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A Completely Randomized Design (CRD) for Tomato Plant Growth and Production on Different Planting Media

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Abstract

Tomatoes possess versatile properties, serving not only as a vegetable but also as a valuable resource in the pharmaceutical, cosmetic, and food processing sectors. The cultivation of tomato plants to attain optimal development and output is significantly influenced by environmental conditions. The objective of this study is to identify optimal planting substrates conducive to the growth and yield of tomato plants. The study employed a Completely Randomized Design (CRD) for its research methodology. The findings of the study indicated that the growth (specifically plant height and number of leaves) and production (including fruit weight and number of fruit) of tomato plants were influenced by the planting media. The treatment, including the combination of soil planting media and cow dung, yielded the most favorable results regarding growing media utilization.

Keywords: Completely Randomized Design; Growing media; Tomato.

Introduction

The tomato plant (Solanum lycopersicum) is an economically significant horticultural commodity in Indonesia and is considered one of the prominent crops in the country. The economic and nutritional benefits of tomatoes make them a promising candidate for agribusiness expansion (da Costa, 2020; Deng, 2018; R. Li, 2018). Tomatoes exhibit a remarkable degree of versatility (Agarwal, 2020; Feng, 2018), functioning not alone as a vegetable but also as a very valued asset within the pharmaceutical, cosmetic, and food processing industries (Ilahy, 2018; Kaiser, 2019; Robledo, 2018).

Environmental circumstances have a crucial role in the growing of tomato plants, affecting their growth and productivity (Shamshiri, 2018; Srinivas, 2019). (Rozana et al., 2021) assert that the development of plants is profoundly impacted by environmental factors, with the choice of growing media being a critical element that requires meticulous deliberation (Kong, 2019; Rothan, 2019). A common practice among agricultural professionals is using NPK fertilizer to augment the productivity of tomato crops. However, chemical fertilizer is a cost-effective option for farming practitioners (Karthik, 2020; Wu, 2020). Furthermore, it is crucial to acknowledge that applying NPK fertilizer can have adverse environmental consequences, resulting in significant impacts on the ecosystem. The escalation in water and soil pollution levels is supported by empirical facts, as indicated in the research undertaken by (Zahara, 2018).

Manure exhibits the attribute of being environmentally benign to soil health, concurrently functioning as a reservoir of essential macro and micro elements for tomato plants (Beris, 2018; Dahliani, 2021; N. Li, 2021). Furthermore, it is important to acknowledge that manure has a significant role in improving various aspects of soil quality. (Prasetya et al., 2019) Highlight that waste contributes to enhancing the soil's ability to resist water, stimulating microbiological activity within the earth, increasing the capacity for cation exchange, and improving soil structure. The study (Bertin, 2018) revealed that the application of cow dung has been observed to improve soil permeability and increase organic matter content while concurrently decreasing soil erodibility. As a result, these enhancements contribute to the increased resilience of soil against erosion (Afonso, 2020; Kwak, 2018; Sun, 2020).

Appropriately selecting appropriate planting material is a crucial determinant in successfully cultivating tomato plants (Wu, 2020; Y. Zhang, 2020). The planting medium provides an optimal environment for plants to grow and develop, supporting their maturation until they reach the point of being ready for harvest (Rangarajan, 2018; Wan, 2018). Other planting mediums can be chosen, such as husk charcoal, sand, wood charcoal, sawdust, manure, and other alternatives. The general population commonly utilizes husk charcoal and dung media due to their affordability and widespread availability. Using organic fertilizer as a planting substrate significantly contributes to the improvement of soil fertility, chemical composition, physical properties, and biological qualities. Moreover, organic fertilizer is crucial in providing essential nutrients and support to soil microbes.

Observed that the utilization of manure led to the attainment of the maximum lettuce plant output (Stevens, 2018). Conducted a study demonstrating that coliseum plants displayed a higher branch count and an enlarged crown when cultivated from seeds subjected to manure treatment. Using rice husk charcoal, a byproduct of the combustion process, shows promise as a suitable medium for horticulture applications. In a study conducted (Dewandari & Kailaku, 2019), it was revealed that the nutrients in rice husks exhibit a notable degree of plant accessibility and can increase soil pH levels.

