilizer mixtures have encouraged clover and certain other broad-leafed plants, whereas, a relatively high nitrogen content in complete fertilizers favor the grasses principally.

In modern fertilizer mixtures, the substance re-

[1]Book of Rothamsted Experiments by A. D. Hall, Published John Murray, Albemarle Street, W., London. 150-189.
Guide to the Experimental Fields, Rothamsted Experimental Station, 7 and 10, 1929.

sponsible for noticeable changes in soil reaction are the nitrogen compounds. The phosphorus and potash compounds have little or no effect on changing soil acidity. Dr. W. H. Pierre of West Virginia Experiment Station recently published some interesting work in regard to the effect of nitrogenous fertilizers on soil acidity[2]. The author shows by actual experiments the effect of a group of nitrogenous fertilizers on soil acidity. He has demonstrated that the acidity produced for each 1% nitrogen per ton of fertilizer from several sources requires the following amounts of lime for neutralization:

1% N (97 pounds) from Sulphate of Ammonia —120 Carbonate of Lime.

1% N (200 pounds) from Ammonium Phosphate, Ammo-phos, etc.—104 Carbonate of Lime.

1% N (77 pounds) from Leuna Salpeter—92 Carbonate of Lime.

1% N (43 pounds) from Urea—60 Carbonate of Lime.

1% N (57 pounds) from Ammonium Nitrate —58 Carbonate of Lime.

Another group of nitrogenous fertilizer materials produced an alkaline reaction in the soil. Nitrate of soda, calcium nitrate, and cyanamid made a neutral soil alkaline when these substances were applied.

One application of the acid or alkaline reacting materials mentioned may not have any significant influence on grass growth. The same materials supplied over a number of years, however, may cause injury to plant growth.

HOW NITROGENOUS FERTILIZERS AFFECT SOIL ACIDITY

THE ease with which nitrogenous fertilizers may effect changes in soil acidity will also depend upon:

1. The degree of acidity or alkalinity of the soil in question. Thus, if we have two soils of the same soil type, one is slightly acid and the other one alkaline, it is obvious that the addition of equal quantities of acid-reacting fertilizers will change the slightly acid soil to a strongly acid condition more readily than the alkaline-reacting soil.

2. Soil types differ in their ability to resist change in acidity. Thus, W. H. Pierre found for example, that a Ruston sandy loam could be changed from a reaction which we may

[2]Industrial and Engineering Chemistry 23, 1440, (1931).

consider favorable to creeping bent and fescues to the degree of acidity very unfavorable by addition of only 340 pounds of sulphate of ammonia per acre. The other extreme, a Cecil clay loam required as much as 4,290 pounds of sulphate of ammonia before the same degree of acidity was produced.

Generally speaking, the light sandy soils undergo significant changes in acidity due to relatively small amounts of acid-reacting substances. On the other hand, the heavy soil types require much larger applications before noticeable changes in acidity take place. The fact remains, irrespective of whether light or heavy soils are used, acid-reacting fertilizers if applied continuously without the addition of a neutralizing agent, will eventually make the soils too acid for good grass growth.

CHICAGO SOILS RESIST INCREASE IN ACIDITY

Most of the soils in this locality and most of the top dressing materials and water used on greens will resist for years rapid increases in acidity due to acid-reacting fertilizers. Eventually, however, a condition will arise where good grass growth cannot be expected unless lime or some other neutralizing agent is added to the soil.

At the Pennsylvania Experiment Station[3] where experiments have been in progress for fifty years, an application of 144 pounds of sulphate of ammonia per acre began to show reduced crop yields after eight years. For the past forty-two years, the yields have been going down annually and today the yield is less than 30% of the original.

As far as change in soil acidity is concerned, it makes little difference whether sulphate of ammonia is applied singly or in conjunction with phosphate and potash. Instead of attempting to modify acidity of soils to such an extent that weeds cannot grow, the aim of a greenkeeper should be to make conditions as favorable for grasses as is possible.

Recent experiments conducted in a number of countries have demonstrated that the best fertilizer combination favoring grasses, growing in competition with other plants, is one which contains a high percentage of nitrogen in a complete fertilizer.

FERTILITY TESTS OF THE U. S. G. A. GREEN SECTION

Here we have a number of fertility tests which have been duplicated at fourteen demonstration gardens during the past three years. As should be expected, the two complete commercial fertilizers made the best showing for putting green grasses. In all the tests listed, the amount of fertilizer applied is based on equivalent amounts of nitrogen from each fertilizer material; thus, for each pound of 12-6-4 applied per 1000 square feet, twice as much, or two pounds of 6-12-4 was necessary. This is due to the fact that the 6-12-4 contains only one-half as much nitrogen in this formula as the 12-6-4.

The rate of application of other fertilizer materials is on the same basis; namely, an application of equivalent amounts of nitrogen. The results indicate clearly that complete fertilizers after only three years of experimentation, made by far, the best showing.

We do not have to be prophets to make a number of predictions in regard to what results may be expected as the years roll on. For instance, we can predict about the nitrate of soda plots that gradually but definitely yields will decrease, the turf will

[3]Noll, C. F., Gardner, F. D., and Irvin, C. J., Pennsylvania Agr. Expt. Sta., Bull. 264 (1931).

get poorer, and weeds will come in—just what we should expect. The soil will become depleted in phosphorus and potash and finally normal grass growth will be absolutely impossible.

The same may be said about straight sulphate of ammonia, except that in this particular case, the soil will become more and more acid until finally high soil acidity, in addition to phosphorus and potash deficiency, will become the limiting factor to plant growth. This applies to Urea which supplies nitrogen only.

Ammonium phosphate will probably hang on a little longer since it supplies nitrogen and phosphorus, two elements of plant food instead of only one; however, in due course of time, potash deficiency will become very noticeable and the ammonium phosphate will show poorer and poorer results.

Activated sludge, tankage, and other nitrogenous materials will probably run parallel to ammonium phosphate as far as results are concerned. In May and June, due to the slow decomposition and nitrification, we find that the complete inorganic plant foods are awarded a much higher rating than the organic forms.

WORMS LIKE ORGANIC FERTILIZERS

We will also find, as time goes on, that the plots receiving large quantities of organic substances will become heavily infested with worms. Beetles and other insects, whose larva will feed on the root system, will give preference to soils rich in organic matter, particularly, if this matter gives off a distinct odor.

Many of the soils on which fertility tests are now conducted are acid in reaction. Generally speaking, most of the soils east of the Mississippi react acid; therefore, the two complete plant foods used, 6-12-4 and 12-6-4, would gradually but definitely increase soil acidity because in these particular mixtures, sulphate of ammonia is the only source of nitrogen.

Let me state, in conclusion, that physiologically neutral fertilizers can be manufactured that will not cause a change in soil acidity. If, therefore, the composition of the two complete fertilizers used in the tests is not modified, there will come a time when an application of lime on the experimental plots receiving the complete plant foods will be highly desirable. From the standpoint of results the complete plant food will, in the long run, probably be the most satisfactory.

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