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Characterization of substrates and their influence on germination and growth of asparagus seedlings

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ABSTRACT

The survival and performance of vegetables in the field production cycle depend on the seedling quality and, in turn, the substrate. Asparagus is not part of the vegetables cultivated in Boa Vista-RR, so basic studies, such as substrate preparation, are necessary. Thus, the present study aimed to evaluate the effect of six substrates on the initial development of asparagus seedlings in two growth phases. For this, an experiment was set up in an entirely randomized design, with treatments arranged in a factorial scheme (6 x 2). In the initial phase of the study, six compositions were evaluated with the following materials: (S - soil; M - goat manure; C - root and shoot of cassava) in two sowing seasons. The $S_{40}M_{30}C_{30}$ substrate stands out by having better particle distribution, 79% ranging between 2 and 0.5 mm and 21% less than 0.5 mm, wet bulk density of 0.823 g cm^{-3} and dry of 0.726 g cm^{-3}, relative humidity of 7.1% and particle density of 1.88 g cm^{-3}. This substrate also provided higher growth variables than the others and is suitable for growing asparagus in its initial phase. Asparagus seeds should be sown in a substrate prepared with soil and organic waste (goat manure and residue from the shoot and roots of cassava) at least seven days before sowing.

Keywords:. *Asparagus officinalis* L., Goat manure, Cassava residue, Organic compost.

Caracterização de substratos e sua influência na germinação e crescimento de mudas de aspargo

RESUMO

O pegamento e desempenho das hortaliças no ciclo produtivo em campo são dependentes da qualidade da muda, e por sua vez do substrato. O aspargo não faz parte das hortaliças cultivadas em Boa Vista-RR, sendo necessários estudos básicos, como elaboração de substratos. Assim, objetivou-se avaliar o efeito de seis substratos no desenvolvimento inicial de mudas de aspargos, em duas fases de crescimento. Para isso, um experimento foi instalado em delineamento inteiramente casualizado, com tratamentos arranjados em esquema fatorial (6 x 2). Na fase inicial do estudo foram avaliadas seis composições com os seguintes materiais: (S - solo; E - esterco de caprino; RPA - Raiz e Parte aérea de mandioca), em duas épocas de semeadura. O substrato $S_{40}E_{30}RPA_{30}$ se desataca por apresentar melhor distribuição de partículas, 79% variando entre 2 e 0,5 mm e 21% inferior a 0,5 mm, densidade volumétrica úmida de 0,823 g cm^{-3} e seca de 0,726 g cm^{-3}, umidade relativa (7,1%) e densidade de partícula de 1,88 g cm^{-3}. Esse substrato, também, determinou variáveis de crescimento superiores aos demais, sendo indicado para o cultivo do aspargo na fase inicial. A semeadura de sementes de aspargo, em substrato elaborado com solo e resíduos orgânicos (esterco de caprino e resíduo da parte aérea e de raízes da mandioca), deve ser realizada no mínimo com sete dias.

Palavras-chave: *Asparagus officinalis* L., Esterco caprino, Resíduo de mandioca, Composto orgânico.

1. Introduction

Asparagus (*Aspargus officinalis* L.) is a very challenging crop, requiring intense manual labor efforts over a long period. Although asparagus has been considered a luxury food item for many years, the crop has grown more widely and has been consumed recently. However, the time and cost required to establish, manage, and harvest asparagus fields, as well as the strong seasonality of the crop, have limited its cultivation in many regions of the world and led to high prices for the crop. This is likely to keep asparagus in the category of the most expensive vegetables until production methods require fewer inputs (Pegiou et al., 2020).

In Brazil, the species is not yet so widespread when compared to other vegetables, such as onions and garlic, which can be an advantage from the commercial point of view because there are still few reports, scientifically proven, of its susceptibility to the attack of pests and diseases, being an excellent alternative to increase local production, besides being a new activity, little known in the country (Santos and Freitas, 2020).

In the seedling production phase, the substrate is one of the most important elements, directly influencing germination and the development of the root system of the new plants, besides being responsible for providing nutrients and retaining water throughout the seedling formation process (Barreto and Testezlaf, 2014; Alves et al., 2021). In the elaboration of a substrate, rarely will only one material count with all the attributes suitable for the particular plant species (Rodrigues et al., 2016), being necessary to mix different raw materials, becoming a challenge since the final quality of the substrate will be the result of the characteristics and interactions of the materials used (Monteiro et al., 2019).

