ordinary conditions to keep the turf in good condition for seven days.

The fact that you have installed a water or irrigation system does not mean that the turf should be drenched continually, giving the player the most unfair lies—in not on a soggy turf. Do not over-water. Give the turf the amount of moisture it requires, never an excess. Water-logging, through excess moisture is surely in store for those who practice excessive watering. This condition is not so easily remedied either.

On the other hand, we have the other extreme; the man who persists in sprinkling, that is, moistening the soil to a depth of about ¼-inch. This method, naturally, of course, brings the feeding roots close to the surface in search of the moisture, where the hot sun just naturally burns those fine roots up. Every successive sprinkling is naturally more and more sapping the life of the plant. Turf treated in this way does not respond quickly to treatment for recovery.

DRAINAGE IS MOST IMPORTANT

For those contemplating irrigation systems, their first thought should be adequate drainage; without it, irrigation will be a failure, unless you have a sandy sub-soil. There must be an outlet for the excess water or a soggy water-logged condition will be the result. It is necessary that the soil be porous to allow air and moisture to penetrate.

Soggy conditions are aggravated through the necessary mowing of the fairways. The continual rolling with even the lightest mowing equipment, eventually gives you a sealed top soil, excluding all air, thus resulting in unhealthy turf.

The next factor is an adequate water supply. The mains must be large enough to maintain equal pressure at all points of the system. Up-to-date hose systems including the water supply and pumping plant will cost between $20,000 and $60,000 to install, depending on local conditions. The lower-priced systems, of course, are those where conditions have made it possible to reduce the cost through natural water supply, or, where booster pumps are used instead of elevated or underground tanks, and where installation of the piping is on or near the surface of the ground.

The higher-priced systems are where the piping is laid below the frost line, necessitating the

opening and filling of ditches; the erection of an elevated tank or the burying of pressure tanks; the construction of reservoir; or building of lakes; the drilling of deep wells; installation of pumping equipment and erection of pump houses.

My idea of a well-built and installed hose system, would be a 6-inch loop main of cast-iron pipe with caulked joints; four-inch laterals, also of cast-iron; leads to greens, tees and fairway outlets of 2-inch galvanized pipe. These sizes will assure an equal pressure at all points. The piping should be placed below the frost line. An elevated tank should be at least 130 feet high and of not less than 100,000 gallons capacity, preferably 200,000. If water supply is direct from wells, pumps of not less than 500 gallons a minute capacity should be installed; the water to be pumped into a lake, with a capacity of 4,000,000 gallons.

AMOUNT OF WATER USED PER DAY

THE amount of water used per day on an 18-hole course is between 25,000 and 500,000 gallons—for the average season between 2,250,000 and 45,000,000 gallons. It is obvious then that an adequate water supply is necessary. Intelligent operation of the hose system is just as necessary as the system itself.

The third and last method of irrigation is the hoseless or pop-up system. They are practically new in the East and Middle West, but, have been in successful operation on the California courses for several years. If Joe Mayo was here, he would tell you the hoseless system solved the irrigation problems on the coast. I will venture to say they will very soon solve our irrigation problems here.

Everything is in favor of the adoption of the hoseless system here. They have now been developed to a high point of efficiency; the experimental period is over; in fact the installation cost is now about the same as for a hose system.

The points in favor of a hoseless system are: The saving on hose and sprinkler purchasing; the saving on labor, and uniform coverage of the entire course, while with the hose system, much over-lapping is bound to result during the night.

POP UP IS ONE-MAN SYSTEM

The pop-up system is a one-man system. One valve controls one or more fairways, depending on the volume of water available. This means the system would not be in daily use during dry periods.

It will be so much easier to regulate the amount of water the turf requires, especially for green sprinkling. Think what that means in a more thorough control of the moisture supply during humid brown patch weather; also during the dormant or resting season of the turf.

The cost of changing an up-to-date hose system to a hoseless would not, I will venture to say, be more than the cost of a five-year hose supply and labor cost. I am for this system because it will reduce costs and maintain high standards of maintenance, and would advise those contemplating new irrigation systems to go into the hoseless systems thoroughly, and be sure when you have chosen, that is the one best adapted to your requirements.

Look well—before you decide.

One more important matter in this irrigation system problem comes to my mind. I say *important,* advisedly—this is the matter of a ground plan —a plan of the entire irrigation system, showing valves, shut-offs, drains, etc. *This plan to be framed and hung in the pump-house in plain view.*

Carolina Greenkeepers Organize

WILLIAM C. FARBER
President

Two-day meeting of those interested in turf culture brings about birth of a new organization. A large and enthusiastic attendance assures success.

