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Development of watermelon seedlings on cattle manure and poultry litter substrates

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Abstract

The importance of watermelon cultivation is widely recognized on a global scale, mainly because it is predominantly grown by small- and medium-sized farmers. This is due to its easy management and reduced costs compared to other fruits and vegetables. This research aimed to analyze the initial growth of watermelon seedlings on various types of substrates, in order to identify which one contributes to greater plant development. The experiment was carried out in randomized blocks, with five treatments: T1 = commercial substrate; T2 = cattle manure; T3 = poultry litter; T4 = poultry litter + sand (2:1); T5 = cattle manure + sand (2:1). Each treatment was replicated five times, totaling 30 viable seedlings per plot. Sowing was carried out in plastic trays, suitable for the production of seedlings. We observed that the T2 and T5 treatments resulted in a higher dry mass of the roots compared to the others, indicating that cattle manure promoted plant development, stimulating greater root production. Regarding the Development Quality Index (DQI), significant differences were found between treatments T2, T5 and T1, confirming the possibility of using the alternative substrate with high quality. In addition to being an affordable and economical material for small farmers, it also contributes to the satisfactory development of plants. It is concluded, therefore, that substrates T2 and T5 achieved positive results in relation to the others. Thus, its use can be considered viable for the production of watermelon seedlings.

Keywords: Poultry litter. Cattle manure. Sustainability. Cucurbitaceae.

Introduction

Watermelon, classified in the family Cucurbitaceae, in the genus *Citrullus* and in the species *C. lanatus* (DIAS *et al.*, 2001), has its origin in Tropical Africa, although there is considerable variability of the species in India and in the Brazilian Northeast (SANTOS, 2005). The crop is widely cultivated throughout Brazil. According to data from the Brazilian Institute of Geography and Statistics (IBGE, 2021), the country recorded the production of 2,141,970 tons of fruits in 2021, from a harvested area of 91,922 hectares, with an average yield of 23,302 kg ha^{-1}. The state of Rio Grande do Norte stood out as the largest producer, producing 340,805 tons in 14,704 hectares. The state of Minas Gerais contributed with 27,201 tons, cultivated in an area of 1,715 hectares.

Watermelon is one of the most important crops worldwide, mainly due to its predominance of cultivation among small and medium farmers, due to its ease of transport and reduced costs compared to other fruits and vegetables. From a social point of view, this culture contributes to the generation of income and jobs, playing a significant role in halting rural exodus (DIAS *et al.*, 2001).

According to the Brazilian Yearbook of Fruits and Vegetables (2023), after consecutive drops in production areas, projections for 2023 indicate stability and slight recovery in watermelon crops. It was recommended that producers avoid large investments in the crop, due to high production costs. Moreover, the export of watermelon in the 2022/2023 harvest started slowly, but recovered throughout the season, facing logistical challenges in the commercialization and production flow.

As Silva (2016) indicates, the predominant method for the production of seedlings involves the use of styrofoam or plastic trays, filled with commercial substrates. The selection of the appropriate substrate has a significant influence on the quality of the seedlings, and their chemical and physical properties play a determining role, impacting both plant growth and production. However, relatively little is known about how alternative substrates, relative to commercial ones, affect the early development of watermelon seedlings, including their quality, quantity, and composition.

Organic fertilizers are widely used in the formulation of substrates for seedlings, as they can retain water and are nutrient-rich. Cattle manure stands out among the alternative substrates, being an organic material originated from agriculture, due to cattle raising for the production of milk and meat. The practice is marked by the large-scale generation of manure, urine, and waste resulting from facilities operations and sanitation. When not treated appropriately, these components may contaminate the environment. Within the category of organic fertilizers, cattle manure is the most used and is effective for the production of seedlings (SILVA, 2016).

Poultry litter originates from the combination of the material used to house poultry on farms mixed with the animal droppings. After undergoing the maturation process, this substance acquires a highly disaggregated texture, dark color, and maintains a low temperature, in addition to substantial nitrogen enrichment and adequate ammonia level. These characteristics make it an exceptional component in substrate formulation. Seedlings grown on these substrates exhibited remarkable biometric development. Consequently, both cattle manure-based and poultry litter-based substrates should provide results comparable to those obtained with commercial substrates (TRAZZI *et al*., 2013).

