# Managing water-repellent soils with inorganic soil amendments

Additional research is needed, but inorganic soil amendments may reduce water repellency in turfgrass root zones of putting greens.

**Clint Waltz, Ph.D., and Bert McCarty, Ph.D.**

Organic coatings on soil particles are widely believed to cause water-repellent soils. These coatings are thought to originate from living or decomposing plants and/or microorganisms. Plants growing in the root-zone media naturally produce organic compounds that influence a soil's tendency to become water-repellent. Likewise, the decomposition of peat, the most common amendment to sand in golf course putting green root zones, can also supply organic acids that coat sand particles.

Coarse-textured sandy soils are most likely to become water-repellent, partly because of the small specific surface area of sand particles. It has been hypothesized that adding small amounts of clay, which has a higher specific surface area, may relieve water repellency of sandy soils (5). Likewise, inorganic soil amendments with high internal pore space may also minimize water repellency in sands.

## Amendments

Since the 1960s, amendments have been investigated intensively to determine whether they can modify turfgrass root zones. Few results of long-term field trials have been reported, however. A 10-year field study (3) found that when calcined clay was the sole amendment, it compromised the ability of well-drained soil to retain water. Hybrid bermudagrass growth and quality were reduced on plots amended with calcined clay. Similarly, other studies have reported poor turfgrass performance when calcined clay was the sole amendment (1,9,11).

Few field studies have examined the use of calcined clay in turfgrass root zones, and even fewer have looked at diatomaceous earth. A moisture-retention study (10) found that Penncross creeping bentgrass plots containing a diatomaceous earth product maintained normal growth for 15 days without irrigation, whereas plots amended with ceramic clay required watering after five days.

The objectives of the present study were to investigate the interaction between amendments commonly used on golf course putting greens and the likelihood of developing water-repellent soil.

## Materials and methods

*Plot construction*

A 20,000-square-foot creeping bentgrass research green located on The Walker Course at Clemson University was established in 1997. In one section of the green, plots were established to evaluate inorganic root-zone amendments. The green consisted of a 12-inch sand root zone placed over a 4-inch-deep gravel blanket. No intermediate layer was used between the sand and the gravel.

Polyvinyl chloride (PVC) sheets were installed vertically, extending 12 inches downward from the soil surface into the top 1 inch of the 4-inch gravel layer, to contain individual amendments. Individual cells were 9 feet by 15 feet and replicated three times in a randomized complete block design. A 4-inch corrugated drain line was installed under the gravel layer of each replication.

**KEY** points
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- **Organic coatings on soil particles** are widely believed to cause water-repellent soils.
- **Adding clay or inorganic soil amendments** may decrease water repellency in coarse, sandy soils.
- **In this study, quartz sand** was amended with Canadian sphagnum peat, calcined clay and diatomaceous earth.
- **Overall, the inorganic soil amendments** reduced water repellency of straight sand.

*Cultural practices*

Plots were leveled to a depth of 12 inches, wetted, rolled and, on Oct. 8, 1997, seeded with L-93 creeping bentgrass at 1.5 pounds per 1,000 square feet. The entire plot area was irrigated to promote adequate soil moisture to achieve germination. During establishment and over the course of the study, plots were fertilized according to standard practices to maintain proper growth. Plots were treated with fungicides and insecticides on a preventive and as-needed basis. All plots were topdressed with straight sand and core-cultivated periodically throughout each growing season to promote healthy turfgrass. Plots were mowed daily at 0.125 inch with a commercial walk-behind reel mower.

*Root-zone media*

Root-zone media were constructed using washed quartz sand commonly used for putting green construction and meeting USGA recommendations. Root-zone media were prepared using one of three amendments: Canadian sphagnum peat, a calcined clay product and a diatomaceous earth product. Root-zone media were prepared at an off-site blender by adding amendments to sand at 15% by volume.

## Sampling

Once during the summer of 1999 and three times during the summer of 2000, two subsamples per plot were obtained using a soil core sampler and a standard golf course cup cutter. Samples were taken at three depths or tiers along the same vertical cross section: from the soil surface to a depth of 4 inches (first tier), from 4 to 8 inches (second tier) and from 8 to 12 inches (third tier).

The first tier was taken using the soil core sampler. After the sample was extracted, the upper 0.5 to 0.75 inch (turfgrass tissue and thatch) was removed, and the remaining sample was stored in a moisture-tight plastic bag. The second and third tiers were sampled using the soil core sampler and the cup cutter. The cup cutter was used to cut around the hole and to the bottom of the first tier (4 inches). This soil was carefully placed aside for refilling after sampling, and then the second tier was sampled in the same manner as the first. Like the second tier, the third tier was extracted by using the cup cutter to remove the upper 8 inches of soil, and then the sample was taken.

