Zoysia grass growth affected by physical attributes of substrates formulation

Crescimento de grama esmeralda afetado pelos atributos físicos de formulações de substratos

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ABSTRACT
Soil compaction causes several damages to turfgrass root system such as less water penetration, nutrient uptake and even photosynthesis processes. These processes leads unappropriated formation of tillers, rhizomes, stolon, reduced shoot growth as well as the chlorosis caused by nitrogen deficiency. This work aimed to evaluate physical characteristics in different formulations and substrate components in relation to Zoysia grass development. The experimental design used was completely randomized, composed by eight treatments and three replicates: T1 - soil; T2 - soil + sand (2:1); T3 - soil + sand (1:1); T4 - soil + organic compound (1:1); T5 - soil + organic compound (2:1); T6 - soil + organic compound + sand (2:1:1); T7 - soil + organic compound + sand (1:1:1); T8 - organic compound + sand (2:1). It was evaluated substrates physical characteristics as total porosity and density and for grass development the dipping fresh mass. There was influence of total porosity and density on different substrates composition in the development of Zoysia grass, and the treatments that have organic matter in their composition obtained the best results for the evaluated traits. T4 and T8 showed the highest values of density, total porosity and values of fresh mass, however, increase the need for cuts to maintain the turfgrass aesthetics.

Keywords: Zoysia japonica Steud., compaction, grass, turfgrass,

RESUMO
A compactação do solo provoca danos ao sistema radicular como a penetração de água, a absorção de nutrientes até a fotossíntese. Este processo leva à formação inapropriada de perfilhos, rizomas, estolões, redução no desenvolvimento da parte aérea, assim como clorose provocada pela deficiência de nitrogênio. Este trabalho objetivou avaliar características físicas em diferentes formulações e componentes de substratos em relação ao desenvolvimento de grama esmeralda. O delineamento experimental utilizado foi inteiramente casualizado composto por oito tratamentos e três repetições: T1 - solo; T2 - solo + areia (2:1); T3 - solo + areia (1:1); T4 - solo + composto orgânico (1:1); T5 - solo + composto orgânico (2:1); T6 - solo + composto orgânico + areia (2:1:1); T7 - solo + composto orgânico + areia (1:1:1); T8 – areia + composto orgânico + areia (1:2). Foram avaliadas características físicas de substratos como porosidade e densidade e para o desenvolvimento da grama a massa fresca de aparas. Houve influência da porosidade e densidade nas diferentes composições de substratos no desenvolvimento de grama esmeralda e os tratamentos que continham matéria orgânica em sua composição, obtiveram os melhores resultados para os caracteres avaliados. T4 e T8 apresentaram os maiores resultados de porosidade, densidade e também de massa fresca de aparas, porém, aumenta a necessidade de cortes para manter a estética do gramado.

Palavras-chave: Zoysia japônica Steud., compactação, grama, gramado.

1 INTRODUCTION

Zoysia grass (*Zoysia japonica*) is a warm-season, perennial, C4 turfgrass, whose origin centre is East Asia. Usually, it is used on intensively managed turfs, such as recreational areas and sports fields, golf course fairways and tees. This grass species is known to have great adaptability in many types of environment all over the world, presenting fast growth rates when cultivated in good biotic and abiotic conditions as presence of water, fertilization, light and great soil chemical and physical attributes (Pompeiano and Patton, 2017; Cohen et al., 2019).

The implanting grass process require many studies and preparation. Numerous urban ecosystem services are provided by turfgrass landscapes, but, the grass growth may have rooting potential restricted due to anthropogenic manipulation or even by shallow top soil natural formation (Monteiro, 2017; Culpepper et al., 2020).

The physical soil attributes, correlated to lawns management may provide subsidies for improvements to management techniques (Peixoto et al., 2018), with the objective of improving crop performance. The study of physical soil attributes variability make it possible to identify regions with most susceptible to degradation processes and growth lag (Silva et al., 2020).

