Evaluation of the USGA Sand-Based Rootzone with various Organic Amendments for Growing Creeping Bentgrass

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Introduction

Addition of sphagnum peat (SP) as an organic amendment to sand-based root zones has been recommended by the United States Golf Association (USGA) when constructing golf greens. However, SP can lead to environmental issues (wetland destruction) and agronomic issues (decomposition, hydrophobicity, reduction in shear strength, etc.). Over the duration of this study (6 years), a loss of nearly half of the soil organic matter (OM) from the original SP content occurred. In contrast, the stoloniferous mat layer saw a nearly doubling of OM. As a creeping bentgrass green ages, this bi-layered rootzone can create management challenges of soil moisture and surface firmness for superintendents and their staff. This can negatively impact playability for golfers. Several other organic amendments (vermicompost, biochar, biosolids, etc.) are well known for their instrumental agronomic role as soil amendments in agriculture. Therefore, organic amendment alternatives to SP in sand-based root zones of golf greens may offer both environmental and agronomic benefits.

Objectives

- To compare the substitution of the organic component in USGA's standard mix of 15% SP + 80% sand v/v.

Material and methods

- **Site Description:** The nursery green was established during September, 2015 at North Shore Country Club, Glenview, Illinois.
- **Experimental Design:** A completely randomized design of 11 treatments with 3 replications (due to space limitations, A11 received 2 replicates). Treatments differed according to soil amendment(s) used (Table 1).
- **Site Preparation:** Existing turf and soil were removed to a depth of 16". Pea gravel was added to a depth of 4" and the remaining 12" comprised the root zone. The area was subdivided into 32 treatment plots by installing temporary plywood partitions (Fig. 1). Each plot measured 5' x 9'. Mixing of sand and amendments occurred by a concrete mixer. Each mixed treatment was then delivered to their respective plots (Fig. 2).
- **Turf Establishment:** Creeping bentgrass (*Agrostis stolonifera* L.) cultivars 'V8' and 'OO7' as a 50/50 blend was seeded. Seeding rate was 1.5 lbs./1000 sq ft and delivered using a rotary spreader. A bunker raking vehicle with a deep lug tread pattern drove over plots to create good seed-to-soil contact. Judicious use of N-P-K fertilizers with micronutrients were utilized for turf establishment.

Treatment	Soil Amendment Mixtures Description (% v/v)
A1	15% SP + 85% sand **(Industry Standard)**
A2	10% biocharged turf media + 90% sand
A3	5% vermicompost + 5% biochar + 90% sand
A4	5% CarbonizPN Soil Enhancer + 95% sand
A5	10% CarbonizPN Soil Enhancer + 90% sand
A6	5% biochar + 15% SP + 80% sand with a preplant vermicompost raked into top 4 inch
A7	15% SP + 85% sand with a pre-plant vermicompost raked into top 4 inch
A8	5% vermicompost + 5% pre-conditioned biochar + 90% sand
A9	5% biochar + 10% biosolids + 85% sand
A10	5% biochar + 10% vermicompost + 85% sand
A11	5% biochar + 10% composted biosolids + 85% sand

Table. 1. Soil amendment mixtures as treatments.

Fig. 1. North Shore CC staff building temporary plywood partitions.

Fig. 2. North Shore CC staff filling soil amendment mixtures.

- **Measurements**
  - ❑ Turfgrass Quality (TQ): Turfgrass quality was visually rated (scale 1-9, with 6 = acceptable and 9 = best).
  - ❑ Normalized Difference Vegetation Index (NDVI): Turfgrass canopy reflectance determined by using Trimble GreenSeeker Handheld Crop Sensor.
  - ❑ Root Length (cm): Length of roots was estimated using soil core sample (4 cores 1" diameter x 10" deep) per 5' x 9' plot.
  - ❑ Dollar Spot (%): Dollar spot was visually rated per 5' x 9' plot.
  - ❑ Moss (%): Moss was visually rated per 5' x 9' plot.
  - ❑ Nematodes (number per 100 g soil): Population density determined via a modified sucrose flotation technique. A 100 gram soil sample from each plot (6 cores ½" diameter x 2" deep) combined for nematode extraction.
- **Data Analysis**
  - ❑ Statistical Analysis System version 9.4 was used for data analysis (SAS Institute Inc. Cary, NC). Fisher's LSD procedure was used to determine the significance at p=0.05.

