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Substrates and fertilization in the development of São Carlos grass

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Abstract: São Carlos grass (*Axonopus affinis*) is recommended for use in industrial areas, residential gardens and country houses, and has tolerance to semi-shaded areas. The experiment was carried out at UNESP, Campus de Ilha Solteira - SP, in the period from 06/28 to 12/14/2014, in a greenhouse (Pad & Fan, mean temp 25°C and average luminosity 2500 lux). The grass was implanted in black plastic containers (8.46 liters), and the experimental design was a 3x4 factorial composed of three substrates: soil, soil + organic matter (1: 1) and soil + organic matter + sand (2:1:1), and three chemical fertilizers: Forth Jardim®, Maxgreen S2® and NPK (10-10-10), and without fertilization. The organic matter showed a beneficial effect on the development of the turfgrass, as well as the use of Forth Jardim®.
Keywords: *Axonopus affinis*, FCI, turfgrass.

Introduction

Ornamental and sports turfgrass are associated with significantly lower levels of symptoms of depression, anxiety and stress (Beyer et al., 2014). In Brazil, are generally used turfgrass that require low maintenance in recreational areas, with the main genera *Zoysia*, *Axonopus* and *Cynodon*.

Axonopus spp (São Carlos or Curitibana) are native to the southern region of Brazil; are characterized by a habit of stoloniferous growth, with broad, hairy leaves (GURGEL, 2003; MACIEL et al., 2016), dark green in color. They exhibit tolerance to temperatures between 12°C to 32°C, but not to frost; adapts well to shaded areas (FAO, 2017), is resistant to drought and has a low tendency to form thatch (JIMÉNEZ, 2003). In an experiment using saline water, São Carlos grass presented a 50% reduction of growth in the shoot and root in ECs (electrical conductivity) between 18.3 and 39.8 dSm-1 and 18.8 to 49.4 dSm-1, respectively (UDIN et al., 2009) and, according to Jiménez (2003), this is a grass that has low resistance to salinity.

In golf courses, it is used in areas adjacent to the fairways (roughs) that can have trees planted, and, with shading, being the level that maintenance of the turfgrass in this area is lower (GODOY; VILLAS BOAS, 2003). It is not recommended for sports lawns due to its stoloniferous habit, and consequent low regeneration capacity to mechanical damages (GURGEL, 2003), being that Marcos et al. (2011) suggests the use in stabilization of slopes, mainly in roads and highways.

For cutting height of the leaves before harvest, Villas Bôas and Godoy (2010) recommend the height of 2 to 4 cm; in the case of ornamental use, ideal height of pruning, according to GURGEL (2003) is around 3 to 4 cm, or up to 5 cm (JIMÉNEZ, 2003). Regardless of the use, due to the recurring cut and the maintenance of the ornamental aspect (color, density and texture), it is necessary to use fertilizers.

Thus, due to the few available works related to the segment, the objective was to verify the effect of substrates, associated or not with chemical fertilizer, on the development of *Axonopus affinis* grass.

Material and methods

The experiment was carried out at the Faculty of Engineering – UNESP (São Paulo state University), Campus of Ilha Solteira, SP, Brazil (latitude 20º 25 '28 "S, longitude 51º21'15" W and altitude of 354 m), in the period of June 28 to December 14, 2014. With average temperature registered in the interior of the greenhouse (Pad & Fan) of 25º C and average luminosity 2500 lux. The species of grass used was São Carlos, implanted in black plastic containers (47.5 x 17.5 cm mouth, 41.5

x 11.3 cm depth, height 15.5 cm, volume 8.46 liters), using carpets (0.62 x 0.45 m), which were trimmed.

The experimental design was a 3x4 factorial composed of three substrates: soil, soil + organic matter (1:1) and soil + organic matter + sand (2:1:1), and three chemical fertilizers: Forth Jardim®, Maxgreen S2® and NPK (10-10-10), and a control (without fertilization).

