Dr. Oakley Returns to Washington

Friends of the Green Section will be glad to learn that Dr. R. A. Oakley, who has been absent from Washington for some months due to ill health, has recently returned to resume his duties with the Department of Agriculture. As most of our readers know, Dr. Oakley became interested in turf problems many years ago and with the late Dr. C. V. Piper, was largely responsible for the formation of the Green Section. At present he is chairman of its Research Committee.

Some Effects of Lime and Fertilizers on Turf Diseases*

By John Monteith, Jr.

The influence of many of the common fertilizers in preventing or inducing some of the common disorders of turf is a subject which has provoked much argument in recent years, but there has been unfortunately very little substantial experimental evidence to support the numerous conflicting opinions. Many men who have been observing fine turf for years are convinced that the widespread damage by brown-patch and other maladies of turf dates back to the beginning of the exclusive use of certain commercial fertilizers. There are many other equally reliable observers who hold that with the advent of commercial fertilizers on golf courses there were also evolutions in machinery, watering, and other maintenance practices which might as logically, or more logically, be blamed for the greater prevalence of brown-patch today than in years gone by. When one considers impartially the vast amount of evidence obtained from the experiences of numerous clubs he is forced to at least one conclusion, namely, that fertilizers must play some part in the presence or severity of turf diseases. In the Bulletin for June, 1926, it is pointed out that "brown-patch may be affected by the kind and amount of certain fertilizers used on greens." However, the evidence available from golf courses has been only general in nature, and could not be interpreted with any degree of assurance because, like most of the tests made on golf courses, the comparisons had to be made between two different greens, or even between one course with one set of conditions as against another course with entirely opposite conditions, and not solely between different fertilizers. At the Arlington turf garden it is possible to observe diseases on turf where soil and other environmental conditions are uniform and where in the separate plots the only variation is that of fertilizers. These observations over a period of years begin to throw some light on the influence of fertilizers on some turf diseases.

For many years the fertilizer question that has been uppermost in the minds of men interested in golf course turf has been that involving the use of fertilizers having a residual acid reaction. Lime was one of the first chemicals generally used on putting greens and its use in time became so excessive as to become decidedly harmful to the turf. It was later found that the finer turf grasses, such as the bents and fescues, thrived in soils having an acid reaction and that certain weeds were less aggressive in acid soils. Sulphate of ammonia proved to be the most promising of the nitrogen-containing ferti-

* In this article is presented the material contained in an address delivered at the annual meeting of the Green Section in New York City January 4, 1929.

lizers, for in addition to its high percentage of nitrogen supplied at low cost it had the advantage of rendering the soil increasingly more acid. Then followed the period of endeavoring to make soils acid by the continued and exclusive use of sulphate of ammonia as a putting green fertilizer. Unquestionably excellent results were obtained on a vast number of courses. At the same time other problems, often more serious than the weed problem, were developing, and the scourge of brown-patch became one of the greatest sources of annoyance to the greenkeeper. For several years there has been full justification for a sincere and constructive difference of opinion as to whether the pendulum of popular usage has not swung too far from

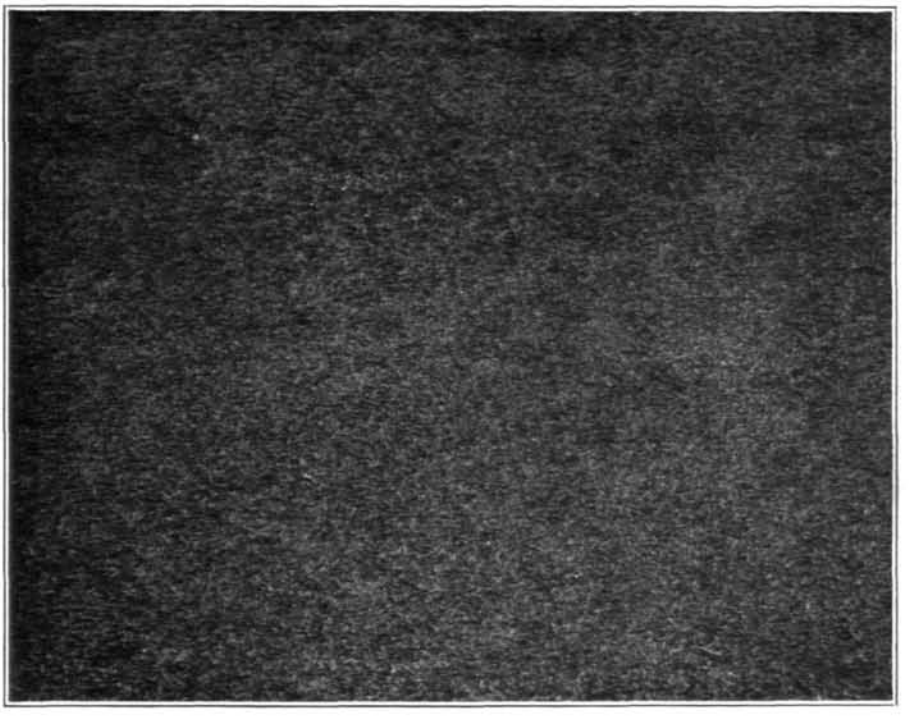

Fig. 1.—Cottonseed meal plot in the fertilizer series on Metropolitan creeping bent. In the interval between the planting of the plot in September, 1924, and the date this photograph was taken, June 11, 1926, this plot had received six applications of cottonseed meal. No compost or other fertilizers had been used since planting. When the photograph was taken this plot did not have a single spot of brown-patch, in striking contrast with the plot in the same series only eight feet away as shown in Fig. 2.

lime to acid-reacting fertilizers, and whether the time has not arrived for a swinging back to some mediate point where both lime and such fertilizers might be used in their proper places to produce a properly balanced soil most favorable to healthy turf production.

When any living thing is weakened by unfavorable conditions in its environment it becomes more readily a victim to certain types of disorders. Persons who have been watching critically the attacks of brown-patch on turf have been aware for many years of a complex interrelationship of soil and climatic conditions which influences the presence and severity of brown-patch. Correlation of large brown-patch with relatively high temperature and humidity has been recognized for many years. Likewise many other influences have been observed to affect the health of turf; but the very existence of these numerous varying conditions has served to confuse the problem. It is apparent that with any complex problem there are bound to be numerous contradictions if one tries to solve it by considering a single factor only. It is the frequency of these apparent contradictions that makes difficult the determination of the actual influence of the many separate soil and climatic conditions that play important parts in plant life. Final conclusions are justified only after repeated observations under circumstances where all factors other than the one being studied are made as nearly alike as it is possible to obtain them.