In compacted soils, there is particles reorganization that make up the soil structure, reducing the amount of air around root zone, causing poor water infiltration and making root growth impossible. As a consequence of this densification, there is a decrease in grass development due to lack of an adequate plant root growth and the expression of this condition is verified with thin and superficial roots formation (Santos et al. 2016). Two soil physical attributes may be considered to qualify soil or substrate: porosity and soil/substrate density.

Total soil porosity may be defined as the fraction of the total volume of a given soil volume that can be occupied by water and/or air, with no solid particles. Soil density is expressed as the mass per dry soil unit volume, which includes solid particles and porous space (Embrapa et al., 2017). For the same authors, this physical attributes serves as an indicator of soil compaction degree, as well as a tool to measure soil changes that occur in soil structure.

The implantation of the lawn will depend on soil composition in which it will be established and therefore it is extremely important that preparation be done and that all physical attributes are observed. On the other hand, on some occasions, the lawns will be planted in substrate, making it easier to manipulate this space to achieve the expected results.

For both cases, the quality of the soil / substrate may be verified by the amount of organic matter, as it is directly linked to the available carbon content. The decrease in these levels will affect soil aggregation, porosity and density (Balin et al., 2017).

The main process of adding organic material to the soil has the plant as an active component, therefore, the stock of organic matter in the soil is the result of processes of addition and loss of organic material, and plants and microorganisms play a fundamental role. Carbon can accumulate in labile or stable fractions of soil organic matter (SOM), which may have implications for the duration of its effect on soil properties (Reis et al., 2016).

Another essential substrate component is sand due to high drainage capacity. When mixture to soil and/or organic matter, as sand has bigger particles, it is possible to increase and supply physical needs (porosity and density). As inert substance, sand does not provide nutrient and also does not fix the same nutrient, therefore, the quantity of sand should be dimensioned in a very good way. Thus, soil is used for substrate mixture to provide initial nutrients, but supplementary fertilization will be need periodically (Santos and Castilho, 2016;2018).

As in Brazil there are no official recommendations for substrate formulations for turfgrass development, this work aimed to test different formulations and substrate components in Zoysia grass development.

2 MATERIAL AND METHODS

The experiment was conducted in full sun and cemented area, in a region whose clime was classified by Köppen as Aw type, characterized by tropical humid with rainy season in summer and dry in winter. The annual mean precipitation was 1,044.2 mm. The relative air humidity varied from 47.9% to 96.2% (annual minimum and maximum humidity, respectively) and annual temperature means was minimum of 19.4 °C and maximum of 32.9 °C (Unesp et al., 2020).

Zoysia grass was implanted in black plastic containers (47.5 x 17.5 cm – top; 41.5 x 11.3 cm – bottom; 15, 5 cm high, 8.46 L volume), using donated carpets from Itograss®, located in municipality of Pereira Barreto-SP.

The experimental design used was completely randomized, composed by eight treatments with three replicates per treatment, being: T1 - soil; T2 - soil + sand (2:1); T3 - soil + sand (1:1); T4 - soil + organic compound (1:1); T5 - soil + organic compound (2:1); T6 - soil + organic compound + sand (2:1:1); T7 - soil + organic compound + sand (1:1:1); T8 - organic compound + sand (2:1). The numbers between parentheses mean the proportion of each material.

The soil used was an Oxisol type (Embrapa, 2018) taken from the 0 - 20 cm layer at the university experimental farm, located in the municipality of Selvíria-MS, whose chemical analysis is in Table 1.

Table 1. Chemical analysis of the soil used as a substrate component that evaluates soil physical attributes and Zoysia grass development.

	pH H_2O	Ca	Mg	K	Al	H + Al	SB	CTC	P mg dm^{-3}	MO g dm^{-3}	V %
			------------------mmol$_c$dm^{-3}----------------								
Solo	5.0	24	1.0	0.7	0	22	25.9	47.9	27.0	31.0	54

Test method: resin method mentioned by Raij (1987).

The organic compound used has been decomposed for one year, being formed from grass blades and cattle manure (1: 1); medium washed sand was purchased from local business.