WALTER J. CARTIER
Secretary-Treasurer

THROUGH the efforts of Walter J. Cartier, superintendent of the Charlotte Park and Recreation Commission, a two-day meeting of Carolina greenkeepers and others interested in golf course maintenance was held at the Charlotte Country Club the latter part of February. The result was the organization of the Carolina Greens Association and the election of the following officers: President, William C. Farber, Forest Lake Club, Columbia, S. C.; First Vice-President Frank Maples, greenkeeper, Pinehurst C. C.; Second Vice-President, R. V. Stout, manager, Hamilton Lake Golf Club, Greensboro, N. C.; Secretary-Treasurer, Walter J. Cartier, Charlotte, N. C.; Corresponding Secretary, Ramsey Dulin, executive secretary, Myers Park Club, Charlotte, N. C.

An interesting program was carried out including visits to golf courses and round table discussions with speakers of national reputation. Perhaps the most outstanding highlights in the program were the discussion periods led by Donald Ross, nationally known golf course architect; E. S. Draper, golf course architect and landscape engineer of Charlotte, and O. J. Noer, of the Milwaukee Sewerage Commission.

It is stated that the association will determine to keep very careful records of seeding, types of fertilizers and results gained, as well as feeding and its results. Many of the greenkeepers intend to establish test plots for the growing of various kinds of seed under different treatment and to make definite reports to the association at regular intervals.

GROUP OF GREENKEEPERS AND TURF CULTURE EXPERTS AT THE CHARLOTTE, N. C. COUNTRY CLUB

This is the first organization of its kind ever attempted in the middle south, and is bound to be of great assistance to the golf and country clubs of that section. The next meeting will be held at the Starmount Golf Club, Greensboro.

List of Delegates Attending the Greens Association Meeting at Charlotte, N. C.

W. P. Kistler, greenkeeper, Charlotte C. C., Charlotte, N. C.
J. A. Simmons, foreman, Charlotte C. C., Charlotte, N. C.
J. P. Traynhan, greenkeeper, Greenville C. C., Greenville, S. C.
Dan Carroll, Charlotte C. C., Charlotte, N. C.
Ralph H. Hall, engineer, Charlotte Park and Recreation Commission, Charlotte, N. C.
C. W. Zaun, Toro Mfg. Co., Jacksonville, Florida
Joe Crayton, Charlotte, N. C.
Elton W. Sault, greenkeeper, Charlotte Park and Recreation Commission
J. L. McClintock, manager, McClintock Corporation, Charlotte, N. C.
W. A. Scoggin, greenkeeper, Guildfort College, Greensboro, N. C.
T. H. Antrim, greenkeeper, Sedgefield C. C., Greensboro, N. C.
M. R. McLaren, Toro Mfg. Company, Minneapolis, Minnesota.
O. J. Noer, Milwaukee Sewerage Commission, Milwaukee, Wisconsin.
C. C. Boshamer, manager, Statesville Golf Course, Statesville, N. C.
William C. Farber, Forest Lake Club, Columbia, S. C.
C. K. Hutchison, manager, Mammoth Oaks, Charlotte, N. C.
Bill Gobel, professional, Municipal Golf Club, Charlotte, N. C.
Wm. Crichton, professional, Lenoir, N. C.
Herman Atkins, professional, Sedgefield C. C., Greensboro, N. C.
Dugan Aycock, professional, Green Valley Golf Club, Greensboro, N. C.
Clarence Callaway, professional, Columbia, S. C.
James B. Orgehart, president, Forest Lake Club, Columbia, S. C.
P. D. Smith, Spartanburg, S. C.
Louis Mayes, Charlotte, N. C.
T. D. Camp, greenkeeper, Charlotte, N. C.
I. J. Tuttle, representative, Dixie Culvert & Metal Co., Atlanta, Ga.
Marshall Crichton, professional.
B. W. Clark, Durham, N. C.
J. W. DeArmon, Statesville, N. C.
D. G. Adams, city engineer, Spartanburg, S. C.
R. V. Stout, manager, Hamilton Lakes Golf Club, Greensboro, N. C.
T. B. Leftwich, manager, Green Valley Golf Club, Greensboro, N. C.
Ellis Maples, greenkeeper, Southern Pines.
Frank Maples, greenkeeper, Pinehurst, N. C.
Donald Ross, golf architect, Pinehurst, N. C.
F. D. Hobart, superintendent of grounds, Davidson College, Davidson, N. C.
E. S. Draper, golf architect, Charlotte, N. C.
Reese A. Coltrane, assistant greenkeeper, Guildford College, Greensboro, N. C.
Walter J. Cartier, superintendent, Charlotte Park and Recreation Commission, Charlotte, N. C.
Raymond W. Wrenn, greenkeeper, Greensboro, N. C.
F. H. McCain, greenkeeper, High Point, N. C.
Earl Clark, greenkeeper, Reidsville, N. C.
Ben Robertson, greenkeeper, Reidsville, N. C.
Joe P. Sexton, greenkeeper, Duncan Park, Spartanburg, S. C.
J. B. Caskey, Spartanburg, S. C.
R. A. Wilhelm, golf architect, Charlotte, N. C.
L. H. Moss, representative, Swift & Co., Greensboro, N. C.
Dr. J. F. Fonder, scientific research department, Swift & Co., Chicago, Ill.
Arthur Ham, professional, Charlotte Country Club, Charlotte, N. C.
Ramsey Dulin, executive secretary, Myers Park Club, Charlotte, N. C.
W. F. Bailey, Highpoint, N. C.
Fred Newnhan, professional, Greensboro, N. C.