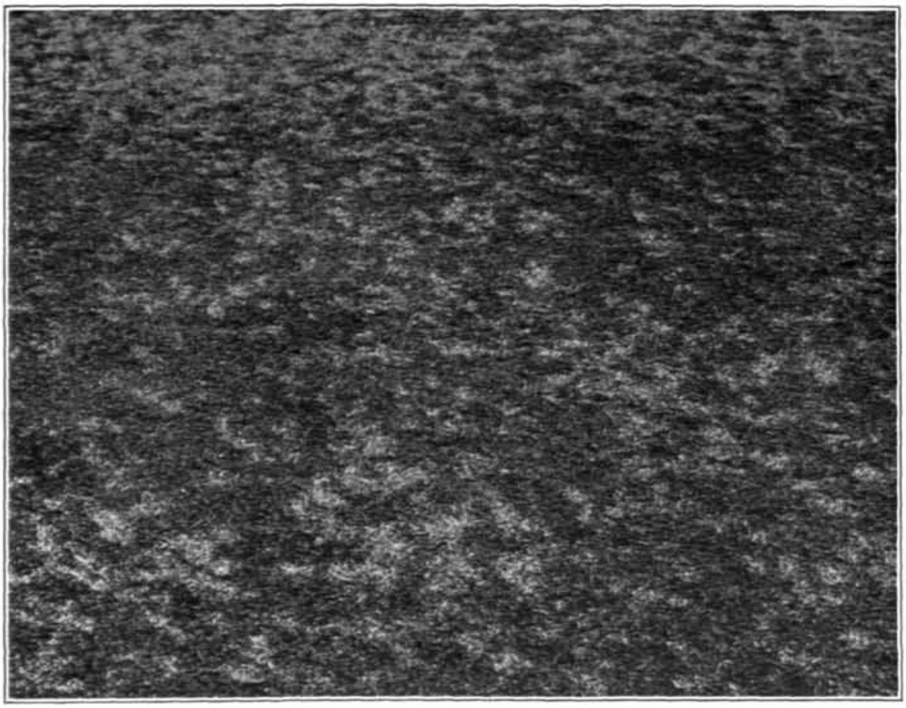

Fig. 2.—Compost and sulphate of ammonia plot in the fertilizer series on Metropolitan creeping bent. This plot was planted at the same time as the nearby cottonseed meal plot shown in Fig. 1, and from the time of planting until the date the photograph was taken, June 11, 1926, received the same amount of nitrogen as the cottonseed meal plot, but in six applications of compost and sulphate of ammonia. No other fertilizers were used. As will be seen from the illustration, this plot was severely damaged by small brown-patch at the time the photograph was taken. The cottonseed meal plot, on the other hand, was disease-free at the same time.

Fertilizers Affecting Brown-Patch

On the Arlington turf garden brown-patch has been observed to occur repeatedly, often causing serious damage, on certain fertilizer plots before any injury whatever has been found on nearby plots which had received different fertilizers. An example of this is illustrated in figures 1 and 2, which show two nearby plots as they appeared in June, 1926. Both of these plots were planted in September, 1924, and fertilizers were first applied in May, 1925. Only cottonseed meal was used on one plot, whereas the other received an equivalent amount of nitrogen in the form of compost and sulphate of ammonia. At the time the photographs were taken the entire 64 square feet of turf in the plot receiving the compost with sulphate of ammonia was thickly spotted with small brown-patch. The nearby plot which had received cottonseed meal did not have a single dis-

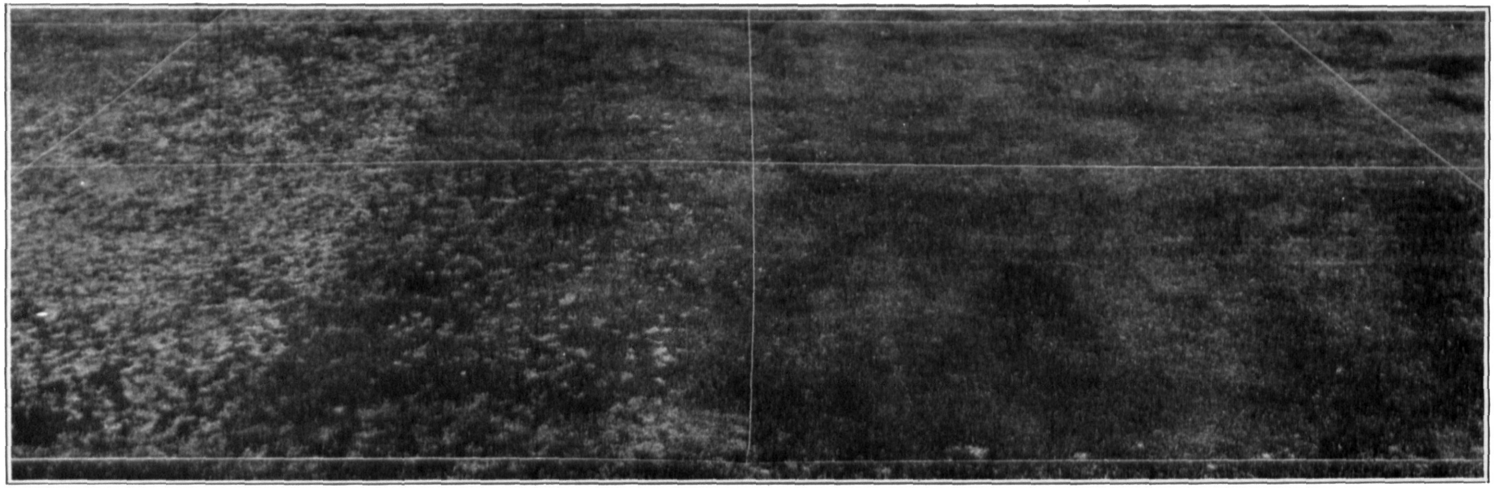

Fig. 3.—**Four plots** *of Washington creeping bent, showing the influence of fertilizers on the severity of small brown-patch.*

All this turf, planted on uniform soil, had been fertilized in monthly applications from the date of planting, September, 1924, until June 8, 1928, the date on which the photograph was taken. The plots are outlined with white cord.

The plot in the right background received only phosphate of ammonia and urea. That in the right foreground was given a mixture of nitrate of potash, phosphate of ammonia, and urea. The one in the left background received compost alone. The plot in the left foreground received applications of sulphate of ammonia with compost.

Half of each plot was protected from brown-patch by periodic applications of corrosive sublimate and calomel (see text) during the summers of 1926 and 1927, but none had been applied in 1928 previous to the time this photograph was taken.

The right half of each of the two plots on the left shows the effect of the preceding season's fungicides in reducing the amount of brown-patch. However, the almost total absence of disease in the two plots at the right, even in the halves where fungicides had never been used, indicates the importance of modification of the fertilizing practice on greens for the production of sturdier grass which will require less fungicide.

Compare with **Fig.** 4.

eased spot. Later in the season, however, the cottonseed meal plot became affected with this disease, showing that the use of this fertilizer alone would not solve entirely the problem of small brown-patch. The striking differences in the severity of this early-season attack on these, as well as on many other plots in the same series, clearly indicated that fertilizers had some important influence on this particular disease and that by learning more about the nature of such influences it might be possible to eliminate many of the lighter attacks of the disease and perhaps greatly reduce the severity of all attacks.

During the summer of 1928 many striking instances of the influence of soil conditions were observed at Arlington. The early attacks of small brown-patch during May in the fertilizer series were concentrated chiefly on a few plots. An example of this is shown in figure 3, which shows four of the fertilizer plots which had received since their planting compost alone, compost with sulphate of ammonia, phosphate of ammonia with urea, and phosphate of ammonia with nitrate of potash and urea, respectively. A comparison of these plots will show that severe damage occurred in both the compost plot and the plot receiving compost with sulphate of ammonia. The other two plots were practically free from brown-patch throughout this early attack and for some time after the photograph was taken on June 8. Another point of interest in this illustration is the contrast in amount of disease in one-half of each of the two plots at the left. It will be noted that the left half of each of these two plots is badly spotted with disease, whereas the spots in the right half of each are not as numerous nor as large. For the past three summers it has been the custom to treat half of each of the fertilizer plots with corrosive sublimate and calomel whenever brown-patch threatened. The same half of each plot is always treated. Thus each fertilizer is tested for its effect on turf with and without the control of diseases with mercury fungicides. The first application of corrosive sublimate and calomel in 1928 was not made until after this photograph was taken. The left half of each of the two left plots has never been treated with any chemical containing mercury. The right halves of these two left plots show the effect of corrosive sublimate and calomel used against brown-patch during the 1927 season. This further substantiates earlier observations, that any residue of mercury in the soil is of benefit to turf rather than harmful, the reverse of what was found to be the case with copper residues when Bordeaux mixture was used against large brown-patch.

