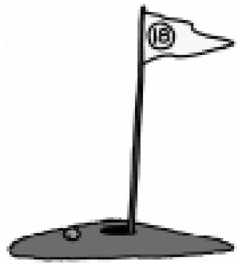

TOP-DRESSING A HIGH-SAND CONTENT PUTTING GREEN WITH INORGANIC SOIL AMENDMENTS

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IMPACT STATEMENT

A field study was designed to study several inorganic soil amendments as a substitute for sand in the top-dressing of an aerified, sand-based putting green. Several forms of natural zeolites, calcined clays, and diatomaceous earth were blended with sand and used to backfill aerification holes on a sand-based putting green. Several of these amendments enhanced turfgrass recovery and quality in this study, but many failed to perform as well as sand. The major chemical property of these amendments that was unique from sand was a high cation exchange capacity (CEC), which should facilitate nutrient retention. However, most of the products failed to meet the proper particle size distribution for inclusion in a U.S. Golf Association (USGA) green. Further study is needed to clarify the role of inorganic amendments in sand-based putting greens.

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BACKGROUND

Since the early 1960s, one of the major advances in the field of golf and sports turf management has been the development of growing media with high sand content for putting greens and athletic fields. The USGA has been the leading proponent and developer of this technology, and the USGA green is the most widely accepted form of green construction being used in the industry today (Anonymous, USGA, 1993). The primary advantages of sand technology are that the growing media remains well-drained under a range of conditions and that it resists foot and equipment compaction. However, a sand medium has poor nutrient-holding characteristics and is subject to leaching of nutrients and agricultural pesticides.

In recent years, there has been an active interest in substituting other inorganic materials for sand in USGA-type green construction. The materials that have received the most attention include various forms of zeolites, calcined clays, and diatomaceous earth. These products have similar physical characteristics to sand (i.e., porous and compaction-resistant) but provide the added benefit of enhancing nutrient-holding capacity through inherent CEC. Several studies have indicated that zeolites, calcined clays, and diatomaceous earth can significantly enhance nutrient retention in a sand matrix (Bigelow et al., 1997; Kithome et al., 1998) and improve the performance of the grass growing in that medium (Ervin et al., 1999; Huang and Petrovic, 1996). The inorganic amendments can also be preloaded with cations such as NH_4^+ to further enhance their performance (Andrews et al., 1999).

Although the construction of new putting greens using inorganic sand substitutes is getting most of the current research effort, many existing sand-based greens may also benefit from this technology. A common management program on greens is to core-aerify the green one to two times per year and backfill the aerification holes with pure sand. This program enhances or maintains the long-term physical structure of the green. Because aerification holes are routinely back-filled with pure sand, there is an opportunity to replace the sand with other amendments, including the inorganic amendments listed above. This report describes one part of a long-term study to modify the sand matrix of a USGA putting green with inorganic amendments; this segment of the study examined the recovery from aerification of a USGA green amended with 14 inorganic amendments. The report also describes the chemical and physical properties of those materials.

RESEARCH DESCRIPTION

This study was conducted on a USGA-type putting green at Pinnacle Country Club in Rogers, Ark. The green was planted with ‘Penn Links’ creeping bentgrass and maintained according to procedures consistent with the remainder of the golf course. On 19 Oct. 1999, the green was aerified in one direction using a hollow-tine aerifier with 0.5 x 3.0-in. tines with 2 x 2-in. spacing. Cores were removed from the green prior to establishment of the plots. The plot layout was a randomized complete block design with three replications. Individual treatment plots were 4 x 4 ft. A total of 13 soil amendment treatments were blended with pure sand at a 20% (v/v) rate. Sand alone was used as the control. A 1-ft^3 volume of blended material was spread evenly across each plot and hand-brushed into the aerification holes. This amount of material was calculated as the approximate amount needed to both fill the aerification holes and topdress the plot with 0.125 in. of mix.

Regrowth of the aerification holes was estimated beginning on day 7 after application of treatments, and continued regularly for approximately 1 month. Regrowth ratings were visually assessed on a scale of 0 to 9, with 0 representing no regrowth and 9 representing complete recovery. The 0 to 9 scale was converted to percent recovery by multiplying by 11.1.

Samples from each amendment were submitted to the University of Arkansas Agricultural Services Laboratory for analysis of nutrient content, pH, electrical conductivity, and CEC (by ammonia acetate substitution). A particle-size analysis was conducted for all the materials, with the primary focus on sand-size separates. A 40-g sample of each amendment was passed through a series of sieves with a minimum hole size of 2 mm, 1 mm, 0.5 mm, 0.25 mm, 0.1 mm, and 0.05 mm. The amount of material collected on each sieve was weighed and the percentage of total sample was calculated for each fraction.