Next, the study conducted by Bafdal et al. (2022) revealed that using 0.5 kg of rice husk charcoal per planting hole has notably enhanced overall crop production. The highest recorded output per tomato plant is 646 grams. According to Ahanger (2021), husk charcoal has been found to augment the effectiveness of fertilization, improve soil properties, and facilitate the binding of nutrients. Based on the research conducted by Musta'inah et al., 2017), it was concluded that the use of husk charcoal in plant cultivation practices yields beneficial effects on multiple facets of plant growth. The results of the study indicated that the utilization of husk charcoal had a positive impact on various growth parameters, including stem diameter, fruit yield per plant, and total fruit weight per plant.

Nevertheless, the current study has not yet been conducted to investigate the effects of several planting media, including soil, charcoal, and cow manure, on plant growth. Specifically, the study aims to compare the growth of plants without any treatment, plants grown in soil and manure, plants grown in charcoal, and plants grown in soil and cow manure. Hence, considering the factors above, it is imperative to research to ascertain the impact of planting media on the growth and yield of tomato plants.

Research methods

The research methodology employed in this study utilizes a completely randomized design (CRD), as depicted in Figure 1 (Martunis et al., 2023).

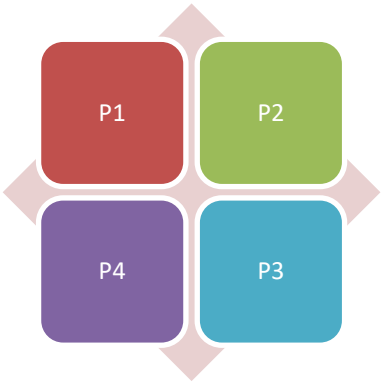

Figure 1. Complete random design (RAL)

Figure 1 illustrates that the present study used a completely randomized design (CRD) consisting of four treatments and replications. In this study, four different soil treatments were examined: P1, which represents soil without any treatment and serves as the control group; P2, which means soil treated with chicken manure; P3, which means soil treated with charcoal husk; and P4, which represents soil treated with cow dung.

The data obtained from the observations of plants P1, P2, P3, and P4 is subsequently analyzed. The analysis of research data involves the utilization of several analytical methods. Once the treatment demonstrates a significant effect, it is subjected to the smallest real difference test (BNT) at a significance level of 5% (Saleh et al., 2021).

Research Methodology Location and Duration of Study: The present study was carried out in Pasuruan, Indonesia, spanning from June 2023 to September 2023. The materials and tools employed in this investigation encompassed tomato varieties of Servo F1, chicken covers, charcoal, cow manure, and soil. The equipment utilized in this research encompassed shovels, 40 x 40 polybags, buckets, baskets, scissors, moans, water hoses, hand spray, ropes, bamboo for lanjaran, scales, meters, ATMs, paper, labels, cameras, branches, and notably, the land as a requisite space for plant storage.

Results and Discussion

Results

The research findings about plants P1, P2, P3, and P4 were subjected to four separate observations, specifically at intervals of 30 days, 44 days, two months, and ultimately 2.5 months, which equates to a precise duration of 90 days. The initial observations indicate that the plants labeled as P1, P2, P3, and P4 have respective measurements of 26.74, 25.65, 28.26, 33.65, and 34.83. After 44 days, the observations revealed the following results for the four plants: 70.31, 64.32, 68.21, and 78.65, respectively. The results of the four plants, as observed after two months, were recorded as follows: 119.21, 115.63, 119.79, and 127.89. The final observation of the results indicated values of 149.27, 145.69, 149.89, and 167.93. The effects can be observed more distinctly in Table 1.

Table 1. Tomato plant height

Tinggi Tanaman/pohon (cm) Hari Ke					
Perlakuan		30	44	60	75
	P1	26,74[a]	70,31 [a]	119,21	149,27
	P2	25,65[a]	64,32 [a]	115,63	145,69
	P3	28,26[a]	68,21 [a]	119,27	149,89
	P4	33,65[b]	78,65 [b]	127,89	167,93
BNT 5%		2,86			
			6,71	-	

Note: The 5% BNT test shows no significant difference between numbers with the same letter.

Measurement of Plant/Tree Height in Centimeters

The results of the 5% BNT test indicate that the utilization of various planting media significantly affects the height of tomato plants at the ages of 30 and 44, 60 HST. At 75 hours since treatment (HST), the utilization of various planting substrates did not have a statistically significant impact on the vertical growth of the tomato plants. The mean height of tomato plants is presented in Table 1.

