APPLICATION OF VARIOUS PLANTING DISTANCES ON GROWTH RESPONSE AND YIELD OF TOMATO PLANTS (*solanum lycopersicum* L.)

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ABSTRACT

Tomatoes are one of the most commonly cultivated vegetables. This vegetable is multipurpose, especially as a daily cooking spice, a raw material for tomato sauce, and has a delicious and slightly sour taste. Considering its still low production, it is necessary to develop cultivation efforts to increase its yield. This study aims to determine the effect of different planting distances on the growth and yield of tomato plants (Solanum lycopersicum L). The research was conducted in La'o Village, Wali Subdistrict, Langke Rembong District, Manggarai Regency, East Nusa Tenggara, from April to July 2024. The method used in this study was a Randomized Block Design, consisting of 4 treatment levels: J1: 50x40 cm, J2: 50x50 cm, J3: 40x30 cm, and J4: 40x40 cm. Each treatment level was repeated 4 times, resulting in 16 experimental units. Each experimental unit contained 10 plants, with a total of 160 plants. Observations were made by examining 5 sample plants per experimental unit, with a total of 80 sample plants. The parameters observed in this study included: plant height (cm), number of leaves (blades), number of branches, flowering age (days), stem diameter (mm), number of harvested fruits (g), and fruit harvest weight (g). The data obtained were analyzed using Analysis of Variance (ANOVA) or F test at the 5% level. If significant differences were found, Duncan's Multiple Range Test was conducted at the 5% level. Research results show that various planting distances do not have a significant effect on all parameters. The ideal planting distance for tomato plants is observed with the following treatments: J3 (40 x 30 cm) for plant height, J2 (50 x 50 cm) for the number of leaves, J1 (50 x 40 cm) for flowering age, stem diameter, and J4 (40 x 40 cm) for the fresh weight of harvested fruit.

Keywords: Improving, multi-purpose, the spacing for planting, tomatoes, vegetables.

INTRODUCTION

The tomato plant (*Solanum lycopersicum* L) belongs to the Solanaceae family. This plant originates from Peru and Ecuador and later spread throughout the Americas, especially to tropical regions where it became a weed. The nutritional content of tomatoes includes vitamins A and C, essential amino acids, fatty acids, and a high content of antioxidants such as flavonoids, phenolic acids, lycopene, ascorbic acid, and minerals (Ca, Cu, Mn, Zn, and Se) (Elbadrawy *et al.*, 2016). In

addition to being consumed or used as a cooking ingredient, tomatoes can also be used as raw materials in the food industry, such as for tomato sauce and juice production (Wahida *et al.*, 2020). Tomato plants can be grown year-round, but the best time to plant tomatoes is during the dry season with adequate watering (Kartika, 2015). The growth and development of tomato plants are greatly influenced by weather elements such as air temperature. However, the most significant factors affecting the development of tomato plants are temperature and day length, while almost all weather elements impact their growth (Yuliana *et al.*, 2020).

Tomatoes rank fifth in vegetable production in Indonesia. Tomato production in Indonesia increased in 2016, reaching 851,701 tons per year. However, in 2017, production decreased to 747,577 tons per year. In 2018, tomato production further declined to 707,601 tons per year (BPS, 2020). The increasing demand for tomatoes necessitates the availability of tomatoes both in terms of quantity and quality. Based on tomato consumption data from 2017, the per capita consumption of tomatoes in Indonesia was 3.76 kg per year, with a total consumption of 878,741 tons. This created a significant gap between demand and the availability of tomatoes, amounting to 15,139 tons for that year. In 2018, the per capita consumption of tomatoes in Indonesia reached 3.57 kg per year, resulting in a total consumption of 915,987 tons. This led to an even larger gap between demand and the availability of tomatoes, amounting to 52,750 tons for that year (BPS, 2018).

The low productivity of agriculture in Indonesia today, particularly in tomato cultivation, is caused by various factors, one of which is the improper planting distance. Farmers tend to believe that the narrower the planting distance, the higher the yield due to the increased plant population (Karokaro, 2015). One effort that can be made to increase tomato production is by using superior varieties and paying attention to cultivation techniques, one of which is by considering the appropriate planting distance. Cultivation techniques that involve adjusting the planting distance are commonly practiced to give each plant enough space to grow properly. Planting distance affects plant density, light usage efficiency, competition among plants for water and nutrients, and ease of maintenance, all of which

influence crop production (Prabowati *et al.*, 2014).

