How Mercury, Lead Arsenate Control Nitrification

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A STUDY of the bulletins of the U. S. G. A. Green Section concerning recommendations for the development and maintenance of turf grasses brings out some interesting facts worthy of consideration. The purpose of this article therefore is to give my impressions of certain recommendations found in these bulletins. I trust that what I have written will not be taken as destructive criticism, but rather as helpful suggestions that may lead to a better understanding of the fundamental principles underlying the art of greenkeeping and fairway management.

After a study of the bulletins in preparation for the first Greenkeepers' conference at Penn State in 1929, I resolved to face the issues squarely even though my ideas may be entirely contrary to those previously presented. Therefore, I wish to review in general the recommendations given at our Penn State conference in 1929 and 1930. The exacting demands of the green committees concerning the development of a perfect turf, free from weeds, lead to recommendations entirely contrary to the fundamental principles of soil fertiilty and which have led to disaster in many instances, especially in our eastern states. Continuous and excessive use of sulphate of ammonia and the ban on lime and phosphorus have been the cause of many of our trials and tribulations. The evils of an extremely acid soil are too well known to the soil chemist to warrant its development as a means of weed control, for a soil too acid to grow weeds can not support a normal growth of turf grasses. The most logical means of weed control is through the development of a vigorous turf which leaves no room for weed invasion. The use of some form of phosphatic fertilizer and lime in moderation should under proper management attain this end. There is no logical reason to believe that golf grasses require fundamentally different treatment than is accorded those found in lawns and well kept pastures.

Maintaining Right Reaction

Grasses which are grown under very acid conditions and are abnormally stimulated in growth by too frequent applications of ammonium sulphate are more susceptible to fungus disease and other injuries than grasses grown under normal soil conditions where the plant has the opportunity to assimilate plant food in accordance with the fundamental principles of plant nutrition.

It is our recommendation in Pennsylvania that the soil reaction should be maintained approximately between pH 5.8 and 6.5 and that superphosphate should be applied each year and also that if necessary limestone should be applied at intervals to maintain the proper control of excessive soil acidity. The amounts of phosphorus, limestone and nitrogen to be applied naturally varies with soil conditions. An annual application of seven pounds of superphosphate per 1,000 sq. ft. should be sufficient under average conditions. If sulphate of ammonia is used as the source of nitrogen, limestone should be applied at the rate of 75 lbs. for each 100 lbs. of ammonium sulphate applied. In other words, an annual application of 11.5 lbs. of ammonium sulphate per 1,000 sq. ft. requires the use of 8.6 lbs. of limestone.

At the time of Penn State's conference it was pointed out that in many instances failure of turf grasses during the summer months was due to the toxic effect of soil acidity and not to the invasion of fungus diseases. This was proven by the fact that mercury compounds even after repeated applications failed to restore the turf to normal color and vigor. However, an application of lime restored the grasses to normal condition. The evils of soil acidity brought about by the excessive use of am-

monium sulphate were first noted on poorly drained greens where there occurred an accumulation of salts. Where it becomes necessary to use lime during the growing season it is recommended that limestone be used rather than hydrated lime since the latter has a tendency to cake and discolor the green while limestone particles, being heavier, work in between the grasses and entirely disappear from view.

Effects on Soil Nitrification

The statement that certain grasses have the ability to utilize nitrogen in the form of ammonia has not been entirely accepted in this country. In accordance with our modern conception of plant nutrition, most of our economic grasses depend upon soil nitrates as their source of nitrogen. The ability of certain grasses such as those of the *Agrostis* family, which includes the bents, to grow under very acid soil conditions is attributed to their ability to utilize ammonia instead of nitrates. The writer believes that the relative resistance to acidity of such grasses as those included in the *Agrostis* family is due primarily to the fact that they are strong feeders of calcium. That is, they have the ability to utilize small amounts of calcium in forms and amounts unavailable to other grasses such as the *Poa* family which includes Kentucky bluegrass. Under sod conditions such as found on greens, fairways, pastures and lawns there exists at all times during the growing season a scarcity of soil nitrates; in other words, nitrates become a limiting factor in plant growth. This is due to several causes:

(1) Under sod there exists keen competition between the grasses and the soil micro-organisms for the available nitrogen present. The soil micro-organisms use, as their source of food or energy, the old roots of the grasses, high in carbon. These soil organisms require nitrogen in a definite proportion to the carbon assimilated in order to balance the composition of their bodies which, like the higher plants, contain definite ratios of carbon to nitrogen.

(2) Under condition of sod, especially in case of greens frequently rolled, nitrification is reduced due to poor aeration; that is, the supply of oxygen in the soil atmosphere is insufficient to meet the demands of the nitrifying organisms.

(3) In case of extreme soil acidity, the activity of the nitrifying organisms is considerably reduced. The optimum reaction for soil nitrification is between pH 6.0 and 7.5.

(4) The presence of an excess of ammonium salts, brought about as the result of poor drainage where large amounts of ammonium sulphate have been applied, has been found to reduce nitrification.

