ASSESSING DIFFERENTIAL ROOT ZONE MIXES FOR PUTTING GREENS OVER TIME UNDER TWO ENVIRONMENTAL CONDITIONS

Progress Report to the United States Golf Association

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Executive Summary

This project is designed to i) improve recommendations for sand particle size distribution and the depth of the root zone by consideration of the microenvironment, ii) evaluate composts as organic additives and inorganic products for root zone mixes compared to peat sources, iii) assess the potential of various root zone mixes to reduce management and resource inputs, and iv) monitor the physical, chemical, and biological changes that occur in root zones as greens mature for understanding factors that contribute to the success or failure of greens. Ten sand mixes have been constructed to give a wide range of size distributions falling within the USGA's recommendations for root zone mixes. Packed cores of the sand mixes have been made, and characterization of the sand mixes in terms of physical properties is underway. Saturated hydraulic conductivity has been measured for the ten sand mixes (without amendments); all are above the lower acceptable limit, and six of the ten mixes are above the upper acceptable limit for the accelerated range of saturated hydraulic conductivity. As expected, correspondance of sand size distrubution with saturated hydraulic conductivity was evident. Air-filled porosity at 40 cm tension was found to be within or slightly above the range recommended by the USGA. It was evident that air-filled porosity at 40-cm water tension did not completely measure porosity responsible for saturated hydraulic conductivity. Other physical properties are currently being measured. Irish moss peat, sphagnum moss peat, reed sedge peat, and sewage sludge products have been obtained as organic matter sources and are in the process of being characterized. Leaf compost and mushroom compost will also be obtained for characterization and inclusion in test mixes. Physical measurements of sand mixes with organic amendments will follow in the near future. Laboratory assessment of the sand mixes alone and in combination with amendments will be completed spring of 1997. Based on these laboratory data, root zone mixes having a range of characteristics will be identified for study in the two microenvironments of the field research facility at North Brunswick, New Jersey. It is anticipated that putting green construction will be completed in late summer of 1997. Therefore, turf grow-in will be performed over the fall, winter, and spring of 1997-1998.

Percentage of time devoted to the project by University personnel include Joshua Honig (graduate student, 50%), James A. Murphy (20%), Stephanie L. Murphy (20%), Bruce B. Clarke (10%), Harry L. Motto (5%), and Robert L. Tate III (5%).

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Narrow sand grades were obtained and mixed in various proportions to produce a total of ten sands with different particle size distributions. The distributions were qualitatively defined to be narrow or broad, within the limits of the fine, medium, or coarse sand classes of the acceptable ranges defined by the USGA (1993), making six distributions (Fig. 1). In addition, sand distributions (Fig. 2) that were predominately in the medium sand size range were adjusted to have the maximum recommended fine and very fine sand and minimal coarse sand (maximum fine tail), moderate amounts of fine and very fine sand and minimal coarse sand (fine tail), and minimal fine sand (coarse tail). An extremely coarse sand mix having all particles within the coarse and very coarse sand size classes was established as well (Fig. 2). These ten distributions are being used to represent the variability of root zone mixes that fit within USGA guidelines in terms of particle size distribution. Table 1 presents the percentages of particles in each sand size class defined by USGA guidelines for each defined sand mix.

In order to establish baseline data for the sand distribution ranges without influence of organic or inorganic amendments, the sand mixes were packed in 3-inch aluminum rings of 3-inch depth and compacted as described by Hummel (1993). With minimal wetting and a special procedure of dispensing the sand into the rings, segregation of the sand sizes within the cores was minimized.

Saturated Hydraulic Conductivity

Saturated hydraulic conductivity (K_{sat}) of the packed sand cores was determined as described in Hummel (1993). As expected, the data (Table 2) showed that K_{sat} generally decreased with decreasing sand size of the mix. "Narrow" distributions illustrate this response very well, with coarse-narrow K_{sat} > medium-narrow K_{sat} > fine-narrow K_{sat}. A coarse tail in the medium and coarse distributions increased K_{sat}; increasing fine sand progressively decreased K_{sat}. Looking at just the "broad" distributions, the coarse broad mix had significantly greater K_{sat} than medium and fine broad mixes. None of the measured K_{sat} values fit into the USGA's "normal" recommended range of K_{sat} (15-30 cm/hr); the four least conductive mixes fell within the "accelerated" recommended range of