The containers irrigation was performed daily until substrate field capacity was reached. Weed control was made whenever necessary, by manually removing weeds. A covering fertilization was made due to grass has slow growth and for presented yellow colour leaves. Fertilizer was applied by dosage of 130 g m^{-2}, which was spread over the lawn and then watered, according to the manufacturer recommendation. The product contained 13% Nitrogen, 5% Phosphorus, 13% Potassium, 1% Calcium, 1% Magnesium, 5% Sulphur, 0.04% Boron, 0.05% Copper, 0.2 % Iron, 0.1% Manganese and 0.15% Zinc.

Total porosity and density analysis of substrates were performed according to Embrapa (2017) methodology at the day of experiment installation with deformed samples, 215 and 422 days after installation with unformed samples

For fresh mass, all grass leaves of each container were collected at 215, 347 and 418 days after installation, which were placed in previously tared paper bags and identified, then the fresh mass was determined on a precision scale 0.01 g.

The data were subjected to analysis of variance (ANOVA) and means compared by Tukey test at 5% probability of error, using the SISVAR program (Ferreira, 2019).

3 RESULTS AND DISCUSSION

The total porosity means are shown in Table 2 and it is possible to observe that in the first assessment there is statistical difference between T5 (soil + organic compound 1:1) and T2 (soil + sand 1:1), with extreme means (66.31% and 45.81%, respectively). All treatments containing organic compost (T4: soil + organic compound 1:1; T5; T6: soil +sand + organic compound 2:1:1; T7: soil + sand + organic compound 1:1:1 and T8:

sand + organic compound 1:2) showed no statistical difference between them being the biggest means. It is worth remembering that the first evaluation was performed before grass implantation just to evaluate the conditions of substrates beginning.

For second and third evaluations, 215 and 422 days after implantation (DAI), T2 (39.77%, 39.69%; respectively) remains the treatment with the lowest mean, but the highest porosity for both assessment is T8 (62.90%, 63.73%; respectively), being both not statistically different from each other (Table 2).

From evaluation one to evaluation two all treatments, except T3 and T8, have decreased the percentage of porosity, while from assessment two to assessment three the only treatments that have not decreased was T6 and T8, being this last one, the only treatment that presented bigger porosity percentage in relation to the time of implantation (Table 2).

There is slight decrease in treatments porosity from second to third evaluation, with T3 and T8 being those that showed an increase in porosity between first and second evaluation and T1 and T3 the most accentuated decrease between last two assessments.

Table 2. Total Porosity means of substrates for evaluations assessed on the day of implantation, 215 and 422 days after implantation of the experiment (DAI) that evaluates soil physical attributes and Zoysia grass development.

Total Porosity (%)			
	Days after implantation (DAI)		
Treatments	0	215	422
T1 – S	49.49 bc	46.2 bc	42.87 bc
T2 – S + SA 1:1	45.81 c	39.77 c	39.69 c
T3 – S + SA 2:1	48.18 bc	54.25 abc	42.84 bc
T4 – S + CO 1:1	59.77 abc	57.49 ab	56.13 ab
T5 – S + CO 2:1	66.31 a	53.17 abc	53.05 abc
T6 – S + SA + CO 2:1:1	52.31 abc	47.05 bc	48.84 bc
T7 – S + SA + CO 1:1:1	59.77 abc	48.46 abc	47.86 bc
T8 – A + CO 1:2	60.91 ab	62.90 a	63.73 a

Means followed by the same letter in the column do not differ at the 5% level of significance by Tukey test. S = soil; SA = sand; OC = organic compound.

The substrate porosity presents great importance for plant growth, because root system requires spaces to perform their gas exchange and water availability and microorganisms need greater aeration to survive (Silva et al. 2017). As shown at Table 2, even with no statistical difference all treatments whose composition had organic compound presented the highest means of porosity, which may influence turfgrass growth.

