RESEARCH/INVESTIGACIÓN

EFFECTS OF PRE-PLANTING INCORPORATION OR POST-PLANTING TOP-DRESSING OF ORGANIC AMENDMENTS ON BERMUDAGRASS FOR TOLERANCE TO *BELONOLAIMUS LONGICAUDATUS*

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ABSTRACT

Jones, W. B., J. K. Kruse, H. A. Enloe, and W. T. Crow. 2020. Effects of pre-planting incorporation or post-planting top-dressing of organic amendments on bermudagrass for tolerance to *Belonolaimus longicaudatus* Nematropica 50:59-66.

The addition of organic amendments can improve several aspects of the soil environment, thereby improving tolerance to plant-parasitic nematodes and, in some cases, suppressing plant-parasitic nematodes. Two organic amendments commonly used in golf and sports turf in the United States are locally produced composts and Canadian sphagnum peat moss (CSPM). Two field trials were conducted to evaluate the impacts of these organic amendments on turf health and suppression of sting nematode, *Belonolaimus longicaudatus*, on bermudagrass athletic turf. One trial evaluated the effects of pre-planting incorporation of either compost or CSPM with soil to create a 20:80 amendment:soil mixture in the turf root zone. Another trial evaluated two kinds of compost blended with sand top-dressed onto the surface of established turf. Both trials evaluated effects on population density of *B. longicaudatus*, and on turf percent green cover. Pre-planting incorporation of organic amendments suppressed *B. longicaudatus* but top-dressing did not. Addition of composts by either pre-planting incorporation or blending with top-dressing improved turf percent green cover and, therefore, enhanced tolerance to *B. longicaudatus*.

Key words: *Belonolaimus longicaudatus*, bermudagrass, Canadian sphagnum peat moss, compost, *Cynodon* spp., organic amendment, sting nematode, nematode tolerance, turfgrass

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RESUMEN

Jones, W. B., J. K. Kruse, H. A. Enloe, and W. T. Crow. 2020. Efectos de la incorporación previa a la siembra o el aderezo posterior a la siembra de las enmiendas orgánicas en bermudagrass para la tolerancia a *Belonolaimus longicaudatus* Nematropica 50:59-66.

La adición de enmiendas orgánicas puede optimizar muchos aspectos del entorno del suelo, mejorando la tolerancia de los nematodos parásitos de plantas y en algunos casos inclusive puede suprimirlos. Los compost producidos localmente y el musgo de turba de sphagnum canadiense (CSPM) de son dos enmiendas orgánicas comúnmente utilizadas en césped para golf y deportivo. Se realizaron dos ensayos de campo para evaluar los impactos de estas enmiendas orgánicas en la salud y la supresión de *Belonolaimus* *longicaudatus* ("Sting nematode") en pasto Bermuda. Un ensayo evaluó los efectos de la incorporación previa a la siembra de compost o CSPM con suelo para crear, en la zona de raíces del césped, una mezcla de enmienda: suelo de 20:80. Otro ensayo evaluó dos tipos de compost mezclado con arena sobre la superficie del césped establecido. Ambos ensayos evaluaron los efectos sobre la densidad poblacional de *B. longicaudatus* y sobre el porcentaje de cobertura verde del césped. La incorporación previa a la siembra de las enmiendas orgánicas suprimió *B. longicaudatus*, no así la aplicación superficial de compost con arena. La adición de compost mediante la incorporación previa a la siembra y el abonado de la mezcla de compost y arena sobre la superficie mejoraron el porcentaje de cubierta verde, por lo tanto, mejoró la tolerancia a *B. longicaudatus*.

Palabras clave: Belonolaimus longicaudatus, bermudagrass, turba de sphagnum Canadiense, compost, *Cynodon* spp., enmienda orgánica, nematodo de picadura, tolerancia a nematodos, césped

INTRODUCTION

Most high-quality sports fields and golf course putting greens in the United States use sand construction to facilitate aeration, drainage, and to reduce compaction. This sand is often mined elsewhere and then transported to the field site. In locations where native soil has a high sand content, as found in much of Florida and coastal regions of other southeastern states, turf is planted onto native soil or grown on sand. While sand has many positive attributes for growing grass, sand also presents several challenges including low cation exchange capacity (CEC), low water retention, and favorable environment for certain plant-parasitic nematodes including the sting nematode *Belonolaimus longicaudatus*.

