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Effect of Alternative Substrates on the Growth of Lycopersicumesculentum (Tomato) Seedlings

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Abstract

Tomato is the most important vegetable crop in Mozambique, being largely produced by the family and commercial sector. In this context, it is important to highlight that the quality of the seedlings is a fundamental factor in obtaining greater productivity andcommercial substrates are the most preferred for seedling production. However, their use is limited due to their high acquisition cost, which makes producers resort to seedling production in nurseries, but this option can cause losses due the risk of causing irregularity or lack of seed germination and poor seedling formation. The objective of this work was to evaluate the effect of the combination of commercial substrate Fertiplus organic substrates and cattle manure on the germination and initial growth of tomato (*Lycopersicumesculentum*) seedlings. A completely randomized statistical design was used, with five treatments and three replications, where the treatments consisted of using the following substrates: A – 100% Fertiplus; B – 80% Fertiplus and 20% cattle manure; C –60% Fertiplus and 40% cattle manure; D – 40% Fertiplus and 60% cattle manure; E – 20% Fertiplus and 80% cattle manure. At 35 days after sowing, the seedlings were evaluated for: Height, Stem Diameter, Number of Leaves, Emergence Rate Index, Dickson Quality Index; Root Dry matter; Total DryMatter andAboveground Dry Matter. The substrate containing 60% Fertiplus and 40% cattle manure showed better germination and initial growth results, which shows that it can be used as alternative to 100% Commercial substrate.

Keywords: Tomato; alternative substrates; different combinations; cattle manure.

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1. Introduction

The tomato (*Lycopersicumesculentum*) originates from the Andean region of South America, having been domesticated in Mexico, in 1544 was introduced to Europe and spread to South and East Asia, Africa and the Middle East [1]. The tomatoholds a greater global importance due to the fact that it contributes to the population's diet, as it is a source of vitamin A, vitamin C, provitamin A (beta-carotene), B1 (Thiamin) B2 (riboflavin) B5 (niacin). It is an antioxidant (lycopene and carotenoids), provides proteins, minerals, carbohydrates, fiber and has a low level of calories [2].Tomatoes are a source of employment and generate income for households. In Mozambique, it is largely produced for commercial purposes, contributing to the national economy with around 77% of the total contribution of horticultural crops [3]. It is consumed fresh, processed in the form of Jamo, syrup and sauces. The volume of tomatoes produced, sold and the jobs worldwidegenerated, allow their importance to be considered economically and socially [3].

Traditionally, in Mozambique, seedlings of these vegetables are grown in beds, a technology that can cause losses to producers due to risk of causing irregularities or lack of seed germination, as well as poor seedling formation [4]. In recent years, commercial substrates have been preferred for the production of quality seedlings, as this is considered one of the main steps leading to high crop productivity. In this regard, commercial substrates are used, although to a limited extent due their high acquisition cost [5].

On the other hand, the quality of seedlings is determined by several factors, with the quality of the substrates being one of the most important factors [6]. Quality seedlings provide greater security and vigor in the fruits, as germination, root initiation and rooting depend on these [7]. The use of alternative substrates, such as organic compounds, can be a viable alternative to optimize production in nursery conditions, as, in addition to providing greater fertility, it is more economically viableand has the advantages of preserving the environment [8].

The objective of this work was to evaluate the effect of alternative organic substrates on the germination and initial growth of tomato (*Lycopersicumesculentum*) seedlings.

2. Materials and Methods

The experiment was conducted in a controlled environment at the Guija District Economic Activities Service (SDAEG), from May 5th to June 11th, 2022, which has geographic coordinates latitude 24 23' 32”S and longitude 32 52' 58 " E.

The treatments consisted of proportions of cattle manure obtained from the farmyards of the Associação dos Criadores da Aldeia de Muzumuia and commercial substrate (Fertiplus), as shown in table 1.

Table 1: Formulations applied in the production of tomato seedlings

Treatments/Substrates	Components	
	Fertiplus (%)	Cattle manure (%)
A	100	0
B	80	20
C	60	40
D	40	60
E	20	80

A Completely Randomized Statistical Design was used, with 5 treatments and 3 replications, comprising 15 plots. The treatments consisted of combining different proportions of commercial substrate (Fertiplus) and cattle manure. Each plot contained 60 seedlings but 20 central seedlings were considered for sampling.