Analysis of Variance

	Source	18-Aug-21	31-Aug-21	1-Oct-21	4-Oct-21	11-Oct-21	4-Nov-21
Turf Quality	Trt	-	-	NS	-	NS	-
NDVI	Trt	-	-	*	-	NS	-
Root Length	Trt	NS	NS	-	NS	-	-
Dollar Spot	Trt	-	-	NS	NS	NS	-
Moss	Trt	-	-	-	-	-	*
Nematodes	Trt	-	-	-	NS	-	-

Table. 2. Summary ANOVA table for evaluated parameters. ' NS ' represents not significantly different and ' * ' represents significantly different among treatments based on Fisher's LSD procedure using P=0.05. ' – ' represents no data collected.

Results

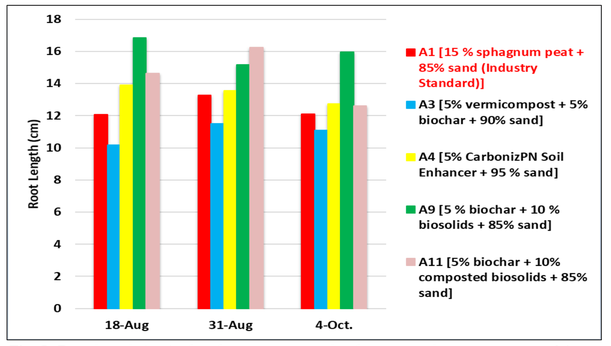

Fig. 3. Root length (cm) of turfgrass core samples from amendment treatments A1, A3, A4, A9, and A11. Not significantly different on any date. Only select treatments are displayed to illustrate trends.

Fig. 4. Washed roots from each amendment treatment (1 replicate), 18-Aug-2021.

Amendments	TQ (1-Oct)	TQ (11-Oct)	NDVI (1-Oct)	NDVI (11-Oct)
A1	4.7	5.3	**0.69b**	0.69
A2	6.0	5.3	0.73ab	0.72
A3	4.3	6.0	**0.68b**	0.70
A4	6.7	6.0	0.70ab	0.70
A5	6.7	6.7	0.72ab	0.72
A6	4.7	5.3	**0.68b**	0.70
A7	4.3	4.7	0.70ab	0.70
A8	6.3	5.7	0.71ab	0.70
A9	7.3	7.0	**0.75a**	0.72
A10	6.3	5.3	0.70ab	0.70
A11	5.5	6.0	**0.69b**	0.69

Table 3. Turfgrass Quality (TQ) and Normalized Difference Vegetation Index (NDVI). Means within column followed by same letter are not significantly different (p=0.05).

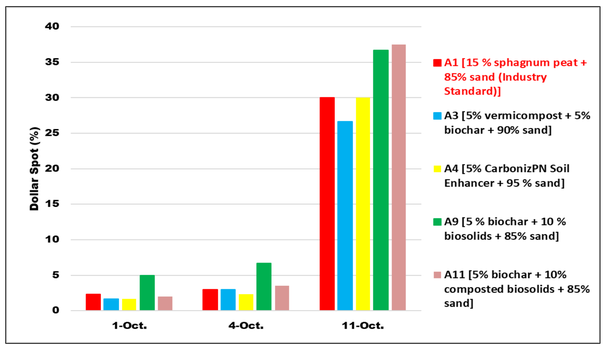

Fig. 5. Dollar spot infestation among selected treatments A1, A3, A4, A6, A9, and A11 Not significantly different on any date. Only select treatments are displayed to illustrate trends.

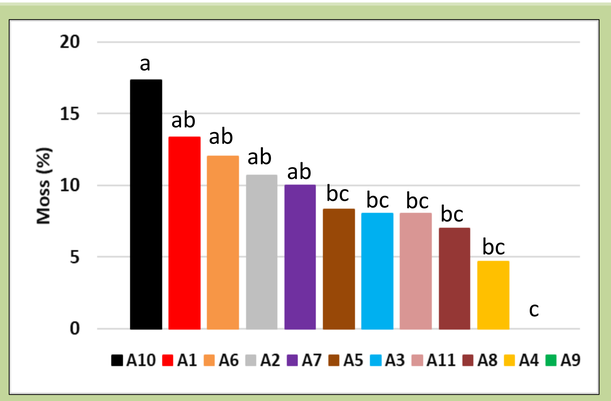

Fig. 6. Moss infestation among amendment treatments on Nov 4, 2021. Means followed by same letter are not significantly different (p=0.05).

