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IRRIGATION AND COMPACTION ON ESTABLISHED FAIRWAY TURF

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The purpose of this investigation was to study the direct and interacting effects of moisture and compaction on established fairway turf of good quality. The investigation was conducted on the campus of Pennsylvania State College. The plots were laid out in the fall of 1947; treatments were initiated in the spring of 1948 and were continued through the fall of 1949.

A good quality, five-year-old turf, consisting of mixed bentgrass, red fescue and Kentucky bluegrass, was used for the study. All maintenance practices, other than the treatments themselves, conformed as nearly as possible to those followed on many modern golf courses.

The treatments employed involved four levels of moisture and five levels of compaction in all possible combinations. The levels of moisture maintained were:

(a) Dry — received no supplemental irrigation. The average soil moisture content for the growing season was approximately 12 per cent to 13 per cent.

(b) As needed — received sufficient supplemental irrigation to sustain normal growth; i.e., turf kept green and vigorous throughout the growing season. The average soil moisture content for the growing season was approximately 16 per cent to 18 per cent.

(c) Field capacity — irrigated often enough to maintain a moisture content of approximately 24 per cent, the field capacity of this soil.

(d) Saturated — irrigated often enough to maintain a moisture content approaching saturation. The total water-holding capacity of this soil is 49 per cent. Due to the very excellent drainage of this soil an average moisture content of only 38 per cent, or approximately 78 per cent of saturation, could be maintained. This moisture content is very close to the aeration-porosity limit of the soil studied.

The compaction treatments employed were:

(1) None—received no compaction.

(2) Light (2 weeks)—approximately 15 P.S.I. (pounds per square inch) applied once every two weeks.
(3) Light (1 week)—approximately 15 P.S.I. applied once each week.
(4) Heavy (2 weeks)—approximately 37 P.S.I. applied once every two weeks.
(5) Heavy (1 week)—approximately 37 P.S.I. applied once each week.

Water applications were made by use of 100-foot, ¾-inch pipe drilled and tapped every three feet with short-throw nozzles. This pipe covered an area approximately 9 feet by 100 feet with each setting; consequently, two settings were required to irrigate a single main plot.

Observational determinations of the condition of the turf on the "as needed" plots governed the frequency of application. Lark soil-moisture tensiometers were used to indicate the need for irrigation on the "field capacity" and "saturated" plots. The tensiometers were of the vacuum-gauge type.

Compaction treatments were made by the use of two hollow steel rollers. The heavier of these rollers was filled with concrete, and sand bags were added to both rollers in order to obtain the weight necessary to deliver the pressure listed above under compaction treatments. The rollers were pulled by a half-ton Model A Ford truck.

A Rototiller soil penetrometer was used to determine the relative degrees of soil compaction developed by the treatments. Twenty readings to the plot were taken, and these readings were averaged for the plot value. Hits occurring on stones were omitted. These readings were taken in September, 1948, and again in October, 1949.

Effectiveness of the penetrometer and the justification for its use were established by correlating the penetrometer readings with Geiger counter X ray spectometer readings in 1949. The intensities of the 1010, or secondary line of quartz, as measured by the X ray spectometer, were found to be highly correlated with penetrometer readings. Both methods were apparently effective indicators of the relative degree of soil evaluations of the following factors:

Turf quality under the various treatments was determined by comparative evaluations of the following factors:

(1) Ecological changes of the permanent species in the turf population. These were studied by use of the inclined-point quadrat. Density

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and the percentages of bentgrass, red fescue and Kentucky bluegrass were considered.

(2) Invasions of crabgrass and clover. Crabgrass estimates were made by the use of a modified string method in 1948 and a grid quadrat in 1949. Clover estimates were based on inclined-point quadrat counts.

(3) Severity of natural-disease incidence. These estimates were based on inclined-point quadrat counts which were converted to percentages from an arbitrary scale.

(4) Root quantities and distribution. Samples were taken at one-inch intervals to a depth of six inches, washed free of soil, oven dried and weighed, and the percentage distribution in the upper two inches and lower four inches was calculated.

Moisture

The dry moisture treatment did not influence the percentage of permanent species over the two-year experimental period. The density increased but the magnitude of change was significantly less than under the other moisture treatments. The balance between the bentgrass, fescue and bluegrass was not materially altered, although there was a slight trend toward a higher percentage of bluegrass. Crabgrass and clover were negligible. Severe loss of color accompanied prolonged drought, but no serious permanent injury occurred since rain invariably stimulated growth. Disease infestation could not be evaluated as the maximum infestation on the watered plots occurred when the turf under the dry treatment was off-color. The deepest root system was developed under this treatment.

