English Version

Evaluation of physical characteristics of substrates formulated with organic waste for the production of forestry seedlings in tubes

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Abstract

The experiment was developed in the Laboratory of Soils of the University Campus of Alta Floresta, which belongs to the UNEMAT - Universidade do Estado de Mato Grosso (State University of Mato Grosso). The compounds used in the formula of the substrates tested were obtained in the municipality of Alta Floresta – northernmost of the state of Mato Grosso. The aim of this study was to evaluate the physical characteristics of different organic substrates formulated with organic waste for production of forest seedlings in tubes. We tested twelve substrate combinations (treatments). The analyzed characteristics were: density, total porosity, micro and porosity and capacity to retain water in tubes of 50 cm^3. T6 (70% of cattle manure and 30% rice hulls) was the substrate that showed the best values for the analyzed parameters, and it can be tested for seedling production.

Key words: substrates; macroporosity; microporosity; porosity

Introduction

The main function of the substrate used in the production of forestry seedlings is to sustain the plant and provide it with nutrients. This compound has a solid phase, constituted of mineral and organic particles; a liquid phase constituted by water, in which it can be found nutrients, named soil or substrate solution; and a gas one, constituted by the air (GOMES and PAIVA, 2004). It also must present appropriate balance between its compounds in order to promote appropriate relation between macro (occupied by air) and microporosity (occupied by water) (GONÇALVES and BENEDETTI, 2005).

In the systems of production of forestry seedlings in tubes, whether by seeds or cuttings, the physical characteristics of the substrate are fundamental to an appropriate rooting and plant growth (VALERI e CORRADINI, 2005). The chemical characteristics of the substrate are relatively easy to be corrected with performance of fertilization of bases and cover (GONÇALVES et al., 2005).

The organic matters more used for the production of forestry seedlings in tubes are: organic compounds, tanned cattle manure, sawdust, poultry litter, carbonized rice husk, among others. Some of these substrates may be used isolated or joint. This practice aims to improve the physical characteristics of the substrate, decreasing the density, and obtaining thus a better drainage.

Among the main limitations in the productions of substrates to forestry seedlings there is the availability of the materials in large scale and the cost of acquisition. In the northernmost region of Mato Grosso, the activities of extraction and transformation of the wood of native species, beef cattle and family agriculture predominate. These activities generate considerable production of accumulated organic waste, which in most cases do not have destined uses. This situation generates pollution in the rural and urban environment, where the waste is deposited.

The necessity of searching for uses of the available organic matter to the production of forestry seedlings firstly begins with the evaluation of the physical properties of the materials. These analyses may be done with only one compound or with the combination among them, aiming to obtain the appropriated physical characteristics. Among the main physical aspects to be considered in the substrates to the production of forestry seedlings, there are: uniformity, capacity of retention of water and low density.

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In this present context, the objective of this work was to evaluate some physical characteristics of different compositions of substrate based in organic agro-industrial waste to the production of forestry seedlings in tubes.

Material and methods

The experiment was developed in the Soil Laboratory of the University Campus of Alta Floresta, which belongs to UNEMAT – Universidade do Estado de Mato Grosso (Mato Grosso State University). The compounds used in the formula of the tested substrates were obtained in the municipality of Alta Floresta – northernmost of the state of Mato Grosso.

Twelve compositions of substrate were tested, ranging the proportions, for the following compounds: cattle manure, poultry litter, decomposed sawdust, decomposed coffee husk, carbonized rice husk and fine charcoal (Table 1). The substrates of each treatment were mixed according to their proportions. The experimental design used was the completely randomized, with five replications.

Based on the recommendations of GONÇALVES and POGGIANI (1996), the characteristics of the substrates used were: global density, total porosity, macroporosity and microporosity and maximum capacity of retention of water. The determination of these characteristics was performed according to methodology proposed by EMBRAPA (1997), except the maximum capacity of retention of water in tubes of 50 cm^3.

The determination of the global density of the twelve tested substrates was performed in the following way: volumetric rings with 102 cm^3, full of substrate, had the base closed with tissue of the type morin, attached by a rubber, which were placed in an oven at 105 ºC for 24 hours, aiming to obtain the dry matter. The determination of the density was obtained by the following formula:

D = Dry matter/ volume of the ring

In order to determine the total porosity, macro and microporosity it was used four samples of each tested substrate (treatment). The rings filled with substrate were placed in a plastic tray with distilled water until half of the rings, remaining there for 24 hours to the saturation. After this period, the rings were weighted and placed in the tension table during 24 hours, which presented 0.006 MPa of tension. After the removal of the rings of the tension table it was performed their weight. Through the formulae bellow it was determine the values of the total porosity, macro and microporosity:

Percentage of saturation (PS)
PS = (a – b) X 100 / c

In which:

Table 1. Proportion of material used in the formation of 12 substrates to the production of forestry seedlings in tubes.