The substrates were chemically characterized for macro and micronutrients in the Soil Laboratory of the Instituto de InvestigaçãoAgrária de Moçambique (IIAM) – Maputo, for Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Matter Organic (MO), Nitrogen (N), Phosphorus (P), pH-H2O and Electrical Conductivity (EC) and the results obtained are presented in table 2.

Table 2: Physicochemical characterization of substrates

Substrates	PARAMETERS								
	Ca	**Mg**	**K**	**Na**	**MO**	**N**	**P**	**PH-H2O**	**CE**
	[mg/L]	[mg/L]	[mg/L]	[mg/L]	**[%]**	**[%]**	**[%]**		**[%]**
A	825	153	1.03	0.04	96.32	0.19	0.05	5.25	1.93
B	1075	1449	22.53	7.74	94.32	0.46	0.45	6.32	1.32
C	880	1188	33.02	10.05	95.75	0.61	0.48	7.2	2.66
D	2115	1293	39.48	10.05	89.74	0.72	0.57	7.74	0.25
E	2690	1284	51.17	12.25	94.41	0.78	0.6	8.16	0.25

Legend: Ca – Calcium; Mg – Magnesium; K – Potassium; Na – Sodium; Mo – Organic Matter; N – Nitrogen; P – Phosphorus, PH-H2O – pH of water, EC – Electrical conductivity. A – 100% Fertiplus; B – 80% Fertiplus and 20% cattle manure; C – 60% Fertiplus and 40% cattle manure; D – 40% Fertiplus and 60% cattle manure; E – 20% Fertiplus and 80% cattle manure.

At 35 days after sowing, the seedlings were evaluated for: H - Height, SD - Stem Diameter, LN- Leaf Number, RDW – Root Dry Matter;TDM - Total Dry Matter;AGDM–Aboveground Dry Matter; The ERI – Emergency Rate Index.

The ERIwas calculated according to [9], using the formula ERI = N1/D1 + N2/D2 +....+Nn/Dn and the Dickson

Quality Index, according to [10], using formula 1 below.

$$DQI = \frac{WTDW}{\left(\frac{PH}{SD}\right)+\left(\frac{WAGDW}{WRDM}\right)} \quad (1)$$

Where:DQI - Dickson quality index; TDM - Total Dry Matter (g); PH - Plant Height (cm); SD–Stem Diameter (cm); WAGDW–Weight of theAboveground Dry (g); WRDM–Weight of the Root Dry Matter (g); RPAR – Weight of the Total Dry Matter; RAD - Relation of the Aboveground Dry to the Root Dry Matter.

The ERI – emergence Rate index was determined according Maguire (1962), ERI = (N1/E1) + N2/E2) + (Nn/En), where ERI – Emergence Rate Index, E1, E2, En = number of normal plants emerged in the first, second, third, fourth, fifth, sixth and last count. The root system and aboveground parts were dried in a forced circulation oven at 60ºC until constant matter, obtained after 72 hours, for subsequent determination of root, aboveground and total dry matter.

The data were subjected to analysis of variance and comparison of means using the Tukey test, at a significance level of 5%, and all data and corresponding analyzes were carried out with the aid of the Minitab statistical package version 18.

3. Results and Discussion

The performance of the substrates is presented in table 3 below, whose results from the analysis of variance indicate that the substrates had a significant effect on all variables analyzed, namely: Plant Height, StemDiameter, Leaf Number, Root Dry Matter, Total Dry Matter and Dickson Quality Index, except Emergence RateIndex as illustrated in table 3 and 4.

Table 3: Influence of substrates on emergence speed index (ESI), plant height (H), Stem Diameter (D), leaf number (LN)

Substrates	PARAMETERS			
	Height	**Stemdiameter**	**LN 35 days**	**ERI**
	[Cm]	**[mm]**	**[/planta]**	**[%]**
A	5.08 ± 0.20^{c}	1.40± 0.005^{b}	3.04 ± 0.36^{c}	56.29
B	8.47 ± 0.61^{bc}	3.23 ± 0.37^{ab}	3.14 ± 0.40^{c}	38.77
C	11.52 ± 1.00^{ab}	3.56 ± 0.07^{a}	4.13 ± 0.23^{b}	49.83
D	10.41 ± 0.80^{ab}	3.24 ± 0.09^{ab}	4.76 ± 0.18^{ab}	47.20
E	12.01 ± 0.26^{a}	3.68 ± 0.06^{a}	4.84 ± 0.29^{a}	48.63
F-value	8.32	6.36	24.25	0.59
P-value	0.003**	0.008**	0.00**	0.676^{ns}

