MINIMIZING COMPACTION IN PUTTING GREENS

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SOIL Compaction in putting greens is widespread and often makes management difficult. Some specialists consider compaction to be the major factor contributing to the loss of turf on putting greens (2). The soil property which probably has the greatest effect on plant growth in putting greens is its capacity to permit gas exchange with the atmosphere. As the oxygen supply in the soil approaches extremely low values, root growth comes to a standstill. It is a common observation on putting greens to find but few active roots below a depth of two inches.

A consideration of the effects of soil compaction and other data discussed hereafter suggest strongly that lack of oxygen in putting greens is a major factor in limiting root growth to shallow depths. At any rate, it is quite apparent that when grass roots are restricted largely to the top inch or two of soil, frequent irrigation and fertilization are necessary. Undoubtedly, grass is also much more vulnerable to disease under these conditions.

While compaction in putting greens is an important factor, it is not the only feature of putting greens which might limit aeration. In many greens in Southern California a plug of the soil will reveal one or more distinct layers of coarse sand. A distinct sand layer in finer textured soil acts as a barrier to the movement of water. When drainage is reduced in a soil, so is the air space. It is often possible to cut a plug from a green and observe the pattern of "aerifier" holes at the points where mats of roots have penetrated the sand layer. When cultivation tools cut holes through a sand layer the drainage of water above the sand layer is not affected. The

FIGURE 1

Water movement in a soil is impeded by a thin layer of a coarse sand. The point on the left where water has moved below the sand layer occurred where the sand layer was not continuous.

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perforations are well aerated, however, and this permits roots to grow densely in them and to penetrate a perforated sand layer. Figure 1 shows that a sand layer in finer textured soil is a barrier to the movement of water.

Usually the compacted layer in putting greens which has been induced by foot traffic is only about two inches deep. Figure 2, which shows a graph of the resistance offered by a soil at various depths to a probe being forced into the soil, is typical of putting greens.* The maximum resistance occurred in the top inch and one half. While there is general agreement

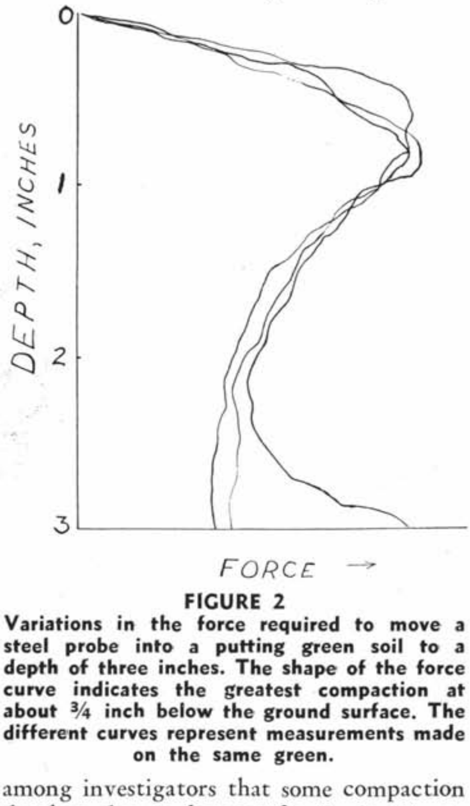

FIGURE 2

Variations in the force required to move a steel probe into a putting green soil to a depth of three inches. The shape of the force curve indicates the greatest compaction at about ¾ inch below the ground surface. The different curves represent measurements made on the same green.

among investigators that some compaction develops due to foot traffic (1, 2, 4), attempts to correlate bulk densities with compaction have been difficult because of the large and variable amount of organic matter present.

