Effects of organic fertilizers on saturated hydraulic conductivity of USGA root zones

Ash from some common organic fertilizers did not adversely affect the saturated hydraulic conductivity of root zones.

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Researchers have reported problems associated with the accumulation of organic matter in sand root zones of golf greens (4,5,7), leading some to question whether applying commercial fertilizers with high organic matter content contributes organic matter and other material to these root zones (8).

The contribution of these fertilizers to the overall organic accumulation of a golf green seems limited considering the amount of organic matter produced by the turfgrass stand each year. Although the amount of organic material a turfgrass stand produces in a year varies depending on species, growing conditions, fertility, etc., a conservative estimate is 5,000 pounds of oven-dried organic matter/acre (560.4 grams/square meter). Researchers have reported amounts higher than 7,000 pounds/acre/year (784.6 grams/square meter/year) (6). If a superintendent applied a fertilizer with high organic matter content, such as Ringer 10-2-6, to his greens to deliver 5 pounds of actual nitrogen/1,000 square feet/year (24.4 grams/square meter/year), the amount of organic matter added annually would be about 1,500 pounds/acre (168.1 grams/square meter).

This estimate of organic matter applied is generated from data reporting Ringer 10-2-6 as having a loss on ignition of about 75% (7). Chances are that not all of this loss is from organic material and thus the 1,500-pound/acre (168.1-gram/square meter) estimate is probably higher than the actual amount applied. Although 1,500 pounds (168.1 grams/square meter) is significant, the amount produced from the turfgrass stand is a magnitude higher. The additional organic matter being applied through the high-organic-matter fertilizer represents a fraction of the total amount of organic matter accumulating in these root zones, and using these fertilizers would not alter the practices used to manage the organic matter.

The nonorganic matter content or the ash that remains could potentially be of greater concern. The ash that remains after a loss-on-ignition test is typically referred to as mineral matter or material that will not ignite and burn at high temperatures. The concern is that these products may contain high amounts of "fines" because traditional USGA-approved methods for measuring the particle size of a sand root zone (2) have yielded data suggesting that some products contained as much as 20% clay. When applied at a rate to deliver 5 pounds of nitrogen/1,000 square feet (24.4 grams/square meter), a fertilizer could add as much as 50 pounds of fines/1,000 square feet (244.1 grams/square meter).

This experiment examined the effect of applications of a few commonly available organic fertilizers on the saturated hydraulic conductivity of a USGA root zone. We specifically wanted to evaluate the effect of the nonorganic portion of the fertilizer products.

Methods and results

Five organic and four nonorganic fertilizer prod-

Ash produced from the fertilizers was applied to cylinders containing a USGA-specified root-zone mix at rates equal to the amount that would be applied when using that product to deliver 5, 10 or 20 pounds of nitrogen/1,000 square feet (24.4, 48.8 or 97.6 grams/square meter). **Photos by A. McNitt**

ucts were selected for evaluation (Table 1). Each fertilizer was dried, weighed and exposed to a temperature of 824 F (440 C) until a constant weight was achieved (1). The remaining ash was weighed, and a loss-on-ignition value was calculated (Table 1). We applied the ash produced from the fertilizers to cylinders containing a USGA-recommended root-zone mix at rates equal to the amount of material that would be applied when using that product to deliver 5, 10 or 20 pounds of nitrogen/1,000 square feet (24.4, 48.8 or 97.6 grams/square meter). Three replications of each treatment were performed where the ash was applied to the surface of the root zone in the cylinder before compaction. Three more replications were performed where the ash was applied to the surface and worked into the top 0.16 inch (4 millimeters).

Noncombusted fertilizer also was applied at a rate to deliver nitrogen at 5 pounds/1,000 square feet (24.4 grams/square meter) to treatment cylinders and worked into the surface 0.16 inch (4 millimeters). It was not practical to apply noncombusted fertilizer at the rates needed to deliver more than 5 pounds/1,000 square feet (24.4 grams/square meter). Saturated hydraulic conductivity was determined for each treatment cylinder (3) (Table 2). None of the treatments tested had a saturated hydraulic conductivity lower than the control. Neither the noncombusted fertilizer nor the ash treatments had a negative effect on the saturated hydraulic conductivity of this root-zone mix.

Fertilizers tested

Product†	$N\text{-}P_2O_5\text{-}K_2O$ analysis	% loss on ignition‡
Earthworks (O)	5-4-5	52.9
Greens King (I)	18-9-18	49.0
IBDU (I)	31-0-0	99.6
Isotek (I)	11-3-22	47.6
Milorganite (O)	6-2-0	75.4
NatureSafe (O)	8-3-5	65.2
Nutralene (I)	40-0-0	99.6
Ringer (O)	10-2-6	73.7
Sustane (O)	5-2-4	56.6

†O, organic; I, inorganic.
‡Determined by exposing samples to 824 F (440 C) for 16 hours.