According to the study, the P4 treatment (including soil and cow dung) exhibited the greatest mean measurements for tomato plants across four harvest stages (30, 44, 60, and 75 days after transplanting). Specifically, the average heights recorded for the tomato plants in the P4 treatment were 33.65 cm, 78.65 cm, 127.89 cm, and 167.93 cm, respectively. This demonstrates that the utilization of soil and cow dung is believed to offer an adequate supply of nitrogen (N) nutrients for the growth of plants, including their height. Cow manure is found to have several nutrients. In addition to these benefits (Aryaseta et al., 2023; Dahliani, 2019; Tran, 2019), it possesses the advantage of enhancing soil composition by serving as a supplier of both macro and micronutrients. Furthermore, it augments the soil's capacity to hold moisture and nutrients while serving as a vital energy source for microorganisms. Cow manure contains the micronutrients manganese (Mn) and zinc (Zn) as well. These two nutrients are crucial in chlorophyll synthesis, serving as coenzymes and activators for several respiratory enzymes involved in nitrogen metabolism reactions and photosynthesis.

Moreover, the requirement for manganese emphasizes the essentiality of nitrogen for promoting vegetative plant growth (Balasopoulou et al., 2017; Bhattacharyya, 2022), including the development of leaves, roots, and stems. Nitrogen is a crucial element in plants as it contributes to the synthesis of chlorophyll for efficient leaf photosynthesis, aids in the production of amino acids, and facilitates the formation of various metabolite chemicals. Nitrogen is an essential constituent of cell walls, playing a crucial

role in providing structural integrity and contributing to plant resilience and protection mechanisms. The absence of nitrogen (N) might result in the disturbance of vegetative growth, namely in stems, potentially causing a decline in production. The activation of nitrate reductase is necessary for plants that are facing a manganese deficiency, as it enables them to utilize NH4+ as a nitrogen source. The involvement of manganese in photosynthesis is closely associated with the liberation of electrons from water during its decomposition into hydrogen and oxygen.

A soil and cow dung mixture as a growth medium yielded the greatest plant height, measuring 26.84 cm 30 days after planting (Nofriati, 2018; Trigo, 2020). The observed variations in the size of tomato plants across different planting media are hypothesized to be attributed to the varying nutritional composition of these media. The findings indicated that the treatment of planting media had a significant impact on the height of the plants at 30, 44, and 60 days after sowing (HST). However, at 75 days after transplantation (DAT), the treatment no longer exhibited any discernible influence on plant height, as depicted in Table 1. At 60 hours after seedling transplantation (HST), tomato plants enter the generative growth phase, during which they prioritize fruit development. Consequently, by 75 HST, the height of the tomato plants exhibits consistent outcomes. Tomato plants transition from the vegetative phase to the generative growth phase upon the emergence of flowers on the plant (Fakhrunnisa & Kartika, 2018; Mustakim et al., 2021). The Servo F1 tomato cultivar exhibits a determinate growth habit, which is characterized by limited vegetative growth, accelerated stem elongation, and culminating in the development of a sequential set of flowers and fruits. Servo tomatoes demonstrate a remarkable ability to readily and rapidly acclimate to diverse environments, including lowland and highland regions (Tashkandi, 2018; Usman, 2020).

Growth encompasses the processes of cellular division and expansion. Change can be assessed using multiple quantitative indicators, including measurements of fresh weight, dry weight, leaf area, and plant height. The most apparent alteration in plant growth is the increase in plant height (Anjarwati et al., 2023; Khoiriyah et al., 2022; Quinet, 2019). The growth and development of plants are subject to the effect of various external and internal elements. These factors include but are not limited to, the variety of the plant, the availability of nutrients, the prevailing temperature and humidity conditions, the intensity and quality of light, and the pH level of the surrounding environment (Laga et al., 2018; Yuniastri et al., 2020).

The quantity of leaves or trees

According to the results of the 5% BNT test, it can be concluded that the utilization of various planting media significantly affects the quantity of tomato leaves observed 30 and 44 days after seedling transplantation (HST). However, while considering the growth stages of tomato plants at 60 and 75 HST, it can be observed that the utilization of various planting materials has a minimal impact on the leaf count. According to the study, the P4 treatment (including soil and cow dung) had the highest mean value of 372.13 strands at HST intervals of 30, 44, 60, and 75. The findings of this study suggest that the utilization of soil planting media and cow dung positively influences the leaf count of tomato plants. Cow manure is characterized by a significant concentration of nitrogen (N) nutrients, around 2.33% (Abidin et al., 2020; Bachtiar et al., 2017).