It would be expected that putting greens in poor physical state would have suffered a loss in the volume of large diameter pores. In this regard the data of Davis (1) is particularly interesting. He found the porosity due to large pore spaces to be strikingly smaller in the top 3½ inches than lower in the profile. The destruction of large size pores is precisely the effect one would expect in soils when traffic occurs when the soil is extremely wet. Soil moisture measurements made on a number of greens in Southern California have frequently been well above the estimated field capacity.** Soil moisture contents were such that the effect of foot traffic is characterized by destruction of

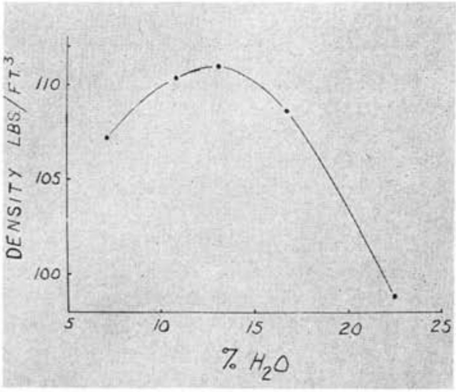

FIGURE 3

The density to which a soil can be compacted with a standardized treatment is a function of the moisture content of the soil.

structure as much as by compaction. Figure 3 shows the relation between the compactibility of a soil and the moisture content at which the compaction is effected. Compaction treatments occurring at moisture contents higher than that required for maximum compactibility tend to destroy structure to a marked degree.

The net affect resulting from the loss of the large diameter pores is that the soil tends to remain wetter and contain less air.

Sand layers in greens, compaction, and destruction of large pores, coupled with

**Appreciation is expressed to Dr. S. J. Richards who assisted on these and the aeration measurements.*

***Field capacity is the moisture content of a well drained soil about 3 days after a thorough irrigation. When field capacity is reached, further drainage practically ceases.*

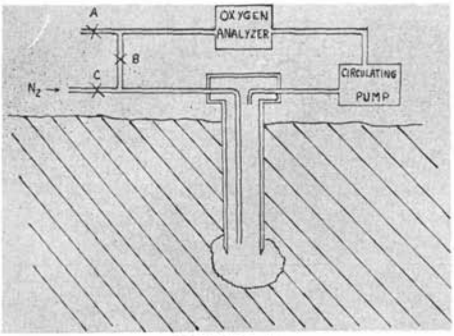

FIGURE 4

Schematic diagram of apparatus used to measure the diffusion rates of gases in soils.

frequent irrigations, combine to produce soils that are nearly saturated with water and devoid of air in many greens. Perhaps the best direct evidence on poor aeration in putting greens comes from air diffusion measurements made *in situ*. This soil property was measured in a number of greens of both good and poor quality, using equipment devised by Dr. S. J. Richards. Figure 4 shows schematically the technique used. A hole was cut in the soil about three inches deep, into which was fitted a rigid plastic tube which extended into the soil two and one-half inches. A small amount of water was applied to the soil surface around the edge of the tube to seal this possible avenue of gas movement. The system was then flushed out with nitrogen with valves A and C open and B closed. Valves A and C were then closed and B opened and the circulation pump operated. A plot was then made of the oxygen concentrations observed as a function of time. The shape of this curve gives an indication of the rate at which air will diffuse into the opening from the soil. In a number of putting greens tested of both good and poor quality, there was at best barely detectable and, in most cases, no measurable air movement at a depth of two and one-half inches. Air diffusion rates were invariably rapid when similar measurements were made just off the greens. These measurements emphasize the reason for the shallow rooting so common in putting greens. It is remarkable, and a tribute to greenkeepers, that satisfactory turf can be produced under the conditions usually prevailing in putting greens.

Improving Aeration in Putting Greens

Frequently it is possible to maintain satisfactory turf under relatively poor soil conditions by a regular program of cultivation. The holes made in turf with these instruments provide localized spots where aeration is adequate and where grass roots may thrive.

