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Does Divot Fill Composition Affect Bermudagrass Recovery from Damage?

George H. Snyder*

PHD Laboratory, 3101 Gulfstream Road, Lake Worth, FL 33461

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Quartz sand is the preferred medium for constructing high quality athletic fields. As a result of play, pieces of sod become detached, and small excavations are created, which are termed "divots" herein. Grounds crews generally fill divots with sand. Investigations were conducted to determine whether amendments to the sand would improve bermudagrass (*Cynodon* sp.) coverage of the divots. The amendments peat (EarthMAX), biosolids (Milorganite), compost (yard clippings), and a pegylated polymer and clay coated sand (PPCCS, Maxand), mixed in various combinations with quartz sand, were used to fill uniformly-constructed divots, and bermudagrass coverage of the divots was recorded over time. Mixes containing PPCCS and biosolids, with or without peat, provided greater divot coverage over time than sand or sand with added peat or compost.

Silica sand, properly sized, has become the preferred medium for construction of athletic fields because it provides large pore spaces (macropores) that facilitate drainage and aeration, is very hard and does not degrade, and it protects against compaction (Puhalla, et al., 1999). However, even though quartz sand provides excellent physical properties for athletic fields, it lacks chemical and biological properties that are favorable for plant growth. Consequently, various products are used as amendments to sand, but it is important that the amendments do not detract appreciably from the favorable physical properties sand provides.

Peat is a common amendment used in sands for golf green and athletic field construction. It may be mixed with sand at rates varying from 100–300 $mL \cdot L^{-1}$ (10% to 30% by volume), which generally amounts to 5–15 $g \cdot kg^{-1}$ (0.5% to 1.5% by weight). A number of inorganic amendments have been used as well, such as clinoptilolite (zeolite), various clays including calcined clays, diatomaceous earth, and volcanic rock, with varying degrees of success (Murphy, 2007). A relative new-comer that is distinctively different from peats and traditional inorganic amendments is a pegylated polymer (strands of polyethylene glycol [PEG] imbedded in the polymer coating) and clay coated sand (PPCCS) that acts as a solid state wetting agent, retains, but does not de-activate, pesticides, and exhibits cation and anion exchange capacity <http://www.ecoverdetech.com/maxand-technoloy/>. Biosolids also can be used to improve turf establishment in sand soils (Snyder and Cisar, 2008).

Athletic fields are damaged by play, which may displace sod and create small craters. This condition is termed "divots," herein. Grounds crews fill the divots to encourage regrowth of the grass, and to provide a level playing surface both for the benefit of the game and for safety reasons. Sand, sometimes with seed if the grass on the field can be propagated by seed, commonly is used to fill divots <http://golf.about.com/cs/tipslessons/ht/repairdivots.htm>. For warm-season turf, which generally cannot be propagated from seed, straight sand is usually used to fill divot scars <http://gsr.lib.msu.edu/2000s/2002/020313.pdf>. However, in some cases the divot sand is amended, particularly with small amounts of peat.

The present studies were inspired by the work of Mr. Jordan Treadway and his staff at Roger Dean Stadium, Jupiter, FL, who compared the sand they had been using with sand amended at the rate of 200 $g \cdot kg^{-1}$ (20% by weight) with a PPCCS (Maxand, EVTI, Pembroke Pines, FL). They observed a considerable improvement in the rate of grass establishment in "divots" filled with the PPCCS/sand mix, relative to sand alone (Fig. 1). Additional studies were conducted by the author utilizing various combinations of sand, peat, PPCCS, and biosolids to evaluate the rate of divot coverage by bermudagrass (*Cynodon* sp.).

Methods and Materials

United States Golf Association (USGA) specification quartz sand (USGA, 1993), alone and in various combinations with a biosolids (Milorganite®, Milwaukee, WI), PPCCS (Maxand,

Fig. 1. Coverage over divots in a sand athletic field at Roger Dean Stadium, Jupiter, FL, by bermudagrass (*Cynodon* sp. 'Celebration') after two months, following divot filling on 13 Feb. 2014. The two divots on the left were filled with sand. The two divots on the right were filled with a sand mix containing 200 $g \cdot kg^{-1}$ of PPCCS (20% by weight).

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*Corresponding author. Phone: 561-714-3011; e-mail: phdlaboratory@hotmail.com

Table 1. Composition of divot mix treatments used in certain of the studies.