The general decrease in substrates total porosity may be explained due to cementing effect, mentioned by Fermino et al. (2018), when smaller particles are lodged between free spaces, formed by the arrangement of the larger particles. As mentioned earlier, at first assessment lawn had not been installed yet and roots growth can cause soil compaction, in addition to internal processes such as wetting and drying, and expansion and contraction of soil mass.

According to Gonçalves and Poggiani (2000), values between 75% and 85% of total porosity are considered adequate for seedlings production, in this case none of substrates achieved such percentage. For the same authors, values between 55-75% are considered medium, below 55% low and bigger than 75% considered high.

In the other hand, according to Usga (2018), adequate values of total porosity, for adequate golf turfgrass growth and development are between 0.35-0.55m^3 m^{-3}, equivalent to 35-55%. In this way, only T4 and T8 showed inadequate porosity, and the others, despite the decrease in total porosity, are within the appropriate interval for lawn development.

Low porosity and low aeration space may be related to the large amount of small particles, which may lead to increased density (Brito et al., 2017).

Table 3 presents the average values of each substrate density.

Table 3. Density means of substrates for evaluations assessed on the day of implantation, 215 and 422 days after implantation of the experiment (DAI) that evaluates soil physical attributes and Zoysia grass development.

Density (g cm^{-3})			
	Days after implantation (DAI)		
Treatments	0	215	422
T1 – S	1,23 b	1,35 b	1,35 ab
T2 – S + SA 1:1	1,49 a	1,53 a	1,46 a
T3 – S + SA 2:1	1,50 a	1,33 b	1,41 a
T4 – S + CO 1:1	0,98 c	0,99 de	1,04 de
T5 – S + CO 2:1	0,73 d	1,11 cd	1,10 cd
T6 – S + SA + CO 2:1:1	1,16 b	1,24 c	1,19 cd
T7 – S + SA + CO 1:1:1	1,22 b	1,23 c	1,22 bc
T8 – A + CO 1:2	0,92 c	0,89 e	0,89 e

Means followed by the same letter in the column do not differ at the 5% level of significance by Tukey test. S = soil; SA = sand; OC = organic compound.

It is noted that at first evaluation, the day of experiment implementation, T5 presented the lowest value and T3 the highest, both differing statistically. It is also observed that at 215 and 422 DAI, T8 was the only one to present low density when compared to other treatments. As mentioned previously, density and porosity are correlated.

The values of density behaviour are inverse to what observed for total porosity, there was a general increase in density with the exception of T3 and T8, which dropped between the first and the second evaluation, possibly, the sand avoided the cementing effect and greater particle compaction, however, the difference in values is great between one and the other. The density of T3 has already been high before grass was implanted, so, more compacted, while T8 had lower values (Table 3).

The third evaluation shows subtle variations with an increase in T3 and T4, and a decrease in T2, T5, T6 and T7 (Table 3).

It may also be observed that T2 stands out from the other treatments with the lowest values of total porosity (Table 2) and with the highest values of density (Table 3) in all evaluations. It is also possible to observe the reverse behaviour presented by T3 in which the porosity shows an increase (second evaluation) followed by a decrease (Third evaluation) and in density it presents a decrease (second evaluation) followed by an increase (third evaluation).

According to Usga (2018) for the range of total porosity previously mentioned (35% a 55%) densities must be between 1.19-1.72 g m^{-3}, where at the day of experiment installation, only T1, T2 , T3 and T7 are within the range, at 215 and 422 DAI, treatments that are in the exposed limits are T1, T2, T3, T6 and T7.

Organic matter, as we may see, is one of the most fundamental components of substrates, being responsible for increasing water and nutrient retention capacity, for plants, in addition to reducing the apparent and overall density of substrate, also increasing its porosity (Sales et al., 2017).

Corroborating this concept, all treatments that contained organic matter, in general, showed greater porosity and lower densities (Tables 2 and 3). The organic matter has high water absorption, preventing the formation of thick films around mineral particles in the soil, reducing the lubricating effect of water between them, reducing the intensity of compaction.