Belonolaimus longicaudatus is native to the coastal regions of the southeastern United States with >80% sand content. *Belonolaimus longicaudatus* is very damaging to warm-season turfgrasses used for golf, sports fields, and lawns in this region. Stunting of turf roots from sting nematodes makes them less efficient in water and nutrient uptake, further exacerbating the negative effects of sand (Luc *et al.*, 2006).

To counteract some of the lack of nutrient and water retention of sand, organic amendments often are added to the sand during construction of sport fields and golf courses. The organic amendment most commonly used for this purpose is Canadian sphagnum peat moss (CSPM) although composts are sometimes used. The United States Golf Association (USGA) recommendations for golf green construction allows for incorporation of peat or compost into the root zone mixture (USGA, 2018). Typically, these organic amendments compose 10 to 20% (by volume) of the root zone material.

Top-dressing is a common cultural practice for turfgrass consisting of applying a thin layer of an organic or inorganic material on the surface of the turf. Top-dressing reduces thatch accumulation, smooths out high traffic areas (Samples and Sorochan, 2008) and improves turf color (Barton *et al.*, 2009). The most common top-dressing material is pure sand, but top-dressing sand is sometimes blended with compost or other organic amendments.

The incorporation of organic amendments into soil can inhibit different species of plant-parasitic nematode species on turfgrass, and in agronomic and horticultural crops. For example, a literature review by Muller and Gooch (1982) found 125 papers in the decade between 1971 and 1981 showing organic amendments were suppressive to plant-parasitic nematodes. However, in much of the previous research, results were variable (McSorley, 2011). There are many factors influencing the nematode-suppressive effects of amendments, including environmental conditions, rate of application, targeted nematode, and type of material. The effects on plant-parasitic nematodes may be a result of variety of factors including an increase in nematode antagonistic microbial activity (Rodriguez-Kabana *et al.*, 1983) or the release of nematicidal compounds such as nitrogen in various forms and organic acids (McSorley, 2011).

In a preliminary microplot experiment, sand amended with Comand® (Life Soils Inc., Gainesville, FL) compost supported much lower reproduction of *B. longicaudatus* than sand amended with CSPM (W. T. Crow, unpublished). Comand compost is a commercial material made from municipal yard waste and spent horse-stable bedding composted using a modified static aerobic pile method with proprietary blended microbial inoculant (Harvest Quest International, Inc., Rocky River, OH). The objectives of this research were to determine if field application of Comand compost, either by preplant incorporation or by post-plant blending with top-dressing sand, improved bermudagrass health and reduced pressure from *B. longicaudatus* compared to standard practices

MATERIALS AND METHODS

Two field trial experiments were conducted at the University of Florida Plant Science Research Unit (PSREU) located in Citra, FL, from May 2016 to March 2018. The soil at this site is an Arredondo fine sand (loamy, siliceous, semiactive, hyperthermic Grossarenic Paleudult). The objectives of these studies were to evaluate the effects of preplant incorporation or post-plant top-dressing with locally available organic amendments on turf health and suppression of sting nematode. Materials used in these experiments were: *i*) Comand compost produced at the LifeSoils facility in Panasoffkee, FL, *ii*) conventional compost from the same landfill produced by conventional thermophilic windrow composting, and *iii*) CSPM originating in Canada and obtained from a local distributer.

Incorporation experiment

This two-year trial took place from May 2016 to March 2018 on bermudagrass (*Cynodon dactylon* × *C. transvaalensis*) cv. T-11 in a field infested with *B. longicaudatus.* The objective of the trial was to determine if incorporation of organic amendments suppressed sting nematode and improved turf health compared to turf growing in unamended soil. There were three treatments in this trial: *i*) unamended control, *ii)* CSPM amended, and *iii)* Comand compost amended. The experiment used a randomized complete block design with three replications of the three treatments. Each plot was 8 m × 1.8 m with a 1-m-wide border between adjacent treatments. Within each plot, a subplot 1.8 m × 1.8 m (3.34 m^2) was established for data collection to minimize sampling variability.