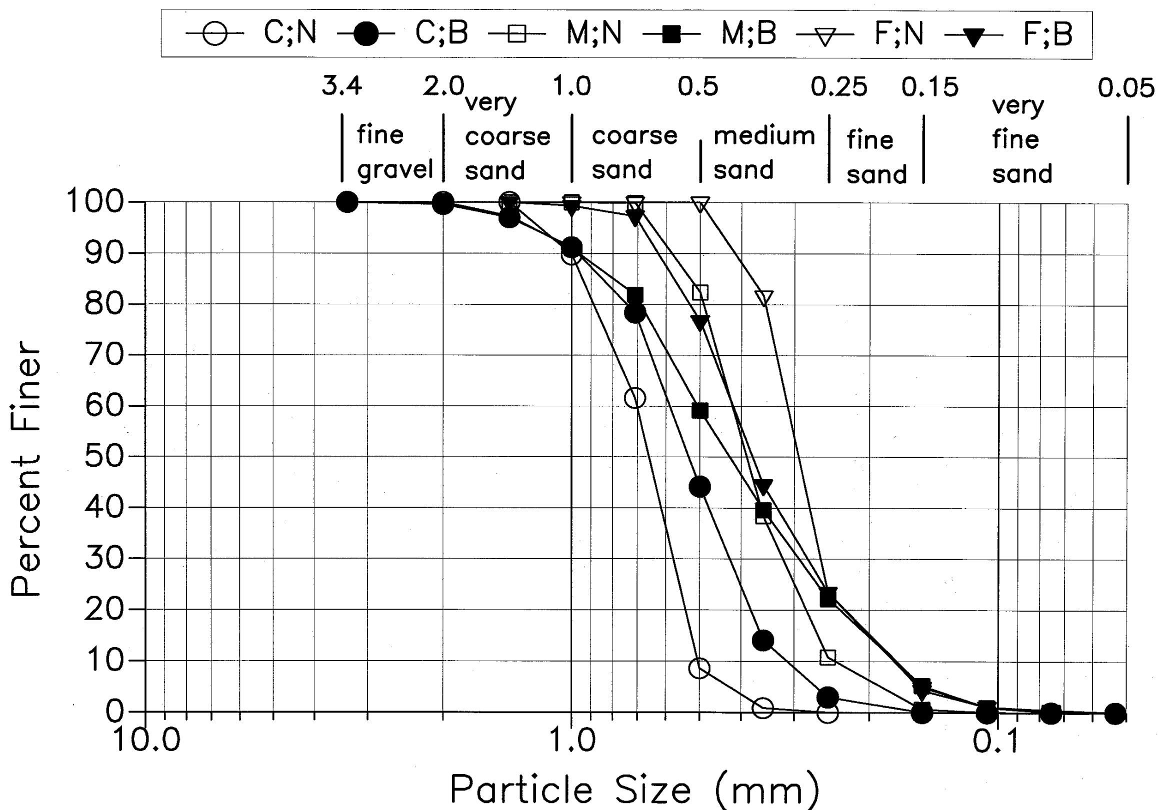

Figure 1. Sand size distribution curves for coarse, medium, and fine mixes with narrow or broad distributions.

