IRRIGATION, COMPACTION AND AERATION OF FAIRWAY TURF

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This investigation was a continuation of the work conducted by J. R. Watson, Jr., from 1947 to 1949 (USGA JOURNAL, August, 1950). The purpose of the investigation was to continue the study of the effects of moisture and compaction on established fairway turf and to initiate studies of the effect of spring aeration on established fairway turf. The effect of phosphorus penetration was of primary interest. These phases of the investigation were carried out on the campus of the Pennsylvania State College from 1949 to 1952.

The tests were conducted on turf originally consisting of mixed bentgrass, red fescue and Kentucky bluegrass. By 1949 bentgrass had become the dominant grass. As far as possible the general maintenance practices of the experimental area were similar to those in common use on almost all of our golf courses. Throughout the experiment the area was clipped at a height of ½ inch, the frequency of the clipping having been determined by the rate of growth of the grass.

The treatments employed in the investigation involved five levels of compaction, four levels of moisture and two levels of aeration.

The compaction treatments employed were:

1. None—received no compaction other than normal maintenance.
2. Lt. 1X—a pressure of approximately 15 P.S.I. was applied once each week.
3. Lt. 2X—a pressure of approximately 15 P.S.I. was applied twice each week.
4. H. 1X—a pressure of approximately 62 P.S.I. was applied once each week.
5. H. 2X—a pressure of approximately 62 P.S.I. was applied twice each week.

The moisture levels employed were:

1. Dry—no supplemental irrigation was applied. The growth of the turf was dependent on the natural rainfall in so far as moisture was concerned.
2. As Needed—supplemental irrigation was applied only in sufficient amounts to maintain a healthy green color and to promote normal growth. The average soil-moisture content was maintained at approximately 15 per cent to 18 per cent during the growing season.
3. Field Capacity—supplemental irrigation was applied in sufficient amounts to maintain a soil-moisture content of approximately 24 per cent, which is the field capacity of that soil. (Field capacity is defined as the amount of water which was held in the soil from 24 hours to 48 hours after the soil had been saturated.)
4. Saturation—supplemental irrigation was applied in sufficient amounts to maintain a soil-moisture content approaching saturation. The total water-holding capacity of this soil is 49 per cent, but due to excellent drainage it was impossible to keep the soil-moisture content above 38 per cent (78 per cent saturation).

The aeration treatments employed were:

1. No aeration.
2. Aeration—aerated once in the spring of 1951 by going over the area three times.

Compaction treatments were applied with two hollow-steel rollers. Sufficient weight in the form of concrete blocks was added to the weight tray of one of these rollers in order to meet the requirements of the Lt. 1X and Lt. 2X treatments.The second roller was filled with concrete, and sufficient concrete blocks were added to meet the requirements of the H. 1X and H. 2X treatments.

The relative degree of soil compaction developed by the compaction treatments was determined by use of the Rototiller soil penetrometer. The effectiveness of the penetrometer and the justification for its use were established by correlating the penetrometer readings with volume weights.

Moisture applications were made by use of 100-foot pipes, drilled and tapped every 3 feet, and equipped with short-throw nozzles. The short-throw nozzles gave a uniform 9-foot throw, allowing a total area of 9 feet by 100 feet to be irrigated at any given time.

In order to maintain as closely as possible the given moisture levels, several methods of determining when to irrigate were used. Periodic soil samples were taken from all of the plots and were analyzed in the laboratory for moisture content. The addition of water to the "As Needed" plots was determined by observing the condition of the turf and mentally correlating those observations with the prevailing weather conditions. On the "Field Capacity" and "Saturation" plots, Lark soil moisture tensionometers were used to indicate the need for irrigation.

Aeration was done with an aerating device equipped with ¾ inch spoons and flexipress. Additional weight was added to the aerating device in order to obtain a maximum penetration of five inches.

The effects of compaction, moisture and aeration were evaluated by five major criteria. They were:

1. Invasion of crabgrass, clover and other weeds. This was determined by the point quadrat count method, the double X line quadrat method and visual observation.

2. Ecological changes in the population of the permanent grass species. Changes in the population of Kentucky bluegrass, red fescue and bentgrass were determined by use of the inclined point quadrat method. Population counts on these plots were taken in the fall of each year in a manner similar to those which were taken by Watson in previous years. This was done in order to permit a comparison of results over the entire period of the two experiments.

3. Root quantities and distribution. Root samples were taken at intervals of one inch to a total depth of six inches, washed free of soil, oven-dried and weighed, and the percentage distribution calculated.

