Costly reconstruction of old compacted golf and bowling greens can be avoided by drilling holes at regular intervals and backfilling with a suitable growth medium, according to the southern California tests reported in the two accompanying articles. Extension Service assistance at Arrowhead Country Club, San Bernardino County, in 1961 and 1962 resulted in tests showing that deep aeration plus irrigation control increased root activity and, at the same time, reduced the amount of water needed to maintain acceptable turf during the fall and early winter by 50 to 60%. Tests last year at Arcadia, Los Angeles County, substantiated the earlier results with data showing that the 3-inch holes drilled by the usual machine-"aerators" are less effective for healthy regrowth than holes drilled to a depth of 8 inches.

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LOS ANGELES COUNTY TESTS

J. LETEY • L. H. STOLZY • WAYNE MORGAN

MAINTENANCE OF GOOD GRASS growth on golf or bowling greens is often difficult, because the heavy traffic of players using the greens causes severe soil compaction. Root growth is restricted by the closely packed soil particles, low water intake rate, and a decrease in rate of oxygen supply to the roots. Complete reconstruction of compacted greens is expensive and time consuming.

For several years, mechanical "aerators" have been used to reduce the effects of soil compaction. Small holes are mechanically cut in the turf to a maximum depth of 3 inches, usually less. This practice has improved the quality of many greens. In 1962, tests described in the accompanying article were conducted in San Bernardino County. Treatments consisted of drilling holes to a depth of 8 inches with a ¾-inch auger and backfilling with sand mixes. The holes were placed on 2-inch and 4-inch centers. The green improved with these treatments.

In tests reported in this article, various treatments were tried on a compacted golf green at the Santa Anita Golf Course in Arcadia, Los Angeles County, during the summer of 1963. The entire soil profile was compacted at this location, rather than the surface layer compaction existing in the San Bernardino tests. The treatments consisted of hand drilling ¾-inch holes to a depth of 6 to 8 inches on 2-inch center-spacing and normal "aeration" by machine. The green was divided into sections, and holes in three sections each of those deep hand drilled and the machine "aerated," were back-filled with either Loamite or a 3-1-6 mixture of peat, nitrohumus, and sand. One treatment consisted of leaving the machine-made holes open without backfill. Unfortunately, those sections which were to remain as checks with no treatment were inadvertently machine "aerated."

The treatments were checked in the fall for their effectiveness in promoting (1) root growth, (2) water intake, and (3) oxygen diffusion rate. Within three weeks, the roots had grown to the bottom of the hand drilled holes and the surface was almost completely covered by the turf. The photograph shows that after five months, roots were growing in the holes, but no roots were in the compacted soil around the holes. The roots grew well in all the holes, but were more dense in the sand mix than Loamite.

The water infiltration velocity was measured by checking the rate of water loss from cylinders which were forced into the ground. The infiltration velocity was quite high for all treatments. The highest velocities occurred on the hand-drilled holes and when Loamite was used for backfill as compared to the mix. Lowest infiltration velocities were found on the machine-"aerated" plots which received no backfill.

The oxygen supply was determined by measuring oxygen diffusion rate to the platinum wire electrode. It was impossible to determine where the holes had been placed by the appearance of the surface so the electrodes were inserted at random. Very high and very low oxygen diffusion rates occurred depending upon the position of the electrode relative to the holes.

The results of this test indicate that compacted golf greens can be reclaimed by providing zones which will allow good root growth. Drilling holes and backfilling with a suitable material leaves a framework to support the traffic that is not subjected to the same compactive forces as it would be if the entire green was replaced. Furthermore, costs for this renovation are about 90% less than the costs for green reconstruction, including the time that the green is out of play.

The regenerated green may actually be preferable, from a performance point of view, because of the rigid framework which would withstand the traffic and leave the refill free from compaction. The soil has two functions to perform: to provide a good medium for plant growth; and to provide support for the players who walk on the surface. Emphasis in the past has been on developing soil mixes which will continue to be a good growth medium even though subjected to compaction. A new concept would be to have part of the soil withstand traffic, and the rest provide for plant growth. Further research is necessary to determine the relative merits of the two procedures.

TED GOLF GREENS
d to Deep Aeration,
rolled Irrigation

SAN BERNARDINO COUNTY TESTS

F. W. DORMAN · C. L. HEMSTREET

LATE IN 1961, the Arrowhead Country Club in San Bernardino County requested Extension Service assistance in its program of green replacements and repair. Two greens had a characteristic surface soil stratification, traffic compaction, impaired root penetration and health. The anaerobic soil condition was sufficiently severe that the cores developed a strong odor after exposure to the atmosphere for 20 to 30 minutes. One green was selected for replacement, and the other, Green No. 4, was selected for repair and rejuvenation tests.