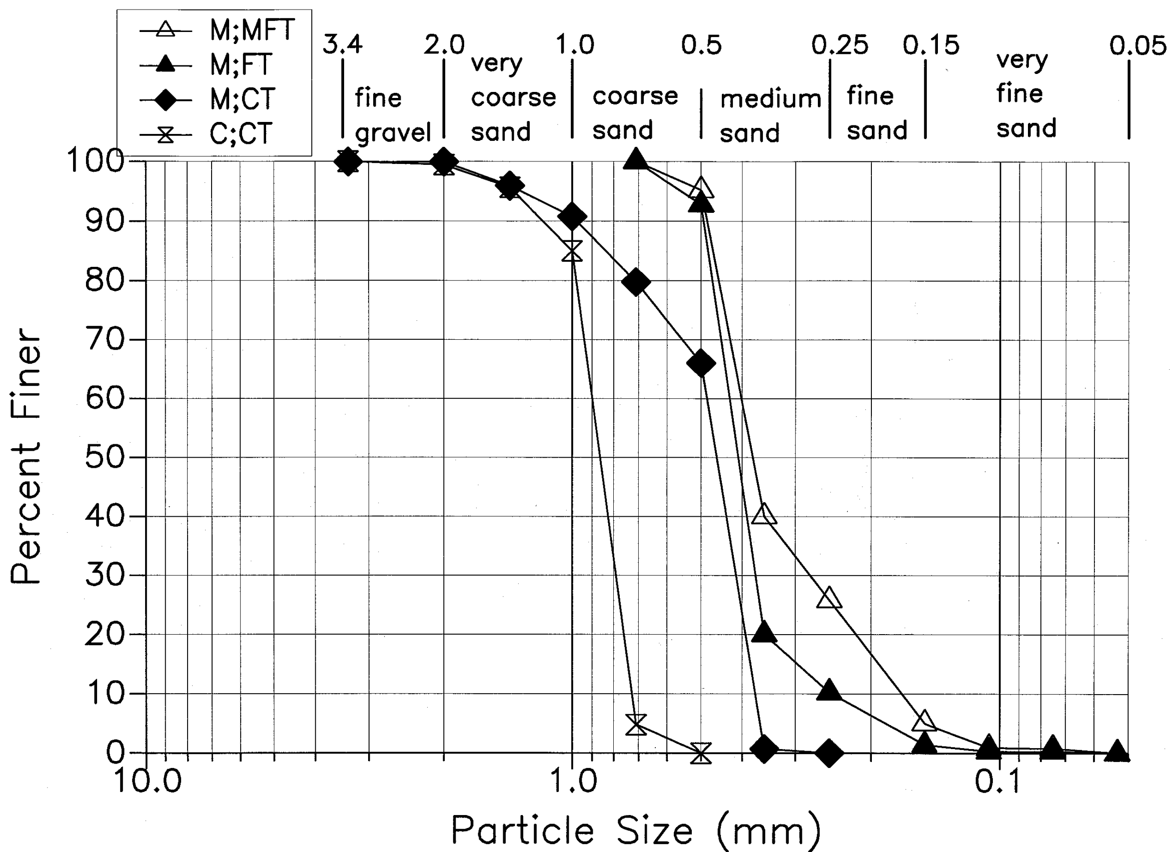

Figure 2. Sand size distribution curves for mixes modified within the fine or coarse sand classes.

Table 1. Particle size distribution of sand mixes according to USGA sand size classes.

3.4 mm ⇓ 2.0 mm ⇓ 1.0 mm ⇓ 0.5 mm ⇓ 0.25 mm ⇓ 0.15 mm ⇓ 0.05 mm ⇓ 0.002 mm ⇓

Sand Mix		Fine gravel	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		percent							
Coarse narrow	(C;N)	0.0	10.2	81.2	8.6	0.0	0.0	0.0	0.0
Coarse broad	(C;B)	0.4	8.4	47.0	41.2	3.0	0.0	0.0	0.0
Coarse coarse tail	(C;CT)	0.5	14.5	85.0	0.0	0.0	0.0	0.0	0.0
Medium narrow	(M;N)	0.0	0.0	17.6	71.6	10.2	0.6	0.0	0.0
Medium broad	(M;B)	0.0	9.0	31.8	37.0	17.0	5.2	0.0	0.0
Medium coarse tail	(M;CT)	0.0	9.4	21.7	68.9	0.0	0.0	0.0	0.0
Medium fine tail	(M;FT)	0.0	0.0	7.2	82.6	8.8	1.4	0.0	0.0
Medium max. fine tail	(M;MFT)	0.0	0.0	4.8	69.4	20.8	5.3	0.0	0.0
Fine narrow	(F;N)	0.0	0.0	0.0	76.9	19.1	4.0	0.0	0.0
Fine broad	(F;B)	0.0	0.7	22.5	53.4	18.5	4.9	0.0	0.0

K_{sat}, and all other mixes exceeded recommended K_{sat} values (USGA, 1993). The four least conductive mixes contained approximately the maximum allowable amount of fine and very fine sand. The influence of organic matter and inorganic additives on K_{sat} for sand mixes is to be determined.

Table 2. Saturated hydraulic conductivity and air-filled porosity at 40 cm water tension of sands varying in particle size distribution.