Commercial substrates are often not uniform and are usually enriched with mineral fertilizers. Then, it is of fundamental importance to develop research that aims to use alternative raw materials of good quality and low cost for producing substrates on farms, respecting the environment (Oliveira et al., 2019; Santos et al., 2019; Carmo et al., 2020).

Among the alternative materials most commonly used to compose substrates are organic composts, which affect microbial processes, aeration, structure, water-holding capacity, and nutrient supply (Rodrigues et al., 2016). These materials can be of animal origin: cattle, sheep, goat manure (Nascimento et al., 2019), chicken manure (Souza et al., 2017), and vegetable, such as: coconut fiber, the residue of coffee drying, sugarcane bagasse, castor cake, banana stalk, pine bark (Klein, 2015; Meneghelli et al., 2017).

Among plant residues, those from the processing of cassava (*Manihot esculenta* Crantz) have generally been improperly disposed of, with harmful impacts on the environment since this material is rich in hydrocyanic acid (Oliveira et al., 2012). These residues can be an alternative in the composition of substrates for producing seedlings of various plant species, including asparagus. Information regarding the potential of these residues in the formulation of substrates is scarce in the literature, although there is information about their use in animal and human nutrition, as they are rich in vitamins, proteins, and minerals (Nogueira et al., 2021).

When making a substrate, you should aim for low density, with values around 0.50 g cm^{-3} (dry) and 1.0 g cm^{-3} (wet). Very high densities, greater than 1.0 g cm^{-3}, indicate low porosity and readily available water content. Thus, the bulk density of a substrate has an important application in seedling production (Fermino and Kampf, 2012).

Using materials easily available on farms, such as vegetable waste, for the composition of substrates to be used in forming asparagus seedlings can be advantageous and stimulate the association between these crops, contributing to its establishment among the horticultural activities in the state of Roraima. Thus, the present study aimed to evaluate the physical quality of six substrates and their effect on the germination and growth of asparagus seedlings at two growth stages.

2. Material and Methods

The study was conducted in a greenhouse under controlled conditions, with a mean temperature variation from 25.1 ± 0.13 to 35.8 ± 0.18 °C, minimum and maximum, respectively, and relative air humidity of 40%. Subsequently, the physical analyses took place in the Soil Physics and Management Laboratory at the Center for Agricultural Sciences - *Campus* of Cauamé of the Federal University of Roraima (CAA/UFRR) in the Boa Vista - Roraima. The region's climate, according to the Köppen-Geiger classification, is of the Aw-type, with average annual precipitation of approximately 1,700 mm, temperature of 27.4 °C, and relative air humidity of around 70% (Araujo et al., 2001).

The following materials were used to prepare the six substrates: soil, tanned goat manure, and cassava residue. The soil was classified as Oxisol and collected in the 0 - 0.20 m layer, uncultivated from the savanna of Roraima, coordinates 2º49'11" N, 60º40'24" W, and altitude of 90 m. A soil sample was sent for chemical analysis, presenting the following characteristics: pH in water 4.83; P and K (mg dm^{-3}) - 0.9 and 12; Ca^{2+}, Mg^{2+}, and Al^{3+} ($cmol_c$ dm^{-3}) - 0.24; 0.08, and 0.68; H+Al - 2.30 $cmol_c$ dm^{-3}; Sum of bases, ECEC, and CEC_7 ($cmol_c$ dm^{-3}) - 0.35; 1.03, and 2.65; Base saturation, aluminum saturation, and SOM (%) - 13; 66, and 0.53. According to the soil analysis results, the liming needs were determined (1.2 t ha^{-1} ECCE 100%) to raise the base saturation to 60%. Approximately 1 m^3 of soil was corrected with dolomitic limestone and incubated for 30 days at 60% of field capacity.

The goat manure was obtained from a medium-technology farm, where the animals were provided with mineral salt, an extensive grazing diet, and all the necessary health care. After collection, the manure was stabilized for 30 days, remaining deposited in an open and ventilated place. After being tanned, it was ground and passed through a 4 mm mesh sieve. Before adding goat manure to the substrate, a 50 g sample was collected, dried in an oven at 105 °C to constant mass (approximately 48 h), and then measured for moisture.