Water penetration tests were conducted on Green No. 4 in November of 1961, with standard 6-inch-diameter infiltrometers. With the Seaside bentgrass in place, the penetration rate averaged 1/16-inch-per-hour four hours after the daily application of 1/2-inch of irrigation water.

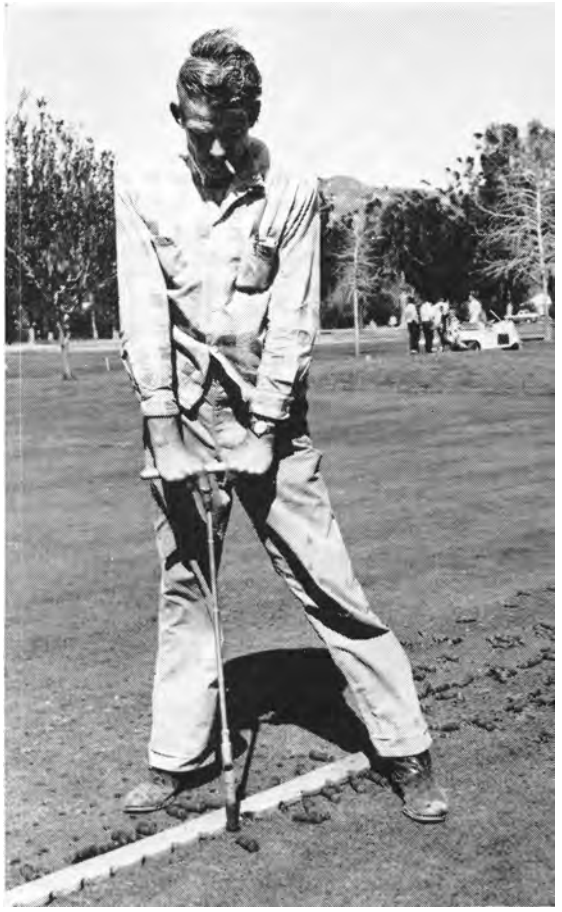
Good grass root growth extends through backfill material in drilled holes in this turf renovation test.

After removal of 1¼ to 1½ inches of thatch and soil, the penetration rate was ¼-inch per hour. When 4 to 6 inches of the stratified, compacted material was removed, the parent soil was found to have a rate of infiltration of approximately 2 inches per hour.

To eliminate any problem of thatch during this test, the green was "verticut" on December 19, 1961, and again on January 17, 1962. Starting April 2, approximately three-fourths of the green was aerified by hand, using Oakfield soil tubes. On the west portion, the holes were spaced 2 inches apart; on the east side, the spacing was at 4 inches. These holes were made 4 to 6 inches deep, completely through the stratified, compacted layer to the permeable parent soil. Notched boards were used as templates, to assure reasonable spacing accuracy. It took approximately 26 man-hours of labor to hand-aerify 1,000 square feet of green at the 2-inch spacing. A 21-foot strip was left on the south edge of the green as a control.

Soon after cores were removed from the green, the ¾-inch aerifier holes were filled with a University of California-approved green soil mixture containing sand, redwood sawdust, and all major and minor plant nutrients. The control area was gone over twice with a machine spoon-type aerifier. The entire green was then given a light top-dressing of fine sand. The green was put into play on April 12, ten days after the work started, but it could have been played three days earlier.

The entire green was aerified with a machine spoon-type aerifier on April 20, the cores were removed, and the holes left



Deep aerifying with a soil tube, to increase water penetration on an old golf green. The notched board insured accurate spacing at 2 inches for the test.

open. The green received the same application of fertilizer and fungicides given the other greens for the rest of the year. Visual observations of foliage and root health were frequently made, as comparisons with other similar, but untreated, greens.

The green healed rapidly after the hand-aerification. Golfers reported it had increased resilience and played better than previously. Plugs cut through the filled hand-aerifier holes showed greater root concentration and depth in the new soil.

Normal irrigation practices, followed until September 1, 1962, included application of six 45-minute irrigations per week during the summer, using an average of 2-acre-inches of water weekly.

Preliminary water infiltration tests conducted during the growing season indicated striking increases in the treated plots. Visually, it was obvious that the water penetration rate on Green No. 4 had been improved. Prior to treatment there was casual water on the green surface after approximately ¼-inch of water

Section of turf shows good grass root growth through backfilled material in drilled holes in renovation test.

had been applied during a 30-minute irrigation. After treatment, casual water showed up after an hour's irrigation only on the control area and on a very small area in the northwest portion of the green where slope was a problem.