Means followed by the same letters in the columns do not differ from each other using the Tukey test at 5% probability. Legend: SF - Fertiplus® Substrate; SF - Fertiplus® Substrate; EB - Bovine Manure; LN– Leaf

Number, ERI – Emergency Rate Index; (ns) not significant, (**) significant. A – Organic substrate composed of 100% Fertiplus; B – organic substrate containing 80% Fertiplus and 20% cattle manure; C – organic substrate containing 60% Fertiplus and 40% cattle manure; D – organic substrate containing 40% Fertiplus and 60% cattle manure; E – organic substrate containing 20% Fertiplus and 80% cattle manure;

a) Final height of the plant

Plant height varied from 5.08 cm to 12.1 cm, with the lowest height being observed in seedlings produced with commercial substrate and the highest in seedlings produced with a mixture of 20% commercial substrate and 80% cattle manure. These results indicate that the greater the percentage of cattle manure, the greater the height of the plant (Figure 3). The greater height in substrates with a greater proportion of manure may be related to the improvement of chemical properties, mainly the increase in Magnesium and Nitrogen concentrations, which are important in the photosynthesis process [10]. In previous studies on alternative substrates, it was found that the height of seedlings produced using manure-based substrates and commercial Hygromix substrate did not differ significantly [11]. Some authors consider plant height a quality standard that helps estimate plant growth in the field [12]. This proves that the classification, identification and management of different plant species, varies according to plant varieties and characteristics, but also is influenced by multiple factors, such as: genetic, environmental and cultural.

The better performance of substrates with a higher percentage of cattle manure throughout the period of the experiment, in terms of height, was noticeable from the beginning of the experiment until the end, as illustrated in the growth rate graph (Figure 1).

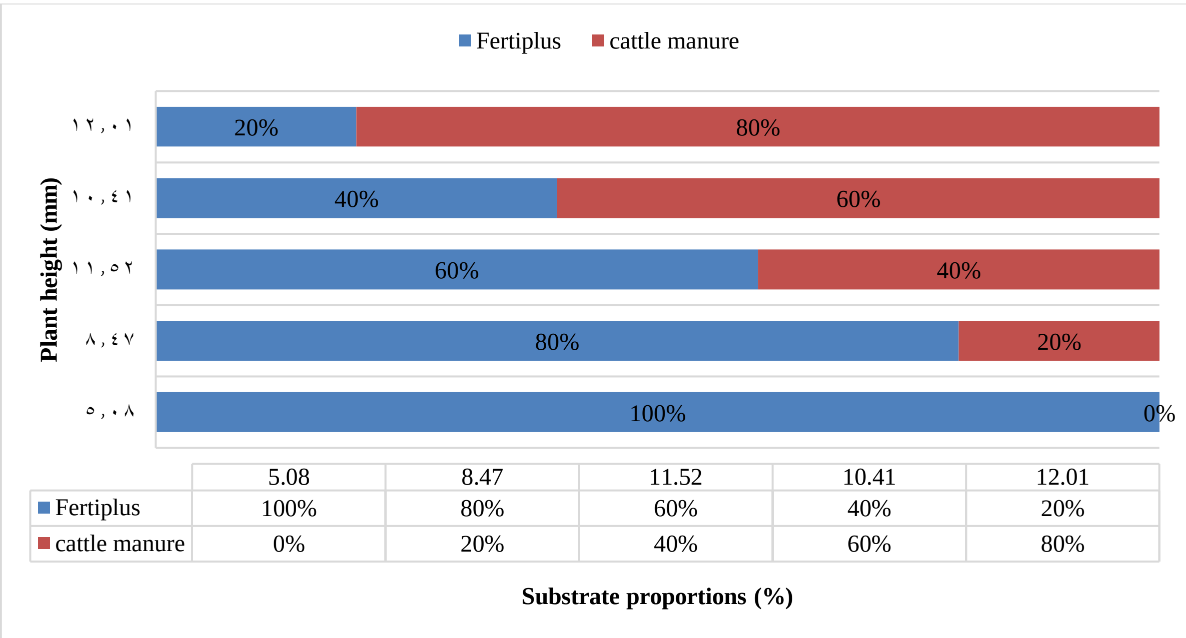
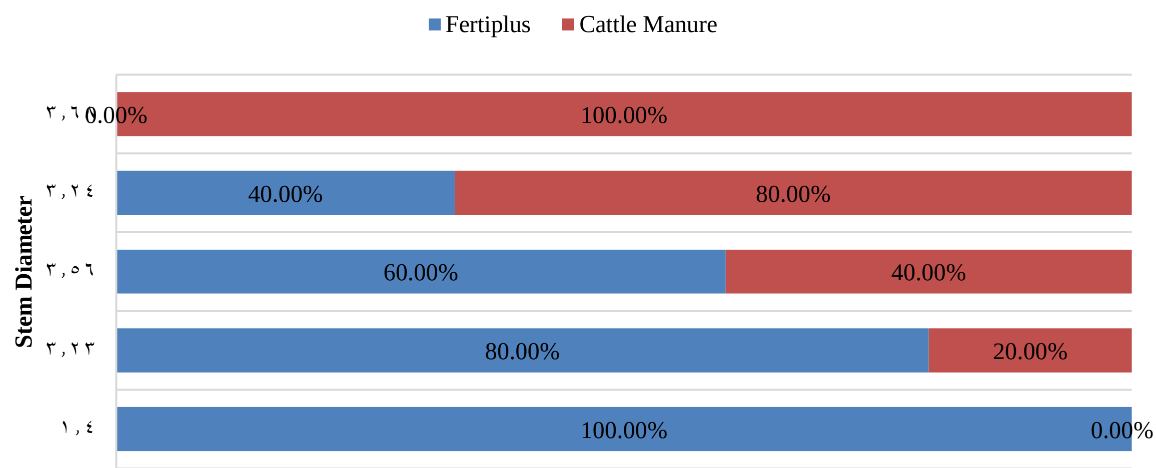


