In general the results under these widely varying conditions were similar to those obtained with these fertilizers on the same grasses at Arlington Experiment Farm, as described elsewhere in this issue of TURF CULTURE.

SUMMARY AND DISCUSSION

Demonstration turf gardens were established by the Green Section on golf courses in different parts of the country. These gardens included series of plots for testing the responses of the bent grasses and Kentucky bluegrass to different fertilizers under various soil and climatic conditions.

This article reports the results of the fertilizer tests from the nine gardens which were continued over a 5-year period, from 1929 to 1933 inclusive.

Although these tests were conducted for only 5 years it is interesting to compare the results with those obtained from the bent plots on the Arlington Turf Garden, some of which have been fertilized with a single combination of materials for the past 18 years, and have been under continuous observation during that time.

The application of nitrogen at the annual rate of 5 pounds to 1,000 square feet has consistently improved bent turf, the amount of improvement varying with the source of nitrogen, the other fertilizer ingredients with which the nitrogen source was combined, and the acidity of the soil.

On the demonstration gardens, the most decided improvement was produced in bent turf with the 6-12-4 and the 12-6-4 inorganic mixtures. There was appreciably more improvement over the unfertilized turf in these plots than in the ones which received sulfate of ammonia alone or ammonium phosphate. Since the nitrogen in these mixtures was supplied

chiefly in the form of sulfate of ammonia with small amounts of ammonium phosphate, the increase in improvement has been credited to the presence of moderate amounts of phosphoric acid and potash. It should be remembered that the tests were conducted for only 5 years. Had they been continued for a longer time all four of these plots probably might have become increasingly acid until the grass suffered as it has on the bent plots at Arlington.

The application of sulfate of ammonia and compost did not produce so much improvement as did the application of sulfate of ammonia alone. This has been explained by the fact that in this mixture only one-half of the nitrogen was supplied by sulfate of ammonia and the remainder by the compost in which the nitrogen was more slowly available.

The improvement shown on the plot which received sulfate of ammonia and lime was much less than that on the plot which received sulfate of ammonia alone. This may be explained by the fact that more lime than necessary was used to neutralize the acid residue from the sulfate of ammonia. It is well recognized that lime is distinctly beneficial to bent turf when added to soil which has had too much sulfate of ammonia added to it. On these plots lime was added the first year and each year thereafter, and it more than counteracted the acidity which was caused by sulfate of ammonia when applied alone.

The other inorganic source of nitrogen in these tests was nitrate of soda, and the plot which received it was one of the two poorest plots in the series. Nitrogen applied at the annual rate of 5 pounds to 1,000 square feet in nitrate of soda produced less than half as much improvement as did the same amount of nitrogen applied in sulfate of ammonia.

The inorganic fertilizers, except for nitrate of soda and the

combination of sulfate of ammonia and lime, produced more improvement than did the organic materials. Among the organic fertilizers, activated sludge gave decidedly the best results.

Phosphorus, when not applied at too heavy a rate, increased the improvement obtained from the application of nitrogen alone, as has been shown by comparing the 6-12-4 and 12-6-4 plots with the sulfate of ammonia plot, or the activated sludge and the poultry manure tankage plots with the one which received urea.

The ammonium phosphate plot received, in addition to ammonia nitrogen, a large amount of phosphoric acid which, as has been shown on the bent plots at Arlington, is injurious in acid soil. Over the 5-year period the ammonium phosphate plot was not so good as the sulfate of ammonia plot which had received nitrogen only. At the Arlington Farm in 1939 the plots which have received ammonium phosphate over a much longer period of time have been the poorest of the entire series. They have been made very acid, however. Had the demonstration gardens been continued for a similar length of time, the plots might have become steadily worse, as they have at Arlington.

The bonemeal plot, which received an even greater amount of phosphorus than did the ammonium phosphate plot, was the poorest of the entire bent series. It has been pointed out that the cause of this low response may have been associated with the nearly neutral soil condition as well as with the excessive amount of phosphoric acid. This conclusion has been supported by the fact that the nitrate of soda plot which showed the same high pH produced turf comparable to that on the bonemeal plot.

The beneficial effect of potassium on bent turf was clearly evident on two gardens which were situated on sandy soil. Neither of these gardens is included in the nine, the results from which are tabulated in this report because they were not in operation during the entire period from 1929 to 1933, inclusive. On the heavier soils of the nine gardens reported, no such striking results were observed.

Considering the average of the nine demonstration gardens, the greatest improvement in the bent turf over that on the checks resulted on the four plots in which the fertilizers produced an average acidity between pH 5.2 and 5.4. These results are comparable to those obtained on the bent plots at Arlington, where the best turf has been produced with those fertilizers which results in a soil acidity ranging from pH 4.6 to 5.9. The least response of bents to fertilizers on the demonstration gardens was shown on the two approximately neutral plots with a pH of 6.9 which received the widely different materials, nitrate of soda and bonemeal.

The nine gardens varied in the acidity of their unfertilized soil from pH 4.7 on the most acid garden at Wheatley Hills, to pH 7.5 on the most alkaline garden at Meadowbrook. It has been demonstrated that the bents showed least response to fertilizers on the alkaline gardens and most on the decidedly acid gardens. Soid acidity tests showed that the fertilizers had much less effect on the pH of the soil on the alkaline gardens than on the acid gardens.

The response of Kentucky bluegrass on the demonstration gardens to various fertilizers and lime has been reported.