Table 1. Fertilizer products included in the experiments, their $N\text{-}P_2O_5\text{-}K_2O$ analyses and their percent loss on ignition.

The amount of ash applied was very high. We questioned how the application of such a large amount of material had no negative effect on the hydraulic conductivity of the sand root zone. Solubility tests were conducted on the ash and fertilizer using both water and sulfuric acid as solvents (Table 3). The total silica content of the ash and fertilizers also was determined (Table 3). The amount of silica present had a high correlation with the percent solubility of both the ash and fertilizer (data not shown). The solubility of the Milorganite and Sustane ash was lower than that of the other products, but sand-sized particles made up 86.5% of the Milorganite ash and 50.7% of

Hydraulic conductivity

Product	Nitrogen rate (pounds/1,000 square feet)	Material applied (pounds/1,000 square feet)	K_{sat} (inches/hour)
Control	—	—	20.8
Earthworks ash	5	47.1	20.9
Earthworks ash	10	94.2	21.9
Earthworks ash	20	188.4	22.2
Earthworks fertilizer	5	100.0	22.7
Greens King ash	20	6.6	19.8
IBDU ash	20	0.3	24.5
Isotek ash	20	87.1	24.3
Milorganite ash	5	20.7	20.3
Milorganite ash	10	41.4	23.4
Milorganite ash	20	82.8	23.2
Milorganite fertilizer	5	83.3	21.5
NatureSafe ash	5	21.8	19.4
NatureSafe ash	10	43.5	22.3
NatureSafe ash	21.6	94.0	22.4
NatureSafe fertilizer	5	62.5	21.8
Nutralene ash	20	0.2	24.0
Ringer ash	20	53.3	20.7
Sustane ash	20	173.6	22.5

Note. Root-zone mix of cylinders consisted of 80% sand:20% peat (by volume). Ash or fertilizer was applied to the top of compacted cylinders at a rate equivalent to the indicated amount of nitrogen per 1,000 square feet.

Table 2. Saturated hydraulic conductivity (K_{sat}) of treatment with ash or fertilizer applied at rates equivalent to varying amounts of nitrogen per 1,000 square feet.

Three replications of each treatment were performed where the ash was applied to the surface of the root zone in the cylinder before compaction, and three more replications were performed where the ash was applied to the surface and worked into the top 0.16 inch (4 millimeters), as shown in the photo.

the Sustane ash and thus had no negative effect on the hydraulic conductivity of the root-zone mix.

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The research says

→ To determine whether applications of commercial fertilizers with high organic matter content contributed excessive organic matter and other material to sand-based root zones, researchers examined the effect of applications of a few commonly available organic fertilizers on the saturated hydraulic conductivity of a USGA root zone.

→ Applying large quantities of the fertilizers used in this study or the ash produced from these fertilizers had no effect on the saturated hydraulic conductivity of a root zone built following USGA recommendations.

→ A significant portion of the ash produced from these organic fertilizers was water-soluble. Ash from Milorganite and Sustane was made up of sand-sized particles.

→ The traditional method of determining particle size distribution through sedimentation is not an appropriate method for determining the particle size of organic fertilizers or the ash produced from these fertilizers because much of the material is soluble in water.

Solubility and silica content

	Ash		Fertilizer		Silica content	
	Distilled water†	0.5 N H_2SO_4‡	Distilled water†	0.5 N H_2SO_4‡	Ash	Fertilizer
Product	% solubility				parts per million	
Earthworks 5-4-5	63.0	38.5	33.3	21.2	12,724	6,731
Greens King 18-9-18	71.3	71.1	34.9	34.9		
Isotek 11-3-22	80.1	87.9	38.1	42.6		
Milorganite 6-2-0	7.3	43.1	5.5	34.5	59,903	45,166
NatureSafe 8-3-5	68.6	80.5	44.7	55.4	11,984	7,814
Ringer 10-2-6	71.9	98.3	53.0	73.3	1,710	1,260
Sustane 5-2-4	28.2	56.0	16.0	33.6	34,915	19,762

†Samples were mixed with 100 milliliters distilled water, boiled for 2 minutes, filtered through No. 43 ashless filter paper, rinsed with approximately 250 milliliters distilled water and exposed to 824 F (440 C) for 16 hours.
‡Samples were soaked in 0.5 N H_2SO_4 for approximately 15 minutes, filtered through No. 43 ashless filter paper, rinsed with approximately 250 milliliters distilled water and exposed to 824 F (440 C) for 16 hours.

Table 3. Percent solubility of fertilizer and ash using water and 0.5 N H_2SO_4 sulfuric acid as solvents, and silica content of ash and organic fertilizers.