Effect of Mercury Compounds and Arsenate of Lead on Soil Nitrification

By J. W. WHITE, *Professor of Soils*

Pennsylvania Agricultural Experiment Station

Read at the 5th Annual Educational Conference of the National Association of Greenkeepers of America, held at Columbus, O., February 3-6.

A STUDY of the bulletins of the United States Golf Association Green Section concerning recommendations for the development and maintenance of turf grasses brings out some interesting facts worthy of consideration at this time. The purpose of my paper, therefore, is to give you my impressions of certain recommendations found in those bulletins in addition to a discussion of the topic assigned to me. I trust that what I may say 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 our 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. With your permission, therefor, I wish to review in general the recommendations given at our Penn State Conferences in 1929 and 1930.

PROFESSOR J. W. WHITE
Penn State College

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 fertility and these have led to disaster in many instances, especially in our Eastern states. The continuous and excessive use of sulphate of ammonia and the ban on lime and phosphorus have been the cause of most of your 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 cannot support a normal growth of turf grasses.

CONTROL WEEDS THROUGH VIGOROUS TURF

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. Grasses grown under very acid conditions and abnormally stimulated in growth by too frequent applications of ammonium sulphate are more susceptible to fungus disease and other injuries than is true of grasses grown under normal conditions. By that I mean soil conditions where the plant has the opportunity to assimulate 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 vary with soil conditions. An annual application of seven pounds of superphosphate per 1,000 square feet 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 pounds for each 100 pounds of ammonium sulphate applied. In other words, an annual application of 11.5 pounds of ammonium sulphate per 1,000 square feet requires the use of 8.6 pounds of limestone.

TOXIC SOIL CAUSES GRASS FAILURE

At the time of the Penn State Conference it was pointed out that in many instances the 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 ammonium 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 should work in between the grasses and entirely disappear from view.

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 speaker 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 blue grass.

SCARCITY OF SOIL NITRATES LIMITS GROWTH

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 soil microorganisms for the available nitrogen present. The soil microorganisms use as their source of food or energy the old roots of the grasses which are high in carbon. These soil organisms require nitrogen in a definite propor-

tion to the carbon assimulated 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 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 microorganisms.

TREATMENT OF SOILS WITH MERCURY COMPOUNDS

IN order to gain further information concerning the controlling influence of mercury compounds on the activity of nitrifying organisms, the speaker applied to both an acid and neutral soil, mercury compounds commonly used for the control of brown patch and other fungus 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 2740 pounds of ammonium sulphate distributed uniformly over a period of 47 years. The 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 sulphat 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 pounds per acre or 5.2

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	Unlimited Soil pH 4.77		Unlimed Soil pH 7.02		Totals	
	No Amm. Sul.	Amm. Sul.	No Amm. Sul.	Amm. Sul.	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	4	66	38	139	104

pounds per 1,000 square feet of soil. The experiment was conducted for a period of two weeks. The accompanying summary 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 accompanying 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 considerably reduced the activity of the nitrifying organisms. Arsenate of lead, on the other hand,

has stimulated the production of soil nitrates in the cases 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 per cent compared to only 1.5 per cent 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 per cent, calomel 26 per cent, and Semesan 17 per cent. Arsenate of lead increased nitrification on the unlimed soil 40 per cent and on the limed soil 5 per cent.

CONTROL OF FUNGUS DISEASES MUST BE CAREFULLY HANDLED

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 fungus 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 fungus 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.