Assert that nitrogen is a fundamental nutrient for optimal plant growth (Mamuaja & Helvriana, 2017). Nitrogen nutrients are of significant importance in the development of plant cells, tissues, and organs. Nitrogen primarily serves as a constituent for synthesizing chlorophyll, protein, and amino acids. Hence, a substantial amount of nitrogen is required for optimal plant growth, particularly during the vegetative stage. The element N, in conjunction with the element P, is crucial in regulating plant growth (Sjarif, 2020; Tumbelaka et al., 2019). Factor N is vital in developing chlorophyll cells, essential for photosynthesis. Through photosynthesis, cells can generate the necessary energy for division, enlargement, and elongation. Plants require the element phosphorus (P) to enhance root growth and promote the development of reproductive structures in plants. Physiologically, phosphorus (P) plays a significant role in the dark phase of photosynthesis, as well as in respiration.

Additionally, it is an essential component of nucleotides (Lu, 2019; Roditakis, 2018). The nitrogen concentration present in cow manure plays a significant role in facilitating the synthesis of chlorophyll in plants. The abundance of chlorophyll within leaves contributes to the heightened efficiency of the photosynthetic process. There exists a positive correlation between the level of photosynthesis in tomato plants and the quantity of leaves they possess. There exists a positive correlation between photosynthesis outcomes and leaf count, indicating that plants can thrive and progress more effectively as photosynthesis rates increase. "optimal" refers to the most favorable or advantageous condition or state (S. Q. Jiang, 2019; C. Li, 2018).

According to the findings of the study, the P4 treatment, which involved the application of a combination of soil and cow manure, yielded superior outcomes in comparison to the other treatments. This phenomenon may be attributed to using a planting medium of soil and cow dung. This particular mixture possesses an ample supply of nutrients essential for the optimal development of tomato plants, including the proliferation of leaves. The presence of enough nutrients facilitates the smooth functioning of plant metabolism, resulting in enhanced development, including an increase in the number of plant leaves (Manasikana et al., 2023; Paul, 2019; Zahroh et al., 2023). The analysis of observations conducted at 60 and 75 HST indicated that using various planting materials had no statistically significant impact on the leaf count. This phenomenon occurs because tomato plants, when exposed to 60 and 75 hours of heat stress treatment (HST), have already entered the generative development phase. Similar to the observed phenomenon of tomato plant height growth, it can be inferred that the number of leaves is no longer subject to the influence of the planting media.

The quantity of fruits and trees

According to the results of the 5% BNT test, it can be observed that the utilization of various planting media significantly impacts the quantity of tomato plants. According to the study's findings, the treatment labeled as P4 (including the combination of soil and cow dung) exhibited the largest mean quantity of fruit, specifically amounting to 37.41 pieces. This implies that using cow manure as a substrate for cultivating tomato plants yields optimal outcomes in terms of fruit development on such plants. Cow manure, being an organic substance, has a vital function in the provision of nutrients for plants. Cow manure is characterized by elevated concentrations of phosphorus (P) nutrients, which have a significant role in facilitating the process of fruit production. P serves as a fundamental substrate in the biochemical function of synthesizing several proteins. This specific nutrient is vital in promoting root development, particularly in the roots of seeds and juvenile plants. According to Adminuniv (2022), P has a crucial role in facilitating plant digestion and respiration, as well as promoting the blossoming and ripening processes of seeds and fruit. Phosphorus exerts a significant influence on fruit development, whereby an increased uptake of phosphorus nutrients by the plant accelerates the rate of fruit production, and tomato plants reach their optimum yield 11 weeks after planting (WAP) (Triono et al., 2023; Yuniwati et al., 2023).

According to the findings of Hali and Telan (2018), the utilization of a blend of cow dung as a substrate for cultivation exhibits a notable impact on the development and productivity of eggplant plants, specifically in terms of the parameter measuring fruit quantity. The decomposition of organic fertilizer by soil organisms results in the formation of humus and soil organic matter. Consequently, applying organic fertilizer to the soil is

imperative for promoting optimal plant growth (Yuliana, Rahmadani, & Permanasari, 2015).

The findings of the performed research indicate that using a combination of soil and cow dung yields the most favorable outcomes. The utilization of cow manure as a planting medium has been found to enhance the activity of soil microorganisms, hence facilitating the increased availability of nutrients (Ichsannudin, Haryono, & Susilowati, 2017). The organic constituents present in cow manure are essential for the sustenance of microbes. Organic matter is a vital supply of plant nutrients and energy for soil organisms (Sengar, 2020). The nutrient availability in the soil has the potential to impact the process of fruit creation, which includes the quantity of fruits produced by each plant. Determined that applying cow dung at a rate of 15 tons per hectare yielded optimal production outcomes for eggplant cultivation (Wahid et al., 2023).