The effectiveness of moderate irrigation was shown by the "as needed" moisture treatment. The percentage of permanent species was not affected greatly. This treatment promoted the greatest increase in the density of permanent species, while crabgrass, clover and disease were again negligible. Root quantities were significantly lower than under the dry treatment but significantly deeper than under the saturated treatment. There was no significant difference in root development between the "as needed" and "field capacity" treatments.

The use of sufficient water to maintain an average soil-moisture content of approximately field capacity produced an undesirable quality of turf. The per cent of permanent species increased significantly, but the increase may be attributed to a highly significant increase in the bentgrass on these plots. Both fescue and bluegrass percentages decreased significantly under this treatment. Disease incidence averaged approximately 12 per cent to 13 per cent higher than on the "as needed" plots. Subsequent invasions of crabgrass and clover were heavy, averaging seven to eight times greater than the percentages of these two species on the dry plots. Root systems were not significantly different from those found under the "as needed" treatment; they were deeper than those under the saturated and shallower than those under the dry treatment.

The application of the large amount of water required for the saturated treatment is of academic importance only. It serves to illustrate, however, the deleterious effects that may be expected from continuous saturation of turf. The soil was soggy, and the turf was shallow-rooted and easily injured throughout the growing season. The effects of this treatment on the permanent species, density, species balance, disease, crabgrass and clover were not materially different from the values found for the "field capacity" treatment. In all probability only the very excellent surface and subsoil drainage of the soil prevented more severe deterioration of the turf under the saturation treatment.

Compaction

The measurable differences found to exist in the degree of soil compaction developed were small in magnitude but very highly significant statistically. Light and no compaction decreased the percentages of permanent species in the

turf; i.e., as the degree of compaction decreased, the percentage of permanent species decreased. Heavy compaction effected the smallest reduction in permanent species. The lower percentage of permanent species present under the light and no-compaction treatments may be attributed directly to the increased percentages of crabgrass and clover on these plots. Compaction exerted no influence on the density of the permanent species. Likewise, there was no significance for the effect of compaction on the percentages of bentgrass and fescue present. Bluegrass was found to increase significantly under the heavier compaction treatments when compared to the light and no-compaction treatments. Compaction decreased the percentages of crabgrass in the turf population. From a replicated greenhouse experiment involving three levels of compaction (none, medium and heavy), it was found that heavy compaction suppressed crabgrass germination. It has been concluded that the decrease in crabgrass percentages under field conditions may be attributed to a suppression of germination by the compaction treatments. Clover increased about equally for all levels of compaction, irrespective of the degree, when compared to the no-compaction treatment. No observable differences were in evidence for the effects of compaction on disease. No significance could be shown for the influence of compaction on root development.

Interaction

There were significantly negative interactions for the effects of moisture by compaction on the percentages of permanent species and the percentages of crabgrass in the turf; i.e., as soil moisture content increased, the percentages of permanent species decreased and the percentages of crabgrass increased—as the degree of soil compaction increased, the percentages of permanent species increased and the percentages of crabgrass decreased.

Conclusions

The results obtained in this study seem to warrant the following conclusions:

1. The soil penetrometer can be used to evaluate effectively relative degrees of soil compaction where existing plant population are uniform and where readings can be made at uniform soil-moisture contents.

2. The Geiger counter X ray spectrometer may be used to evaluate relative degrees of soil compaction.

3. The limited evidence presented suggets that the Geiger counter X ray spectrometer may be used under a wider range of conditions than a penetrometer for evaluating soil compaction.

4. Moisture levels exerted a greater influence on turf quality, during the experimental period, than did soil compaction.

5. The moderate use of supplemental irrigation seems necessary to produce high quality playing turf that will remain green throughout the growing season when bluegrass, bent and fescue are involved.

6. The unwatered plots were brown and in poor condition for play over an extended period of time.

7. Moderate usage of supplemental irrigation on intensively managed turf will favor development of bentgrass at the expense of the slower growing species, so that eventually the turf will consist largely of bentgrass.

8. Supplemental irrigation in quantities great enough to maintain a soil at approximately field capacity is unnecessary and encourages disease and the subsequent invasion of crabgrass and clover.

9. Excessive watering creates a soggy soil condition, promotes shallow rooting of the turf, encourages disease and the invasion of crabgrass and clover.

10. Higher percentages of permanent species occurred under the heavier levels of compaction than under the light and no compaction treatments.

11. Compaction increased the percentages of clover in the turf.

12. Compaction depresses crabgrass germination, but the deteriorating effects on soil structure should preclude using it as a control for crabgrass.