Data for each rating day were analyzed by analysis of variance procedures using SAS. Mean separation was conducted by least significant difference (LSD) with a probability level of 0.05. Chemical and physical data for each material was determined on a single sample, so statistical analysis was not possible on that data. Regression analysis was used to assess the relationship between nitrogen (N) content and CEC of the amendment to regrowth of the aerification holes.

FINDINGS

Chemical and physical analysis of the materials indicated that the inorganic amendments have distinct properties relative to sand

(Tables 1 and 2). Most of these amendments have a high CEC relative to sand (Table 1), and several of the products contain a significant amount of total N, which is preloaded by the submitting companies. The N content of the materials ranged from 133 mg/kg for sand to 13,090 mg/g for ZeoSand 25DR. As a group, the zeolites had a much higher CEC, followed by diatomaceous earth and calcined clays. The high CEC relative to sand would likely affect the long-term ability of the root-zone to retain nutrients. Many of the products also have chemical properties that would be considered undesirable over an extended period. Clinolite and Ecosand have a very high pH (8.9 and 8.6, respectively) which would affect nutrient availability over time. In addition, several of the zeolite materials contained 40 to 70 times more sodium than sand, a property that could affect total salinity in the system.

In order for these inorganic amendments to be used in a USGA green, the physical properties of the material must meet size characteristics that will prevent changes in porosity or hydraulic conductivity of the root zone (Anonymous, USGA, 1993). Of the 14 inorganic amendments tested in this study, only five products met the requirements set forth by the USGA with respect to particle size distribution (Table 2): sand, Zeoponix A, ZeoSand N, Red Plus, and Profile. All the other products contained too many particles in the 1-2 mm range, which according to USGA specifications can only make up 10% of the total size class.

Performance of these materials as topdressing amendments was assessed by evaluating the recovery of aerification holes after amendments were added (Table 3). Analysis of variance indicated a significant treatment effect on all rating days. Over the course of the study, a few general trends were noted. The amendments Red Plus 25DR, Zeoponix B, and Ecosand 25DR enhanced regrowth of aerification holes at all rating dates compared with Ecosand, Clinolite, Red Plus, and PSA. The other products were intermediate at all rating dates and were not statistically different from each other or from the high and low performers. A significant aspect of these results was that none of the products produced a significantly better regrowth than sand, and several actually failed to perform at a level equivalent to sand.

It was predicted that the nutrient-holding capacity (i.e., CEC) or N content of these materials was a likely explanation for the variable regrowth patterns observed in the test. Regression analysis of CEC or total N against regrowth at 29 days after treatment indicated no correlation with either of these parameters (data not shown). Similar results were obtained when N and CEC were regressed against regrowth at other evaluation periods. The explanation for this lack of response may reside in the fact that the N release characteristics of these materials is dependent on pH, temperature, and amount of N loaded relative to CEC (Kithome et al., 1998). Therefore, some of the total N that was reported in the analysis (Table 1) may have not been available for plant growth or was released at a rate that was not sufficient for optimal growth.

In summary, several inorganic soil amendments proved to be as good or better than sand for topdressing and filling aerification holes. Several of these products had high CEC values and matched the appropriate textural class for a USGA green. Ongoing research will include further amending of the same plots with the inorganic materials and analysis of the long-term effects of those amendments on turf performance and soil physical and chemical properties.

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Table 1. Electrical conductivity (EC), pH, cation exchange capacity (CEC), and mineral content of inorganic soil amendments, as determined by the Agricultural Services Laboratory,[z] Fayetteville.