The plot in the left foreground of figure 3 received the same treatment as that illustrated in figure 2. The cottonseed meal plot illustrated in figure 1 was again free from disease at the time of taking the photograph used in figure 3. A casual review of these three figures might lead one to conclude that they served to support the old theory that compost was the source of brown-patch evil, for certainly the two plots that had received compost might well be used as evidence to sway any jury to a hasty conviction of compost as the culprit responsible for brown-patch. However, figure 4 shows a plot in the same series photographed the same day. On this plot no compost had been used from the time of planting in 1924. Sulphate of ammonia had been applied in solution at the same rate and at the same time as on the plot shown in figure 2 and the plot at the lower left of figure 3. In the case of this plot in figure 4, no fertilizer or other material whatever was used other than the allotted sulphate of ammonia and the customary amount of corrosive sublimate and calomel, previous to 1928, for brown-patch control on the half shown in the upper part of the square.

To further check on some of these observations, a series of plots of velvet bent was treated with different rates of cottonseed meal and sulphate of ammonia. The turf treated with excessive amounts of sulphate of ammonia soon became badly spotted with small brown-patch, whereas that treated with cottonseed meal at a rate having the nitrogen equivalent of the sulphate of ammonia escaped infection.

A somewhat similar influence of fertilizers has been repeatedly observed on large brown-patch, although the observations in this

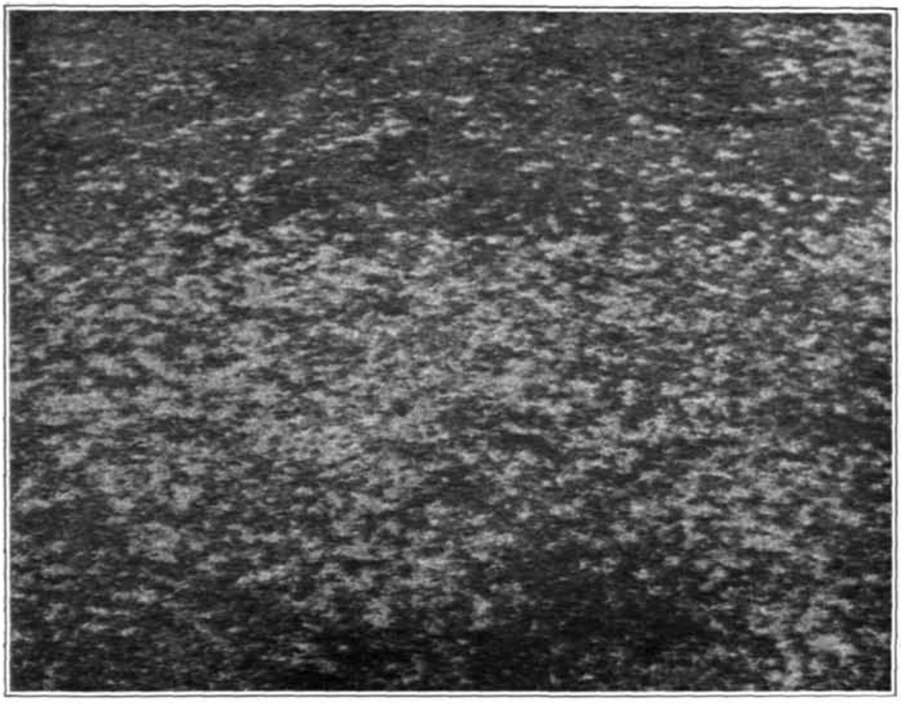

Fig. 4.—This plot of Washington creeping bent, from the time of planting in the fall of 1924, had received no compost and no fertilizer other than monthly applications of sulphate of ammonia. The severe spotting by small brown-patch indicates the danger in the exclusive use of this fertilizer. Compare with other plots in the same series, shown in Fig. 3, which were photographed the same day as this plot of Washington bent.

case have not proved as consistent as those on small brown-patch. In the case of the large patch, in these variations there may not be so much difference in prevalence as in severity of attack. In other words, in a comparison of two distinct treatments, it may be found that the same total area is diseased in each case, but in one the injury is relatively insignificant whereas in the other most of the turf may be killed or at least badly scarred. A soft, lush growth of turf is invariably more severely damaged by large brown-patch than is the more hardy, dark green, vigorous grass which is the product of an ideal environment. Fertilizers which quickly release large quantities of nitrogen for use by the grass are undoubtedly highly beneficial at times, but if large quantities of nitrogen are released a few days before a period of "large brown-patch weather" there is apt to be an overproduction of that soft growth most likely to be damaged by this disease. Observations of several years have indicated that the excessive and exclusive use of any one fertilizer rich in nitrogen is apt to increase the damage caused by large brown-patch.

Effect of Lime on Brown-Patch

Numerous observations on the fertilizer plots at the Arlington turf garden and on golf courses have indicated that a deficiency of lime might in some way account for some of the lack of vigor of turf and the great damage from brown-patch. A few preliminary

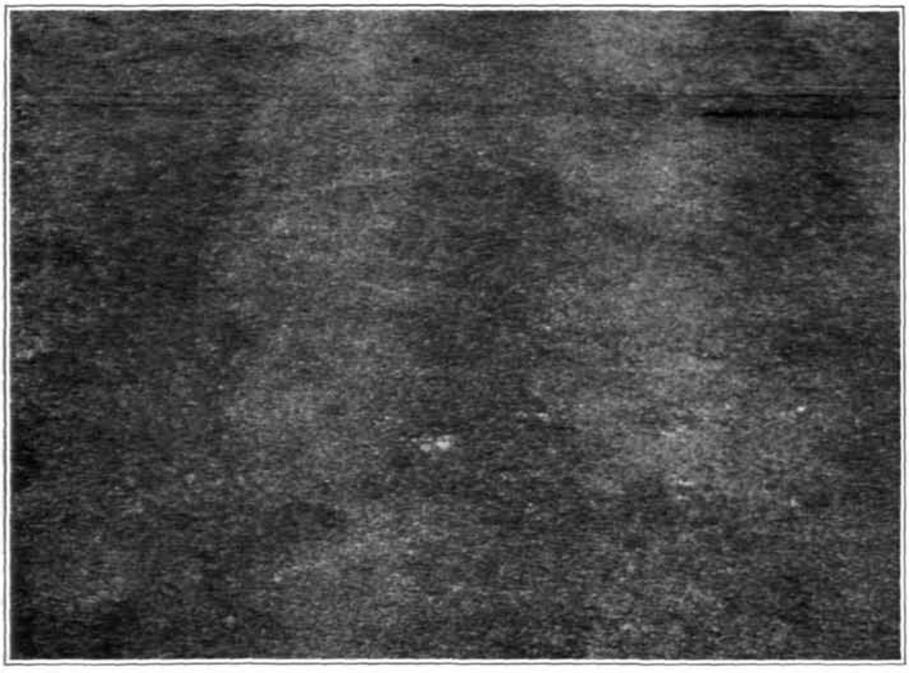

Fig. 5.—Th's plot of Metropolitan creeping bent was given an application of lime at the rate of 1 ton to the acre on July 10, 1928, when small brown-patch was scattered over the entire area of the plot. The photograph was made three weeks later, and shows the recovery due to the application of lime. No fungicides were used on this plot in 1928. Compare with Fig. 6, which shows the plot adjoining on the left.