4. Phosphorus penetration. Soil samples of phosphorus determination were taken six weeks after aeration and fertilizer application. Samples were taken with a soil-sampling tube at intervals of one inch to a total depth of six inches. The soil samples were taken to the laboratory and extracted by the Truog method, and the extracted phosphorus was analyzed by the Demge's Stannous-Reduced Phosphomolybdic blue color method as adapted to photo-electric measurement.

5. The severity of natural disease infection. Estimates of the amount of turf damaged by brownpatch, dollarspot and snow mold were made at the time of occurrence.

Ecological Changes

The percentage of permanent species present in the turf was not influenced greatly by the compaction, moisture or aeration treatments. The original population, as shown by Watson, consisted of 95 per cent permanent species. In the fall of 1951 results showed 95 per cent permanent species.

The percentage of permanent species present in the original turf was not influenced by the "Dry" and "As Needed" moisture treatments. The "Field Capacity" and "Saturation" moisture treatments decreased slightly the percentage of permanent species present. That was undoubtedly due to an increase in weed population, especially crabgrass, under the higher-moisture levels. The greatest reduction in the percentage of permanent species present under the various compaction levels occurred on the H. IX and H. 2X plots. This was due to the reduced vigor in the permanent species and a large increase in weeds, especially clover, on those plots.

Aeration showed no effect on the percentage of permanent species present.

The relatively small changes which occurred in the percentage of permanent species present does not indicate the actual changes in the turf population. The individual species were influenced greatly by the various treatments.

The unbalanced condition that existed among the permanent species in 1949 was changed little during the summers of 1950 and 1951. Bentgrass continued its complete dominance. Under the high levels of irrigation, bentgrass continued to increase at the expense of the Kentucky bluegrass and the red fescue. By 1952 the percentage of bentgrass present on the "As Needed," "Field Capacity" and "Saturation" plots approached 100 per cent. The rapid-growth rate, coupled with its ability to withstand high temperatures when given sufficient moisture, allowed the bentgrass to continue growth during the hot summer months while the Kentucky bluegrass and red fescue remained semi-dormant. This characteristic of bentgrass makes it quite desirable in many regions for use on the irrigated fairways of our modern golf courses.

The results of this investigation show clearly that, under summer irrigation rates high enough to maintain desirable playing conditions, bentgrass will naturally become the dominant species present in the turf population.

Compaction had no effect on the percentage of bentgrass and red fescue present, although heavy compaction did tend to reduce the general vigor of the bentgrass. Kentucky bluegrass persisted much better on the heaviest compacted plots than it did on the no-compacted and light-compacted plots. A possible explanation lies in the fact that the bentgrass was not so vigorous on the heavy-compacted plots and therefore did not offer so much competition to the bluegrass under compacted conditions. Conversely, Kentucky bluegrass decreased on the aerated plots because aeration increased greatly the vigor of the bentgrasses and offered severe competition to the Kentucky bluegrass.

Weed Invasion

Clover infestation of the experimental area during that investigation was quite low. The low clover population undoubtedly can be attributed to the high fertility level maintained throughout the investigation and the vigorous growth of the bentgrass, especially on the irrigated plots. The greatest clover population was found on the heavy-compacted, high-moisture plots. Plantain, knotweed and chickweed populations were higher on the heavy-compacted plots than they were on the light-compacted plots.

Crabgrass populations appeared to be higher on the no-compacted plots than on the compacted plots. It is believed, however, that the reduction in crabgrass on the compacted plots can be attributed to the injurious effects of the rollers used in making the compaction treatments rather than to the compaction itself. Watson has reported that the use of a heavy roller crushed or severely injured the young crabgrass seedlings so that they did not develop. The "Field Capacity" and "Saturation" plots had an extremely high crabgrass population as compared to the "Dry" and "As Needed" plots.

The high moisture levels apparently were ideal for crabgrass germination.

Weeds of all types were increased by spring aeration. The plugs pulled by the aerating device undoubtedly contained weed seed that had been buried too deeply to germinate. The matting operation broke up those plugs and distributed the weed-infested soil over the area, providing ideal germination conditions. It is pointed out here that aeration was done May 1 when weed-seed germination conditions were ideal and that if aeration is done early in the spring, when conditions are not ideal for weed germination but are favorable for grass growth, there should be less weed infestation from aeration.

Root Quantities and Distribution

Under the higher-moisture levels the root systems developed were very shallow. On those plots over 80 per cent of the total roots found in a six-inch layer were in the upper two inches of that layer. Under low moisture conditions, roots tend to elongate in their search for moisture, whereas there is no need for elongation when abundant moisture is available at the surface. In addition to the increased percentage of total roots found below the two-inch layer on the "Dry" plots, it also was shown that there was a greater total quantity of roots under those plots. Without question the amount, and particularly the distribution, of irrigation water is one of the prime essentials in any program of fine turf management where high-quality turf is desired.