The residues of the cassava cultivar Aciolina (Oliveira et al., 2011) were collected from 12 month old plants. The different parts of the cassava that composed the substrates were harvested, ground, and dried in the greenhouse until completely withering. This material was ground and passed through a 4 mm mesh sieve. A sample of each part of the material was collected, and the remaining moisture was measured to calculate the dry matter. Table 1 shows the materials and their proportions that, after being mixed, generated the substrates. Before planting the asparagus seeds, the substrates were sieved with a 4 mm mesh.

After preparation, the substrates were sampled, and then the following physical properties were determined: current moisture and particle size (Zorzeto et al., 2014); bulk density (Brazil, 2007); particle density by the volumetric balloon method, according to the methodology described by Rowell (1994). In the first phase of the experiment, the design was entirely randomized and arranged in a factorial scheme (6 x 2) with six repetitions. The experimental unit was composed of a polypropylene tube with a volumetric capacity of 200 mL for storing the substrate, containing a 5 mm diameter drain at the bottom for water percolation.

Six substrates (Table 1) represented the first factor, and the second factor corresponded to two sowing times (ST1 and ST2). ST1 corresponded to sowing on the same day as the mixture of substrate components. For ST2, sowing only occurred seven days after mixing the components. During this period, the substrate was maintained at 60% of field capacity in a protected environment. Asparagus was sown on April 6, 2022. Four seeds of the Olivio cultivar from the Isla company were sown per experimental unit (Figure 1).

Table 1. Substrates with different proportions of soil and organic matter for the initial development of Asparagus, cultivar Olivio.

Substrates	Soil[1] (%)	Goat Manure[2] (%)	Root and Shoot Cassava[3] (%)
$S_{00}M_{50}C_{50}$	0	50	50
$S_{20}M_{40}C_{40}$	20	40	40
$S_{40}M_{30}C_{30}$	40	30	30
$S_{60}M_{20}C_{20}$	60	20	20
$S_{80}M_{10}C_{10}$	80	10	10
$S_{100}M_{0}C_{0}$	100	0	0

[1]- Oxisol from the 0-0.20 m layer of Roraima's savanna; [2]- Tanned goat manure; [3]- Root and shoot of cassava after the starch extraction, dried and ground.

Figure 1. Fruits of *Asparagus officinalis* L. (A), seeds of *Asparagus officinalis* L, cultivar Olivio (B), and sowing in 200 mL volumetric tubes (C).

The seedlings were irrigated daily by micro sprinkler, with a flow rate of 113 L h^{-1}, in two shifts (morning and afternoon) for 10 minutes. At 23 days after sowing, the following variables were evaluated: germination percentage (GP), number of leaves (NL), seedling height (SH), and root length (RL) of the asparagus seedlings. A 30 cm ruler was used to measure the plants, they were removed from the substrates, evaluated, and then replanted in the same substrate.

After the evaluations of Phase I, only the seedlings that were sown on the seventh day after the substrate was prepared and was grown, maintaining all growing conditions. For Phase II, the experimental design was entirely randomized, with six treatments and six repetitions. The treatments consisted of the substrates (Table 1). The experimental unit was composed of a 200 mL capacity tube. At 60 days after emergence (DAE), the following variables were evaluated: seedling height (SH), first leaf height (FLH), number of branches (NB), length of the longest branch (LLB), number of leaves (NL), and root length (RL) of the asparagus seedlings. A 50 cm ruler was used to measure the seedlings.

The data obtained in the two phases of the study were subjected to the Shapiro-Wilk normality test. Once the normal distribution and other assumptions were met, we proceeded to the analysis of variance, in which, if significant effects were observed, the means were grouped by the Scott-Knott test at 5% probability using the software SISVAR 5.1 (Ferreira, 2014). The data from the variables germination percentage, seedling height, and root length were transformed to root(x) for statistical analysis.

3. Results and Discussion

Figures from 2a to 2f show the particle size of the substrates studied, with the texture predominantly less than 2.0 mm. The particle size distribution of the substrate is one of the parameters that significantly affect the physical performance of the substrate (Barreto and Testezlaf, 2014). Thus, there was a greater expression of the 0.50 mm fraction for most substrates, except in substrates $S_{20}M_{40}C_{40}$ and $S_{40}M_{30}C_{30}$, possibly due to the heterogeneity of the materials used, highlighting the cassava waste, lighter and more resistant to decomposition, being preponderantly retained on the 2.0 mm sieve (Figure 2).