On 31 May 2016 the sod was removed from the field prior to plot establishment. On amended plots, the amendment was applied to a depth of 2.5 cm across the plot surface and then incorporated into the soil using a tractor-mounted rototiller to a depth of 12.5 cm, creating a 20% amendment (V:V) mixture in the top 12.5 cm of the soil profile. Unamended plots were also rototilled to a depth of 12.5 cm. After this, the sod was replanted using the standard turf planting technique called "sprigging" by macerating the sod and then spreading it evenly across the field. The turf was then irrigated and fertilized according to standard practices for turf establishment until mature, and thereafter for turf athletic field maintenance by the PSREU staff.

To evaluate turf establishment and, later, turf health, the plots were photographed approximately every 2 wk using a digital camera mounted on a custom-built photobox to ensure identical lighting and distance. Turf percent green cover was measured from these images using the percentage of green pixels (hue 45 to 105, saturation 15 to 100) present in each image measured with SigmaScan Pro (Systat Software, San Jose, CA) software (Karcher and Richardson, 2005).

Nematode samples were collected after the initial sod removal and prior to amendment application on 31 May 2016, and afterwards on 9 August 2016, 13 October 2016, 19 December 2016, 27 April 2017, 5 July 2017, 29 September 2017, and 4 March 2018. Nine 1.9 cm-diameter and 12.5 cm-deep cores were taken from each data subplot, combined, and thoroughly mixed. Nematodes were extracted from a 100 cm^3 subsample using the centrifugal flotation method (Jenkins, 1964). Nematodes were identified to genus and counted using an inverted microscope. At the end of the trial, soil remaining from the final nematode extraction was sent to the University of Florida IFAS Analytical Services Laboratory for analysis of pH, and for plant-available phosphorus and potassium using Melich-3 extraction (Mehlich, 1984).

For nematode analysis, the data were subjected to analysis of variance and amendment means were compared to the unamended control using simple contrasts. Differences between the organic amendment treatments and the unamended are indicated according to the resulting P-value ($P \leq 0.1, 0.05, 0.01$). For turf percent green cover, the measurements from each month were pooled for analysis. To quantify effects on percent green cover at specific months, the data for each month was subjected to analysis of variance and treatment means were separated according to Duncan's multiple-range test ($P \leq 0.05$).

Top-dressing experiment

This two-year trial was conducted from May 2016 to March 2018. The objective was to evaluate the impacts of top-dressing with sand blended with organic amendments compared to top-dressing with sand alone on turf health and population density of *B. longicaudatus*. The experiment was conducted on established bermudagrass cv. Tifway, which was naturally infested with *B. longicaudatus,* and maintained by the PSU staff using standard agronomic practices for athletic field maintenance. The experiment used a completely randomized-block design with five replications of three top-dressing treatments. Treatments were assigned to blocks according to their initial *B. longicaudatus* population density. The top-dressing treatments were: *i*) 100% sand:0% amendment (V:V), *ii*) 80% sand:20% Comand compost, and *iii*) 80% sand: 20 conventional compost. Plots were 3.35 m^2 with 0.6 m untreated borders between adjacent plots.

Top-dressing treatments were applied on 31 May 2016, 9 August 2016, 13 October 2016, 27 April 2017, 5 July 2017, and 29 September 2017. Prior to each top-dressing, the plot area was core-aerified using a tractor mounted aerifier with 16 mm-diameter tines. During aerification, 16-mm-diameter plugs were removed to a depth of 7.5 cm. The spacing between cores was 15 cm by 15 cm. After removal of aerification debris, the top-dressing treatments were spread evenly across the plots to a depth of 0.66 cm and then irrigated with 0.66 cm of water to move the top-dressing into the aerification holes.

To evaluate treatment effects on turf health, turf green cover was measured every 2 wk as described previously. To evaluate treatment effects on *B. longicaudatus*, nematode soil samples were collected before treatment on 16 March 2016, and after treatment on 9 August 2016, 13 October 2016, 19 December 2016, 27 April 2017, 5 July 2017, 29 September 2017, and 4 March 2018. Nematode sampling, extraction, and counting were as described previously.

For nematode analysis the data were subjected to analysis of variance and amendment means were compared to the unamended control using simple contrasts. Differences between the organic amendment treatments and the unamended are indicated according to the resulting P-value ($P \leq$ 0.1, 0.05, 0.01). For turf percent green cover, the measurements from each month were pooled for analysis. To quantify effects on percent green cover at specific months, the data for each month was subjected to analysis of variance and treatment means were separated according to Duncan's multiple-range test ($P \leq 0.05$).

