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Volume 6, Number 12
June 15, 2007

PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 290 projects at a cost of $25 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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The Effects of Organic Fertilizers on the Saturated Hydraulic Conductivity of USGA Rootzones

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SUMMARY

Because of concerns regarding the contribution of organic matter and other material to sand-based rootzones through the application of high organic matter commercial fertilizers, researchers at the Pennsylvania State University examined the effect of applications of a few commonly available organic fertilizers to the saturated hydraulic conductivity of a USGA rootzones. The study's findings include:

- The application of 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 USGA-specified rootzone.
- A significant portion of the ash produced from these organic fertilizers was water soluble or in the case of Milorganite and Sustane, sand-sized particles.
- The traditional method to determine particle size distribution through sedimentation is not an appropriate method to determine the particle size of organic fertilizers or the ash produced from these fertilizers because much of the material is soluble in water.

Problems associated with organic matter accumulation in golf green sand rootzones have been widely reported (4, 5, 7). Questions have been raised about the contribution of organic matter and other material to these rootzones through the application of high organic matter commercial fertilizers (8).

The contribution of these high organic matter content 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. The amount of organic material a turfgrass stand produces in a year varies depending on species, growing conditions, fertility, etc., but the addition of 5,000 pounds of oven dry organic matter per acre per year is a conservative estimate. Researchers have reported amounts higher than 7,000 pounds per year (6). If a superintendent applied a high organic matter content fertilizer source such as Ringer 10-2-6 to their greens to deliver 5 pounds of actual nitrogen per thousand square feet per year, the amount of organic matter added would be about 1,500 pounds per acre.

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 estimate is probably higher than the actual amount applied. While a significant amount, the amount produced from the turfgrass stand is a magnitude higher. The additional organic matter being applied through the use of high organic matter represents a fraction of the total amount of organic matter accumulating in these rootzones, and the practices used to manage the organic matter would not be

Enough ash was produced from the fertilizers to apply the equivalent amount of ash to cylinders containing a USGA specified rootzone mix at rates equal to the amount of material that would be applied when using that product to deliver 5, 10, and 20 lbs of N per thousand square feet

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Product	Analysis
IBDU	31-0-0
Nutralene	40-0-0
Isotek	11-3-22
Greens King	18-9-18
Milorganite	6-2-0
Earthworks	5-4-5
NatureSafe	8-3-5
Ringer	10-2-6
Sustane	5-2-4

Table 1. Fertilizer products and their N-P_2O_5-K_2O analyses that were included in the experiments

altered due to the use of these fertilizers.

The non-organic 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 there may be high amounts of "fines" in these products as traditional USGA approved methods for measuring the particle size of a sand rootzone (2) yielded data suggesting that some products contained as much as 20% clay. When applied at a rate to deliver 5 pounds of nitrogen per thousand square feet, a fertilizer conceivably would be adding as much as 50 pounds of fines per thousand square feet.

Product	Percent loss on ignition*
	--(%)--
IBDU 31-0-0	99.6
Nutralene 40-0-0	99.6
Milorganite 6-2-0	75.4
Ringer 10-2-6	73.7
NatureSafe 8-3-5	65.2
Sustane 5-2-4	56.6
Earthworks 5-4-5	52.9
Greens King 18-9-18	49.0
Isotek 11-3-22	47.6

* Determined by exposing samples to 440^{o}C for 16 hours.

Table 2. Percent loss on ignition of various organic and non-organic fertilizers

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

Methods and Results

Five organic and four nonorganic fertilizer products were selected for evaluation and are listed in Table 1. Each fertilizer was dried, weighed, and exposed to temperature of 440^{o} C until a constant weight was achieved (1). The remaining ash was weighed and a loss on ignition value was calculated (Table 2). Enough ash was produced from the fertilizers to apply the equivalent amount of ash to cylinders containing a USGA specified rootzone mix at rates equal to the amount of material that would be applied when using that product to deliver 5, 10, and 20 pounds of N per thousand square feet. Three replications of each treatment were performed where the ash was applied to the surface of the rootzone in the cylinder prior to compaction. Three more replications were performed where the ash was applied to the surface

Three replications of each treatment were performed where the ash was applied to the surface of the rootzone in the cylinder prior to compaction and three more replications were performed where the ash was applied to the surface and worked into the top 4 mm (shown above).