In building new greens, or in renovating and rebuilding greens which have become unsatisfactory, consideration should be given to using a soil which is resistant to compaction and which will drain well. All recent studies are in general agreement regarding the requirements of a soil mix with these properties. Work done by Garman (3), Kunze† and work at UCLA all point to the fact that satisfactory infiltration and drainage will occur in putting greens, notwithstanding compaction from foot traffic, if the soil mix is sufficiently high in sand. In some parts of the country turfgrass service companies have successfully used the high sand mixes for a number of years. Specifications for the soil mix will be given below.

In laboratory tests using soil columns it was shown that soil mixes containing as much as 80 percent sand could be compacted so that percolation rates became low. When the sand content of a mix was as high as 90 percent, compaction treatments did not reduce percolation rates to low values. In all probability 85 percent sand in putting greens will maintain high infiltration rates provided particle size distribution is right. Other practical considerations are: A. How thick need a sand layer be? B. What size of sand is desirable? C. What should the other constituents in the soil mix be? D. What special fertilizer or irrigation practices should be developed?

The first question can be answered rather accurately. Equations used in soil mechanics studies, as well as laboratory measurements, indicate that a 4 inch layer of sand on top of a soil susceptible to compaction

†*Personal communication.*

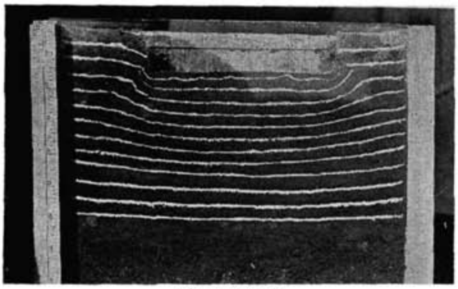

FIGURE 5

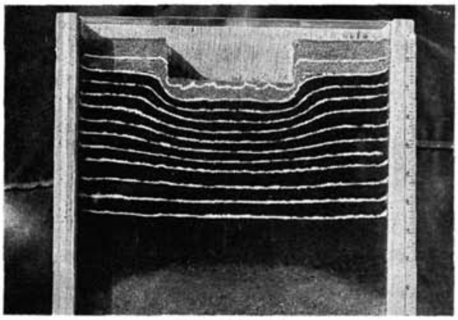

FIGURE 6

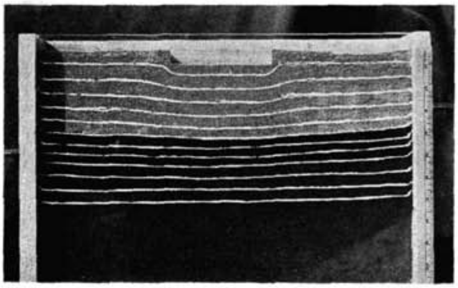

FIGURE 7

In these figures the white lines were approximately parallel before the compaction treatment. A force of 35 pounds per square inch was applied six times for each square inch of soil. The subsidence and the distortion of the lines in the soil became progressively less as the sand layer increased in thickness. There was no sand layer in Figure 5. The depth of the sand layer in Figures 6 and 7 was 1.25 and 3.50 inches respectively.

will distribute the load occurring from foot traffic sufficiently to effectively protect the soil underneath from compaction. Figures 5, 6 and 7 show how this occurs. The white lines in the soil were originally approximately parallel. The moist soil which was loosely packed into the boxes was then compacted with a pressure of about 35 pounds per square inch of soil. Both the fact that the greatest compaction occurs very close to the surface and that four inches of sand protects the soil underneath is clearly shown in the pictures. Actual measurements on the amount of compression resulting from compaction treatments on sand layers of various thicknesses over clay loam are as follows:

Depth in Inches of Layers Before Compaction		Compression in Inches After Compaction	
Sand	*Clay Loam*	*Sand*	*Clay Loam*
1.2	8.7	.51	.94
2.4	7.5	.35	.63
3.5	6.3	.47	.20

These data indicate that a 4 inch layer of sandy mix on top of a soil susceptible to compaction will protect the soil. The underlying soil should be so prepared, of course, by cultivation or other means, so that it is in good physical condition and drains well. It is advisable to treat the top two inches of the soil with Krilium at the rate of 7.5 pounds per 1000 square feet before applying the sand layer. This may be done by going over the soil while moist with a rototiller—the Krilium having previously been dusted on. No particular attempt should be made to mix the sand with the soil.

