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.

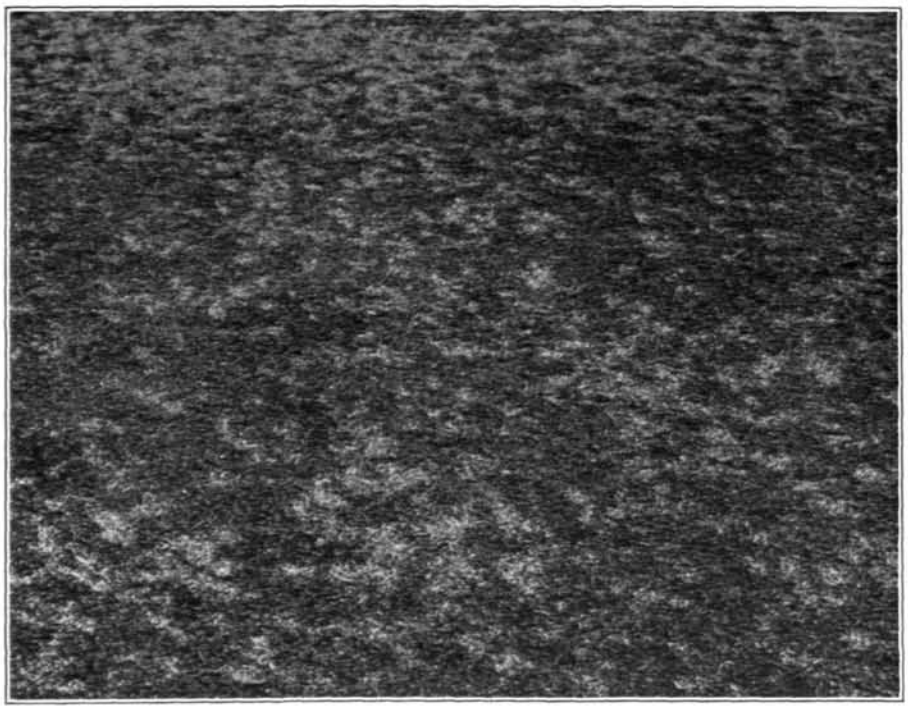

Fig. 2.—Compost and sulphate of ammonia plot in the fertilizer series on Metropolitan creeping bent. This plot was planted at the same time as the nearby cottonseed meal plot shown in Fig. 1, and from the time of planting until the date the photograph was taken, June 11, 1926, received the same amount 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-

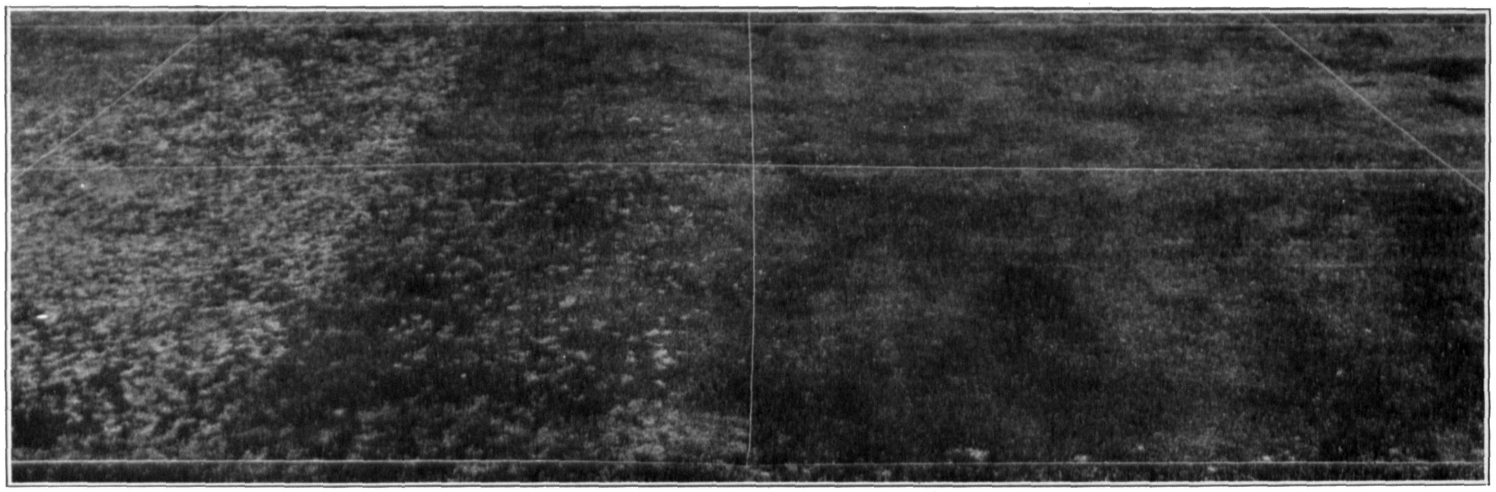

Fig. 3.—Four plots of Washington creeping bent, showing the influence of fertilizers on the severity of small brown-patch.