From the Experimental Farm of UNESP/Ilha Solteira-SP, the Dystroferric Red Latosol (layer 0-20 cm) was used, and the organic compound, which had been decomposed for 1 year, was composed of bahiagrass (*Paspalum notatum*) leaves and manure of corral (1:1); the average washed sand was acquired in local commerce.

Were used: 100 g m^{-2} of Forth Jardim®, 45 g m^{-2} of Maxgreen S2®, according to the manufacturer's recommendations, and 60 g m^{-2} of NPK (10-10-10). The composition of the fertilizers used, supplied by the manufacturers: Forth Jardim® (13% N; 5% P_2O_5; 13% K_2O; 1% Ca; 0,04% B; 0,08% Mn; 1% Mg; 0,05% Cu; 0,005% Mo; 5% S; 0,2% Fe and 0,15% Zn); and Maxgreen S2® (24% N; 15% K_2O; 0,18% S; 0,005% Mo; 0,08% Mn; 0,2% Fe; 0,05% Cu and 0,2% Zn). Fertilization was carried out soon after the turfgrass implantation and in the days after fresh mass collection.

Irrigation management was performed manually daily, and the containers received water until saturation, in order to ensure that the water factor did not interfere in the results of the experiment

On July 28, September 8, October 8 and November 7, 2014, the FCI (Foliar Chlorophyll Index) was evaluated using the manual chlorophyllometer (Falker), and fresh and dry mass (g m^{-2}).

The data collected were submitted to analysis of variance and, afterwards, the means were compared by the Tukey test at 5% probability; being the analyzes made using the program System for Analysis of Variance - SISVAR.

Results and discussion

The data for FCI - Foliar Chlorophyll Index, are shown in Table 1 and Table 2. There was no interaction between substrate and fertilization in the 1st and 4th collect. The FCI ranged from 30.06 to 38.89, and there was a decrease from the 1st collection to the 4th collection, and in the soil. The values were generally (less 3rd and 4th collections, when comparing Maxgreen S2®) lower than in the substrates. Treatments with fertilization were shown to be better in Forth Jardim® (13-5-13) and NPK (10-10-10); Maxgreen S2® (24-0-15) presented lower results, in the 3rd and 4th collection. According to Jiménez (2003), the genus *Axonopus* has low N requirement; but the response of the grass to fertilization depends on the P content available in the substrate, since the greater effects of this nutrient are observed in the implantation of the turfgrass (Carrow et al., 2001).

Table 1. ICF values of the São Carlos grass according to the treatments, in six evaluations. UNESP, Ilha Solteira/SP, 2014.

Treatments	FCI			
	1st	2nd	3rd	4th
Substrates (S)				
Soil	35,97	34,07	34,41 b	30,06
Soil + O.M. (1:1)	37,96	35,23	37,29 a	31,35
Soil + O.M. + Sand (2:1:1)	36,14	35,83	37,35 a	30,72
C.V.C. (5%)	2,81	2,21	2,23	1,68
Fertilizers (F)				
Without fertilization	32,76 b	30,45	33,90 b	28,45 b
Forth Jardim®	39,60 a	36,51	38,12 a	32,97 a
Maxgreen S2®	36,51 a	34,32	35,22 b	28,78 b
NPK	37,90 a	38,89	38,17 a	32,63 a
C.V.C. (5%)	3,58	2,81	2,85	2,13
C.V. (%)	8,82	7,26	7,09	6,29
$F_{S \times F}$	$0,69^{ns}$	$2,39^{*}$	$0,68^{ns}$	$1,88^{ns}$

Averages followed by the same letter in the column do not differ by the Tukey test, at 5% probability. ns; *; ** not significant; significant at 5% and 1% by the F test. S - soil; O.M. - organic matter. C.V.C. - Critical Value for Comparison.