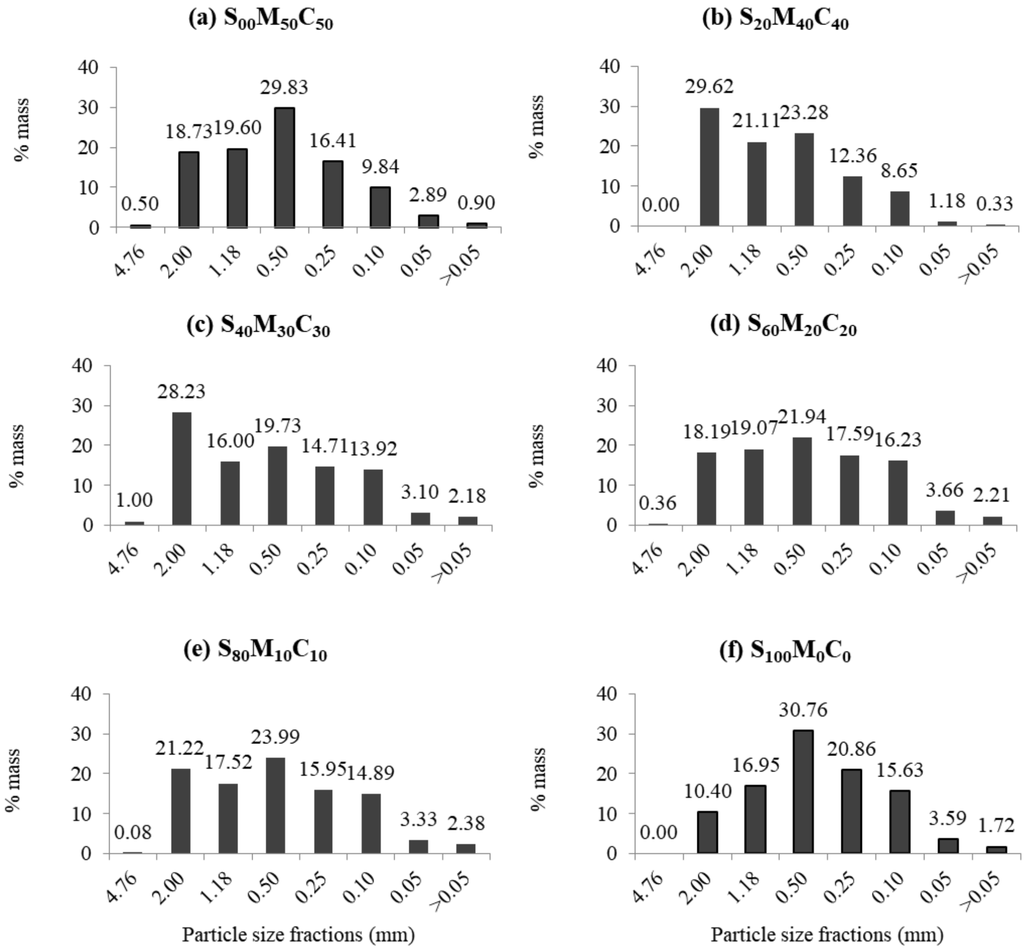

Figure 2 - Percent distribution of substrate particles by size according to the sieve diameter.

The substrate $S_{40}M_{30}C_{30}$, in turn, showed a higher proportion of particles between 2.0 and 0.5 mm (79%), intermediate texture, and 21% fine texture. This condition in the substrate is suitable when good aeration and water retention are sought (Zorzeto et al., 2014). The substrates evaluated presented different physical properties. The wet and dry bulk densities (Table 2) tended to increase their values by including soil in the substrates.

Table 2. Bulk density of the six substrate mixtures in Wd - wet density and Dd - dry D density.

	Bulk density	
Substrates[1]	Wd (g cm^{-3})	Dd (g cm^{-3})
$S_{00}M_{50}C_{50}$	0.538	0.444
$S_{20}M_{40}C_{40}$	0.728	0.567
$S_{40}M_{30}C_{30}$	0.823	0.726
$S_{60}M_{20}C_{20}$	0.969	0.853
$S_{80}M_{10}C_{10}$	1.030	0.983
$S_{100}M_{00}C_{00}$	1.233	1.221

Except for substrate $S_{00}M_{50}C_{50}$, the others were within the range indicated in the literature, between 0.65 and 1.46 g cm^{-3} for dry density (Dd) and between 0.31 and 1.75 g cm^{-3} for wet density (Wd) (Fermino and Kãmpf, 2012). For the $S_{100}M_{0}C_{0}$ substrate, due to the higher addition of soil, Wd and Dd exceeded the value of 1.0 g cm^{-3}, indicating low water availability. On the other hand, $S_{00}M_{50}C_{50}$ showed high water availability, but the lightness of the structure may not give firmness to plant roots.