Treatment	Composition
Sand	Quartz, > 600 g·kg^{-1} 0.25 – 1.00 mm, < 300 g·kg^{-1} 0.15 mm
80/20 sand/PPCCS	800 mL sand + 200 mL·L^{-1} PPCCS (80% sand, 20% PPCCS, by volume)
Sand + peat	227 g peat + 19 L sand (approx. 1% peat, by weight)
Sand + biosolids	114 g biosolids + 19 L sand (10 lbs of biosolids added to one cubic yard of sand)
80/20 sand/PPCCS + peat	800 mL sand + 200 mL·L^{-1} PPCCS (80% sand, 20% PPCCS, by volume) + 227 g peat/19 L (approx. 1% peat, by weight)
80/20 sand/PPCCS + biosolids	800 mL sand + 200 mL·L^{-1} PPCCS (80% sand, 20% PPCCS, by volume) + 114 g biosolids/19 L (10 lbs of biosolids per one cubic yard of 80/20 sand/PPCCS)
Sand + peat + biosolids	227 g peat + 114 g biosolids/19 L sand (approx. 1% peat, by weight and 10 lbs of biosolids per cubic yard)
80/20 sand/PPCCS + peat + biosolids	800 mL sand + 200 mL·L^{-1} PPCCS (80% sand, 20% PPCCS, by volume) + 227 g peat/19 L (1% peat, by weight) and 114 g biosolids/19 L (10 lbs of biosolids per cubic yard of 80/20 sand/PPCCS)
70/30 sand/compost	Commercial product. 700 mL sand + 300 mL·L^{-1} compost final mix (70% sand, 30% compost, by volume)

EVTI, Ft. Lauderdale, FL), and a humified peat (EarthMAX™ G, Harrell's LLC, Lakeland, FL) were evaluated for bermudagrass (*Cynodon* sp.) surface coverage over time following creation of "divots". Study 1 was conducted on a 'Tifeagle' bermudagrass sand-based golf green at the University of Florida Ft. Lauderdale Research and Education Center. Five replications of holes 7.5 x 7.5 x 5.0 cm deep (3 x 3 x 2 inches deep) in a randomized complete-block design were cut into the green, and backfilled with various combinations of sand, biosolids, PPCCS, and peat on 22 May 2014 (Table 1). The plot area was maintained as a golf green, which included irrigations and fertilizations. Visual ratings were made for bermudagrass coverage (% cover) 4 and 6 weeks later. Study 2 was conducted on 'Celebration' bermudagrass on 23 May 2014, on a sand-based field at Roger Dean Stadium in Jupiter, FL, using the same "divot" mix combinations used in Study 1. One replication, in a randomized complete-block design, utilized the same size "divot" holes used for Study 1. Two more replications utilized holes 15 x 15 x 10 cm deep (6 x 6 x 4 inches deep). The plot area was maintained as an athletic field, and received multiple fertilizations during the study period. Visual ratings were made for bermudagrass coverage (% cover) 4 and 5 weeks later. Data were only utilized from the larger holes at 5 weeks because the smaller holes were completely covered. Study 3 was conducted on 'Celebration' bermudagrass grown on a sand field soil at the University of Florida Ft. Lauderdale Research and Education Center. The same treatments utilized for Studies 1 and 2, plus the addition of a treatment containing biosolids and peat (Table 1), which permitted analyzing the data as a factorial experiment, were added to four replications of holes 17.5 x 17.5 x 10 cm deep (7 x 7 x 4 inches deep) in a randomized complete-block design on 14 Aug. 2014. The area was irrigated, but had not been fertilized recently prior to the initiation of the study. A complete fertilizer was applied at the rate of 2.5 g·m^{-2} N (0.5 lb/1000 ft^2 of N) 3 weeks after the study was initiated. Bermudagrass coverage ratings were made 3, 4, and 5 weeks after the study was initiated. Study 4 was conducted on a 'Celebration' sand-based athletic field at the Palm Beach Atlantic University Athletic Campus in West Palm Beach, FL. On 13 Oct. 2014, three replications of holes 17.5 x 17.5 x 10 cm deep (7 x 7 x 4 inches deep) in a randomized complete-block design were filled with either the commercial 70/30 sand/compost mix (Atlas Peat and Soil, Boynton Beach, FL) being utilized by the athletic field staff, or with the biosolids/PPCCS/peat mix that was utilized in Studies 1–3. The plot area was maintained as an athletic field, which included irrigation and multiple fertilizations. Bermudagrass coverage ratings were made over an 11-week period, since coverage was slower for the winter-established study than it was for the studies established in May and August.

Data were subjected to analysis of variance and means were separated by the Duncan's Multiple Range procedure ($P = 0.05$) using a statistical analysis program package (SAS Institute Inc., Cary NC, ver. 9.3).

Results and Discussion

Statistically-significant differences in bermudagrass coverage over the divots were observed for each rating date in Studies 1 and 2, which were conducted on a 'Tifeagle' bermudagrass golf green and a 'Celebration' bermudagrass athletic field, respectively (Table 2). Coverage was poor for the sand treatment on all rating dates. The divot mix combination that included PPCCS and biosolids, with or without peat, was superior to sand alone or sand + peat ($P < 0.05$), and provided numerically greater coverage ratings than the other treatments on all rating dates (Table 2).

