The USGA Green After 15 Years

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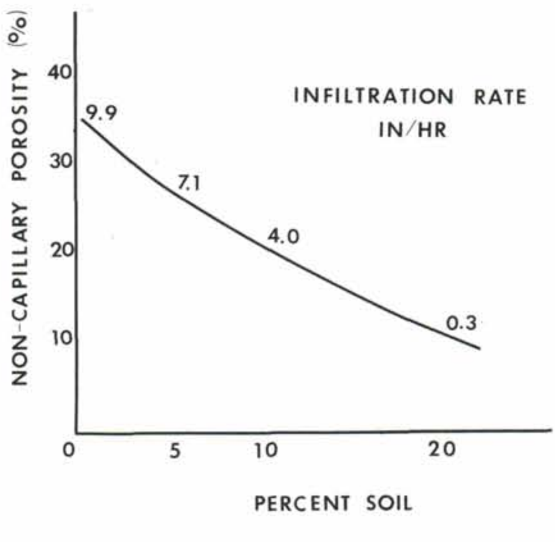
The area of soil mixtures for golf green construction has been extensively researched in the last 15 years. The USGA Green Section may be largely credited for initiating and supporting research work in this area. Specifications are based on research evidence collected during the 1950s were first published by the Green Section in 1960. These specifications, when followed by a contractor, resulted in golf greens that were tolerant of heavy traffic and were manageable with respect to water and nutrients. Modification of the specifications by the architect, the contractor, or the superintendent usually resulted in greens that were difficult to manage. John Madison, turf researcher at the University of California at Davis, stated in an article on USGA golf greens that "given the USGA specs for green construction, 90 per cent of the people would feel they could make changes and improve on them."

The USGA specifications were not proposed as the final or ultimate solution to green construction. Rather, continuous upgrading of the specifications was a part of the original plan, and research on methods and materials for green construction was continued. Increased interest in golf created heavy traffic on the nation's overcrowded golf courses during the 1960s, and construction of new golf facilities soared. Automatic irrigation systems added to the compaction problem associated with traffic, since greens were often overwatered. This combination of wet soils and heavy traffic reduced the quality of turf on many golf greens. The Green Section Staff became concerned that the original specifications may not be adequate to carry this extra traffic load and still maintain playability under wet weather conditions. Observations of greens constructed with a sand-organic mixture in place of the sand-soil-peat mixture suggested that a higher infiltration rate might be desirable in green mixtures, particularly for bentgrass. Also, contractors complained that installation of the 1½ inch layer of coarse sand between the gravel and the soil mixture was too expensive and time consuming to include in the specifications.

Research was initiated at Texas A&M University in 1970 to investigate soil mixtures with higher infiltration rates, requirements for a sand layer above the gravel, and nutrient and water retention capacities of high sand mixtures. This research was supported by the USGA Green Section Research and Education Fund, Inc.

The components of the USGA green include medium and coarse textured sand, organic matter, clay or clay loam soil, pea gravel and tile drains. The pea gravel is spread over the tile drains and subsoil which has been graded to correspond to the desired finished surface. The pea gravel should have a minimum depth of four inches. A 1½-inch layer of coarse sand is spread over the gravel. The medium textured sand, organic matter and soil are mixed uniformly at a ratio described by the USGA Soil Lab at Mississippi State University and placed over the coarse-textured sand layer. Early specifications described a soil mixture of sands were examined in combinations with peat and soil. Sand textures for golf green that had a ½ to 1½ inch-per-hour infiltration rate after compaction. However, slight errors in mixing or in calculations could result in greens with an infiltration rate of less than ½ inch per hour. In order to find mixtures that resulted in greater infiltration rates but that held adequate water and nutrients, quantities and qualities

FIGURE 1.