When dealing with sustainability on the property, the principle arises from three paths: environmental sustainability, related to good agricultural practices, conserving fauna and flora; social sustainability, ensuring that human rights are respected, with adequate working conditions and access to health, education and basic sanitation; economic sustainability, which aims to ensure that farmers receive the fair price for their production, that they have dignity and quality of life (SILVA *et al.*, 2021). Agricultural production to achieve the economic sustainability must have a lower production cost than marketed price (SOUZA *et al*., 2019).

Therefore, by employing alternative substrates, such as cattle manure and poultry litter, we seek to take advantage of local resources in an economical way, reducing the need for chemicals. This promotes greater environmental balance, contributing to the preservation of biodiversity and ensuring high-quality seedlings. This approach aims to enable sustainable family farming. Organic substrates have gained prominence due to their ability to meet plant requirements (AGUILERA; ZUFFO, 2019). This work was developed with the objective of evaluating the development of watermelon seedlings on different types of substrates, to identify which one provides the maximum seedling growth and vigor.

Material and methods

The experiment was carried out from January to April 2022, in the Horticulture Sector of the Federal Institute of Education, Science and Technology of Southern Minas (IFSULDEMINAS), Inconfidentes *Campus* (MG), located at 940 meters of altitude, at 22°18'47"South latitude and 46°19'54.9" West longitude (PEREIRA *et al.*, 2011).

The variety used was Crimson Sweet of the Feltrin Sementes® brand, with a growth cycle of 75 to 85 days and resistance to anthracnose and *fusarium* wilt. The seeds are brown and small in size. The fruits are rounded in shape, light green in color with darker striations. We opted for the experimental arrangement in randomized blocks, composed of five treatments and five repetitions. Details of treatments can be found in Table 1.

The seeds were distributed in plastic trays with 128 cells each, with two treatments per tray and two empty rows between them. Each plot had 30 useful seedlings. The substrates composed of poultry litter and cattle manure were subjected to processes to ensure uniformity and stability of the material. Initially, the substrate passed through a 2 mm mesh sieve to remove larger particles. Then, it was properly mixed and distributed in the plastic trays, as shown in Figure 1. The trays were placed in a protected environment and kept for 15 days before sowing, with constant irrigation to keep the substrate always moist.

The trays were positioned on a wooden bench, keeping a distance of 1.5 meters from the ground. Two watermelon seeds were placed in each cell of the trays, in which they were left to germinate and grow over seven days. During this period, seedlings emerged and began their development. Thinning was performed after seven days, when all excess seedlings were removed, leaving only one per cell in the tray. Thinning is essential to provide adequate space for the development and growth of the selected seedling, avoiding competition for resources with other seedlings.

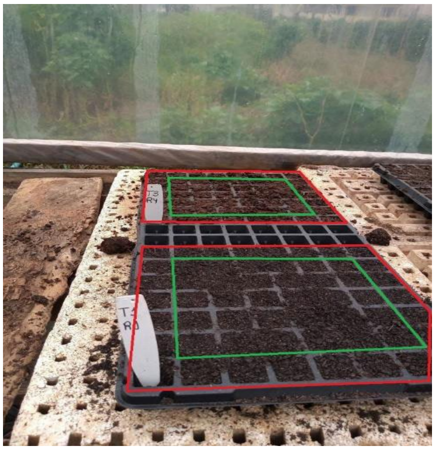
Fifteen days after sowing, ten seedlings were randomly chosen from each plot, excluding the border. The plants were gently removed from the cells and subjected to washing with running water and a sieve to remove the substrate from the roots.

Table 1. Treatments used to carry out the experiment – 2023.

Treatment	Material	Ratio
T1	Commercial substrate	1
T2	Cattle manure	1
T3	Poultry litter	1
T4	Poultry litter + sand	2:1
T5	Cattle manure + sand	2:1

Source: The authors (2023).

Figure 1. Demonstration of arrangement of substrates in the tray – 2022.



Source: The authors, 2022.

Subsequently, growth analysis was performed using the following parameters: average number of leaves (NUM); plant height (PH, mm); leaf length (LL, mm); leaf width (LW, mm); root length (RL, mm); leaf area (LA, mm^2); fresh leaf mass (FLM, mg); fresh stem mass (MFC, mg); fresh root mass (MFR, mg); dry leaf mass (LDM, mg); dry stem mass (SDM, mg); dry root mass (RDM, mg); seedling neck diameter (ND, mm); and Development Quality Index (IQD).