trials with lime during 1926 and 1927, in conjunction with other investigations reported elsewhere in this discussion, indicated that lime in certain cases might reduce the brown-patch losses. As a result of these previous observations a number of tests were planned for the season of 1928. Figures 5 and 6 show examples of the results obtained. During the seasons of 1926 and 1927 the turf in these plots had been uniformly treated with regular monthly top-dressings of compost and sulphate of ammonia and had been protected against brown-patch by periodic treatments with corrosive sublimate and calomel. The applications of mercury fungicides were discontinued in 1928, and in June of that year small brown-patch became generally distributed over the two plots. The turf between the diseased patches did not have a healthy color and failed to show the usual response to fertilizers. On July 10 hydrated lime at the rate of one ton to the acre was applied to one of these plots. The other was left untreated for comparison with the limed plot and thereafter both were fertilized and otherwise cared for alike. The limed turf in a few days turned a dark green, healthy color, and the scars of brown-patch were soon obliterated by the new turf. The adjoining unlimed plot still had the yellowish green color of unthrifty turf, and small brown-patch continued to be very much in evidence. As shown in these figures, when the plots were photographed on July 30, there was a most striking difference in the two plots in favor of the lime treatment. The limed grass continued to grow much more vigorously than that in the unlimed plot throughout the remainder of the summer.

In another series of tests, on several plots of German mixed bent, one plot was treated with lime and then divided into four squares

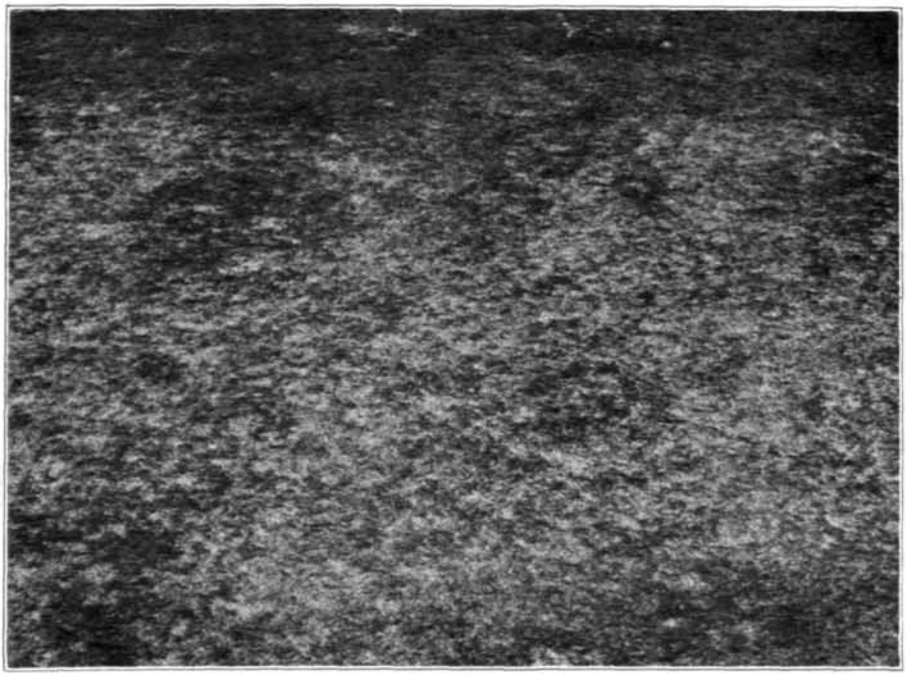

Fig. 6.—Plot of Metropolitan creeping bent which previous to July 10, 1928, had received the identical treatment as the plot shown in Fig. 5. When the latter plot was limed July 10, 1928, the plot in the accompanying illustration was left as a check, being treated with neither lime nor any other chemical. The small brown-patch scars in this plot did not heal, whereas almost all trace of the disease had disappeared from the adjoining limed plot shown in Fig. 5 at the time the two plots were photographed, July 30, 1928.

which were given different rates of sulphate of ammonia. One of these squares was left as a check without any sulphate; the second received an application of sulphate at the rate of 2½ pounds to 1,000 square feet a month; the third received this same application every two weeks; and the fourth was given the same application every week, which amounted to the very heavy rate of 10 pounds within four weeks. The adjoining plot received no lime, but was likewise divided into four parts and treated with similar amounts of sulphate of ammonia. When large brown-patch first became active on this series of several plots it occurred on all with the exception of the one receiving lime. The plots receiving lime and sulphate of ammonia are shown in figure 7 and the adjoining plot receiving sulphate of ammonia alone is shown in figure 8. The other plots in the series which received different combinations of fertilizers were affected with disease in much the same manner as the one shown in figure 8. Later in the season large brown-patch appeared in the limed plot shown in figure 7 but the injury was slight and recovery rapid.

Figure 7 also shows another interesting point brought out in this series. The upper left corner appears darker, due to the more vigorous growth of turf in this quarter where heavy applications of sulphate of ammonia had been used. On the other plots in this series where lime had not been used, sulphate of ammonia, even though mixed with fertilizers which contained phosphorous and potash, failed to give the grass the characteristic color of well fertilized turf. Whether this difference was due merely to a change in acidity of the soil, to a release of other plant foods, or correction of some toxic condition, is not known. From the practical standpoint it makes no