Farias et al. (2012) found that working with fruit fibers (acerola, coconut, pineapple, and cashew), without soil, obtained densities in coconut and acerola fibers higher than in this study, with particle densities ranging from 1.62 to 2.40 g cm^{-3} for commercial substrates. These substrates are not within the appropriate ranges, 0.50 g cm^{-3} for dry density and 1.0 g cm^{-3} for wet density, unlike those obtained in this study. It is emphasized that understanding the bulk density values contributes to determining the type of container used in cultivation, irrigation management, and nutritional recommendation (Fermino and Kampf, 2012).

Figure 3 shows that the available relative humidity (RH) of the substrates decreased with an increasing proportion of soil ($S_{100}M_{00}C_{00}$). The results for the relative humidity of substrates demonstrate that, although the soil is an important component in the production of a substrate since it is easily accessible on the farm, the proportion employed should not compromise the main substrate characteristics such as total porosity, aeration space, density, pH, and nutrient availability (Ludwig et al., 2010). In addition, the soil used in the substrate should be analyzed for chemical characteristics to estimate the need for liming to correct the pH to near 6, neutralize the toxic action of exchangeable aluminum, and raise the base saturation (Raij, 2011). Figure 4 shows the particle density (Pd) of each substrate.

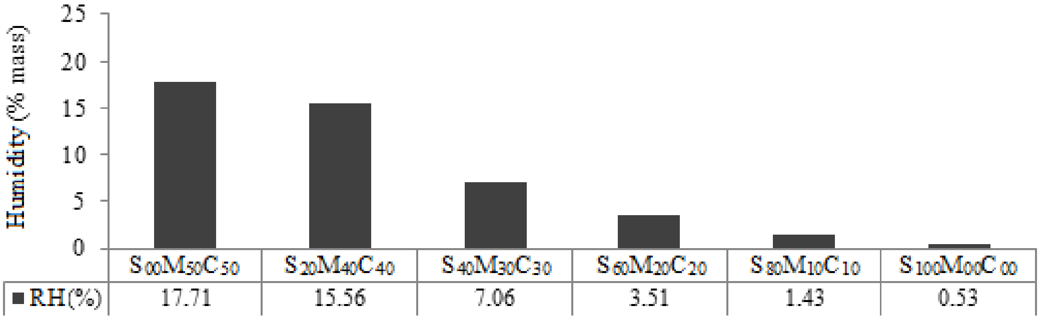

Figure 3. Relative humidity (RH) of substrates formulated with different proportions of soil, tanned goat manure, and root and shoot of cassava after the starch extraction, dried, and ground.

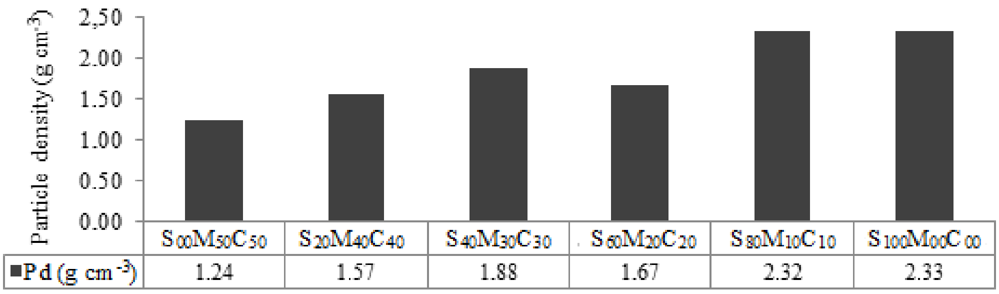

Figure 4. Particle density of substrates formulated with different proportions of soil, tanned goat manure, and root and shoot of cassava after the starch extraction, dried, and ground.

The values for this parameter ranged from 1.24 to 2.33g cm^{-3}. This property separates a more organic-based substrate from a mineral-based one (1.45 g cm^{-3} for organics and 2.65 g cm^{-3} for minerals) (Rowell, 1994). According to Silva et al., (2016), substrates with a particle density of 2.3 g cm^{-3} are the most recommended for producing butter kale seedlings. The interaction between the factors under study in Phase I of the experiment was best expressed in the SH and NL variables, but all the variables studied were affected by simple effects (Table 3). There was variability among the repetitions, possibly due to the early seedling stage and possibly influenced by the reserve in the seeds.