mixtures have been studied by several workers. David Bingaman, at Purdue University, established that size, shape, and distribution of sand particles are important criteria for evaluating sands for golf greens. Dr. Ray A. Keen, at Kansas State, found that ¼ to ½ mm diameter sand provided greater root development, better playing surfaces and had more latitude for management than coarser textured sands. Dr. J.M. Duich, at Penn State, notes that different combinations of particle sizes may be used to achieve the same results, but that the voids or pores must not be plugged. Dr. John Madison, at California, concluded that fine- to medium-textured sands with a narrow size distribution were best suited for golf green mixtures. With this information at hand a medium textured sand with most of the particles ½ mm in diameter was selected as a reference material, and coarser and finer textured sands were included for comparison (Table 1). Golf greens were constructed in the laboratory and in the field with 70, 80, 85 and 90 per cent sand by volume; 20, 10, 5 and 0 per cent clay loam soil by volume; and 10 per cent peat moss by volume, respectively. The profiles were compacted, planted and maintained for several years. The coarse textured sand was very close to establish a turf and resulted in a drouthy golf green profile. The fine textured sand (most of the particles between 0.1 and 0.5 mm in diameter) was fast to establish, but the profile held excessive water and remained soggy or became very hard after drying. Infiltration rates were very low on mixtures with 20 per cent soil and on the fine textured sand profiles (Table 2). All mixtures using the Lakeland sand had infiltration rates of less than 1.0 inch water-per-hour and held excessive water. If this type of sand were to be used, the depth of the profile would need to be increased to 16-18 inches. Although the type of soil included in the mixture had little apparent influence on the infiltration rate, the clay or clay loam soils increased the water and nutrient retention of the profile. Also, the well aggregated soils, such as the Houston clay loam and the Lake Charles clay, are less likely to migrate or move through the profile than the soils with a weak structure.

Table 1. Size distribution of the three sands included in the investigations.

Particle size (mm)	Concrete[1] sand	Brick[1] sand	Lakeland[1] sand
5-2	20	0	0
2-1	15	5	0
1-0.5	31	30	5
0.5-0.25	24	53	40
0.25-0.10	6	12	45
0.10	2	0	10

[1] Commercial washed and screened concrete and brick or mortar sands.
[2] Native soil.

Likewise, soils high in silt or very fine sand particles are undesirable from the standpoint of particle migration. The medium textured sand (brick sand) produced excellent quality golf greens with 80, 85 or 90 per cent sand; 10, 5 or 0 per cent soil and 10 per cent organic matter. These greens were covered six weeks after sprigging bermudagrass or eight weeks after seeding bentgrass, moisture retention averaged greater than two inches of available moisture and filtration rates ranged from four to nine inches per hour. Such greens could be played immediately after a heavy rain, yet held enough water to support growth for three to five days after irrigation. Measurements of available water showed that the perched water table created by the USGA layered profile increased available water by 20 per cent in the 12 inches of soil mixture.

Measurements of bulk density and porosity indicated that the surface few inches of soil suffered most from compaction. The surface layer of mixtures containing more than 10 per cent soil became very tight and water movement through the layer became negligible. Mixtures that contained 5 per cent soil, 85 per cent sand, and 10 per cent peat moss were ideal from the standpoint of porosity and water movement. In all examples studied the percentage of non-capillary porosity, which functions in water movement, decreased as the percentage of soil in the mixtures increased (Figure 1). The greens constructed without soil, 90 per cent sand and 10 per cent organic matter or 100 per cent sand, were very high in non-capillary porosity but were very low in capillary porosity which is important in water retention. In other words, the total porosity of the mixtures did not change appreciably (41-44 per cent) with changes in per cent soil, but the size distribution of the pore space changed greatly. Again, all evidence suggests that 5 to 10 per cent soil with a medium textured sand is ideal with respect to water movement and moisture retention.

Table 2. Infiltration rates (hydraulic conductivity) of undisturbed golf green profiles.

Sand—Soil components	Sand — Soil — Peat Ratios			
	7-2-1	8-1-1	8.5-0.5-1	9-0-1
Concrete sand—Houston clay loam	1.1	3.8	2.5	10.0
Brick sand—Houston clay loam	2.1	3.2	4.0	9.0
Brick sand—Norwood silt loam	1.0	3.5	4.0	9.0
Brick sand—Lake Charles clay	3.0	5.1	6.5	9.0
Lakeland sand—Houston clay loam	0.1	0.2	0.4	1.0
Lakeland sand—Norwood silt loam	0.1	0.3	0.4	1.0