Sand Mix	Code	Saturated Hydraulic Conductivity	Air-filled Porosity at 40 cm
		($cm\ h^{-1}$)	(%)
Coarse narrow	(C;N)	138	30.0
Coarse broad	(C;B)	93	29.8
Coarse coarse tail	(C;CT)	153	30.3
Medium narrow	(M;N)	80	31.8
Medium broad	(M;B)	41	24.0
Medium coarse tail	(M;CT)	97	31.5
Medium fine tail	(M;FT)	73	30.9
Medium maximum fine tail	(M;MFT)	40	27.7
Fine narrow	(F;N)	43	29.1
Fine broad	(F;B)	42	25.8
$LSD_{0.05}$		22	1.0
C.V.		19	2.4

Air-filled Porosity

The cores then were drained under 40 cm tension (Hummel, 1993). Table 2 presents the percent volume of (macro-) pores emptied at this tension. The three coarse mixes were not significantly different in air-filled porosity at 40 cm. Strong differences were evident between narrow and broad distributions of mixes predominantly in the medium or fine sand size; broad distributions had lower air-filled porosity. Of the mixes predominantly medium in sand size, the coarse tail and the fine tail were not different from the narrow distribution, but the maximum fine tail had significantly less air-filled porosity. Most mixes had an air-filled porosity value that fell within the range (15 - 30%) recommended by the USGA (1993) for root zone mixes; exceptions are just over the upper limit.

It is interesting that there were widely ranging values of K_{sat} even when macroporespace (as indicated by air-filled porosity at 40 cm tension) was not significantly different. The poor correlation likely reflected the influence of smaller pores that contribute to saturated flow.

Bulk density and total porosity on a percent basis cannot be calculated at this point because dry weights of the cores are necessary to determine those values. Other tests are currently being run with these wetted samples before the sand cores can be dried for final weights.

Organic Matter Sources

The potential organic matter components of root zone mixes are being characterized prior to their inclusion in the sand mixes. Five sources have been identified and obtained. Irish moss peat, sphagnum moss peat, reed sedge peat, and a compost of sewage sludge and wood waste (screened and unscreened) are currently being analyzed. Leaf mulch compost and mushroom compost are being obtained for inclusion in the experiment as well.

The organic matter sources have been measured for initial water content, organic matter content by loss on ignition at 500°C, and ash content (Table 3). Moisture content of the organic matter ranged from 42% (composted sewage sludge) to 224% (Irish moss peat) of dry weight. Organic matter fractions of Irish moss peat and sphagnum moss peat were highest, while the sewage sludge compost had the lowest organic matter content and greatest ash content.

Table 3. Average initial water content, organic matter content, and ash content of five organic matter sources to be used for amending sand.

Organic Source	Water	Organic Matter	Ash
		%	
Irish moss peat	225	97.8	43.3
Sphagnum moss peat	73.4	92.6	46.3
Reed sedge peat	68.8	85.7	50.1
Sewage sludge compost	59.0	54.5	68.4
Screened SS compost	42.3	49.3	71.4
$LSD_{0.05}$	3.4	1.5	0.9
C.V. (%)	1.9	1.1	0.8

Inorganic Amendments

Several commercial inorganic amendments have been obtained. Axis, Profile, Isolite, and Greenschoice will be evaluated in sand mixes to determine the available water content and the permeability. The mixes containing these amendments will also be exposed to compactive forces as might be encountered on a golf green (e.g., foot traffic and coring tines) to determine the potential for breakdown of these products and the consequences in terms of hydraulic conductivity, available water, transport of fines (crushed product), and air-filled porosity.

Plan of Work

Laboratory assessment of the sand mixes alone and in combination with amendments will be completed spring of 1997. Based on these laboratory data, root zone mixes having a range of characteristics will be identified for study in the two microenvironments of the field research facility at North Brunswick, New Jersey. It is anticipated that putting green construction will be completed in late summer of 1997. Therefore, turf grow-in will be performed over the fall, winter, and spring of 1997-1998.

References

Hummel, N.W. 1993. Laboratory methods for evaluation of putting green root zone mixes. USGA Green Section Record (March/April).

USGA Green Section staff. 1993. USGA recommendations for a method of putting green construction. USGA Green Section Record (March/April).