In the unfolding of the effects for %G (Table 4), it was found that regardless of the substrate, the germination percentage was higher in ST2. Immediate planting after substrate preparation (ST1) determined low or no germination, with no significant differences among most substrates, especially treatments $S_{100}M_0C_0$ and $S_{60}M_{20}C_{10}$, which differed from the others, with average germination of 20.8 and 37.5, respectively. In ST2, treatments $S_{00}M_{50}C_{50}$ and $S_{100}M_0C_0$ had lower germination, lower than 55%, possibly due to the physical characteristics of the substrates.

The concentration of the toxic components of the cassava plant may have influenced the %G of the seeds in ST1 since the germination percentage of the seeds in ST2 was higher. The substrates kept for seven days (ST2) in the process of mineralization and losses of hydrocyanic acid (HCN) consisted of more suitable media for the germination of asparagus seeds because the different parts of cassava have high HCN contents (Oliveira et al., 2012), which caused the difficulty of germination in the seeds in ST1.

The substrate influenced the height of the plants independently of the sowing time. In ST2, the plants presented heights significantly greater than those in ST1. In ST1, substrates $S_{100}M_0C_0$ and $S_{60}M_{20}C_{20}$ determined seedling heights, statistically similar and superior to the other treatments. These same substrates and $S_{80}M_{10}C_{10}$, on the seventh day after substrate preparation, also determined the highest heights of asparagus seedlings (Table 5).

The results of seedling height show that the shoot growth of asparagus plants is more dependent on the mineral fraction of the substrate than on the organic fraction since these substrates ($S_{80}M_{10}C_{10}$ and $S_{100}M_0C_0$) obtained higher particle densities of 2.32 and 2.33, respectively (Figure 4). In Table 5, at 13 DAE, the asparagus plants reached an average height of 11.1 cm, obtaining seedlings with greater vigor since the seedling length is directly related to seed vigor. Guedes et al. (2015) demonstrate that more vigorous seeds produce seedlings of greater length and with more uniformity, which can influence the production of seedlings in the field due to the greater acceleration of metabolic processes.

Table 6 shows the number of leaves of the asparagus seedlings. In ST2, the plants had the greatest number of leaves, regardless of the substrate, with an average of 15.4. In ST2, the highest NL was obtained in seedlings grown on substrates $S_{60}M_{20}C_{20}$ and $S_{100}M_0C_0$, with 6.7 and 9.8 leaves per plant, respectively. The results obtained indicate that possibly the expression of this character did not depend on the physical properties of the substrates but possibly due to toxic residues released from the organic fraction of the cassava plant residues, since in ST1, there is the effect of substrates on this character.

Although cassava leaves are a source of valuable nutrients, they also present toxicity due to the presence of cyanogenic glycosides and anti-nutritional factors, such as the high contents of fiber, tannins, phenolic compounds, and phytic acid, which reduce the bioavailability and digestibility of nutrients, and eventually can have toxic effects, depending on the type of processing and the amount consumed (Wobeto et al., 2007; Montagnac et al., 2009).

Table 3. Summary of the analysis of variance for germination percentage (%G), seedling height (SH), number of leaves (NL), and root length (RL) of asparagus plants sown in six substrates on the day of the substrate preparation and at seven days after the substrate preparation, evaluated at 13 days after emergence. Boa Vista, Roraima, 2022.

Sources of variation	DF	Mean Square			
		%G	SH	NL	RL
Substrates (Subs.)	5	21.78^{***}	4.06^{***}	4.52^{**}	6.99^{***}
Sowing (Sow.)	1	631.81^{***}	83.05^{***}	141.54^{***}	37.88^{***}
Subs. x Sow.	5	7.79^{ns}	2.09^{*}	3.18^{*}	5.41^{ns}
Residue	60	4.06	0.79	0.99	45.67
Total	71	-	-	-	-
C.V(%)		37.45	39.80	40.22	55.11

ns,***, **, * - Not significant and Significant up to 0.1, 1 and 5 % probability by F test. C.V(%)-Coefficient of variation. The data were transformed into the root(x) for statistical analysis.

Table 4. Germination percentage of asparagus seeds, cultivar Olivio, sown in six substrates at two times considering the substrate preparation. Boa Vista, Roraima, 2022.