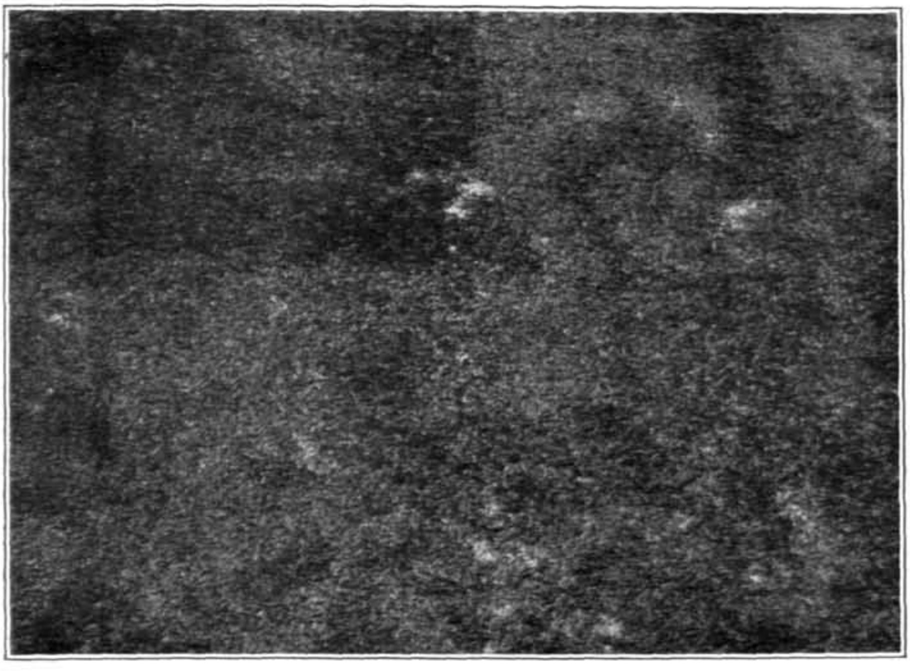

Fig. 7.—Limed plot of German mixed bent. There was no trace of large brown-patch in this plot when the photograph was taken, July 30, 1928. In addition to receiving the application of lime, this plot, like the adjoining plot shown in Fig. 8, had been divided into quarters, which were treated with sulphate of ammonia at different rates. The heaviest rate in this case was used on the quarter in the upper left, resulting in the darker color of its more vigorous growth. All the grass in this plot was more vigorous than the grass in any part of the plot shown in Fig. 8. The scattered light spots in this illustration show the scars where weeds had been removed shortly before the plot was photographed, for like the bent the weeds were more vigorous in the limed plot.

difference whether the action of lime be direct or indirect. The fact of importance to golf clubs, which was brought out in these tests, is that lime on some soils can bring about beneficial results which none of the fertilizers nor combinations of fertilizers tested were able to accomplish. The heavy rate of sulphate of ammonia used on the quarter plot shown in the upper left of figure 7 is more than should be used on golf courses. This extreme rate, however, serves to illustrate how sulphate of ammonia may be used to advantage when soil conditions are favorable, whereas it may utterly fail to aid turf, or may be actually harmful, when soil conditions are unfavorable.

Many tests have been made on golf courses which indicate the value of lime on certain soils for checking the ravages of brown-patch as well as increasing the vigor of turf. One of the most convincing of these tests called to the writer's attention was that on the course of the Upper Montclair Country Club (New Jersey), in the late summer of 1928. Mr. R. F. Arnott and Mr. William Braid of that club visited the turf garden at Arlington, and after seeing the results obtained there with lime they felt certain that the unthrifty appearance of turf on some of their putting greens resembled the turf on the unlimed plots at Arlington. However, instead of drawing hasty conclusions and applying lime over their greens in the customary indiscriminate manner, they chose the wiser method of delaying any general application until they determined whether their turf actually needed lime. Across one of the poorest greens they marked off a narrow strip, on which they applied lime. In a few days they had no difficulty in determining positively as to whether

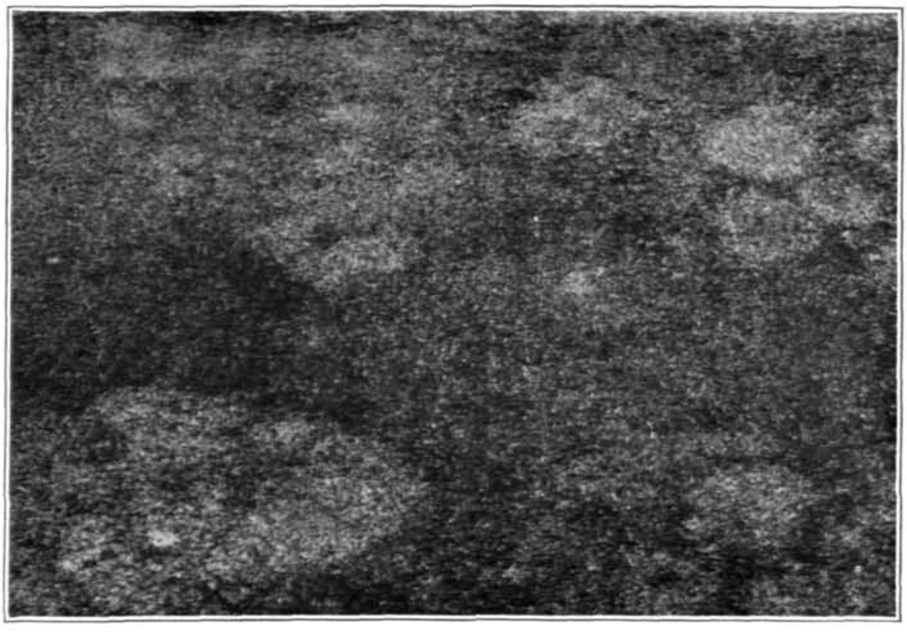

Fig. 8.—Large brown-patch on German mixed bent. This plot had been divided into quarters, which were treated with sulphate of ammonia at different rates. The heaviest rate was used on the quarter in the lower left, where a conspicuous large area of diseased turf developed. Compare with the adjoining plot, shown in Fig. 7, photographed the same day.

lime would benefit their greens. The limed band across this green soon turned a dark, healthy color, in striking contrast to the yellowish, unthrifty turf on the unlimed portion. Soon after this change had occurred there was an attack of large brown-patch on this green. The disease was generally distributed throughout the unlimed portion but did not affect the limed strip. Several interesting patches occurred along the borders of the limed area; instead of the usual circular patches there were semicircular spots, where the disease had developed up to the border line of the limed portion and there stopped. The rest of the green was then limed and the entire green soon appeared uniformly healthy. After this simple and convincing test had been made it was possible to use lime with entire confidence on that course wherever the turf showed a similar unthrifty condition.

SCALD

The word scald has been used by greenkeepers for many years to designate an injury to turf which has never been adequately defined. One of the reasons for this lack of clearness is that different greenkeepers have undoubtedly meant different injuries, to which they have applied the term indiscriminately, just as it has been customary to use the term "brown-patch" for almost any kind of browned turf. The term came into use with the belief that injury of this kind was actually a scalding of the grass due to applying water at a time when the soil was so hot that water was immediately heated beyond the point endurable by plants. Indeed in many instances the symptoms are such as to suggest that boiling water has been poured on the turf. Aside from this general appearance, there is little substantial evidence to support the contention that much, if any, of the so-called scald is due to the presence of excessively hot water. Too much water settling in areas from which escape is slow is undoubtedly responsible for much loss of turf, but this damage is probably more dependent on the exclusion of air than on the temperature of the water. Common use of this term does not include injuries due to careless use of chemicals, oil, and the like.

Scald usually appears as irregular and indefinitely outlined discolored patches of turf varying in size from a few inches to several feet across. The turf as a rule finally turns brown, and in severe cases may leave the ground bare. The injury is usually worse near the center of the affected area and is gradually less severe toward the outer borders. This characteristic serves to distinguish scald from the sharply outlined areas affected with the common brown-patch fungi. In the early stages of scald the grass may have a purplish tinge and the leaves may be rolled and shriveled as though suffering from lack of water. Often the development of these injured areas is very rapid, and within a few hours apparently healthy turf may be badly scarred. This rapid development is apt to occur only during periods of excessive heat. The affected area may continue to spread for weeks although the weather seem favorable for turf. Often these injured places recover during periods when growing conditions are favorable, but they may quickly reappear with a change of weather.