Product	N Rate	Material applied	K_{sat}
	(lb/1000ft^2)	(lb/1000ft^2)	(in/hr)
Control	--	--	20.8
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
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
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
Ringer ash	20	53.3	20.7
Sustane ash	20	173.6	22.5
IBDU ash	20	0.3	24.5
Nutralene ash	20	0.2	24.0
Isotek ash	20	87.1	24.3
Greens King ash	20	6.6	19.8

Rootzone 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 1000 ft^2.

Table 3. Saturated hydraulic conductivity (K_{sat}) of treatment with ash or fertilizer applied at rates equivalent to varying amounts of N/1000 ft^2.

Product	Ash		Fertilizer	
	Distilled water[1]	0.5 N H_2SO_4[2]	Distilled water	0.5 N H_2SO_4
	%			
Isotek 11-3-22	80.1	87.9	38.1	42.6
Ringer 10-2-6	71.9	98.3	53.0	73.3
Greens King 18-9-18	71.3	71.1	34.9	34.9
NatureSafe 8-3-5	68.6	80.5	44.7	55.4
Earthworks 5-4-5	63.0	38.5	33.3	21.2
Sustane 5-2-4	28.2	56.0	16.0	33.6
Milorganite 6-2-0	7.3	43.1	5.5	34.5

[1] Samples were mixed with 100 ml distilled water, boiled for 2 minutes, filtered through No. 43 ashless filter paper, rinsed with approximately 250 ml distilled water and exposed to 440^{o} C for 16 hours.

[2] 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 ml distilled water and exposed to 440^{o} C for 16 hours.

Table 4. Percent solubility of fertilizer and ash using water and 0.5 N sulfuric acid as solvents

Product	Ash	Fertilizer
	ppm	
Ringer	1,710	1,260
NatureSafe	11,984	7,814
Earthworks	12,724	6,731
Sustane	34,915	19,762
Milorganite	59,903	45,166

Table 5. Silica content of ash and organic fertilizers

and worked into the top 4 mm.

Non-combusted fertilizer was also applied at a rate to deliver 5 pounds of N per thousand square feet to treatment cylinders and worked into the surface 4 mm. Rates of non-combusted fertilizer above the rates needed to deliver 5 pounds of N per thousand square feet were not practical. Saturated hydraulic conductivity was determined on each treatment cylinder (3). The results are listed in Table 3. None of the treatments tested had a saturated hydraulic conductivity lower than the control. Neither the non-combusted fertilizer nor the ash treatments negatively affected the saturated hydraulic conductivity of this rootzone mix.

The amount of ash applied was very high. We questioned how the application of such a large amount of material had no negative affect on the hydraulic conductivity of the sand rootzone. Solubility tests were conducted on the ash and fertilizer using both water and sulfuric acid as solvents. The results are listed in Table 4. The total silica content of the ash and fertilizers was also determined and results are listed in Table 5. The amount of silica present had a high correlation with the percent solubility of both the ash and fertilizer (Table 6). The solubility of the Milorganite and Sustane ash was lower than the other products; however, 86.5% of the Milorganite ash and 50.7% of the Sustane ash was sand-sized particles and thus had no negative affect on the hydraulic conductivity of the rootzone mix.

	Fertilizer Solubility	Si ash	Si fertilizer
Ash Solubility	0.97	-0.98	-0.96
Fertilizer Solubility		-0.96	-0.91

Table 6. Correlation coefficients comparing the water solubility of organic fertilizers, the ash remaining after loss on ignition, and the total Silica (Si) content (ppm) of the fertilizers and ash.

Acknowledgements

The authors would like to thank USGA's Turfgrass and Environmental Research Program for funding this project.

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