Brandy and Weil (2013) consider ideal density ranges between 1.3 to 1.6 g cm^{-3} and densities above 1.7 g cm^{-3} restrictive for plant growth. In these conditions, only T1, T2 and T3 would provide sufficient density for grass development, due to the results presented in the last two evaluations, since all other treatments show results below for proposed interval.

Santos et al. (2016) working with different substrates for development of Zoysia grass, found a density range between 0.99 to 1.46 g cm^{-3}, corroborating with the present study.

Table 4 shows the fresh weight means of all treatments for assessments at 215, 347 and 418 DAI.

Table 4. Fresh mass of Zoysia grass cutting in different substrates for evaluations assessed on the day of implantation, 215 and 422 days after implantation of the experiment (DAI) that evaluates soil physical attributes and grass development.

Fresh mass (g)						
	Days after implantation (DAI)					
Treatments	215		347		418	
T1 – S	110.63	c	51.71	b	37.57	a
T2 – S + SA 1:1	90.06	c	90.96	ab	44.74	a
T3 – S + SA 2:1	123.44	bc	84.74	ab	26.26	a
T4 – S + CO 1:1	199.82	a	97.31	ab	78.38	a
T5 – S + CO 2:1	193.20	a	106.74	ab	83.85	a
T6 – S + SA + CO 2:1:1	186.92	a	71.34	b	54.39	a
T7 – S + SA + CO 1:1:1	173.32	ab	90.48	ab	55.49	a
T8 – A + CO 1:2	187.48	a	135.43	a	73.99	a

Means followed by the same letter in the column do not differ at the 5% level of significance by Tukey test. S = soil; SA = sand; OC = organic compound.

The fresh mass represents plant growth, and it is noted that at first evaluation T4, T5, T6 and T8 obtained the highest averages, not differing statistically from each other, but differed from the others, while T2 obtained the lowest average.

At second evaluation, T8 presented the highest fresh mass among treatments, with the lowest value being presented by T1. The third evaluation did not show any statistical difference among treatments means, however numerically T5 and T3 obtained the highest and lowest mean, respectively.

As well as physical characteristics evaluated previously, it is observed that, in general, treatments with organic matter in its composition, presented the highest grass fresh masses. The grass planted on these substrates managed to develop more and probably deepened its root system and, thus, absorb more water and nutrients to the detriment of treatments with more superficial and even less developed root system.

Dinalli et al. (2015) working with application of nitrogen sources to evaluate fresh matter content in Zoysia grass in the municipality of Ilha Solteira-SP, found intervals of 8.6 g to 10.4 g, with no statistical difference between treatments, as the save occurred with Amaral et al (2016) when tested substrates in Bermuda grass, which does not occur with the present work.

On the other hand, Santos et al. (2016) studied the influence of fertilization and compaction of different substrates on the development of Zoysia grass, observed an interval between 45.59 to 70.75 g of fresh mass for treatments without fertilization. In the present study, at 215 days, the date before fertilization, none of substrates was shown to be within this range. Still, according to the same author, intervals between 56.28 to 95.91 g of fresh mass were found for treatments fertilized with Forth Jardim®. In the present work, at 347 days, treatments had already been fertilized with the same product, and only T2, T3, T6 and T7 were found in the exposed, already at 418 DAI, only T4, T5 and T8 are within that range.

All treatments have soil as a component, except T8, so most of them have the same base in relation to initial nutrients. It is important to remember that sand is an inert material and due to not having electrical charges, it is unable to retain any type of element. Thus, the grass growth in the treatments with organic matter is greater than in the treatments without, it may be inferred that the organic matter also made available essential nutrients to plant development as Cabreira et al. (2017).

4 CONCLUSIONS

There was influence of total porosity and density on different substrates composition in the development of Zoysia grass, and the treatments that have organic matter in their composition obtained the best results for the evaluated traits.

T4 (soil + organic compound 1:1) and T8 (sand + organic compound 1:2) showed the highest values of density, total porosity and, also values of fresh mass, however, increase the need for cuts to maintain the turfgrass aesthetics.

AUTHOR CONTRIBUTION

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