RESULTS

Incorporation experiment

Population densities of *B. longicaudatus* were reduced by CSPM relative to the untreated *(*$P \leq 0.1$*)* on 13 October 2016, and by Comand compost on 27 April 2017 and 26 July 2017 (Table 1). Overall, repeated measure analysis revealed no differences ($P > 0.05$) among treatments over the course of the trial (data not shown). However, month-by-month analysis revealed differences among treatments in percent green cover during the cooler months of both years when the turf was not actively growing, but the results were different in

Table 1. Effects of incorporation of either Canadian Sphagnum Peat Moss (CSPM) or Comand compost prior to planting bermudagrass on population density of *Belonolaimus longicaudatus*/100 cm^3 of soil.

Amendment	May 2016	Aug 2016	Oct 2016	Dec 2016	Mar 2017	Jul 2017	Sep 2017	Mar 2018
None	4	36	57	38	19	9	2	4
CSPM	11	19	16*	18	16	9	1	2
Compost	13	33	31	21	7*	4*	< 1	5

Data are means of three replications.

*Different from the unamended control at the same date according to the contract procedure ($P \leq 0.1$).

year 1 than in year 2 (Fig. 1). In year 1, the Comand compost amended plots had highest turf percent green cover during the cooler months while in year 2, the unamended controls had the highest percent green cover during the cooler months. The soil analysis indicated that the pH was reduced ($P < 0.1$) by the CSPM (pH 6.85) compared to the unamended treatment (pH 7.20) while the Comand treatment had elevated ($P < 0.1$) phosphorus levels (295 mg/kg) compared to the untreated control (150 mg/kg). No differences in potassium levels among treatments were detected ($P > 0.1$).

Top-dressing experiment

No differences ($P > 0.1$) in population density of *B. longicaudatus* among treatments were observed (Table 2). Repeated measures analysis revealed that throughout the trial percent green cover was higher on plots top-dressed with Comand compost-blended sand than on plots top-dressed with sand alone (Fig. 2). Month-by-month analysis indicated that improvement in percent green cover from Comand compost was greatest during the warmer months when the turf was actively growing (Fig. 2).

DISCUSSION

Muller and Gooch (1982) noted that in order to suppress plant-parasitic nematodes, organic amendments were often bulky and needed to be applied in large quantities. For perennial turf, the only opportunity to incorporate a large amount of organic amendment at once is prior to planting, something that typically only happens once a decade or less. However, regular top-dressing events provide the opportunity to apply small