Treatment	DS	CM	PL	DCH	CRH	FC
T1	30%	50%	- -	- -	20%	- -
T2	50%	- -	30%	- -	20%	- -
T3	70%	- -	- -	20%	- -	10%
T4	- -	30%	40%	30%	- -	- -
T5	- -	50%	- -	30%	- -	20%
T6	- -	70%	- -	- -	30%	- -
T7	- -	20%	30%	30%	20%	- -
T8	- -	- -	50%	40%	- -	10%
T9	- -	- -	70%	20%	- -	10%
T10	- -	30%	30%	30%	10%	- -
T11	- -	- -	30%	50%	- -	20%
T12	- -	30%	- -	70%	- -	- -

Being: DS = decomposed sawdust; CM = cattle manure; PL = poultry litter; DCH = decomposed coffee husk; CRH = carbonized rice husk; FC = fine charcoal.

a = weight of the block of saturated substrate;
b = weight of the block of dray substrate at 105 °C;
c = volume of the cylinder

Microporosity (Micp)
Micp = (a – b) X 100 / c

In which:
a = weight of the sample after being submitted to a tension of 0.006 MPa (60 cm of water depth);
b = weight of the dry sample at 105 °C;
c = volume of the cylinder

Macroporosity (Macp)
Macp = PS – Micp

Total porosity (TP)
TP = Micp +Macp

The maximum capacity of retention of water in the 50 cm^3 tubes was obtained with the addition of water in tubes, filled with each substrate formulated, until it begins the dropping, i.e., until the field capacity, determining thus the quantity of water retained in the tubes.

The data without transformation of the physical characteristics analyzed were submitted to analysis of variance and the means were compared using the Skott-Knott test at 5% of probability of error. These analyses were performed with aid of the program SISVAR (FERREIRA, 2003).

Results and discussion

Table 2 presents the results of the physical characteristics of the 12 substrates tested. The data obtained in the present work were compared with the classification proposed by GONÇALVES and POGGIANI (1996), who determined scale of values to interpret the physical characteristics of the substrates (Table 3).

According to the classification cited above, none of the treatments evaluated presented density classified as appropriated or high, which ranged from 0.23 to 0.40 g cm^{-3}, being similar to the values of density found by WENDLING et al. (2007) in fourteen substrates tested. In treatments between T1 and T11 the values of density were considered medium, among these T1 and T2 had values close to the appropriated level, only T12 had a low density. It is believed that the increase in the density of T2 is related to the proportion of sawdust (50%) combined with poultry litter (30%), considering

Table 2. Physical characteristics of twelve substrates formulated with organic waste to production of forestry seedlings in tubes.

Treatments	Global density (g cm^{-3})	Total porosity (%)	Microporosity(%)	Macroporosity (%)	Maximum capacity of retention of water (ml 50 cm^{-3})
T1	0.38 b (M)	60.2 d (M)	45.0 b (A)	15.5 e (M)	15.0 a (M)
T2	0.40 a (M)	51.0 f (L)	39.5 d (M)	11.0 f (L)	14.1 b (L)
T3	0.31 d (M)	39.5 g (L)	33.7 e (M)	6.0 g (L)	6.0 f (L)
T4	0.35 c (M)	65.5 c (M)	45.0 b (A)	20.5 c (M)	12.0 c (L)
T5	0.30 d (M)	68.7 b (M)	48.2 a (A)	20.5 c (M)	14.0 b (L)
T6	0.32 d (M)	72.7 a (M)	49.7 a (A)	22.5 c (M)	15.1 a (M)
T7	0.28 e (M)	64.7 c (M)	40.5 c (M)	24.2 b (M)	14.1 b (L)
T8	0.31 d (M)	57.2 e (M)	39.2 d (M)	17.7 d (L)	9.0 e (L)
T9	0.34 c (M)	58.2 e (M)	42.0 c (M)	16.0 e (L)	10.0 d (L)
T10	0.30 e (M)	68.2 b (M)	44.5 b (M)	23.5 b (M)	14.2 b (L)
T11	0.28 e (M)	60.0 d (M)	38.5 d (M)	21.5 c (M)	12.0 c (L)
T12	0.23 f (L)	66.7 c (M)	38.5 d (M)	28.2 a (M)	14.8 a (L)
CV (%)	4.0	3.0	4.0	7.0	2.0

- Averages followed by the same lowercase letter do not differ statistically by the Scott-Knott test at 5% of probability.
- Letters between brackets are referent to the classification of the quality of the physical characteristics of the substrate, according to the proposal of GONÇALVES and POGGIANI (1996), in which: L=low, M=medium, H=High and A=appropriated.

that the sawdust is poorly graded reducing the pore spaces. The prevalence of treatments with medium density is possibly due to the use of great proportions in the mixture of substrate of organic matter with low density.