Although the nutrient retention of the high sand golf greens are much less than native soils, mixtures containing as little as 5 per cent soil and 10 per cent organic amendments have adequate nutrient storage capacities for golf greens. Mixtures with 10 per cent soil had slightly greater nutrient holding capacities, but 20 per cent or more soil was necessary to significantly increase nutrient retention. However, such mixtures were undesirable from the standpoint of water movement through the profile. Nitrogen and potassium are the most readily leached plant nutrients; however, slow-release formulations of nitrogen that meet the requirements for turf are available. Ureaformaldehyde, IBDU and Milorganite are all excellent N-sources for golf greens with a high sand content. Less than 10 per cent of the N applied from these sources at rates of two to three pounds N per 1,000 square feet is lost through leaching (Table 3). Nitrogen release from a combination of these materials can be calculated to meet the requirements of bermuda grass or bentgrass turf. As much as 40 per cent of the applied N from inorganic sources such as ammonium nitrate may be lost through leaching. Although potassium is also leached from the soil mixtures, it can be readily replaced by bi-monthly applications of K_2SO_4. Many sands contain enough K-minerals to supply the requirements with only infrequent applications of K fertilizers.

The final phase of the re-evaluation of the USGA Green Section specifications involved the requirement for the 1½ inch coarse sand layer between the soil mixture and the gravel. Golf greens with and without the sand layer were constructed in the laboratory and in the field. Measurements of nutrient and water retention, infiltration rate and particle migration showed that the sand layer was not essential if materials of the right size distribution were used. However, if the sand used in the soil mixture was too fine, or the gravel too coarse, the layers did mix and the perched water table was destroyed. In all of the profiles, grass roots, clay, and organic matter helped to stabilize the soil particles and prevent their movement into the gravel. At the conclusion of the investigation, the soil profiles were dissasembled, and where medium textured sand and pea gravel were used, a very sharp boundary was found between the soil mixture and the gravel, both with and without the coarse sand layer.

A possible alternative to the layer of coarse sand between the gravel and soil mixture, a fibrous mat approximately 1 mm in thickness, is being investigated at Texas A&M University. The mat is less expensive and requires less time to incorporate and is more effective than the sand layer. It creates a perfect boundary between the two layers of materials, prevents clogging of the gravel, and does not interfere with water movement.

In summary, the most important considerations include the size distribution of the sand particles, the texture and structure of the soil, the nature of the organic amendment, and the size of the gravel. The sand must have the majority of its particles between 0.25 and 1.0 mm (16-60 mesh). Ideally, the majority of the particles would be in the range of 0.3 to 0.7 mm in diameter, but more practically, less than 5 per cent particles greater than 1.0 mm and no more than 20 per cent particles less than 0.25 mm in diamter. The soil should have a clay or clay loam texture and a well aggregated structure. Such soils require shredding and screening prior to mixing with the sand. Soil aggregates should pass a ¼ to ⅜ inch screen. The organic amendments should be finely divided, largely organic, and should increase the water and nutrient retention of the mixture. Also, the organic amendments, such as gin trash, wood chips, sawdust, and rice hulls should be well rotted or composted prior to incorporation in the greens mix. The pea gravel should range from ¼ to ⅜ inch in diameter. If larger gravel or crushed rock is used, a layer of pea gravel will be required prior to adding the soil mixture. Also, if fine sand is used in place of medium sand, a layer of coarse sand between the pea gravel and soil mixture will be required.

The success of the Green Section method of putting green construction is dependent not only upon proper selection of materials, but also on proper mixing and handling of these materials. Precautions must be taken to mix the materials uniformly in the recommended ratio and to see that the layered profile is not disrupted by equipment.

Table 3. Leaching losses of nitrogen (N) and potassium (K) from golf greens fertilized at 3 lbs. N and K per 1,000 square feet from various N-sourcse and K_2SO_4.

Soil Mixture			N-losses (% applied)					K-losses (% applied)
Sand	Soil	Peat	Ammonium nitrate	Urea	Ureaform	Milorganite	IBDU	(124 days)
(% by volume)			(30 days)	(27 days)	(50 days)	(47 days)	(50 days)	
100	—	—	38.0	13.5	5.9	3.6	7.5	50
90	—	10	31.5	10.0	5.0	4.0	8.0	65
85	5	10	30.0	10.0	5.0	2.1	6.5	50
80	10	10	26.7	8.2	3.5	1.5	5.0	45
—	100	—	11.2	0.5	2.2	0.7	1.9	20