Substrates	% Germination	
	ST1	ST2
$S_{00}M_{50}C_{50}$	12.5 Bb*	55.0 Ab
$S_{20}M_{40}C_{40}$	12.5 Bb	70.8 Aa
$S_{40}M_{30}C_{30}$	0.0 Bb	50.0 Ab
$S_{60}M_{20}C_{20}$	37.5 Ab	87.5 Aa
$S_{80}M_{10}C_{10}$	4.2 Bb	87.5 Aa
$S_{100}M_{00}C_{00}$	20.8 Ba	79.2 Aa
Average	14.6 B	71.7 A

ST1 - Sowing on the day of the substrate mixture; ST2 - Sowing seven days after the substrate mixture; *Means followed by the same lowercase letters in the column and uppercase letters in the line belong to the same group by the Scott-Knott test at 5% probability. The data were transformed into the root(x) for statistical analysis.

Table 5. Seedling height of asparagus, cultivar Olivio, sown in six substrates at two times considering the substrate preparation. Boa Vista, Roraima, 2022.

Substrates	Seedling height (cm)	
	ST1	ST2
$S_{00}M_{50}C_{50}$	2.2 Bb*	7.5 Ab
$S_{20}M_{40}C_{40}$	2.3 Bb	10.0 Ab
$S_{40}M_{30}C_{30}$	0.0 Bb	10.0 Ab
$S_{60}M_{20}C_{20}$	6.8 Ba	13.1 Aa
$S_{80}M_{10}C_{10}$	1.3 Bb	13.1 Aa
$S_{100}M_{00}C_{00}$	7.5 Ba	12.8 Aa
Average	3.3 B	11.1 A

ST1 - Sowing on the day of the substrate mixture; ST2 - Sowing seven days after the substrate mixture; *Means followed by the same lowercase letters in the column and uppercase letters in the line belong to the same group by the Scott-Knott test at 5% probability. The data were transformed into the root(x) for statistical analysis.

Table 6. Number of leaves of asparagus plants, cultivar Olivio, sown in six substrates at two times considering the substrate preparation. Boa Vista, Roraima, 2022.

Substrates	Number of leaves (NL)	
	ST1	ST2
$S_{00}M_{50}C_{50}$	3.6 Bb*	11.8 Aa
$S_{20}M_{40}C_{40}$	0.2 Bb	14.4 Aa
$S_{40}M_{30}C_{30}$	0.0 Bb	15.1 Aa
$S_{60}M_{20}C_{20}$	6.7 Ba	15.8 Aa
$S_{80}M_{10}C_{10}$	1.0 Bb	17.4 Aa
$S_{100}M_{00}C_{00}$	9.8 Ba	17.7 Aa
Average	3.5 B	15.4 A

ST1 - Sowing on the day of the substrate mixture; ST2 - Sowing seven days after the substrate mixture; *Means followed by the same lowercase letters in the column and uppercase letters in the line belong to the same group by the Scott-Knott test at 5% probability.

The substrate influenced root length, regardless of the sowing season (Table 7). In ST2, all plants had greater root lengths except for the substrate without soil ($S_0E_{50}RPA_{50}$). In the ST2, except for $S_0M_{50}C_{50}$, the other substrates showed no significant differences and were superior to the substrate $S_0M_{50}C_{50}$. In phase II of the experiment, there was a reduction in the CV for most variables, indicating that the effect of the sowing time after the preparation of the substrates was a determining factor for the higher CV values in phase I. At 60 days after emergence, all variables were affected by the substrates ($p \leq 0.05$) (Table 8).

Table 7. Root length (cm) of asparagus plants, cultivar Olivio, sown in six substrates at two times considering the substrate preparation. Boa Vista, Roraima, 2022.

Substrates	Root length (cm)	
	ST1	ST2
$S_{00}M_{50}C_{50}$	0.1 Ba*	1.7 Ab
$S_{20}M_{40}C_{40}$	1.5 Bb	5.3 Aa
$S_{40}M_{30}C_{30}$	0.0 Bb	5.4 Aa
$S_{60}M_{20}C_{20}$	3.9 Ba	7.4 Aa
$S_{80}M_{10}C_{10}$	1.1 Bb	6.9 Aa
$S_{100}M_0C_0$	6.9 Ba	10.6 Aa
Average	2.3 B	6.2 A

ST1 - Sowing on the day of the substrate mixture; ST2 - Sowing seven days after the substrate mixture; *Means followed by the same lowercase letters in the column and uppercase letters in the line belong to the same group by the Scott-Knott test at 5% probability. The data were transformed into the root(x) for statistical analysis.