Amendment	Material	pH	EC	CEC	N	P	K	Ca	Mg	Na	S	Fe
			(μmhos cm^{-1})	(cmol kg^{-1})	(mg g^{-1})							
Clinolite	zeolite	8.9	46	49.4	207	3	804	2108	250	219	20	15
Ecosand	zeolite	8.6	475	112.4	298	4	4220	6157	172	4019	70	20
Profile	calcined clay	7.0	684	23.9	161	21	987	2732	258	94	349	179
PSA	diatomaceous earth	6.3	203	47.3	426	17	917	2218	384	988	86	78
Red Plus	calcined clay	5.9	203	7.3	245	47	609	606	185	49	264	142
Red Plus 25 DR	calcined clay	6.8	7780	27.7	5528	441	6157	4714	1236	2526	2118	230
Sand	sand	8.6	123	0.7	133	7	37	119	23	21	7	19
ZeoSand T	zeolite	7.4	6270	109.0	434	4	4405	7295	678	4672	8558	12340
ZeoSand N	zeolite	6.5	10040	144.8	3557	6	6237	5031	317	14790	2504	1610
Zeoponix A	zeolite	7.6	350	133.9	3089	485	6406	5464	300	1576	129	31
Zeoponix B	zeolite	7.6	1230	94.1	4839	522	1699	3722	226	692	662	20
ZeoPro	zeolite	7.7	1051	86.0	2831	411	2521	4839	277	695	933	19
ZeoSand 25DR	zeolite	7.3	5420	104.1	13090	504	6641	6549	724	4608	1363	120
ZeoSand 10DR	zeolite	7.5	2730	108.2	3974	286	5388	6425	488	4285	812	79

[z] Procedures: pH and EC by electrode, Mehlich III extraction, ICP; CEC by exchange with 1M ammonium acetate (pH = 7.0).

Table 2. Particle size analysis (sand separates only) of inorganic soil amendments used in topdressing study. USGA specifications for particle size analysis are given for comparison.

Amendment	>2 mm	1-2 mm	0.5-1 mm	0.25-0.5 mm	0.1-0.25 mm	<0.1 mm
	——— % of total ———					
Clinolite	0.1	34.7	46.6	13.9	3.7	1.0
Ecosand	0.1	38.1	52.8	8.7	0.1	0.2
Profile	0.0	0.0	66.8	32.5	0.5	0.1
PSA	0.2	56.4	38.0	4.0	1.1	0.4
Red Plus 25DR	0.0	13.1	68.4	17.7	0.7	0.1
Red Plus	0.1	0.3	77.2	21.0	1.1	0.3
Sand	0.0	0.3	5.5	71.8	22.5	0.1
Zeoponix A	0.4	7.8	55.8	27.0	6.0	3.1
Zeoponix B	0.1	18.2	54.2	25.1	1.9	0.5
ZeoPro	0.0	21.0	53.9	21.9	2.8	0.4
ZeoSand 25DR	0.3	49.3	45.3	5.0	0.1	0.1
ZeoSand T	0.8	30.8	56.3	11.7	0.4	0.0
ZeoSand N	0.4	1.6	66.2	17.1	7.1	7.6
ZeoSand 10DR	0.2	41.1	50.1	8.1	0.3	0.2
USGA specs [z]	——— < 10% [y] ———		——— > 60% [y] ———		<25%	<10%

[z] USGA specifications for constructing a putting green (http://www.usga.org/green/).

[y] The two size classes above the dashed line are combined for comparison to the specifications.

Table 3. Recovery of creeping bentgrass (cv. Penn Links) following core-aerification, as affected by several inorganic soil amendments.[z]

Amendment	Days after aerification						
	7	14	17	20	23	26	29
	% recovery of aerification holes						
Red Plus 25DR	44.4	70.3	81.4	85.1	85.1	85.1	96.2
ZeoponixB	48.1	62.9	74.0	75.9	85.1	85.1	92.5
ZeoSand 25DR	40.7	55.5	72.8	74.0	74.0	77.7	85.1
Sand	37.0	62.9	69.1	70.3	70.3	70.3	81.4
ZeoPro	40.7	59.2	60.0	61.0	74.0	74.0	81.4
Profile	44.4	74.0	74.0	77.7	77.7	77.7	81.4
ZeoponixA	37.0	48.1	71.6	72.1	74.0	74.0	81.4
ZeoSand N	40.7	55.5	65.4	66.6	70.3	74.0	77.7
ZeoSand T	40.7	48.1	60.0	59.2	74.0	74.0	74.0
ZeoSand 10DR	33.3	51.8	64.1	64.8	66.6	66.6	74.0
Red Plus	37.0	55.5	61.7	62.9	66.6	66.6	70.3
PSA	29.6	44.4	50.6	55.5	55.5	59.2	66.6
Clinolite	29.6	48.1	50.6	50.0	55.5	55.5	59.2
Ecosand	25.9	40.7	43.2	44.4	44.4	44.4	55.5
LSD (0.05)[y]	11.9	15.8	15.4	15.5	14.5	14.9	16.5

[z] Amendments were mixed at 20% (v/v) with sand and topdressed to fill aerification holes and cover plot surface to a depth of 3 mm.

[y] LSD = Mean separation for treatments within a column at the 0.05 level of probability.