Figure 1: Tomato seedling growth rate in different proportions of commercial substrate and cattle manure

a) Stem diameter

For stem diameter, statistically significant differences (p>0.05) were also observed in the different treatments evaluated in the present research, except between treatments E and C, as well as between treatments D and B, with treatment E having the highest value and treatment A with the lowest value 3.83±0.06 and 1.4±0.06 mm, respectively, which is a clear evidence of the contribution of organic substrates to the growth performance of seedlings. The experience of other authors in the use of organic substances in the performance of tomato seedlings states that it is possible to obtain greater stem diameter values with the use of organic materials, confirming the result obtained in our study [13]. Along the same path, as an increase in diameter was observed with an increase in the concentration of cattle manure [14], they report that the highest SD of seedlings that have higher percentages of survival in the field, as plants with higher SD have a greater capacity to form and the growth of new roots.

The performance of the substrates throughout the period of the experiment, with regard to stem diameter, the treatments demonstrated a significant difference from the beginning of the experiment to the end, where treatment E demonstrated better results with a larger diameter in relation to the remaining and treatment A had a smaller diameter. When observing the results obtained, it may suggest a considerable increase in confidence in the use of similar substrates for future production of seedlings for crops.



	1.4	3.23	3.56	3.24	3.68
Fertiplus	100.00%	80.00%	60.00%	40.00%	0.00%
Cattle Manure	0.00%	20.00%	40.00%	80.00%	100.00%

Figure 2: Tomato seedling growth rate in different proportions of commercial substrate and cattle manure

The number of leaves after 35 days of sowing differed statistically between treatments (p>0.05), treatment with organic substrate containing 20% Fertiplus and 80% cattle manure, presenting the highest value and treatment A presenting the lowest value, being 4.84±0.29 and 3.043±0.40, respectively. For treatments with a greater number of leaves, they are probably associated with the Magnesium content in their composition, as this is considered a constituent of chlorophyll [15], where it is linked to the plant's energy metabolism. A lower percentage of Magnesium concentration was found in the Fertiplus commercial substrate when compared to substrates with a higher percentage of cattle manure, which was probably associated with obtaining a reduced number of leaves within 35 days after emergence.

Regarding the Emergency Rate Index (ERI), after its direct contact with the treatments, it was noticeable that only treatment A, which was made up of Fertiplus commercial substrate, presented a high index of almost over 50% when compared to the rest, thus standing out with good quality in seedling development.