Table 8 shows that the substrates affected the variables SH, HFL, and NB with greater or lesser intensity. In general, the substrates without organic matter ($S_{100}M_0C_0$) and without soil ($S_{00}M_{50}C_{50}$) determined the worst results, reflecting the physical properties of these substrates. Due to the higher addition of soil in substrate $S_{100}M_0C_0$ and $S_{80}M_{10}C_{10}$, Wd exceeded the 1.0 g cm^{-3}, indicating low water availability. On the other hand, substrate $S_{00}M_{50}C_{50}$ showed high water availability, but the lightness of the structure may not give firmness to the roots.

Among the substrates made with the addition of alternative materials available on the farm, the substrate $S_{60}M_{20}C_{20}$ was the one that provided the greatest increase in the values of the variables analyzed. Monteiro Neto et al. (2016), in producing bell pepper seedlings, found the fertilization potential of waste generated on the property as a viable alternative to commercial composts for producing seedlings of various vegetable species.

Composing substrates with farm-sourced materials can reduce costs and have as good results as those purchased commercially. Silva et al. (2009), evaluating different types of substrates in producing watermelon seedlings, found that both the commercial substrate and the one prepared with cattle manure and sand presented satisfactory characteristics for good seedling development.

Table 8. Summary of analysis of variance for seedling height (SH), first leaf height (HFL), number of branches (NB), length of the longest branch (LB), number of leaves (NL), and root length (RL) of asparagus plants, cultivar Olivio, sown at six substrates, evaluated at 60 days after emergence. Boa Vista, Roraima, 2022.

Sources of variation	DF	Mean Square					
		SH	HFL	NB	LB	NL	RL
Substrates	5	122.1**	29.3**	10.9**	39.1**	201.5*	19.3**
Residue	30	10.1	1.7	1.1	6.0	56.7	1.9
Total	35	-	-	-	-	-	-
C.V(%)		14.67	16.78	41.25	17.43	27.35	13.16

**, and * - Significant at 1 and 5% probability by F test, respectively. C.V(%) - Coefficient of variation.

Table 9. Growth variables in asparagus plants, cultivar Olivio, grown in six substrates. Boa Vista, Roraima, 2022.

Substrates	SH (cm)	HFL (cm)	NB (n°)	LB (cm)	NL (n°)	RL (cm)
$S_{00}M_{50}C_{50}$	19.1 b*	7.5 b	2.0 b	11.5 b	27.6 a	7.6 b
$S_{20}M_{40}C_{40}$	23.8 a	8.5 b	4.3 a	16.1 a	33.1 a	10.1 a
$S_{40}M_{30}C_{30}$	26.6 a	10.0 a	4.0 a	16.6 a	31.9 a	11.8 a
$S_{60}M_{20}C_{20}$	25.6 a	9.7 a	2.6 b	16.0 a	29.8 a	11.3 a
$S_{80}M_{10}C_{10}$	20.1 b	6.4 c	1.6 b	13.8 a	25.8 a	10.9 a
$S_{100}M_{0}C_{0}$	14.7 c	4.1 d	0.9 b	10.6 b	17.1 b	12.8 a

SH - seedling height; HFL - first leaf height; NB - number of branches; LB - length of the longest branch; NL - number of leaves; RL - Root length. *Means followed by the same lowercase letter in the column belong to the same group by the Scott-Knott test at 5% probability.

The possibility of the grower having a substrate generated from residues from his property is a stimulus for adopting this vegetable to his production system.

4. Conclusions

The substrates formulated with added soil and organic waste have physical properties within the range considered suitable. Asparagus should be sown in a substrate with organic residue from the seventh day after the mixture of components to compose the substrate. The $S_{40}M_{30}C_{30}$ substrate shows better particle distribution, bulk density within the ideal range, intermediate relative humidity, and ideal particle density, making it the most suitable for the initial development of asparagus seedlings propagated by seed.

Authors' Contribution

Ingridy do Nascimento Tavares: Investigation, data Curation and Writing - original draft. José Maria Arcanjo Alves and Sandra Catia Pereira Uchôa: Conceptualization, formal analysis, project administration, supervision, validation and writing - review and editing. Carlos Enrique Canche Iuit and Yenara Alves Guedes: Investigation and methodology. Deyse Cristina Oliveira Silva: Formal analysis, visualization and writing - review and editing.

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