T2 presented the highest value of global density (0.40 g cm^{-3}), differing statistically from the other treatments; treatments T7, T10 and T11 did not present statistical differences in the values of density, which were 0.28 and 0.30 g cm^{-3}, i.e., the lowest densities together with T12 (0.23 g cm^{-3}).

Regarding to the total porosity of the substrates tested, T2 and T3 were classified with low porosity, which can be caused by the presence of 50 and 70% of sawdust, respectively. With total porosity considered medium, it was observed T1 and T4 to T12, which were composed by proportions ranging from 30 to 50% of poultry litter, cattle manure and coffee husks. Close to the appropriated level to the total porosity it was noteworthy T5, T6 and T10, possibly due to the use of organic compounds with pore material in the composition of the substrate as carbonized rice husk and charcoal. LACERDA et al. (2006) also found higher porosity in organic substrates based in coconut powder and sisal waste.

In the evaluated treatments the values of total porosity range between 39.5 to 72.7%, in which T6 (72.7%) with the highest value obtained, differing statistically from the other treatments. The treatments which had lowest values of total porosity were T2 (51%) and T3 (39.5%), which presented statistical differences between them.

Regarding to the micro porosity of the substrates tested, treatment T2, T3, T7, T8, T9, T10, T11 and T12 presented medium microporosity. T1, T4, T5 and T6 had the values of microporosity classified as appropriated, which leaves a suspicion that this fact is caused by the occurrence of cattle manure in the proportion of 30 to 70/% in the composition of these substrates. The lowest value of microporosity was found in T3, and may be motivated by the considerable concentration of sawdust (70%), which gives to this substrate low capacity of retention of water. This fact is opposed to BURÉS (1997), who comments that substrates with high percentage of sawdust may present problems of excessive retention of humidity, recommended to increase the drainage and reduce the accumulation of water with the mixture with materials of better gradation and lower capacity of retention of water. The values of microporosity of the substrates tested range between 33.7 and 49.7%, in which the highest values were obtained in treatments T5 (48.2%) and T6 (49.7%), which did not differ statistically. The lowest microporosity occurred in T3 (33.7%).

For the macroporosity of the substrates evaluated, seven treatments presented values classified as medium (T4, T5, T6, T7, T10, T11 e T12). This situation was probably motivated by the presence of coffee husk, poultry litter and carbonized rice husk, present in 6, 4 and 3 substrates tested, respectively. According to VALERI and CORRADINI (2005), carbonized rice husk increases the porosity of the substrates. Values of macroporosity classified as low were verified in T1, T2, T3, T8 and T9, which can be caused by the use of sawdust in the first three treatments and charcoal in the two last treatments.

According to BURÉS (1997), the main problem of the use of sawdust with high amount of fine particles is the risk of compaction which reduces aeration, in which may occur anaerobic processes of fermentation, generating organic acids which interfere in the growth of roots. The range in the values of macroporosity of the treatments analyzed was from 6.0 to 28.2% for the treatments T3 and T12, respectively. Treatments T8 (17.7%), T2 (11%) and T3 (6%) presented the three lowest values of macroporosity.

Regarding the maximum capacity of retention of water, it was observed low values for the treatments T2, T3, T4, T5, T7, T8, T9, T10, T11 and T12, and medium values for T1 and T6. The attribution of low values to the substrates tested was possibly due to be composed by sawdust in the two first ones and poultry litter in the others. For the medium values, it is believed that it is the participation of the cattle manure in the composition of the substrate. The treatments which presented the three lowest values were T3 (6 ml 50 cm^{-3}), T8 (9 ml 50 cm^{-3}) and T9 (10 ml 50 cm^{-3}), differing statistically one of the other and the treatments with highest values, which did not differ one of the other were T1 (15 ml 50 cm^{-3}), T6 (15.1 ml 50 cm^{-3}) and T12 (14.8 ml 50 cm^{-3}).

With the presumption that the ideal substrate for the production of forestry seedlings in tubes must present appropriate equilibrium among its compounds, aiming to provide appropriate relation between macro and microporosity, in treatment T6, the values of the physical characteristics analyzed were those which were more balanced, between medium and appropriated levels. To a lesser expression that T6, there are T5, T10 and T12 which were also noteworthy regarding to the physical parameters evaluated. It is suggested that the presence of the carbonized rice husk may have contributed to the balance between macro and microporosity in T6. It must be considered, besides the physical characteristics wanted, the availability of the material used and the facility to prepare the substrate. Treatments T5, T10 and T12 were considered good to use as substrate, since besides they present the best physical characteristics they are compound by two materials easily found in the northernmost region of the state of Mato Grosso.

Conclusion

Treatments T2 and T3 presented undesirable values for the physical characteristics evaluated, and thus are not recommended for the use as substrate to the production of seedlings. Treatment T6 presented the best values of total porosity, microporosity and maximum capacity of retention of water, being this the best treatment, recommended for the production of forestry seedlings in tubes.

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