After sampling, all holes were back-filled with the spoils, and a laboratory-prepared mix, similar to the original blend, was used to bring the surface to grade.

### WATER-REPELLENCY CLASSIFICATIONS

| WDPT (seconds) | Description |
|---|---|
| 0 - 5 | wettable; not water-repellent |
| 5 - 60 | slightly water-repellent |
| 60 - 600 | moderately to strongly water-repellent |
| 600 - 3,600 | severely water-repellent |
| >3,600 | extremely water-repellent |

**Table 1.** Classification of water repellency is based on water-drop penetration time (WDPT).

### ORGANIC MATTER IN TIERS

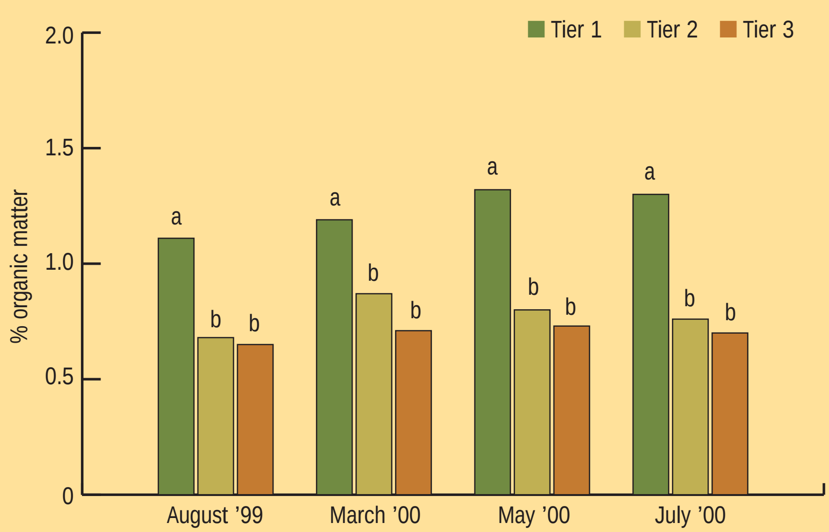


**Figure 1.** The percentage of organic matter in three tiers of a putting green root zone: tier 1, from the soil surface to a depth of 4 inches; tier 2, 4 to 8 inches below the surface; and tier 3, 8 to 12 inches below the surface. For a single rating date, columns with the same letter are not significantly different.

*Sample preparation*

After samples were collected, they were dried and ground in the laboratory. Particle-size distribution and physical properties (that is, bulk density, total porosity, air-filled porosity, capillary porosity and saturated hydraulic conductivity) were measured for each mixture by standard practices. Organic content for each sampling date and tier was measured by burning the sample in a furnace at 1,472 F (800 C) for four hours.

*Water repellency*

Water repellency was determined with the water-drop penetration time (WDPT) test (2,7). For each root-zone mixture and tier, a 15- to 20-gram subsample of ground and homogenized oven-dried sample was put into a ceramic crucible. A medicine dropper was used to place three drops of distilled deionized water on the leveled surface of the subsample. The time, in seconds, for the drops to infiltrate the soil was recorded and averaged. The water-repellency classifications are shown in Table 1 (2,12).

## Results and discussion

*Organic matter*

In all cases, tier 1 had significantly greater organic matter content than tiers 2 and 3 (Figure 1). For all sampling dates, tier 1 had greater than 1% organic matter by weight. For tiers 2 and 3, the highest organic matter content for any of the sampling dates was in March 2000.

Tier 1 plots amended with Canadian sphagnum peat and calcined clay had organic matter content 0.25 to 0.95% greater than that in unamended plots and plots amended with diatomaceous earth (Figure 2). A similar trend was observed in tiers 2 and 3.

*Water repellency*

Some degree of water repellency was measured in all root-zone mixtures for all tiers and sampling dates (Table 2). For all sampling dates and depths, the Canadian sphagnum peat mixture had WDPT greater than 60 seconds (100 to 478 seconds), indicating the mixture was moderately to strongly water-repellent. Among the other three root-zone mixtures, differences in degrees of repellency were measured among tiers.

In tier 1, which had the highest percentage of organic matter (0.72 to 1.78%), all root-zone mixtures were strongly water-repellent. The only exceptions were for the August 1999 and March 2000 samplings of the diatomaceous earth mixture, which were slightly water-repellent.

In tier 2, straight sand was slightly repellent on three of the four sampling dates; the exception was the July 2000 sampling with a WDPT of 106 seconds. In tier 3, root-zone sand was wettable for the March 2000 and May 2000 samplings and slightly water-repellent in August 1999 and July 2000.