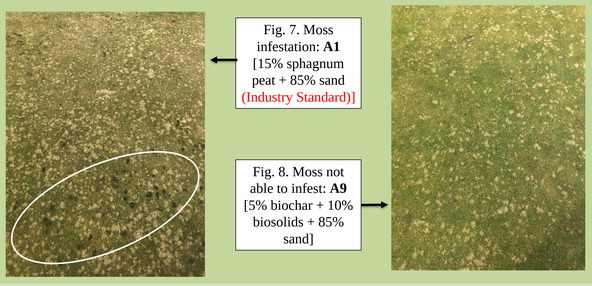

Fig. 7. Moss infestation: **A1** [15% sphagnum peat + 85% sand (Industry Standard)]

Fig. 8. Moss not able to infest: **A9** [5% biochar + 10% biosolids + 85% sand]

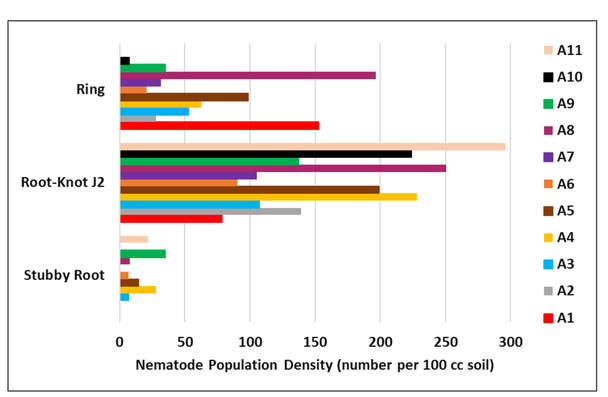

Fig. 9. Select root-feeding nematodes among amendment treatments on Oct 1, 2021. Not significantly different (p=0.05).

Fig. 10. J2 juvenile root-knot nematode. 10-4-21

Fig. 11. Male root-knot nematode. 10-4-21

Fig. 12. J2 juvenile root-knot nematode trapped by fungi. 10-4-21

Results and Discussion

- **Turf Quality:** SP treatments saw unacceptable turf quality on both dates rated. In contrast, A9 (biochar + biosolids) amendment saw acceptable TQ on both rating dates.
- **NDVI:** A9 (biochar + biosolids) amendment tended to have highest NDVI (highest reading on first date).
- **Root Length:** Not significantly different. However, rooting depth in treatments containing biochar and biosolids (A9, and A10, and A11) were visually longer and denser in comparison to other amendments containing sphagnum peat (A1), vermicompost (A3), and carbonizPN soil enhancer (A4) (Fig. 3). The image of washed roots also illustrated these trends (Fig.4).
- **Dollar Spot:** Not significantly different. Nevertheless, treatments having biochar and biosolids (A9 and A11) tended to be most vulnerable to dollar spot disease, while vermicompost and sphagnum peat amendments (A1 and A6) were less so.
- **Moss:** No infestation of moss was observed in treatment A9 (Biochar + biosolids). A9 appeared as a dense and healthy turfgrass stand with excellent turf quality ratings and high NDVI values. In contrast, moss was highest in A10 followed by A1 (Industry Standard). We speculate that our A1 SP rootzone may have created increased soil moisture during wet periods which then reduced plant density. Thin turf is known to exacerbate moss establishment in creeping bentgrass golf greens.
- **Nematodes:** Dense populations of root-knot nematodes were found in all treatments. Other nematodes were ring and stubby root. The rapid establishment of root-feeding nematodes in this study could have been caused by regular use of contaminated sand for top-dressing purposes. Alternatively, nematodes may have entered from surrounding native-soil bluegrass rough areas.

Conclusions

NDVI and moss data indicate that biochar + biosolids may provide an advantage over SP in USGA's sand-based root zone for golf greens. This suggests that both biochar and biosolids are good OM alternatives for sand-based golf greens. Nevertheless, amendment treatments were not significantly different for most of the evaluated parameters. A major limitation of this study, as dictated by available space, was that only 3 replications were used. Thus, treatment differences may have been obscured given the heterogenous nature of sand-based root zones. This study will continue given root zone amendments x moss establishment has not previously been reported to our knowledge.

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