Table 4: Influence of substrate concentration on the Aboveground DryMatter (AGDM), Root Dry Matter (RDM), Total Dry Matter (TDM) and Dickson Quality Index (DQI)

Substrates	**PARAMETERS**			
	DQI	**AGDM**	**RDM**	**TDM**
	[g]	**[g/pl]**	**[g/pl]**	**[g/pl]**
A	0.026 ± 0.00^{b}	0.098 ± 0.03^{b}	0.05 ± 0.16^{b}	0.15 ± 0.04^{b}
B	0.112 ± 0.00^{ab}	0.44 ± 0.05^{a}	0.16 ± 0.03^{a}	0.60 ± 0.04^{ab}
C	0.148 ± 0.03^{a}	0.47 ± 0.17^{a}	0.27 ± 0.23^{a}	0.74 ± 0.35^{a}
D	0.033 ± 0.00^{ab}	0.45 ± 0.12^{a}	0.04 ± 0.01^{b}	0.48 ± 0.13^{ab}
E	0.041 ± 0.00^{ab}	0.49 ± 0.07^{a}	0.05 ± 0.09^{b}	0.53 ± 0.07^{ab}
F-value	5.47	7.62	2.87	4.91
P-value	0.013^{**}	0.004^{**}	0.080^{ns}	0.019^{**}

Means followed by the same letters in the columns do not differ from each other using the Tukey test at 5% probability. Caption: DQI – Dickson Quality Index; RDW – Root Dry Matter; TDM – Total Dry Matter; AGDM – Aboveground Dry Matter. (ns) not significant, (**) significant. A – organic substrate composed of 100% Fertiplus; B – organic substrate containing 80% Fertiplus and 20% cattle manure; C – organic substrate containing 60% Fertiplus and 40% cattle manure; D – Organic substrate containing 40% Fertiplus and 60% cattle manure; E – Organic substrate containing 20% Fertiplus and 80% cattle manure;

Regarding the Dickson Quality Index (DQI), statistically significant differences were observed, with treatment C presenting the highest value and treatment A with the lowest value, being 0.060±0.03 and 0.010±0.00, respectively. In this regard, in the comparison between the commercial substrate Fertiplus and the alternative formulations developed in the present research, it was clear that with the partial addition of almost 40% of cattle manure satisfactory results were obtained in the initial growth of tomato seedlings. It is known that DQI is one of the indicators of seedling quality, which leads us to realize that the commercial substrate (Fertiplus) used does not have satisfactory effects when used in isolation, the same scenario is applied to cattle manure.

The Aboveground Dry Matter (AGDM) did not show statistically significant difference between treatments*($p>0.05$)* except treatment consisting of 100% Fertiplus organic substrate, which was significantly lower. Different scenarios were observed by [16], in their study on evaluating the development of tomato seedlings in 6 different substrates, as the best results were obtained in the commercial substrate DDL Agroindustry.This suggests that the nutritional properties of substrates, has a direct influence on the conservation of dry matter in the seedling.

Regarding Root Dry Matter (RDM), there were no statistically significant differences between treatments B and C, with means corresponding to 0.27±0.23 and 0.16±0.03, respectively, and also no statistically significant differences were observed between the remaining treatments, with treatments A and E showing similar values and treatment D showing lower ones. According to [17], the variable development of tomato seedlings is influenced by factors such as physicochemical properties of the substrate and other physical characteristics of the substrates, such as porosity, water retention capacity and others.

For Total Dry Matter (TDM), the results were statistically significant for the three treatments evaluated, with treatment C presenting the highest value and treatment E with the lowest value of 0.53±0.07 to 0.74±0.35, respectively. The highest values were obtained in the treatment in which 60% of Fertiplus substrate and 40% were used, probably due to the greater amount of mass in the substrate tissues. According to [18], the greater accumulation of mass may be essential to provide greater support to the seedling, as it has a greater quantity of reserve tissues, influencing the initial phase of development of the fasciculated roots.

3. Conclusion

Regarding the physical-chemical characteristics of the substrates, an increase in their availability level was noticeable with the increase in the percentage of cattle manure, in some cases tending to levels suitable for the initial growth of the tomato plant. Regarding performance parameters, it was found that of the treatments evaluated, treatment C, which contained 60% Fertiplus and 40% cattle manure, showed greater performance in germination and initial growth of tomato seedlings. Thus, it can be seen that a well-combined Fertiplus and cattle manure substrate is ideal for the germination and initial growth of the tomato plant, thus contributing to the reduction of the percentage of commercial substrate, in addition to the environmental gains due to the reuse of the residue.

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