The total quantity of roots found under the aerated plots was not increased greatly over the amounts of roots under the non-aerated plots. Under 5,000 square feet of turf there was an increase of 2.25 pounds of roots (dry matter) under the aerated, as compared to the non-aerated plots. This may appear as a rather insignificant amount of roots, but when it is converted into the number of lineal feet or miles of roots available for plant feeding, it presents a different picture. It was found by actual measurement that one pound of bentgrass roots contains approximately 540,476 lineal feet, or 102 miles, exclusive of root hairs. The inclusion of root hairs would increase this figure greatly. By applying those measurements to the data from the aerated and non-aerated plots, it was found that there were approximately 230 more miles of roots under 5,000 square feet of aerated turf as compared to 5,000 square feet of non-aerated turf. On an acre basis, there would be approximately 2,040 more miles of roots due to aeration. These figures were calculated on the basis of total quantity of roots to a given area under all levels of moisture and compaction. These differences are even greater under extreme conditions.

Phosphorus Penetration

Water was found to have a significant effect on phosphorus penetration under conditions of high-phosphorus application and excessive irrigation. The results indicated that there was considerable movement of phosphorus downward when high amounts of water were applied. Excessive watering will move some phosphorus downward to the root feeding zone, but the deteriorating effects of excessive moisture on turf quality and soil structure preclude using it as a method of moving phosphorus. From a financial standpoint, it would not be an economical use of water. It is necessary, therefore, to resort to some mechanical means of moving phosphorus into the root-feeding zone.

Aeration had a very significant effect on phosphorus penetration in this investigation. The exact means by which the phosphorus moved mechanically down the holes is not known, but it may be assumed that it occurred in three ways: (1) the fertilizer may have fallen directly into the aerator holes from the spreader, (2) it may have been dragged into the holes during the matting operation and (3) it may have been washed into the holes by rain or irrigation water. In every instance it was found that there was more phosphorus present in the 3-6 inch zone of the aerated plots than there was in the same zone of the non-aerated plots. Under all compaction levels there was an average increase of 27.4 per cent more phosphorus in the 3-6 inch soil zone where aeration had been used. Under all moisture levels there was an average increase of 23.6 per cent more phosphorus in the 3-6 inch soil zone where aeration had been used. Under all moisture and compaction treatments combined there was an average increase of 25.5 per cent more phosphorus in the 3-6 inch soil zone of the aerated plots. It has been shown that aeration plays a very important part in the movement of phosphorus into the root-feeding zone. On that basis alone, the use of an aeration device in any program of good turf management is justifiable.

Disease

Very little disease was observed on any of the plots during the summers of 1950 and 1951. There were no serious infestations of large brownpatch or dollarspot on the plots at any time. During the winter of 1950 some snow mold was observed on localized spots where the plots had been trampled on while frozen or where the snow had drifted and persisted for a considerable length of time.

CONCLUSIONS

The following conclusions may be drawn from the results obtained in that investigation:

1. Moisture and aeration treatments exerted greater influence on turf quality during that investigation than did compaction treatments.

2. The use of supplemental irrigation in a turf containing bentgrass will favor the development of the bentgrass at the expense of red fescue and Kentucky bluegrass.

3. Aeration significantly will aid in the downward movement of superphosphate applications applied on the surface at the time of aeration.

4. Excessive use of supplemental irrigation will result in shallow-rooted turf.

5. Turf containing a high percentage of bentgrass requires some supplemental irrigation over the growing season in order to maintain desirable playing conditions.

6. Spring aeration, if done at a time when conditions are ideal for weed seed germination, may increase the weed population in an established turf.

7. Excessive use of supplemental irrigation will increase the crabgrass population in an established turf.

8. Surface applications of superphosphate may move downward under excessive watering.

9. Compaction tends to increase the weed population, especially clover, in an established turf.

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No Trick At All

While a good number of hopeful golfers are still waiting for their first hole-in-one, Larry Dempsey, of Greensboro, N. C., made two and almost a third on the same hole in the same day last spring.

Playing at the Green Valley Golf Course, Dempsey holed a No. 7 iron shot for a one at the fifth hole. The next time around, he did the same thing again. The third time around his luck ran out and he had to be content with a 2.

For the record, this is a rarity of rarities, but similar things have been done before, and at least two golfers, Bob Halverty, in Long Beach, Cal., and Alex Duthrie, in Vancouver, B. C., are said to have made ones on consecutive holes.