The average number of leaves (NUM) was determined by counting in the ten plants selected. The PH variable (mm) was determined from the substrate level to the insertion of the last leaf. The variables PH, LL, LW and RL were measured using a digital caliper, in millimeters. Leaf area was estimated using the method described by Severino *et al.* (2007), based on two variables, in which P represents the main rib and L the leaf width.

$$Area = 0.84 \times (P \times L) \times 0.99$$

To determine the FLM, MFR and MFC, the plant was cut at the substrate level and separated into leaves, roots and stems, then they were weighed on an analytical balance, obtaining the result in milligrams. Afterwards, the LDM, RDM and SDM were analyzed, which were obtained after drying in an oven with forced air circulation, at 60 °C, until the mass remained constant. Subsequently, the material was weighed and the result in milligrams was assessed.

The Development Quality Index (IQD), methodology of Dickson, Leaf and Hosner (1960), is calculated by the formula that comprises the division of the total dry mass (TDM, g) by the height (H, in cm), plus the diameter of the neck (ND, in centimeters), added to the dry matter mass of the plant shoot (PMSPA, g) divided by the dry matter mass of the root (PRDMA, g).

$$IQD = \frac{MST\,(g)}{\frac{H\,(cm)}{DC\,(cm)} + \frac{PMSPA\,(g)}{PMSRA\,(g)}}$$

The second evaluation was performed 30 days after the emergence of the seedlings, using another ten random seedlings per plot. According to Severino *et al.* (2007), this period is considered ideal for seedling transplantation. The variables NUM, PH, LL, LW, RL, LA, FLM, MFC, MFR, LDM, SDM, MFR, ND, and IQD were again verified, using the same methodology previously described.

To statistically analyze the experiment, the Sisvar statistical program was used (FERREIRA, 2019). The collected data were subjected to analysis of variance (ANOVA), with a 5 % significance level by the F test. The means were compared using the Tukey's test with 5 % probability.

Results and discussion

According to the results of the first evaluation (Table 2), it is possible to notice that the treatments T1, T2 and T5 achieved superior performance in relation to the variables NUM, PH, LL, LW, LA, FLM and MFC. The treatments with poultry litter and poultry litter with sand underperformed compared to the others. These results are consistent with those found by Silva (2016) in watermelon seedlings, in which better performance was also found for commercial and manure substrates in relation to plant height and number of leaves. This is directly related to the availability of water and nutrients, as well as the porosity of the substrates that performed best.

Table 2. Number of leaves (NUM), height (PH), leaf length (LL), leaf widths (LW), leaf area (LA), fresh leaf mass (FLM) and fresh stem mass (MFC) measured at the first assessment, at 15 days after emergence. Inconfidentes, 2022

Treatment	NUM	PH (mm)	LL (mm)	LW (mm)	LA (mm)	FLM (g)	MFC (g)
T1	3.02 a	39.51 a	24.96 a	16.08 a	350.84 a	342.92 a	172.34 a
T2	3.00 a	35.63 a	23.75 a	16.40 a	324.99 a	320.52 a	157.80 a
T3	0.80 b	4.46 b	4.11 b	2.63 a	22.67 a	8.70 a	6.86 b
T4	0.80 b	7.92 b	4.69 b	2.95 a	25.95 a	12.42 a	10.06 b
T5	2.98 a	32.63 a	22.64 a	16.03 a	303.56 a	299.06 a	143.86 a
CV (%)	32.19	27.84	23.52	22.42	16.10	17.01	20.49

Means with the same letter in the same column do not present a statistically significant difference by Tukey's test at a significance level of 5 %. T1 – commercial substrate; T2 – cattle manure; T3 – poultry litter; T4 – poultry litter + sand; and T5 – cattle manure + sand.

CV: coefficient of variation obtained by the percentage relation between the standard deviation and the overall mean of the experiment.

Source: The authors (2023).

As for the RL parameter, the commercial treatment stood out with statistical difference in relation to the substrates that contained cattle manure in their composition (Table 3). Silva *et al.* (2020), when working with alternative substrates for the production of lettuce seedlings, also observed better performance in relation to plant height in commercial and cattle manure substrates. On the other hand, the treatments that contained poultry litter had lower performance, differing from the others.

The most relevant treatment, with the highest rates of ND, was the commercial treatment. Therefore, the use of treatments T1, T2 and T5 for seedling production is considered qualitatively feasible (Table 3).