Chang, Chung and Kuo (2015) working with *Axonopus compressus*, cultivated on substrate of perlite + peat + vermiculite (2:2:1), found values of 24.8 to 26.7 FCI. Springer, Eudoxie and Gouveia (2014) in an FCI *Axonopus* field evaluation (St. Augustine, Trinidad), obtained FCI of 25.04; the values in both cited Works are shown below those shown in Table 1, but the substrate and soil conditions are different.

There was interaction, in the second collection, and the effect of the fertilization is effective, for FCI, in S + O.M. + Sand, with the use of Forth jardim® and with NPK in all the substrates (Table 2).

When cultivated in full sunlight, *A. affinis* had, in the same treatments of the present study, FCI variation between12.64 and 21.66, that is, lower values than Tables 1 and 2, showing that the high luminosity has color interference of this species (SARAIVA et al., 2015).

The values of leaf fresh mass (g m^{-2}) decreased throughout the collections (except for

second collection), with the lowest values, between collections, being observed for soil and the highest values found in Soil + O.M.; Forth Jardim® was more effective in the production of fresh pasta (Table 3).

Table 2. FCI values of the São Carlos grass obtained from the split for second evaluation (09/08/2014), between the substrates and the applied fertilizers. UNESP, Ilha Solteira/SP, 2012/13.

Substrates	Fertilizers			
	Without fertilization	Forth Jardim®	Maxgreen S2®	NPK
S	26,54 bB	35,59 aAB	34,81 aB	39,34 aA
S + O.M. (1:1)	31,55 aB	35,81 aAB	34,47 aAB	39,10 aA
S + O.M. + Sand (2:1:1)	33,26 aB	38,13 aA	33,69 aB	38,25 aA
C.V.C. (S)		4,42		
C.V.C. (F)		4,87		

Averages followed by the same letter lowercase in column and uppercase in row do not differ by the Tukey test, at 5% probability. S - soil; O.M. - organic matter. C.V.C. - Critical Value for Comparison.

Table 3. Values of leaf fresh mass (g m^{-2}) of São Carlos grass according to treatments, in six evaluations. UNESP, Ilha Solteira/SP, 2014.

Treatments	Fresh Mass (g m^{-2})			
	1st	2nd	3rd	4th
Substrates (S)				
Soil	798,54 b	1046,01	637,75	520,00
Soil + O.M. (1:1)	965,60 a	1124,22	744,96	727,98
Soil + O.M. + Sand (2:1:1)	902,13 ab	1058,23	733,45	517,46
C.V.C. (5%)	107,80	144,79	118,86	77,57
Fertilizers (F)				
Without fertilization	614,28 b	521,20	344,02 c	466,803
Forth Jardim®	1005,09 a	1284,11	899,81 a	686,57
Maxgreen S2®	956,51 a	1174,29	740,26 b	592,89
NPK	979,15 a	1325,00	837,46 ab	608,44
C.V.C. (5%)	137,22	184,31	151,30	98,74
C.V. (%)	13,98	15,50	19,42	15,19
$F_{S \times F}$	$1,94^{ns}$	$2,64^{*}$	$1,78^{ns}$	$6,79^{**}$

Averages followed by the same letter in the column do not differ by the Tukey test, at 5% probability. ns; *; ** not significant; significant at 5% and 1% by the F test. S - soil; O.M. - organic matter. C.V.C. - Critical Value for Comparison.

There was interaction in the 2nd and 4th collection; in the second collection (Table 4) the effect of O.M. in the substrate is visible (and differs statistically) in Soil + O.M. and Soil + O.M. + Sand, without the use of fertilizers. It is also observed that the fertilization provided higher values of fresh mass leaf (g m^{-2}) when compared to that without fertilization.

In the 4th collection, the same occurred as in the 2nd, where occurred the effect of O.M., without the use of fertilizers. The highest figure was found for Soil + O.M. X Forth Jardim®, and the lowest for Soil X without fertilization, both statistically different, in the row (Table 5).