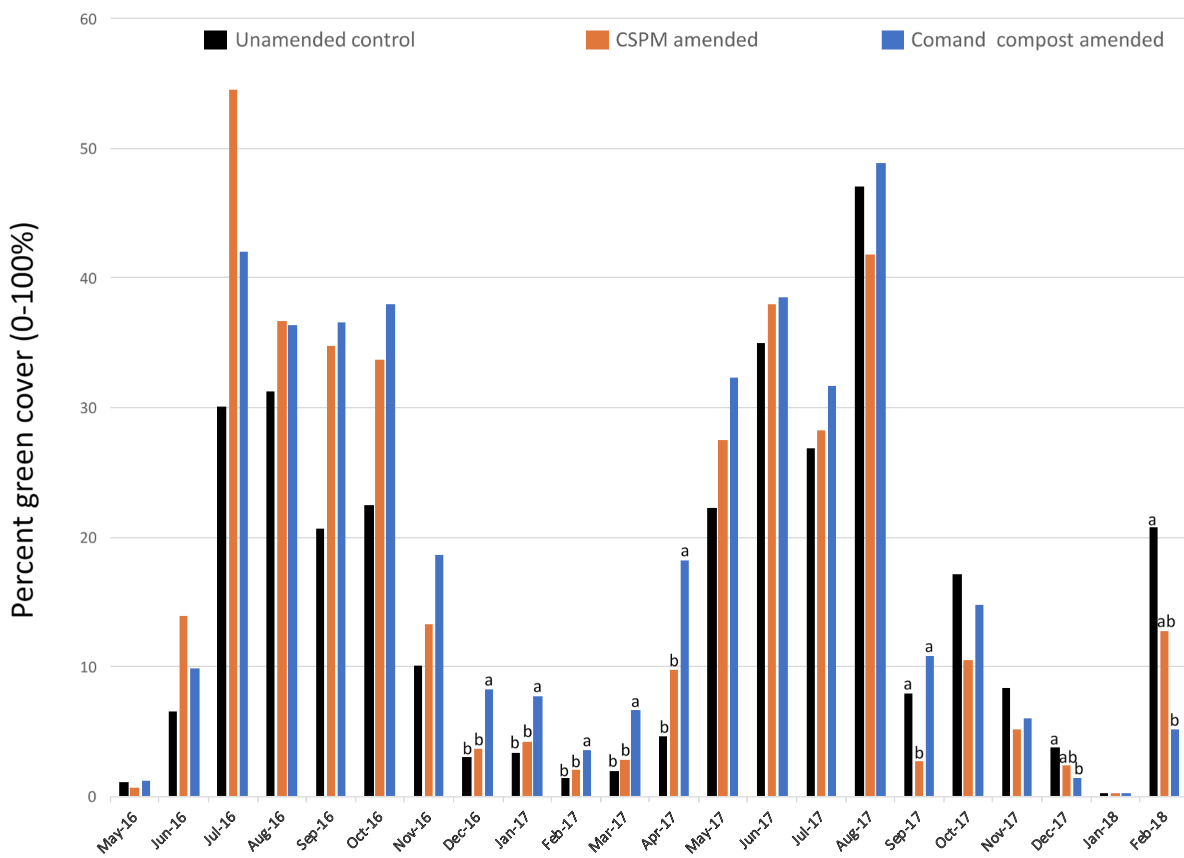

Figure 1. Effects of preplant incorporation of Canadian Sphagnum Peat Moss (CSPM) or Comand compost compared to the unamended control on bermudagrass percent green cover each month during a 2-yr field trial. Columns with common letters within the same month are not different according to Duncan's multiple-range test ($P \leq 0.05$).

Table 2. Effects of top-dressing established bermudagrass, three times per year for two years, with sand blended with either Comand compost or conventional compost on population density of *Belonolaimus longicaudatus*/100 cm^3 of soil.

Amendment	May 2016	Aug 2016	Oct 2016	Dec 2016	Apr 2017	Jul 2017	Sep 2017	Mar 2018
None	60	33	40	21	31	25	17	52
Conventional	62	39	47	23	22	23	16	64
Comand	61	31	27	24	24	23	19	52

Data are means of five replications.
No significant differences among treatments were found ($P > 0.1$).

amounts of the organic amendment blended with sand on a regular basis. These studies evaluated both methods. The combined amount of organic amendment applied to the turf surface from the six top-dressing events was only 20% the amount of amendment used in the incorporation experiment. Each top-dressing event buries the preceding top-dressing, so if the sand-blended top-dressing continued three times annually, a 20% compost soil profile similar to that resulting from the incorporation study would be achieved in 10 years.

The cause of the loss in percent green cover in the amended treatments at the end of the incorporation trial is unknown but may have been environmental. From September 2017 through February 2018 the cumulative rainfall at the trial location was more than twice that of September 2016 through February 2017, 64 cm and 31 cm, respectively. Perhaps the organic amendments reduced drainage, which combined with cool temperatures, created a favorable environment for root pathogens like *Pythium* spp. (Smiley *et al*., 2005).

Direct impacts on the population density of *B. longicaudatus* from the organic amendments were slight in the incorporation experiment and not observed in the top-dress experiment. Even though no reduction in population densities of *B. longicaudatus* were observed from top-dressing with an organic amendment, there were improvements on turf health during seasons of active turf growth (April through November). This is likely due to nutrients released from the organic amendments and associated microbial activity (Duong *et al*., 2013), and improved soil characteristics. Therefore, tolerance to *B. longicaudatus* increased from addition of organic amendments to top-dressing sand even though nematode population density was not impacted.

Disease and nematode suppression from composts are typically much more variable than from pesticides, being influenced by many factors including the source of the compost material, compost maturity, and microbial community and activity (Mehta *et al*., 2014; De Corato, 2020). Even compost from the same facility can vary greatly throughout the year in the source material, composting environment, and resulting microbial community. Modern metagenomic and DNA barcoding tools allow for rapid analysis of compost and soil microbial communities and allow more accurate estimation and evaluation of the plant-disease suppressive ability of specific composts (Mehta *et al*., 2014). De Corato (2020) suggested that identifying the abundance of specific pathogen-suppressive taxa in compost is the most accurate predictor of its efficacy against soil-borne pathogens. In our future trials we hope to use DNA barcoding to identify nematode suppressive bacteria and fungi in composts with the goal of improving the consistency of nematode suppression by composts.