Several fertilizers produced a decided improvement over the check plots. The 6-12-4 fertilizer produced the best turf and

the activated sludge and 12-6-4 tied for second place. The bonemeal was fourth—somewhat below these three.

These figures show a slight lead for the 6-12-4, but it should be remembered that they represent the average results on nine different gardens over a 5-year period. It has been shown that when these average figures are separated into the results for the different gardens, each one of these fertilizers led all the rest on some gardens and was the poorest of the three on others. When comparing these first three fertilizers in this way the results are about equal. The bonemeal was generally less effective. The effectiveness of all four fertilizers varied on the different gardens due to soil and climatic conditions.

Inorganic fertilizers effected a much quicker response than did the organic. This is especially noticeable in the results of the first 2 years.

Sulfate of ammonia and stable manure were less effective than the other fertilizers in producing an improvement of the turf. Lime was also less effective but produced better turf than did the manure.

In making a comparison of these results with those secured at the Arlington Experiment Farm the difference in type of turf and climatic conditions should be taken into consideration. On the demonstration gardens the experiments were started on the newly seeded turf. On the Capital course and at Arlington they were on a thin weedy old turf. Naturally the weed and clover seedlings appearing in the newly seeded turf were more easily crowded out and eliminated by clipping than were the large weeds in established turf.

The demonstration gardens were located in regions where crabgrass is not the serious problem that it is at Arlington, so

the crowding out of the bluegrass due to the stimulation of the crabgrass by certain fertilizers was not so evident.

While improvement due to fertilizers on the demonstration gardens was high, the improvement of the old turf at Arlington and the Capital course was several times as much. This was due to the greater abundance of weeds and clover on the check plots on these latter areas and the great increase in density of turf on the fertilized plots. The soil at the Capital course and Arlington was extremely low in fertility and so supported a very poor turf, much worse than that on the average check plots on the demonstration gardens.

The best bluegrass turf was produced on plots having an average soil reaction of pH 5.2 on the demonstration gardens and of pH 5.3 at the Arlington Farm. The unfertilized soil on the various demonstration gardens ranged in acidity from pH 4.7 to 7.5, yet when properly fertilized good turf was produced on all of them. The greatest response to fertilizers was evident on soils having a pH of 5.3 and of 6.7. On the acid soil at Arlington a satisfactory turf could not be produced unless lime was added. However, on the plots having the best turf where lime was added the pH of the soil was still 5.3. These irregularities show that if a soil is acid in reaction it does not necessarily follow that it will grow better bluegrass if the acidity is reduced. Neither does it follow that because the soil is nearly neutral it will not benefit from applications of lime.

The organic fertilizers on the demonstration gardens rated much higher than at Arlington or the Capital course. The organic fertilizers were not so effective in reducing the amount of weeds and clover present in the old turf and naturally did not rate so high at Arlington or the Capital course. In earlier

trials at Arlington on turf that had been established recently from seed the organics compared more favorably with the inorganics. The results on these plots were similar to those obtained from the demonstration gardens.

On two of the other gardens (not included in this article) that were located on a sandy soil, marked response from the addition of potassium was noted. On these two gardens, ammonium phosphate and bonemeal produced no marked improvement in the turf. A 12-6-4 produced excellent turf. Evidently this small amount of potassium was sufficient. On the four gardens where the 6-12-4 had a commanding lead, potassium might have been the determining factor. However, since other factors were also involved the potassium influence could not be determined. At Arlington the best turf was produced where potassium was not used.

The response of the turf on the various gardens to the relatively large amounts of phosphorus in the 6-12-4 fertilizer had no relation to the amount of available phosphoric acid originally in the soil. One of the gardens showing the best results from the 6-12-4 originally had the lowest amount of available phosphoric acid, while another garden where the 6-12-4 led had one of the highest amounts of P_2O_5 in the original soil. Activated sludge, with the smallest amount of P_2O_5 of the three leading fertilizers, also led the others on one garden with very low P_2O_5 and on another with the highest available P_2O_5.

The turf produced by any of the three leading fertilizers was good. The improvement produced by the three leading fertilizers was nearly equal on the demonstration gardens. Therefore the relatively small amounts of phosphoric acid or potash supplied by the activated sludge and 12-6-4 apparently

were as effective as the larger amounts supplied by the 6-12-4. Since all fertilizers were applied on an equal nitrogen basis a good turf was produced with half the amount of total nutrients with 12-6-4 than with 6-12-4.

The low rating of the stable manure was presumably due to the tendency for it to stimulate the weeds and clover as well as the grass. It was thought that spring and fall may not have been the best time to apply manure. Therefore trials were carried on at the Capital course in which manure was compared with organic and inorganic fertilizers at different months of the year. In no case did it compare favorably with the commercial fertilizers.

The addition of lime alone produced a more marked response on the demonstration gardens than at Arlington or the Capital course. This was especially noticeable during the last year but at this time most of the response was due to the large increase on one garden. In combination with fertilizers at Arlington, however, there was a decided improvement from the use of lime.

The variations in the response of turf to these fertilizers in different years and different sections of the country show the desirability of continuing tests of this kind over a longer period than 5 years. More extended and long-time trials should tend to explain these variations and show whether harmful or beneficial materials accumulate in the soil from fertilizers applied annually to turf.

Peat, muck and sandy soils are generally more deficient in potash than are most clay soils. Fertilizer formulas should be modified accordingly.