The values of those with organic matter stand out, and this is supported by Figueiredo, Ramos and Tostes (2008). Where they comment that this allows a greater cation exchange capacity of the soil (CEC) favors nutrient cycling, avoids sudden changes in pH, and improves soil physical conditions, maintaining good particle aggregation, aeration, and greater retention and storage of water, leading to better plant development. Nevertheless, Soil + O.M. + Sand, presents values smaller than Soil + O.M., since sand particles have a low retention capacity of water and nutrients.

Although Maxgreen S2® (24-0-15) had a higher N content than Forth Jardim® (13-5-13) and NPK (10-10-10), this showed inferior results of fresh mass (g m^{-2}), since it does not have P in its composition. Since phosphorus, deficiency can reduce both respiration and photosynthesis, leading to retardation and paralysis of cell growth and consequent reduction in dry matter production, among others (GRANT et al., 2001).

The data of leaf dry mass (g m^{-2}) (Table 6) agree with those of leaf fresh mass (g m^{-2}) (Table 5), when values decreased during the collections (except 2nd collection), being that the smaller ones, between collections, are observed for soil and the highest values are found in Soil + O.M.

There was interaction in the 1st and 3rd collection for leaf dry mass (g m^{-2}), with the unfolding shown in Tables 7 and 8, where the effect of the organic matter, without the use of fertilizers, is observed, the same as the 4th collection and 2nd, for leaf fresh mass (g m-2). The largest value, and statistically different (for row and column) is seen in Soil + O.M. + Sand X Forth Jardim®.

Table 4. Mean values of the leaf fresh mass (g m^{-2}) of the São Carlos grass obtained from the split for second evaluation (08/09/2014), between the substrates and the applied fertilizers. UNESP, Ilha Solteira/SP, 2014.

Substrates	**Fertilizers**			
	Without fertilizer	Forth Jardim®	Maxgreen S2®	NPK
S	293,72 bB	1305,26 A	1215,70 aA	1417,36 aA
S + O.M. (1:1)	726,35 aB	1253,62 A	1234,89 aA	1282,02 aA
S + O.M. + Sand (2:1:1)	543,55 abB	1293,44 A	1072,27 aA	1275,64 aA
C.V.C. (S)		289,58		
C.V.C. (F)		319,23		

Averages followed by the same letter lowercase in column and uppercase in row do not differ by the Tukey test, at 5% probability. S - soil; O.M. - organic matter. C.V.C. - Critical Value for Comparison.

Table 5. Values of the leaf fresh mass (g m^{-2}) of the São Carlos grass obtained from the unfolding for fourth evaluation (11/07/2014), between the substrates and the applied fertilizers. UNESP, Ilha Solteira/SP, 2014.

Substrates	**Fertilizers**			
	Without fertilizer	Forth Jardim®	Maxgreen S2®	NPK
S	240,03 cB	694,80 aA	595,55 A	534,17 bA
S + O.M. (1:1)	723,52 aAB	826,38 aA	611,04 B	766,47 aAB
S + O.M. + Sand (2:1:1)	434,53 bA	538,53 bA	572,09 A	524,69 bA
C.V.C. (S)		155,13		
C.V.C. (F)		171,02		

Averages followed by the same letter lowercase in column and uppercase in row do not differ by the Tukey test, at 5% probability. S - soil; O.M. - organic matter. C.V.C. - Critical Value for Comparison.

Table 6. Values of leaf dry mass (g m^{-2}) of São Carlos grass according to treatments, in six evaluations. UNESP, Ilha Solteira/SP, 2014.