In tiers 2 and 3, both inorganic soil amendment mixtures were wettable (WDPT < 5 seconds). The only exception was a slightly water-repellent rating (WDPT = 6 seconds) for diatomaceous earth in tier 2 in July 2000.

Interestingly, different WDPT were recorded for straight sand and diatomaceous earth mixtures that contained identical organic matter contents (0.52%) in tier 2. The diatomaceous earth mixture was not water-repellent (WDPT = 3 seconds), but straight sand was moderately to strongly water-repellent.

Some research (8) has shown a tendency for water repellency to decrease as soil size fractions decrease. Physical analysis showed the diatomaceous earth mixture had a greater number (four times greater than the other combinations) of fines, particles smaller than 0.5 millimeters. The higher content of fine particles measured in the diatomaceous earth mixture may have made it less water-repellent than the straight sand.

## Conclusions

This study further demonstrates the interaction between organic matter and water repellency. Given the results of previous studies (4,6,8,13,14), it was not surprising to find a higher WDPT (that is, more water repellency) in the mixture containing organic matter (Canadian sphagnum peat). Because of their texture and internal pores, inorganic soil amendments may decrease the tendency toward organic coating accumulation and decrease the likelihood that amended sand will become water-repellent.

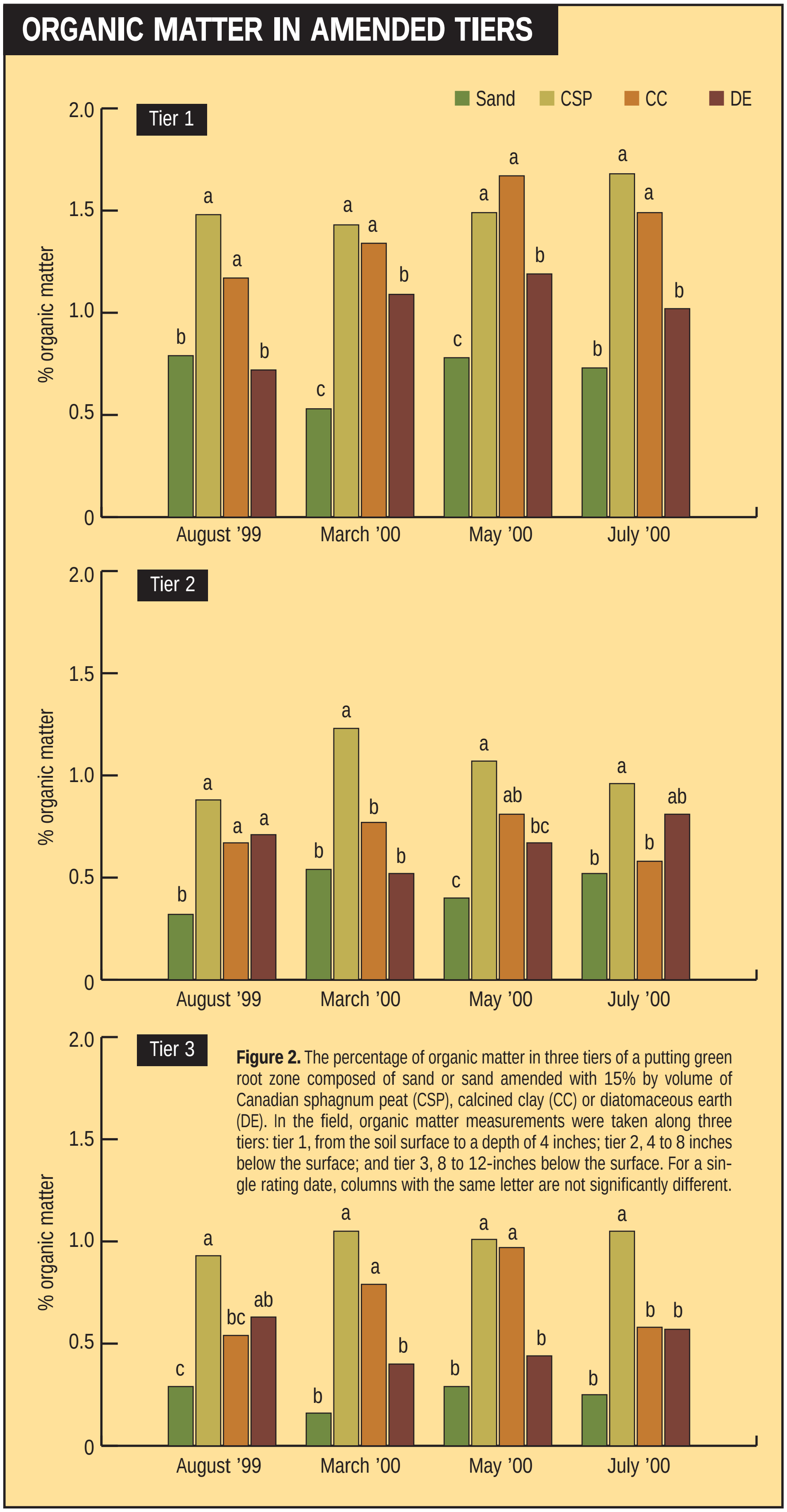


**Figure 2.** The percentage of organic matter in three tiers of a putting green root zone composed of sand or sand amended with 15% by volume of Canadian sphagnum peat (CSP), calcined clay (CC) or diatomaceous earth (DE). In the field, organic matter measurements were taken along three tiers: tier 1, from the soil surface to a depth of 4 inches; tier 2, 4 to 8 inches below the surface; and tier 3, 8 to 12-inches below the surface. For a single rating date, columns with the same letter are not significantly different.

# RESEARCH

Research involving water repellency and inorganic soil amendments is limited, but these data demonstrate a positive effect of inorganic soil amendments on root-zone mixtures. Future research is needed to investigate the effect of inorganic soil amendments on water-contact angle and the occurrence of organic coatings on the amendment surfaces.