Weight of Fruit on Trees (in grams)

The results of the BNT test indicate that the utilization of various planting materials has a notable impact on the fruit weight of tomato plants, as evidenced by the 5% significance level. According to the research findings presented in Table 7, it can be observed that treatments P1, P2, and P3 exhibit comparable outcomes. However, treatment P4 demonstrates statistically significant differences compared to P1, P2, and P3. The positive impact of the P4 treatment, which involves the application of a mixture of soil and cow dung, on the weight of tomato fruits is widely acknowledged. Cow dung has been found to yield the highest fruit weight, and applying a substantial amount of manure to plants can positively affect plant growth and development (Jailani, 2022).

According to the study's findings, the treatment denoted as P4 (comprising of soil and cow dung) exhibited the highest mean fruit weight for tomato plants, specifically measuring 1,870.93g. This finding demonstrates that planting media in conjunction with soil and cow dung yields superior outcomes in terms of enhancing the fruit weight of tomato plants as compared to alternative treatments. Asserts that cow dung is composed of essential nutrients such as P2O5 (0.9%) and K2O (0.3%), which have a crucial role in facilitating the process of fruit production (N. Jiang, 2018; Razifard, 2020). Phosphorus (P) is an essential element that is a fundamental building block for various enzymes, proteins, ATP, RNA, and DNA. Adenosine triphosphate (ATP) facilitates energy flow within biological systems. At the same time, ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) are responsible for encoding the genetic traits of plants. Potassium is a crucial element that serves as a regulator of various physiological processes in plants. These functions include but are not limited to photosynthesis, carbohydrate buildup, translocation and transportation, stomatal regulation, and the regulation of water distribution within plant tissues and cells. Phosphorus, in conjunction with the nutrient potassium, is utilized to promote the initiation and progression of the blooming process (Riono et al., 2023; Sari et al., 2023; Wulandari et al., 2022).

The utilization of cow dung in agricultural practices has been highlighted in several media outlets due to its potential to enhance soil structure and facilitate optimal microbial growth (Chen, 2019; Cheng, 2020). Using organic fertilizer results in the soil becoming more porous and conducive to developing plant roots. Organic fertilizer can potentially enhance the cation exchange capacity inside the ground at a chemical level. A higher proportion of organic matter in the soil is positively correlated with an increased cation exchange capacity. The cation exchange capacity serves the purpose of facilitating the release of essential elements, enabling plants to readily uptake them. From a biological standpoint, organic fertilizer is a favorable substrate for the proliferation of soil organisms. The presence of microorganisms in soil enhances nutritional content, hence facilitating the growth and development of plants. This phenomenon reduces the efficient absorption of nutrients by plants.

It is incorrect to assume that a deficiency in macronutrients will impact the growth rate, cell multiplication, enlargement, and flower production of plants, ultimately affecting the weight and volume of tomatoes (Lee, 2018; M. Zhang, 2018). Plants that exhibit robust growth during the vegetative stage demonstrate an enhanced photosynthetic capacity (Bhunia, 2021; Pourmovahed et al., 2022). This heightened photosynthetic activity subsequently impacts the generative phase, particularly regarding fruit weight.

The film in question is "Made," released in 2010. The presence of ideal conditions throughout the vegetative phase of a plant's life cycle can influence its subsequent generative phase. Using a planting medium of soil and cow manure in research yielded favorable outcomes regarding vegetative growth, as evidenced by increased plant height and leaf count. Subsequently, a positive trend in generative growth was seen, namely in terms of fruit weight and fruit quantity. Using cow manure as a growth substrate for tomato plants yielded superior outcomes than other planting media. This phenomenon is believed to occur due to the ability of cow manure to fulfill the nitrogen requirements of plants. This assertion aligns with the viewpoint expressed by Muhammad (2019) regarding the comparative characteristics of various types of manure. According to their research, cow dung stands out due to its elevated fiber content, particularly cellulose, as well as its substantial presence of macronutrients such as nitrogen (N), phosphorus pentoxide (P2O5), potassium oxide (K2O), and water, in addition to other vital elements.

Conclusion

In conclusion, it can be inferred that the points above collectively support the notion that, respectively. The results of the four plants were observed after a period of two. The research findings indicate that the growth (specifically plant height and number of leaves) and production (including fruit weight and number of fruit) of tomato plants were influenced by the planting medium. The optimal utilization of planting media was achieved by applying soil planting media and cow manure.

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