With regard to MFR (Table 3), the most effective treatment was T2, followed by T5 and T1. As noted by Silva (2016), the use of animal manure serves as a corrective and source of nutrients for plants, promoting balanced nutrition, which is in line with the results of this research.

When considering the statistical average of the use of cattle manure substrates, cattle manure + sand, and commercial substrate to quantify SDM, cattle manure was superior to the others. The quantification of SDM showed no significant differences between substrates T2, T5 and T1 (Table 3).

The results referring to the variables RDM, LDM, TDM and IQD (Table 4) show that the treatments T1, T2 and T5 were superior to the others, with no differences between them. Similar results were found by Silva *et al.* (2020), in which the treatments with commercial substrate and cattle manure were superior to the others. This suggests that, for these evaluations, substrates with cattle manure in their composition are viable for the growth of watermelon seedlings.

The second evaluation, performed 30 days after sowing, showed no significant variation in the variables NUM, PH, LL, ND, LW, FLM, RL, SDM and TDM between treatments T1, T5 and T2; however, they differed statistically from T4 and T3 (Table 5). Therefore, the substrates containing cattle manure in their composition achieved similar results to the commercial substrate, being a promising alternative for production due to their interesting chemical and physical characteristics for the production of seedlings. Similar results were obtained by Xavier (2021), in which the use of substrates containing manure in the production of melon seedlings did not present statistically significant differences in relation to the commercial substrate.

Table 3. Root length (RL), neck diameter (ND), fresh root mass (MFR) and stem dry mass (SDM) measured in the first evaluation, at 15 days after emergence. Inconfidentes, 2022

Treatment	RL (mm)	ND (mm)	MFR (mg)	SDM (mg)
T1	82.72 a	3.24 a	202.16 b	15.96 a
T2	67.19 b	2.57 ab	290.10 a	13.60 a
T3	0.77 c	0.91 b	0.94 c	0.62 b
T4	4.43 c	1.41 ab	1.42 c	0.30 b
T5	62.59 b	2.54 ab	241.26 ab	13.48 a
CV (%)	15.12	48.76 %	26.81	26.52

Means with the same letter in the same column do not present a statistically significant difference by Tukey's test at a significance level of 5 %. T1 – commercial substrate; T2 – cattle manure; T3 – poultry litter; T4 – poultry litter + sand; and T5 – cattle manure + sand.

CV: coefficient of variation obtained by the percentage relation between the standard deviation and the overall mean of the experiment.

Source: The authors (2023).

Table 4. Leaves dry mass (LDM), dry mass of roots (RDM), total dry mass (TDM) and Development Quality Index (IQD) measured at the first assessment, at 15 days after emergence. Inconfidentes, 2022

Treatment	LDM (mg)	RDM (mg)	TDM (mg)	IQD
T1	42.10 a	14.14 a	72.20 a	0.00508 a
T2	43.96 a	18.50 a	76.06 a	0.00490 to
T3	1.80 a	0.12 b	2.54 b	0.00022 b
T4	1.30 a	0.00 b	1.60 b	0.00000 b
T5	40.62 a	15.12 a	69.22 a	0.00474 a
CV (%)	18.29	26.61	17.73	29.85

Means with the same letter in the same column do not present a statistically significant difference by Tukey's test at a significance level of 5 %. T1 – commercial substrate; T2 – cattle manure; T3 – poultry litter; T4 – poultry litter + sand; and T5 – cattle manure + sand.

CV: coefficient of variation obtained by the percentage relation between the standard deviation and the overall mean of the experiment.

Source: The authors (2023).

Table 5 shows that, in relation to the LA variable, the T2 treatment stood out, followed by T1 and T5, in which there was no significant difference. However, treatments T3 and T4 had lower results, differing from the others.

When analyzing the MFC variable (Table 6), a similar performance was observed according to the statistical analysis in treatments T1, T2 and T5. On the other hand, treatments that included poultry litter in their composition had the worst performances. Similar results were found by Ferreira (2022), whose conclusion was that poultry litter is not a viable option for the production of lettuce seedlings. However, the use of cattle manure matched the commercial substrate.