While the importance of a sand layer at least 4 inches thick on the surface has been emphasized here, somewhat deeper layers are desirable if available materials and construction costs permit. Some fine greens have been built on sandy soils whose composition is approximately that being proposed. The courses at Palm Springs, California, are an example.

What size of sand is satisfactory? The experimental sand surface green at UCLA has the following particle size distribution:

Sand Diameter in Millimeters		%
Larger Than	.5	25.1
	.5 —.42	5.2
	.42—.30	16.8
	.30—.21	17.7
	.21—.10	22.2
Smaller Than	.10	13.0

Although this green has not been subjected to heavy traffic, infiltration rates remain very high. The quality of the turf is quite satisfactory.

The most desirable sand size fraction is the range from 0.4 to 0.2 mm. and an ideal source would have about 75% of the sand in this range, and not more than about 6 to 10% in the range smaller than 0.10 mm. and not more than a percent or two of silt and clay. Fine sands—0.25 to 0.10 mm.—may be satisfactory, provided they are relatively free of silt and clay. Very fine sands—0.10 to 0.05 mm.—should be very carefully evaluated, since small amounts of unaggregated silt and clay in sandy soils are subject to migration and the soil may very well seal up. Very fine sands are particularly susceptible to this hazard. If 85 to 90% of the soil mix is composed of sand as described above, the remaining 10 to 15% of the mix should be composed of fibrous peat and *well aggregated clay*. A desirable amount of clay appears to be about 7.5% or less. In laboratory tests soil columns composed of 85% sand, principally in the range of 0.42-0.21 mm., 7.5% Krilium treated clay, and 7.5% peat by volume have maintained infiltration rates in excess of one inch per hour after having received a compaction treatment.

The suggestion of Kunze† of blending a small amount of Krilium treated clay into sand mixes increases slightly the capacity of the mix to retain fertilizers and water. The 85-90% sand, 5-7.5% Krilium treated clay, and 5-7.5% peat mix may be obtained by mixing 10 parts of sand, two parts of sandy clay loam and three parts of loose peat. This mixture when it settles, yields about 13 volume units rather than the 15 which went into it.

The Bob Dunning-Jones Company, of Oklahoma, has had good success constructing greens according to the following specifications:

- 60% coarse sharp approved sand, coarser than concrete sand
- 25% approved soil (loam or sandy loam)
- 15% fibrous peat

The volume proportions in this mix, when prepared, would be approximately:

Sand	about 80%
Silt and Clay	about 10%
Peat	about 10%

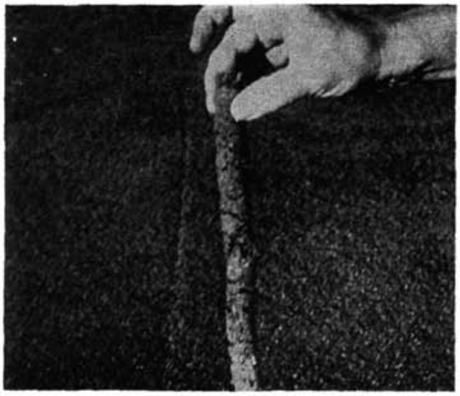

FIGURE 8

Excellent root development may be expected in sand greens.

A layer of this mix 10 inches deep is recommended by Dunning-Jones. Figure 8, supplied through the courtesy of Mr. Al Houchin, of Dunning-Jones, shows the type of root action that is obtained in a well drained mix.

The specifications of the Dunning-Jones Company are a close approximation of those arrived at above, principally on the basis of laboratory studies.