Pest and disease attacks can also be prevented by adjusting planting distance. At low planting densities, plants face less competition with other plants, allowing for better growth. Conversely, at high planting densities, the level of competition among plants for light, water, and nutrients becomes more intense, potentially hindering plant growth (Pembayun, 2008). Based on the aforementioned points, efforts must be made to implement an optimal planting distance. This study aims to determine the ideal planting distance for the growth and yield of tomato plants.

RESEARCH METHODS

This research was conducted in La'o Village, Wali Subdistrict, Langke Rembong District, Manggarai Regency. The research was carried out from April to July 2024. The tools used in this study included: hoe, sickle, label paper, camera, and necessary stationery. The materials needed were: Servo F1 tomato seeds and chicken manure fertilizer. This study used a Randomized Block Design (RBD) with planting distance treatments consisting of 4 treatments, namely: J1 : 50 x 40 cm planting distance, J2 : 50 x 50 cm planting distance, J3 : 40 x 30 cm planting distance, and J4 : 40 x 40 cm planting distance. Each treatment level was repeated 4 times, resulting in 16 experimental units. Each experimental unit contained 10 plants, making the total number of plants 160. Observations were made by examining 5 sample plants per experimental unit, with a total of 80 sample plants. The data obtained were analyzed statistically using Analysis of Variance (ANOVA). If significant differences were found, further testing was conducted using Duncan's Multiple Range Test (DMRT) at the 5% significance level.

RESULTS AND DISCUSSION

Plant Height (cm)

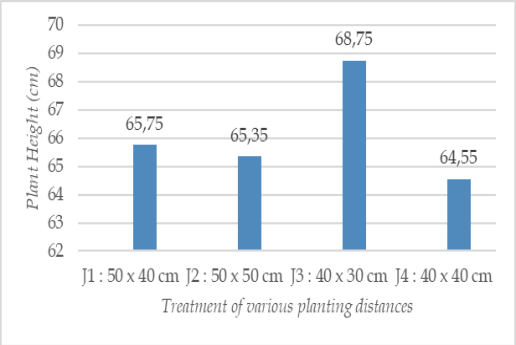

Figure 1. Average plant height (cm) 6 weeks after planting

The analysis results show that observations of tomato plant height at 6 weeks after planting did not show a significant effect based on the Analysis of Variance (ANOVA) test. The lowest average plant height was found in the treatment with planting distance J4: 40 x

40 cm, with a plant height of 64.55 cm, while the highest plant height was found in the treatment with planting distance J3: 40 x 30 cm, with a plant height of 68.75 cm. This suggests that an appropriate planting distance may help create space for root growth, which in turn aids in the movement of roots that absorb nutrients and water for plant growth. This is in line with the statement of Valdhini and Aini (2017) that if the planting distance is too close, the roots of one plant may enter the root zone of another plant, leading to competition for nutrient absorption. Igirisa (2015) explains that planting distance can affect nutrient absorption and the space available for plant growth, which ultimately impacts the growth and production of tomato plants. This is consistent with the opinion of Hatta (2012) in Tongkingoto (2017) that the correct planting distance will provide maximum growth and yield. Besides genetic factors, environmental factors such as humidity and temperature around the plants also significantly affect the growth and yield of tomato plants.

Nugrahini (2013) states that in more densely planted crops, the plants experience a shortage of light (reducing the photosynthesis process), leading to fewer leaves and taller plants due to etiolation. Etiolation is the process of cell elongation caused by continuous production of auxin hormones in plants. The use of planting spacing affects plant height, and this effect diminishes as the plant ages. This is because narrow planting spacing results in competition for nutrients and light intensity Desyanto (2014).