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

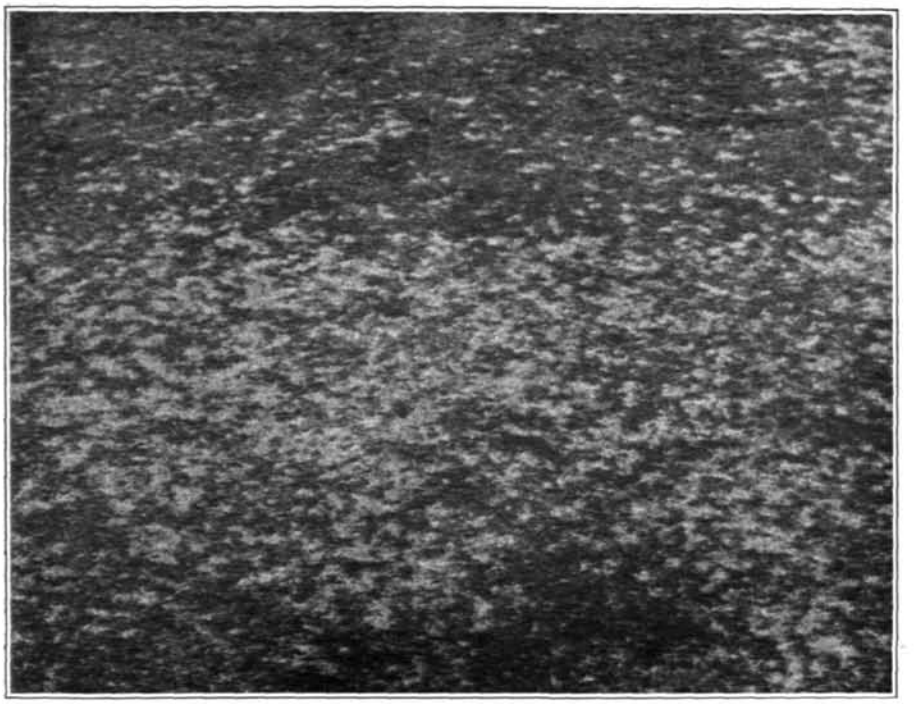

Fig. 4.—This plot of Washington creeping bent, from the time of planting in the fall of 1924, had received no compost and no fertilizer other than monthly applications of sulphate of ammonia. The severe spotting by small brown-patch indicates the danger in the exclusive use of this fertilizer. Compare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

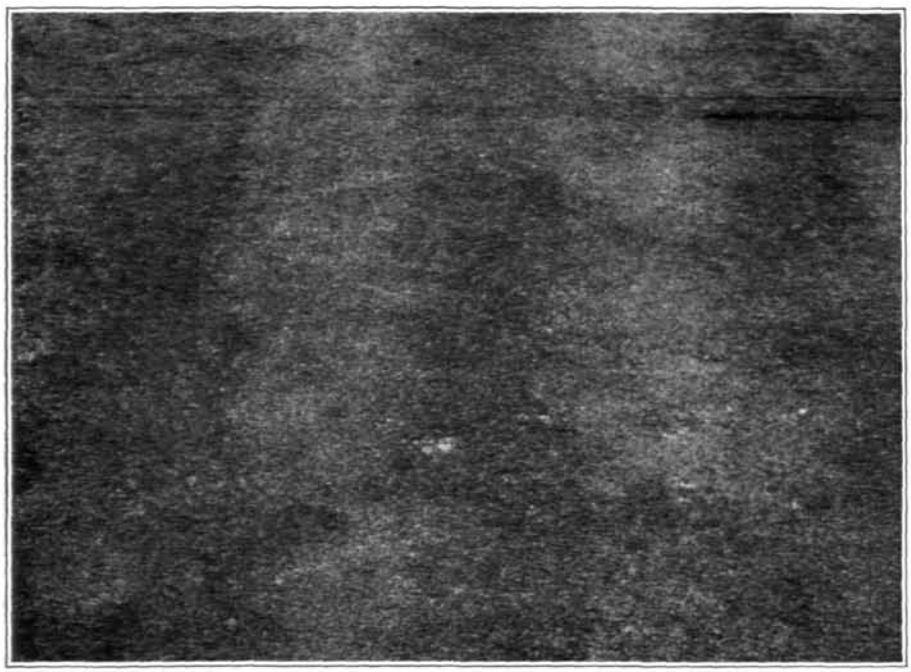

Fig. 5.—This plot of Metropolitan creeping bent was given an application of lime at the rate of 1 ton to the acre on July 10, 1928, when small brown-patch was scattered over the entire area of the plot. The photograph was made three weeks later, and shows the recovery due to the application of lime. 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