Even though drainage was adequate and root growth had increased from a depth of 3 or 4 inches to 6 or 7 inches in the deep-aerified (vertically mulched) holes, tensiometer readings indicated that moisture from 2 to 6 inches in the root zone was seldom reduced below field capacity when irrigated daily. Water infiltration tests were conducted on Green No. 4 in January, 1963, giving the following infiltration rates, averaging eight replications: west, aerifier holes 2 inches apart, 2.83 inches per hour; east, aerifier holes 4 inches apart, 1.82 inches per hour; and control, 1.46 inches per hour.

Disregarding one replication on each portion of the green where infiltration rates were obviously abnormal, due to irregularities in the turf soil, the following results were recorded: west, aerifier holes 2 inches apart, average of seven replications, 2.54 inches per hour; east, aerifier holes 4 inches apart, average of seven replications, 1.60 inches per hour; control, south, average seven replications, 1.07 inches per hour. These figures are not suggested as the true infiltration rate of the green surface, but as the relative rate of water infiltration between treatments and control.

Tensiometers at 2-, 4-, and 6-inch depths indicated a surplus of water was being applied during the summer. During the period from September 1 to October 9, 1962, the irrigation program on Green No. 4 was manipulated to apply water each Tuesday, Thursday, and Saturday, using approximately .854 inch total per week. On warm days, dry spots (hydrophobic areas) would develop the second or third day after irrigation.

A piston-type aerifying machine with ¼-inch hollow tines was used on the entire green, to observe the effect of this treatment on the development of these dry spots. A commercial wetting agent was applied at the recommended concentration to these hydrophobic areas. As soon as it was evident that the green developed far fewer of these spots, the entire green was treated with the wetting agent.

Except for two periods, the three-times-weekly irrigations were adequate for good green maintenance. Soon after changing from a six-times-weekly to a three-times-weekly irrigation schedule, hot weather required light hand-waterings on two Mondays—following 48 to 60 hours without irrigation. During September of 1962, the average maximum temperature was 95°F., average minimum 58°F., and average relative humidity at noon, 44%.

From October 9 to November 23, the green was irrigated only when visual observations and tensiometer readings indicated damage would be incurred by further withholding of irrigation water. Sufficient water would then be applied to wet the green to a depth of more than 6 inches. During this period, irrigation water applications averaged ½-inch per week. During October, the average maximum temperature was 87°F., average minimum was 50°F., and average relative humidity at noon was 48%.

When the green was on this minimum-irrigation schedule from October to November, water was withheld until a gray-blue off color of the turf indicated some stress. In one instance, no water was applied for seven days, in another for 10 days. After application of the wetting agent and machine aerification, no isolated dry spots occurred.

During this period of restricted water application, no complaints were received from golfers on the increased firmness of the green. Balls did not cut holes in the sod, but did bruise the turf foliage sufficiently that small brown spots occurred temporarily. Turf foliage was maintained in a healthy but not luxuriant condition, as evidenced by a reduction in quantity of clippings. It was evident that a gradual decrease in irrigation frequency and in total water applied had caused the turf to harden. Tensiometer readings indicated increased root activity at the 4- to 6-inch depths.

From November 24 to December 12, approximately .1 to .2 acre-inch of water was applied at a time, to wet only the upper portion of the root zone. The entire root zone was wetted when the 6-inch tensiometer indicated the possible danger point was being reached, as evidenced by recent experience. Average weekly water use was .3 acre-inch. During November, the average maximum temperature was 70°F., the average minimum was 45°F., and the average relative humidity at noon was 42%.

Deep aeration at 2- or 4-inch spacings and filling the holes with an approved greens soil mix was a successful method of increasing the rate of infiltration under the conditions of this test. Resilience of the green was increased for 12 to 18 months after treatment. Deep aeration plus irrigation control resulted in increased root activity at greater depths, and apparently less at the shallower depths. This expanded root zone and the hardening of the turf enabled the turf to go longer periods without irrigation and to more efficiently utilize the water that was applied. It was possible to reduce the amount of water normally applied to this green during the fall and early winter by from 50 to 60% and still maintain acceptable turf.

Tensiometers are an excellent tool when used as a guide for improving greens irrigation practices, after tensiometer readings are equated to turf irrigation needs. Tensiometer gauges with a greater calibration range between 0 and 30 millibars of suction would be helpful.

The procedures used in this test are a practical means of extending the useful life of old greens with compacted, stratified soils overlying permeable parent material such as existed on Green No. 4 at the Arrowhead Country Club. The total cost was approximately 10 to 15% of the cost of rebuilding the green, and it was out of play only a short time.

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