There are many other soil factors which may control nitrification such as excess of water, low temperature and the presence of an excess of soluble organic matter and certain mineral salts. Of the heavier metals mercury and silver have the most pronounced effect in reducing the activity of nitrifying organisms. The effect of these metals is to precipitate the protoplasms or destroy the cell structure of soil micro-organisms.

Tests Mercury Compound Effect

In order to gain further information concerning the controlling influence of mercury compounds on the activity of nitrifying organisms, the writer applied to both an acid and neutral soil mercury compound commonly used for the control of brown-patch and other fungous diseases of turf grasses. The soil used was taken from the ammonium sulphate plot of the Pennsylvania field experiments which had received a total of 2,740 lbs. of ammonium sulphate distributed uniformly over a period of 47 years. This soil has a pH of 4.77. An equal portion of the same soil was treated with limestone in amounts sufficient to produce a neutral soil of pH 7.0.

The field plot soil in addition to ammonium sulphate had received liberal applications of superphosphate and muriate of potash during the period of the field experiment. In addition to the mercury compounds, lead arsenate used for the control of grubs was also included in the nitrification studies. One-half of each soil was treated with ammonium sulphate at the rate of 226 lbs. per acre or 5.2 lbs. per 1,000 sq. ft. of soil. The experiment was conducted for a period of two weeks. The table herewith shows the rate of application of mercury and arsenic compounds and the total nitric nitrogen produced in case of each treatment.

A study of the results shown in the above table brings out the fact that on the unlimed soil, parallel to the condition found on many greens and fairways of our eastern golf courses, mercury has consid-

Effect of Mercury Compounds and Arsenate of Lead on Soil Nitrification.
Results expressed as parts per million of nitric nitrogen produced in 14 days.

Materials used and rate per 1,000 sq. ft. of soil.	Unlimed Soil pH 4.77. No Amm. Sul.	Amm. Sul.	Limed Soil pH 7.02. No Amm. Sul.	Amm. Sul.	Totals— No Lime.	Limed.
Untreated soil	55	43	58	41	98	99
½ lb. bichloride of mercury	41	25	61	38	66	99
2 lbs. bichloride of mercury	44	26	61	41	70	102
½ lb. calomel	46	30	52	38	76	90
2 lbs. calomel	46	24	58	44	70	102
1 lb. semesan	55	34	56	37	89	93
3 lbs. semesan	45	28	60	38	73	98
11½ lbs. arsenate of lead	59	45	62	40	104	102
46 lbs. arsenate of lead	94	44	66	38	138	104

erably reduced the activity of the nitrifying organisms. Arsenate of lead, on the other hand, has stimulated the production of soil nitrates in case of each soil. The addition of lime, however, has eliminated the injurious effect of the mercury compounds as shown from the fact that on the unlimed soil the three mercury compounds reduced nitrification on an average of 25% compared to only 1.5% on the soil which had received limestone. The reduction of nitrification in case of each of the three mercury compounds used was as follows: bichloride 31%, calomel 26% and semesan 17%. Arsenate of lead increased nitrification on the unlimed soil 40% and on the limed soil 5%.

Shows Lime Need

In addition to the factors already mentioned which may reduce the supply of available nitrates in the soil, we now learn that mercury compounds used for the control of fungous diseases also produce an injurious effect on nitrifying organisms in acid soils. The addition of lime, however, has been shown to overcome this toxic effect. The results of this experiment are presented to you with no idea in mind of discouraging the use of compounds of mercury necessary to combat fungous diseases of turf grasses, but rather to call to your attention the fact that such materials may reduce the available nitrogen of the soil, especially in case of those soils which are in need of lime.

The slow recovery of grasses, often noted following repeated application of fungicides, may be due to the reduction in the supply of available nitrogen in the soil as the result of injury to nitrifying organisms.

In conclusion may I say that today we are facing a new era in the scientific management of greens and fairways. The greenkeepers are turning to their state agricultural experiment stations for advice gained as the result of many years of careful research. The soil chemist, the pathologist and the plant breeder are joining hands in an effort to aid those responsible for the development and maintenance of our American golf greens and fairways. The results of various turf grass experiments initiated by the United States Department of Agriculture are beginning to bear fruit. Art and science, theory and practice are going forward hand in hand and there should be no conflict between them.

Illinois Pros Entertain Club Officials at Meeting

FOR their first meeting of the year, the Illinois P. G. A. on April 20 put over a novel and valuable stunt by inviting club officials to sit with them for an evening and learn the many ways in which pros expect to serve their clubs better in 1931 than ever before.

Among the speakers were Jim Wilson, pro at Ravisloe and president of the local body, who told of the association's aims for the year; Albert R. Gates, administrator of the national P. G. A., who gave the latest news of that organization; George Laadt, chairman of the Chicago Junior Association of Commerce tournament committee, who described the J. A. C.'s progress toward sponsoring a Chicago $10,000 open tournament this summer; and Bob Harlow, manager of the P. G. A. tournament bureau, who gave a resume of the winter circuit.

As an additional feature, the slow motion reels of Jones, Vardon and Joyce Wethered were presented.

The meeting was the first of its type ever attempted by the Illinois P. G. A. and the results indicate more to come.