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Clint Waltz, Ph.D. (cwaltz@uga.edu), is an assistant professor in the department of crop and soil science, University of Georgia, Griffin. Bert McCarty, Ph.D., is a professor in the department of horticulture, Clemson University, Clemson, S.C.


## ORGANIC MATTER AND WDPT IN ROOT-ZONE MEDIA

| Sampling date | Sand | | | | | | Sand : CSP | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tier 1 | | Tier 2 | | Tier 3 | | Tier 1 | | Tier 2 | | Tier 3 | |
| | OM (%) | WDPT (seconds) | OM (%) | WDPT (seconds) | OM (%) | WDPT (seconds) | OM (%) | WDPT (seconds) | OM (%) | WDPT (seconds) | OM (%) | WDPT (seconds) |
| August 1999 | 0.79 | 203 | 0.32 | 30 | 0.29 | 7 | 1.57 | 478 | 0.88 | 314 | 0.93 | 210 |
| March 2000 | 0.71 | 127 | 0.50 | 30 | 0.13 | 4 | 1.43 | 166 | 1.24 | 227 | 1.05 | 124 |
| May 2000 | 0.78 | 307 | 0.40 | 54 | 0.29 | 5 | 1.46 | 364 | 1.07 | 173 | 1.01 | 100 |
| July 2000 | 0.73 | 474 | 0.52 | 106 | 0.25 | 14 | 1.78 | 452 | 0.99 | 232 | 1.05 | 145 |

| Sampling date | Sand : CC | | | | | | Sand : DE | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tier 1 | | Tier 2 | | Tier 3 | | Tier 1 | | Tier 2 | | Tier 3 | |
| | OM (%) | WDPT (seconds) | OM (%) | WDPT (seconds) | OM (%) | WDPT (seconds) | OM (%) | WDPT (seconds) | OM (%) | WDPT (seconds) | OM (%) | WDPT (seconds) |
| August 1999 | 1.16 | 109 | 0.67 | < 1 | 0.53 | < 1 | 0.72 | 60 | 0.71 | 2 | 0.63 | < 1 |
| March 2000 | 1.34 | 142 | 0.77 | 1 | 0.79 | < 1 | 1.25 | 27 | 0.52 | 3 | 0.40 | < 1 |
| May 2000 | 1.67 | 296 | 0.81 | 2 | 0.97 | < 1 | 1.19 | 151 | 0.67 | 4 | 0.44 | < 1 |
| July 2000 | 1.49 | 344 | 0.58 | 1 | 0.57 | < 1 | 1.02 | 95 | 0.95 | 6 | 0.57 | < 1 |

Note. — Core samples were ground and homogenized for each tier (tier 1, soil surface to 4 inches; tier 2, 4 to 8 inches; and tier 3, from 8 to 12 inches). Organic matter (OM) was measured as % loss on ignition. Average water-drop penetration time (WDPT) of three drops of distilled de-ionized water.

**Table 2**. The percentage of organic matter (OM) content and the water-drop penetration time (WDPT) in seconds are shown for sand and root-zone media amended at 15% by volume with Canadian sphagnum peat (CSP), calcined clay (CC) or diatomaceous earth (DE).