Treatments	Dry Mass (g m^{-2})			
	1st	**2nd**	**3rd**	**4th**
Substrates (S)				
Soil	147,85	228,35 a	147,83	129,54 b
Soil + O.M. (1:1)	175,48	244,91 a	190,08	168,27 a
Soil + O.M. + Sand (2:1:1)	176,38	232,96 a	173,80	136,36 b
C.V.C. (5%)	18,56	29,63	28,16	25,94
Fertilizers (F)				
Without fertilization	128,76	133,96 b	116,83	116,11 b
Forth Jardim®	180,89	271,37 a	202,53	157,51 a
Maxgreen S2®	171,76	252,93 a	172,24	151,00 a
NPK	184,87	283,38 a	190,67	154,29 a
C.V.C. (5%)	23,63	37,72	35,85	33,01
C.V. (%)	12,84	14,50	19,03	20,65
$F_{S\,x\,F}$	$2,83^{*}$	$2,20^{ns}$	$2,97^{*}$	$1,06^{ns}$

Averages followed by the same letter in the column do not differ by the Tukey test, at 5% probability. ns; *; ** not significant; significant at 5% and 1% by the F test. S - soil; O.M. - organic matter. C.V.C. - Critical Value for Comparison.

Table 7. Values of the leaf dry mass (g m^{-2}) of the São Carlos grass obtained from the split for the first evaluation (28/07/2014), between the substrates and the applied fertilizers. UNESP, Ilha Solteira/SP, 2014.

Substrates	**Fertilizers**			
	Without fertilizer	Forth Jardim®	Maxgreen S2®	NPK
Soil	100,97 bB	155,82 bA	164,96 aA	169,66 aA
Soil + O.M. (1:1)	136,75 abB	172,96 bAB	189,60 aA	202,62 aA
Soil + O.M. + Sand (2:1:1)	148,57 aB	213,90 aA	160,72 aB	182,34 aAB
C.V.C. (S)		37,12		
C.V.C. (F)		40,92		

Averages followed by the same letter lowercase in column and uppercase in row do not differ by the Tukey test, at 5% probability. S - soil; O.M. - organic matter. C.V.C. - Critical Value for Comparison.

Table 8. Values of the leaf dry mass (g m-2) of the São Carlos grass obtained from the unfolding for the third evaluation (08/10/2014), between the substrates and the applied fertilizers. UNESP, Ilha Solteira/SP, 2014.

Substratos	Fertilizers			
	Without fertilizer	Forth Jardim®	Maxgreen S2®	NPK
Soil	65,63 bB	186,47 aA	158,68 aA	180,54 aA
Soil + O.M. (1:1)	180,69 aA	216,94 aA	183,25 aA	179,43 aA
Soil + O.M. + Sand (2:1:1)	104,18 bB	204,18 a	174,80 aA	212,03 aA
C.V.C. (S)		56,33		
C.V.C. (F)		62,09		

Averages followed by the same letter lowercase in column and uppercase in row do not differ by the Tukey test, at 5% probability. S - soil; O.M. - organic matter. C.V.C. - Critical Value for Comparison.

Costa et al. (2010) in a study with *A. compressus*, in cultivated soil (not described in the work) at Botucatu/SP, obtained 141.4 g m^{-2} of leaf dry mass. Already, in work with *A. affinis* (grass-carpet or São Carlos), under humid subtropical climate of the South, Silva-Kojoroski et al. (2011) found 204.6 g m^{-2} in leaf dry mass, when this was cultivated in soil (not described in the work). Approximate value of the present study when using Soil + O.M. + Sand X Forth Jardim® and Soil + O.M. X NPK (Table 7) and Soil + O.M. + Sand X Forth Jardim® and Soil + O.M. + Sand X NPK (Tables 7 and 8, respectively). We take into account that the authors cited developed the work under conditions not similar to the present, and therefore, different behavior of the grass occurred.

Although, according to Greene et al. (2008), *Axonopus* it has reduced fertilization requirement, it can be concluded that fertilizer application effect occurred, mainly due to the N content of these, since Tables 1 to 8 show an increase in shoot growth (fresh and dry mass) and the intensity of leaf green coloration (FCI), which corroborates with Carrow et al. (2001).

Conclusions

The organic matter (organic compound), together with the use of fertilizers, proved to be efficient for the better development of the São Carlos grass.

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"Itograss" and "TecNutri do Brasil".

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