Number of leaves (blades)

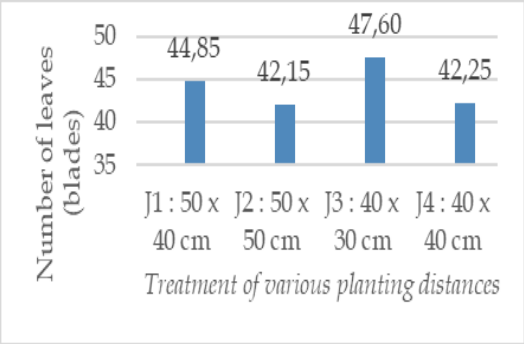

Figure 2. Average number of leaves (strands) 6 weeks after planting

The analysis results show that the observation of the number of tomato leaves at 6 weeks after planting did not have a significant effect based on the Analysis of Variance (ANOVA). The lowest average number of leaves was found in the J2 planting distance treatment 50 x 50 cm, with 42.15 leaves, while the highest number of leaves was observed in the J3 planting distance treatment: 40 x 30 cm, with 47.60 leaves. This suggests that the planting distance

directly affects the density of the plant population and the canopy cover on the soil surface. Meanwhile, in the rhizosphere, root competition occurs in the same land area, affecting the intensity of essential nutrient uptake (Las and Setyorini, 2010). Beja (2020) added that denser foliage results in more photosynthesis, more stored food reserves, and more energy available to support plant reproductive development, thus increasing plant production.

Plants, as living organisms, require carbohydrates for respiration, and plant growth is evident in the balance between photosynthesis and the breakdown of carbohydrates. The number of leaves is an indicator of growth and a parameter that describes the plant's ability to perform photosynthesis Misbahulzanah *et al*., (2014). A wider planting distance will reduce competition for nutrients, light, and water, allowing the plants to be more optimal (Wahyudin *et al.*, 2017).

Flowering Age (days)

Table 1. Average age of flowering

Treatment	Flowering age (days)
J1 : 50 x 40 cm	28,00 b
J2 : 50 x 50 cm	26,50 a
J3 : 40 x 30 cm	28,00 c
J4 : 40 x 40 cm	27,45 ab

Description: Numbers in columns and rows followed by the same letter indicate no significant difference, while numbers not followed by the same letter indicate a significant difference based on Duncan's multiple regression test at the 5% level.

The analysis results indicate that observations of flowering age in tomato plants show a significant effect based on the Analysis of Variance (ANOVA) test. The shortest average flowering age was found in the planting distance treatment J2: 50 x 50 cm, with a flowering age of 26.50 days, while the longest flowering age was observed in treatments J1: 50 x 40 cm and J3: 40 x 30 cm, with a flowering age of 28.00 days. Factors that affect the number of flowers on a plant include climate, sunlight, and water, which aligns with the views of Sudartik and Thamrin (2019) who state that sunlight is essential in the flowering process of a plant. When utilized effectively, plants can leverage sunlight in the photosynthesis process, with the results of photosynthesis increasing the percentage of flower formation in plants, which requires good sunlight during the flowering process. Hapsoh et al. (2017) also stated that sunlight significantly affects plant growth in the field through the duration of exposure (day length) and

influences plant flowering through three factors: quality, intensity, and photoperiodism.

Number of branches

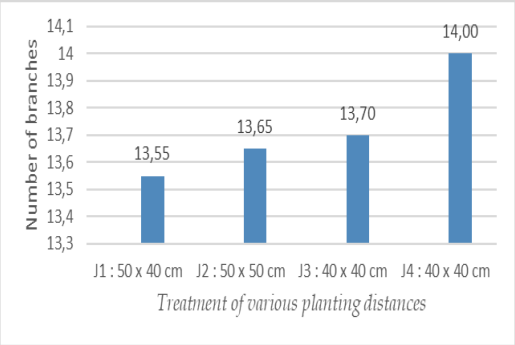

Figure 3. Average number of branches

The analysis results indicate that the observed number of tomato plant branches shows no significant effect based on the Analysis of Variance (ANOVA) test. The highest average number of branches was found in the planting distance treatment J4: 40 x 40 cm, with 14.00 branches, while the lowest number of branches was observed in the J1: 50 x 40 cm treatment, with 13.55 branches. Another factor contributing to the insignificant average number of branches is suspected to be an inadequate planting distance, which affects the number of leaves. An ideal planting distance allows plants to receive more sunlight, leading to faster growth and an increased number of branches. Pangli (2014) adds that a wider planting distance can increase the amount of solar energy received by the plants for photosynthesis.