There have been several theories advanced to account for scald in addition to the hot water explanation. At present there is ample evidence to indicate that it can not be attributed to any single cause. It is probable that parasitic organisms are not factors in causing most of the injury designated as scald. Fungi are frequently found associated with scald, but at the present time there is not sufficient evidence to justify any decision as to whether these fungi are in any way responsible for the damage or are merely present feeding on the dead grass tissue. Some of the recent observations where fungicides have reduced the severity of scald suggest that some organism susceptible to these fungicides may have a part in causing scald. It seems entirely probable that future work will more clearly differentiate between the different types of injury now lumped together under the word scald and that such information will disclose that part of it is due to parasitic fungi. In the light of present information, however, scald will be considered as a disease non-parasitic in nature. Scald has frequently been associated with poisons in the soil. As has been repeatedly pointed out in the Bulletin, an accumulation in the soil of copper from Bordeaux mixture may cause the grass to turn dark in color and finally die in irregular blotches. Aluminum in a form toxic to grass roots has been suggested as a cause of some of this type of injury. Sulphur or other chemicals accumulating in soil have been observed to produce injuries practically indistinguishable from that produced by copper. In all such cases it is usually found that the roots of the grass are shallow and not vigorous, and yet the grass may respond to fertilization and otherwise appear practically normal during certain seasons most favorable for growth. On extremely acid soils this same type of injury may be due to the excessive use of certain fertilizers and fungicides which, although they may cause no harm at the time of application, may nevertheless produce such a highly concentrated solution in the soil at certain times that it may cause injury to turf. These and other explanations are

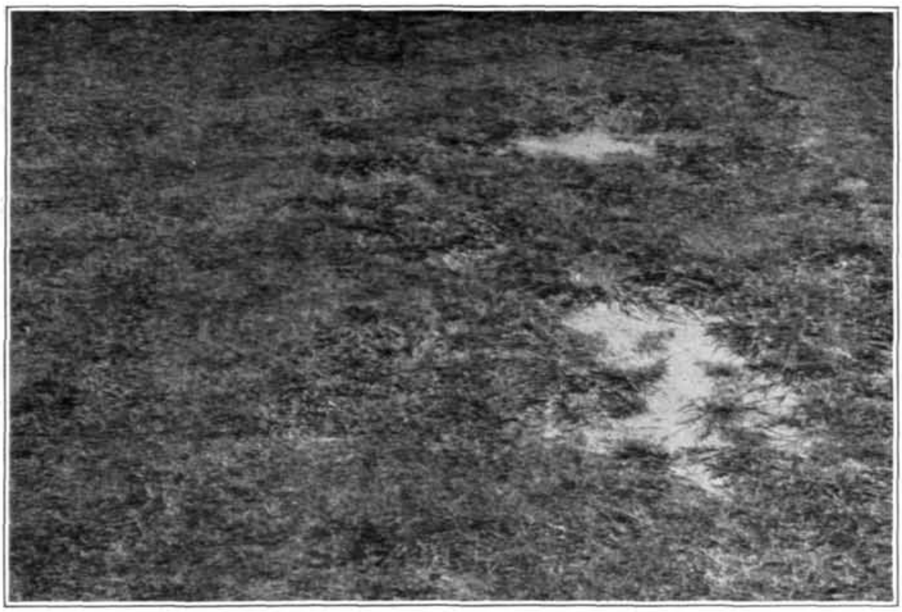

Fig. 9.—Bent turf which had repeatedly turned brown during the summer due apparently to some unfavorable soil condition. It was evident that the damage was not the result of brown-patch. In the summer of 1926 the left half was limed, and the turf immediately began to recover and remained healthy throughout the season of 1927. The turf on the half not limed, however, continued unthrifty and was badly scarred. Photographed July 15, 1927.

by no means confirmed as yet, and until the cause is fully determined no positive remedy can be prescribed. The following observations, however, will at least serve to throw some light on this problem which has baffled men interested in turf culture for years.

Effect of Lime on Scald

Some old established turf of Rhode Island bent at the Arlington turf garden had repeatedly turned brown during the summer months. It was apparent that this turf was not suffering from brown-patch or other fungous diseases. The soil in these plots was very acid, and in the late summer of 1926 half of each plot was treated with lime at the rate of 50 pounds to 1,000 square feet. The limed area immediately showed improvement and its turf remained healthy throughout the following summer. The portion receiving no lime, however, continued to be unthrifty, and the old scars did not entirely heal before it again turned brown, in the summer of 1927 (see figure 9). Other plots treated with lime and with sulphuric acid before planting in 1926 produced results which were in favor of the lime as compared with the plot receiving sulphuric acid or even the check plot which received neither lime nor acid.

In the early summer of 1927 some turf which showed symptoms of scald was treated with hydrated lime (calcium hydroxide), and an adjacent strip was treated with caustic soda (sodium hydroxide).

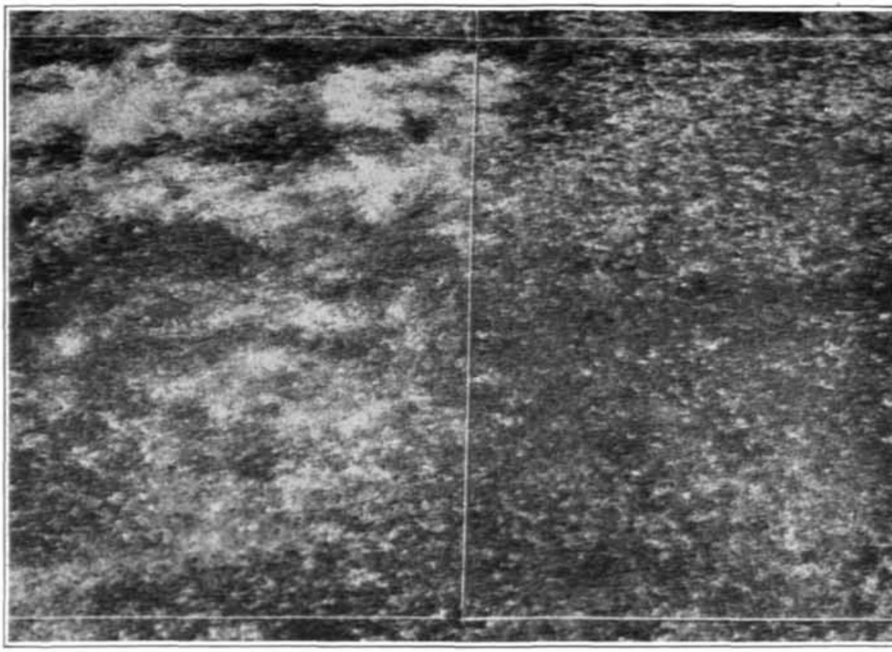

Fig. 10.—Two plots of Metropolitan creeping bent showing the influence of soil acidity on scald. The soil in the plot at the left was treated with oxalic acid in September, 1926, just before the stolons were planted. The plot at the right received lime at the same time. Both plots since planting were treated alike. The large irregular blotches of browned turf, or scald, on the plot at the left and the absence of this type of injury on the limed plot indicate that soil acidity has some influence on this particular type of turf disorder. Incidentally, the abundance of small brown-patch in the plot at the right shows that liming alone will not solve the brown-patch problem.

Within a few days the turf which had been treated with either of these chemicals showed a decided improvement over the untreated turf beside it, indicating that the neutralization of the soil acidity by these chemicals was beneficial to this bent turf. The results of this test were pointed out to the greenkeepers during their convention at Arlington in August, 1927.