It can be determined that treatments containing bovine manure resulted in higher LDM

Table 5. Number of leaves (NUM), plant height (PH), leaf length (LL), leaf width (LW), neck diameter (ND), fresh leaf mass (FLM), root length (RL), stem dry mass (SDM) and total dry mass (TDM) measured in the second evaluation, 30 days after emergence. Inconfidentes, 2022

Treatment	NUM	PH (mm)	LL (mm)	LW (mm)	ND (mm)	FLM (g)	RL (g)	SDM (g)	TDM (g)
T1	5.42 a	93.05 a	26.65 a	16.80 a	3.86 a	7.78 a	83.89 a	0.35 a	1.64 a
T2	5.12 a	90.31 a	26.26 a	17.26 a	3.55 a	8.73 a	76.32 a	0.32 a	1.86 a
T3	0.60 b	6.93 c	3.31 c	2.47 b	0.50 c	0.14 b	9.59 b	0.00 b	0.02 b
T4	1.80 b	35.19 b	12.89 b	8.45 b	1.86 b	0.21 b	19.21 b	0.01 b	0.08 b
T5	5.14 a	85.55 a	24.71 a	16.11 a	3.41 a	6.82 a	72.48 a	0.32 a	1.86 a
CV (%)	19.70	21.90	24.86	25.63	25.35	36.93	23.44	14.89	10.65

Means with the same letter in the same column do not present a statistically significant difference by Tukey's test at a significance level of 5 %. T1 – commercial substrate; T2 – cattle manure; T3 – poultry litter; T4 – poultry litter + sand; and T5 – cattle manure + sand.

CV: coefficient of variation obtained by the percentage relation between the standard deviation and the overall mean of the experiment.

Source: The authors (2023).

compared to the others (Table 6). However, it can be seen that T5 had no significant difference in relation to T1. In other words, the substrate composed only of cattle manure outperformed the commercial substrate, and T5 obtained results similar to T1 and T2. Therefore, in terms of LDM, the use of cattle manure as an alternative substrate had comparable or superior results to the commercial substrate.

The T2 and T5 treatments stood out in relation to the RDM (Table 6), providing a higher dry mass of the roots compared to the others, including the commercial substrate. Similar results were observed by Azevedo *et al.* (2021), who, when using cattle manure as an alternative substrate in the production of açaí seedlings, found a rich source of nitrogen and organic matter in the manure, essential for the high quality rooting of the seedlings. One can see that cattle manure promoted plant development, stimulating greater root production.

As for the IQD variable (Table 6), there was no statistical difference for treatments T1, T2 and T5. The IQD is an indicator of developmental quality and, in this aspect, the T5 treatment had higher data than the others. This shows the possibility of using this alternative substrate with quality. In addition to being a low-cost and easily accessible material for small producers, it also promotes satisfactory plant development.

It can be observed in all evaluations that the treatments that included poultry litter in their composition resulted in lower performance in relation to the others. Therefore, it is concluded that the use of this substrate for the production of watermelon seedlings is unfeasible in agronomic terms.

Conclusions

The use of the cattle manure-based substrates, both pure and mixed with sand, generated equivalent or superior results compared to the commercial substrate. The treatments that used cattle manure, when compared to the others, resulted in higher root production. On the other hand, the substrates containing poultry litter in their composition had the worst results in all variables analyzed.

Table 6. Leaf area (LA), fresh stem mass (MFC), fresh root mass (MFR), dry leaf mass (SDM), dry root mass (RDM) and Developmental Quality Index (IQD) measured at the second assessment, 30 days after emergence. Inconfidentes, 2022

Treatments	LA (mm^2)	MFC (g)	MFR (g)	LDM (g)	RDM (g)	IQD
T1	372.85 a	2.82 a	3.60 b	1.03 b	0.26 b	0.05 a
T2	377.9 a	2.50 ab	6.47 a	1.19 a	0.36 a	0.06 a
T3	7.13 c	0.04 c	0.04 c	0.10 c	0.01 c	0.00 b
T4	121.92 b	0.09 c	0.09 c	0.30 c	0.04 c	0.00 b
T5	332.06 a	2.35 b	6.07 a	1.17 ab	0.38 a	0.07 a
CV (%)	20.26	11.24	24.64	11.10	21.58	19.07

Means with the same letter in the same column do not present a statistically significant difference by Tukey's test at a significance level of 5 %. T1 – commercial substrate; T2 – cattle manure; T3 – poultry litter; T4 – poultry litter + sand; and T5 – cattle manure + sand.

CV: coefficient of variation obtained by the percentage relation between the standard deviation and the overall mean of the experiment.

Source: The authors (2023).

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