In Study 3, which was conducted with 'Celebration' bermudagrass on a sand field soil, divot mix combinations that included PPCCS and/or biosolids provided greater ($P < 0.05$) coverage over divots than the sand or sand + peat treatments (Table 3). Considerable improvement in coverage was observed between weeks 4 and 5 (Table 3), which may have been a response to the fertilizer applied 3 weeks after the study was initiated. Nevertheless, the sand treatment, and sand + peat, had the least amount of bermudagrass coverage. As in studies 1 and 2, The CCPPS + biosolids treatment, with or without peat, consistently provided the greatest numerical coverage ratings (Table 3). The factors PPCCS and biosolids were significant ($P < 0.05$) on all rating dates, and peat was significant at 5 weeks (Table 4). The PPCCS x biosolids interaction on week 5 was due to PPCCS providing a greater increase in coverage rating relative to sand in the absence of biosolids than when biosolids was included.

Table 2. Estimated grass coverage over divots at various intervals for bermudagrass (*Cynodon* sp. 'Tifeagle') in Study 1 and 'Celebration' in Study 2.

	Study 1		Study 2	
Treatment	4 weeks	6 weeks	4 weeks	5 weeks
Sand	17 b	20 b	20 c	15 d
80/20 sand/PPCCS	22 ab	21 b	42 bc	38 b
Sand + peat	17 b	19 b	37 bc	20 d
Sand + biosolids	15 b	23 b	33 bc	23 cd
80/20 sand/PPCCS + peat	20 ab	35 ab	46 ab	63 b
80/20 sand/PPCCS + biosolids	32 a	52 a	68 a	90 a
80/20 sand/PPCCS + peat + biosolids	27 ab	49 a	50 ab	88 a

Values within a column followed by the same letter are not significantly different ($P < 0.05$) by the Duncan's Multiple Range Test.

Table 3. Estimated coverage over divots at various intervals for bermudagrass (*Cynodon* sp. 'Celebration') in Study 3.

	Time after study initiation (weeks)		
Treatment	3	4	5
Sand	4 b	9 c	53 c
80/20 sand/PPCCS	14 ab	35 b	79 b
Sand + peat	4 b	13 c	65 c
Sand + biosolids	16 ab	45 b	85 ab
Sand + peat + biosolids	15 a	51 ab	86 ab
80/20 sand/PPCCS + peat	16 ab	49 ab	93 ab
80/20 sand/PPCCS + biosolids	28 a	51 ab	96 a
80/20 sand/PPCCS + peat + biosolids	26 a	70 a	99 a

Values within a column followed by the same letter are not significantly different ($P < 0.05$) by the Duncan's Multiple Range Test.

Table 4. Factorial analysis of bermudagrass (*Cynodon* sp. 'Celebration') coverage over divots at various intervals for Study 3.

	Time after study initiation (weeks)		
Factor	3	4	5
PPCCS	*	**	**
Peat	NS	+	**
Biosolids	*	**	**
PPCCS x Peat	NS	NS	NS
PPCCS x Biosolids	NS	+	*
Peat x Biosolids	NS	NS	+
PPCCS x Peat x Biosolids	NS	NS	NS

**, *, + and NS refer to $P < 0.01, 0.05, 0.10$, and $P > 0.10$, respectively.

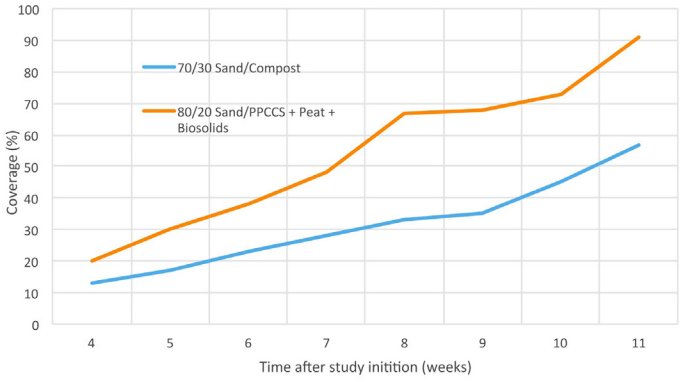

Fig. 2. Effect of divot mix composition on divot coverage by bermudagrass (*Cynodon* sp. 'Celebration') for Study 4.

Coverage over divots was slower in Study 4, which was established in October, than it was in the previous three studies that began in the warmer part of the year. The divot mix consisting of 80/20 sand/PPCCS + biosolids + peat provided greater 'Celebration' coverage over divots ($P < 0.10$) than the 70/30 sand/compost mix on all rating dates except week 7, when it still was numerically superior (Fig. 2).

Conclusion

Divot fill composition affected bermudagrass recovery from damage. Mixes containing PPCCS and biosolids, with or without peat, increased grass coverage of divots over time.

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