In an attempt to study the effect on brown-patch of soil with a decidedly acid reaction as compared with a slightly acid and a nearly neutral soil, a series of six plots was prepared for planting in September, 1926. A heavy application of lime was incorporated into the soil of two plots. Into the soil of two other plots was worked a heavy application of oxalic acid, which was used to make the soil acid without leaving any possible harmful residue. The two remaining plots received no chemicals. One set of these three differently prepared plots was planted to Metropolitan and the other three to Washington creeping bent stolons. When scald was so prevalent at Arlington during the summer of 1928 these plots showed interesting differences. In the limed plots of this series scald did not develop except at the very borders, where apparently the lime was counteracted by the acid. In the two plots receiving neither lime nor acid there was some scald, but by far the worst damage was done in the plots receiving the acid. Two of these plots are illustrated in figure 10.

In other plots where lime was used on turf badly scarred with both brown-patch and scald there was a relatively quick recovery in the limed plots as compared with those where lime was not used. However, where the injury was due to previous use of Bordeaux mixture resulting in an accumulation of copper in the soil, the use of lime failed to bring about recovery of the turf. There are no doubt other poisons to be found in some soils which will not be remedied by lime. In such cases the only remedy so far found to be effective is to remove the poisoned soil and replace with fresh earth.

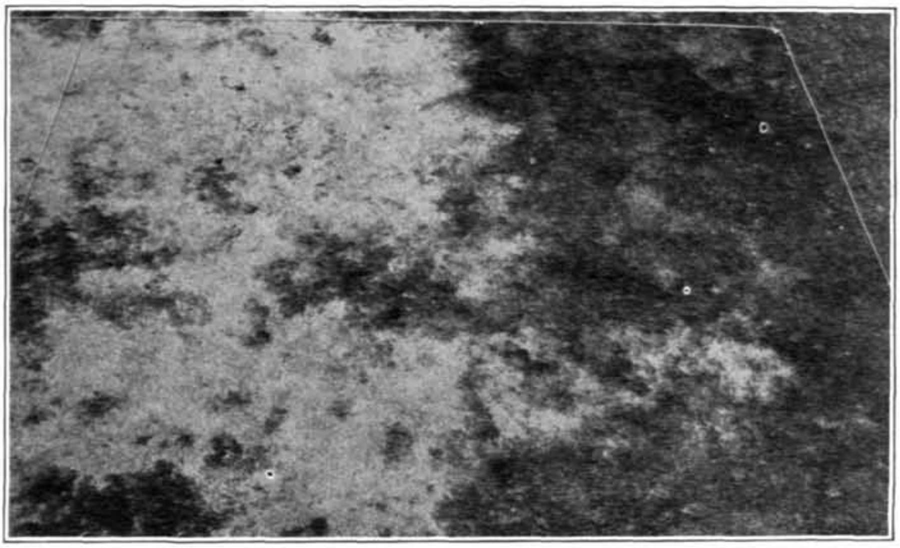

Fig. 11.—Cottonseed meal plot in the fertilizer series on Washington creeping bent. The large irregular blotches of browned turn on the left are the type of injury that was common throughout the East and Middle West during the summer of 1928. The right half of the plot was treated with corrosive sublimate and calomel. This treatment greatly reduced the amount of injury even though it did not completely control it. Photographed August 13, 1928.

Fertilizers Affecting Scald

Another though similar type of scale is that shown in figure 11. This type produces the same irregular patches of dead turf, but the symptoms are somewhat different and the causes are probably not the same. At the present time, however, there is not sufficient knowledge of either type to warrant any distinctive names. In this latter type the injured grass has more the appearance of having been burned by a recent excessive application of some chemical such as sulphate of ammonia or corrosive sublimate. These symptoms are so similar that several cases have been experienced where the greenkeeper or green committee members have been inclined to blame the injury on some malicious individual who was suspected of having thrown chemicals upon the turf when none had been used by the club staff for perhaps three or four weeks. In the fertilizer series at Arlington this injury was most serious in the plots where the more slowly available fertilizers were used. In the spring of 1928 there seemed to be little response to some of these fertilizers even though the turf appeared to need food. Apparently the process of decomposition of the fertilizers was a slow one, due to some unfavorable factor. During the latter part of June and during July decomposition of these fertilizers was rapid and the grass became soft and succulent. Scald soon spread through this tender grass. Similar injury was observed on golf courses, and in many cases the strong odor in the vicinity of the greens testified to the rapid decomposition of the fertilizers which were applied even weeks before that time. Whether this sudden decomposition of the accumulated slowly available fertilizers was sufficient to release nitrogen and other foods too fast for the welfare of the grass is not definitely known. Many cases were observed which certainly might readily be explained in this manner. The checking of the spread of this injury by corrosive sublimate and calomel in some of the plots at Arlington, as is shown in figure 11, indicated that some living organism was responsible for the injury. Whether the actual damage was due to some unknown plant parasite which was able to destroy the grass under these particular conditions, or whether the corrosive sublimate and calomel held in check the microorganisms causing disintegration of these fertilizers, remains for future work to disclose. Attention is called to this injury at this time to warn readers against the indiscriminate repetition of applications of such fertilizers during seasons when it is obvious that the grass is not able to use these plant foods. If the grass does not respond to a normal application of such fertilizers it is probable that decomposition has not been accomplished, and further piling on of such material is not likely to aid the turf but is merely inviting disaster at any time that conditions become suitable for rapid decay. Cottonseed meal, soy bean meal, bone meal, and urea were some of the fertilizers that seemed to favor this particular type of injury.

Some Practical Applications of the Foregoing Observations

It is recognized that observations and experimentation such as are detailed in the foregoing often appear extremely confusing to those who would like to put such findings into practical use. Many readers who have been struggling against small brown-patch will probably emit sighs of relief when they look at figure 1, for instance, only to have new hopes rudely strangled when they see an illustration of the results with this same fertilizer in figure 11. The individual who is looking for some simple cure-all for turf ailments will find little encouragement in this report, and it is probably safe to predict that such expectancy is most likely doomed for similar disappointment for many years to come. However, for those who are willing to admit that turf culture is a complex problem with consequently complex solutions, this report may serve some useful purpose in checking turf losses.

In interpreting these results it must be remembered that the tests were made at Arlington and that results with the same treatments may vary with different soil and climatic conditions. However, these tests are supported by observations on golf courses in widely different sections of the country. In working out a solution for any complex problem it is to be expected that contradictions will be relatively frequent. Time, with added hundreds of observations, will be needed to work out the many details and exceptions. Even if these observations were to serve no other useful purpose they would at least be of service in showing that some of the recent dogmas, like old ones, must be subject to revision if progress is to be made toward ultimate solution. All information must be given out in the light of present knowledge, and what may seem the best treatment today may be found to be inadequate, or even harmful, when subjected to the tests that time alone can give. The original golf ball was replaced by the gutta and the rubber ball in turn. In spite of certain admitted advantages of its predecessor, a new implement or a new method is presented to meet changed conditions. Likewise changes must be made in greenkeeping practice, and it should be possible to make such changes without denying the merits of the methods replaced or modified. These perhaps superfluous remarks are inserted here to refute the attitude of many individuals who have watched these developments at Arlington during the past few years and who have hailed some of the results as a complete reversal of previous practices. To those who choose extreme interpretation, some of these results will seem to be reversals of previous reports, but to those who regard them critically and judiciously they will appear merely as modifications of earlier principles which will need further modification in the future as knowledge advances.