Dr. Jesse Skoss, who recently returned from Australia, reports sand greens are being employed with good success in that country.

In building greens in areas where the base subsoil is especially dense the use of tile drains may be advisable. In such cases consultation with a person experienced in drainage problems is advisable.

It should be noted that any future topdressing should be done with material of the same composition as the green surface.

A disadvantage of the high sand content greens is the care required to establish the grass, and the attention that needs to be given to the fertilization program, which should generally include all six of the major elements supplied by the soil.

Fertilization may involve frequent feedings or the use of fertilizer materials of low solubility which do not leach rapidly. Fortunately all fertilizer materials are now available in slightly soluble forms. The fertility management of the experimental green at UCLA has not been difficult.

In view of the greater depth of rooting which can be expected in sand greens, the frequency of irrigation should be less than that of the typical green in which rooting is limited to about two inches. Two irrigations per week during hot weather have been ample for the experimental sand green at UCLA.

(1) *Davis, R. R.—The Physical Condition of Putting Green Soils and Other Environmental Factors Affecting the Quality of Greens, Ph.D. Thesis, Purdue University,* 1950.

(2) *Ferguson, M.—Compaction, Drainage and Aeration, United States Golf Association Journal and Turf Management* 3(2):32 33, 1950.

(3) *Garman, W. L.—Permeability of Various Grades of Sand and Peat and Mixtures of These With Soil and Vermiculite, United States Golf Association Journal and Turf Management* 5: *Number* 1, 27-28, 1952.

(4) *Watson, J. R., Jr., Musser, H. B., and Jeffries, C. D.—Soil Compaction Determinations with a Soil Penetrometer As Compared With the Geiger Counter X-ray Spectrometer, Agron. Journal* 43:255-258, 1951.

OBSERVATIONS ON POA ANNUA

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THE discussion of all who have been working with turfgrasses the past two months has been predominated by *Poa annua*, and in some instances this grass has caused comments from golfers.

The population of *Poa annua* in greens has raised numerous questions. It was readily distinguished as its winter dormancy period was changing to spring greenness. Where it was mixed with bents it was noticeable that the bentgrasses started growth prior to the *Poa annua*. It became a real talking point as the late April temperatures approached 80°, due to the rapid development of seedheads. Where *Poa annua* was growing in bunches, bumpy putting surfaces resulted.

There was wide variation on the amount of *Poa annua* in different greens on the same course, the stronger creeping bentgrasses in most instances having less *Poa annua*. The Arlington and Congressional greens at Woodmont Country Club, Bethesda, Md., built in the past 10 years and supervised by Bob Shields, showed only a trace of *Poa annua*. A green on a long-established golf course that was rebuilt two years ago after the soil was sterilized with methyl bromide, then stolonized with Arlington-Congressional bent, showed considerable *Poa annua*. After this observation it was evident that the soil sterilant did not control seed of *Poa annua*.

Was there more *Poa annua* in 1956 than a year ago? That is difficult to determine since there is no measuring stick to show the exact amount of *Poa annua* in greens each year. It was noticeable that wherever the bentgrasses were injured, either by excessive mat, high temperatures, or hurricanes last summer, *Poa annua* had filled in rapidly. There were indications that disturbing the greens in October had given *Poa annua* a chance to get a start.

Practice putting greens where tramping was severe after a heavy rainfall or soon after watering showed more *Poa annua* than a year ago. Greens constructed so that much of the water moved from the sides to the middle show the most *Poa annua* in the area remaining wet the longest. With the bent in the higher portion and the *Poa annua* in the lower portion, the overall result is an uneven putting surface.

A Review of Literature

There are numerous articles in reference to *Poa annua* being objectionable in putting greens.

In the March, 1921, issue of the Bulletin of the Green Section of the United States Golf Association, Drs. C. V. Piper and R. A. Oakley discussed this plant and outlined its characteristics, stating that it can be a detriment to golf greens. Checking further through the bound volumes