Overall, turf health effects from organic amendments whether incorporated pre-planting or by top-dressing post-planting were positive even when nematode effects were inconclusive. Similar to McSorley (2011), we found that the impacts of organic amendments can vary with the type of amendment used. This highlights the need to evaluate locally available organic amendments under local conditions to help users select the most effective and economically viable amendments to achieve the desired effects.

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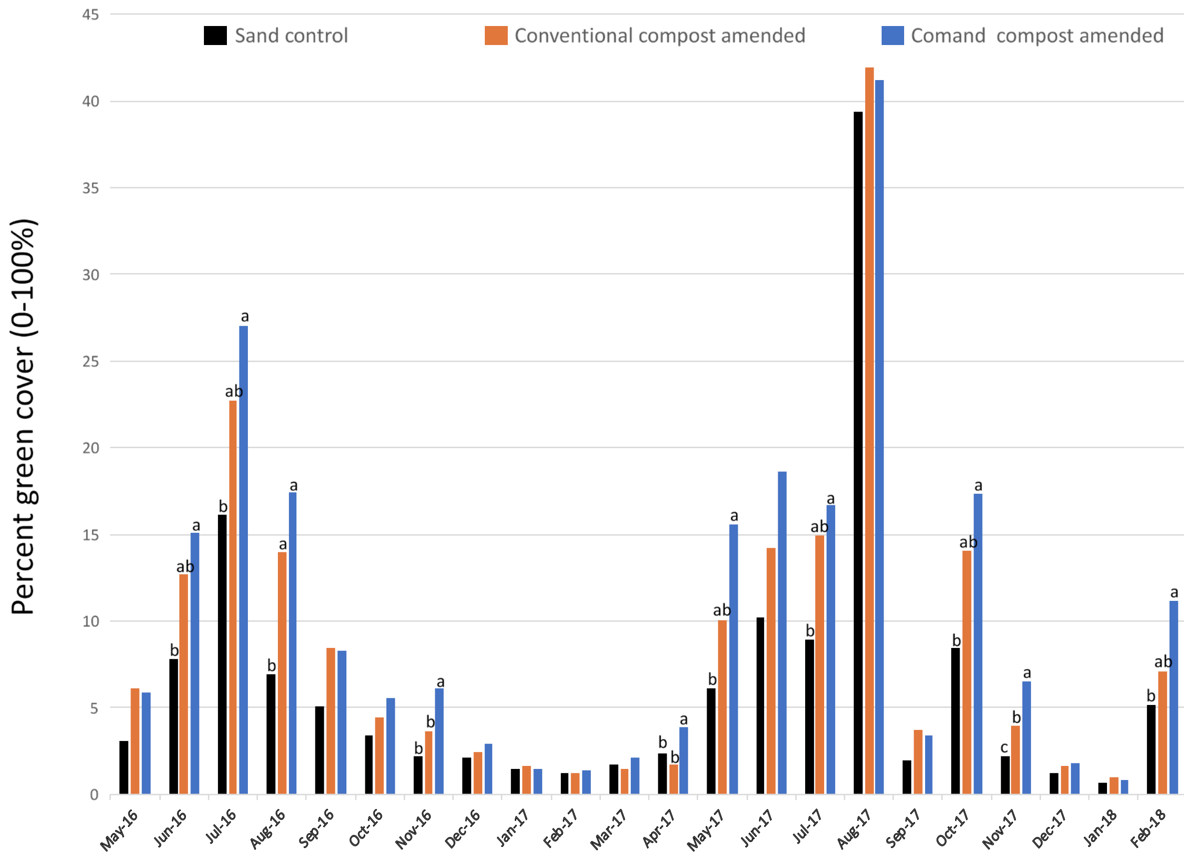

Figure 2. Effects of top-dressing three times per year with unamended sand (sand control), sand amended with conventional compost, or sand amended with Comand compost on bermudagrass percent green cover each month during a 2-yr field trial. Columns with common letters within the same month are not different according to Duncan's multiple-range test ($P \leq 0.05$).

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