The phase of this report dealing with lime will no doubt prove of greatest interest and be of most practical use to clubs. The exclusive use of sulphate of ammonia as a fertilizer for putting greens during recent years now appears to be responsible for some of the difficulties in maintaining good greens. The undeniably beneficial effect of sulphate of ammonia on turf has led to overenthusiasm and overconfidence in its properties as a turf producer. Correlated with the overuse of sulphate of ammonia has been an overemphasis of the need for acid soils to produce fine turf. Although the finer turf grasses undoubtedly thrive in an acid soil, it now appears that excessive acidity can not be tolerated. These grasses may thrive in an extremely acid soil during certain seasons, but during the hot summer months on such soil they are more likely to be injured by brownpatch and scald.

To correct conditions brought about by excessive use of sulphate of ammonia an application of lime has been found to be effective. On the acid soil at the Arlington turf garden lime was found to increase the vigor of bent turf and greatly reduce the amount and severity of both large and small brown-patch as well as scald. When lime is applied to turf and increases the vigor of grass it follows that more clippings may be removed by the mowers and in consequence the fertility of the soil may be more rapidly depleted. To counteract this condition adequate supplies of fertilizer must be supplied if a vigorous turf is to be maintained. The use of lime alone or in excess will soon bring about a starved condition of the turf and lead to a condition more objectionable than that resulting from the opposite extreme.

Lime will not benefit all soils. On many courses the soil and compost used on greens have been abundantly supplied with lime. Sand containing a relatively high percentage of lime has been used in some regions, and in many cases the water supply contains sufficient lime to neutralize any acid applied in the normal use of acid-reacting fertilizers. In any such instance an application of lime would probably prove to be mere waste, or may even be harmful.

In these experiments there was nothing to indicate that the use of lime would preclude the use of sulphate of ammonia on turf. There has apparently been a tendency to overestimate the value of the acid reaction of soil brought about by sulphate of ammonia. Lime has been regarded as incompatible with acid-reacting fertilizers because it neutralizes acids. The acid theory, however, has never been any too well established, because the influence of nitrogen in the readily available form in which it exists in sulphate of ammonia has usually been confounded with soil acidity. Many of the benefits attributed to acidity have been observed on greens where sulphate of ammonia has been used repeatedly but where tests revealed that the soil actually was almost neutral. The residue of lime already in such soils and the use of hard water containing much more lime than necessary to neutralize the acid residue from sulphate of ammonia prevented any increased acidity of the soil. Nevertheless the enthusiastic users attributed the decided benefits to the acidifying of their soils, without further inquiry. Sulphate of ammonia has other virtues than its acid residue and these amply justify its continued use on golf courses.

There is nothing to indicate that the use of lime alone will entirely prevent brown-patch. Its use on certain soils in reasonable amounts, however, will undoubtedly reduce the extent of the brown-patch damage and will greatly lessen the amount of mercury fungicides required. To completely control both large and small brown-patch it will still be necessary to rely on the mercury fungicides.

There is no simple laboratory means for testing soils to determine exactly whether lime will prove beneficial. The degree of acidity tolerated by grass apparently varies in different types of soil. If grass fails to show the customary response to such fertilizers as sulphate of ammonia it indicates that soil conditions are unfavorable. Plugs of turf if sent to the Green Section office will be tested for acidity and suggestions will be given as to whether lime is likely to prove of benefit. In most cases the ultimate decision can best be made following some simple test such as that conducted on the Upper Montclair course as mentioned on page 91.

The use of organic fertilizers on greens apparently needs more attention than it has been given in the past. If a heavy application of such fertilizers is used and fails to produce the results that can reasonably be expected, such failure may be due to some unfavorable condition. If such be the case it should be apparent that further applications are apt to be likewise ineffective. If small amounts of food can not be digested and utilized, large amounts are no more likely to be beneficial whether the user be animal or plant. Large accumulations of unused foods on turf may prove disastrous if they are suddenly broken down and released for immediate use. If slowly available fertilizers fail to give the desired results at any time it would be well to use moderate amounts of some quickly available fertilizer, such as sulphate of ammonia or phosphate of ammonia. The color of the turf and amount of clippings removed from the greens are good indicators for guidance in the use of fertilizers.

Applying Lime to Turf

In applying lime to turf it must be remembered that it, like any chemical, should be distributed evenly to prevent a mottled appearance due to overdosage in one place and shortage in another. It should be remembered also that, like any chemical, its use can be abused, and such abuse leads to burning and other injuries to turf. For those with long experience in turf work this warning is probably not necessary, since they can perhaps well remember the futility of the use of too much lime in the so-called "whitewash era" when greens regularly were coated with layers of lime. However, there has already been evidence on many courses of blind optimism which has led to a belief that at last a simple remedy has been found for all turf difficulties, and greens have been made to look like snowdrifts. The wails of the disappointed are already heard, for not only will lime fail to benefit some greens but it may result in terrific burns, especially if hydrated lime is used carelessly.

For turf work either finely ground limestone (calcium carbonate) or the hydrated lime (calcium hydroxide) may be used. In either form the rate should not exceed 50 pounds to 1,000 square feet in any one application. In many cases more may be needed, but it is well to err on the safe side until the lime requirements of the individual soils are determined. Since hydrated lime is more apt to produce a chemical burn it is well not to use more than 20 or 25 pounds to 1,000 square feet at any one time. Lighter applications may be repeated at intervals of one to two weeks if necessary. It is probably best to use lime in the fall or early spring, but it may be used at any time if handled with proper care. Hydrated lime is especially dangerous when applied to soils heavily fertilized with sulphate of ammonia, Ammo-Phos, or some of the quickly effective organic fertilizers. It should never be used on greens within a week after using such fertilizers, and should not be mixed with the fertilizers for joint application. Lime may be distributed alone or mixed with a little soil to give enough bulk to insure more even distribution. As is the case with other chemicals, lime is more likely to burn some grasses than others. Velvet bent, for instance, is easily injured by excessive use of lime, although it shows marked response to moderate amounts.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, OF THE BULLETIN OF THE UNITED STATES GOLF ASSOCIATION GREEN SECTION, PUBLISHED MONTHLY AT WASHINGTON, D. C., FOR APRIL 1, 1929.

District of Columbia, ss:

Before me, a notary public, in and for the District of Columbia, personally appeared H. L. Westover, who, having been duly sworn according to law, deposes and says that he is the acting chairman of the United States Golf Association Green Section and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, to wit:

1. That the names and addresses of the publisher, editors, managing editors, and business managers are: Publisher, United States Golf Association, 110 East Forty-second Street, New York, N. Y.; editors, managing editors, and business managers, John Monteith, Jr., and Kenneth Welton, Washington, D. C.

2. That the owner is the United States Golf Association, a corporation organized and existing under the law not for profit and having no capital stock.

3. That there are no outstanding bonds, mortgages, or other securities.

(Signed) H. L. WESTOVER, *Acting Chairman,*
U. S. G. A. Green Section.

Sworn to and subscribed before me this 1st day of April, 1929.

(SEAL) (Signed) JOSEPH L. MAHONEY.

My commission expires June 13, 1929.

Drainage problems can be best studied after a heavy rain. It is then advisable to go over the entire course and examine the low or soggy spots. If there is insufficient drainage in any place it can then be observed and steps inaugurated for correcting it. In course of time poor drainage will be certain to ruin any piece of good turf.