The sunlight absorbed by the leaves is essential for metabolism that produces carbohydrates through photosynthesis, and the roots will easily absorb nutrients from the soil. Besides the necessary sunlight, nutrients and water are also required to be maximized to all parts of the plant. Proper pruning treatment is needed during the vegetative phase for plant formation and the generative phase for the formation of productive branches, aiming for optimal yields. It is suspected that the nutrients absorbed by the plant from the photosynthate produced are not maximized in forming biomass. Meanwhile, maximum nutrient allocation by leaves due to pruning results in an increase in plant biomass, enabling it to receive more photosynthate and boost plant production (Sulistyo et al., 2016).

Supported by data on the number of branch growth in tomato plants, according to Nasrulloh et al. (2016), the number of branches in plants is directly proportional to the number of leaves produced. The more optimal the branch growth on each plant, the more leaves are produced. Leaves serve as the site of

photosynthesis, which triggers the maximal growth of flowers and fruits.

Number of harvested fruits

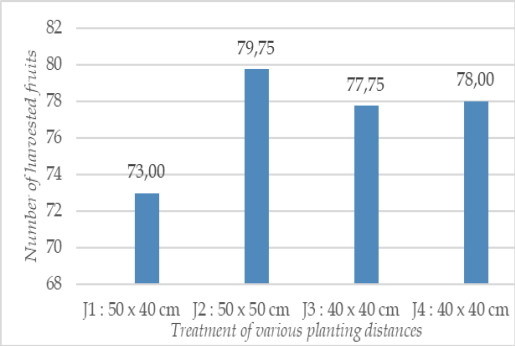

Figure 4. Average number of harvested fruits

The analysis results indicate that the observation of the number of harvested tomato fruits showed no significant effect based on Analysis of Variance (ANOVA). The lowest average number of fruits was found in the planting distance treatment J1: 50 x 40 cm, with 73.00 fruits, while the highest number was found in the treatment J2: 50 x 50 cm, with 79.75 fruits. This is suspected to be because a planting distance that is too close can adversely affect fruit production, resulting in fewer fruits. Planting distance management is part of the intensification efforts by regulating the spacing between plants and rows. Additionally, proper planting distance can optimize the plant's ability to utilize necessary elements in the photosynthesis process, such as sunlight, water, and nutrients (Suprianto *et al*., 2017). A closer planting distance leads to suboptimal results. Dense planting increases air humidity, making plants more susceptible to pest and disease attacks.

Fresh Weight of Harvested Fruit (g)

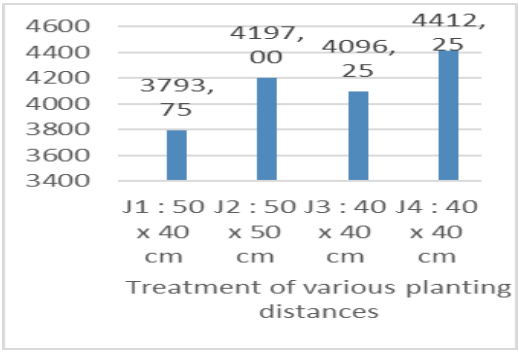

Figure 5. Average fresh weight of harvested fruit

The analysis results show that the observation of fresh fruit weight from tomato plant harvests had no significant effect based on the Analysis of Variance (ANOVA) test. The lowest average fresh fruit weight was found in the planting distance treatment J1: 50 x 40 cm with a fresh fruit weight of 3793.75 g, while the heaviest fresh fruit weight was found in the treatment J4: 40 x 40 cm with a fresh fruit weight of 4412.25 g. According to Kartika et al. (2015), plant growth and development are greatly influenced by weather elements such as temperature. The application of liquid organic fertilizer affects the fruit weight per sample.

Alamri (2015) stated that the application of liquid organic fertilizer and environmental factors positively support the flowering process up to fruit formation, resulting in significant fruit weight. Fruit weight is influenced by plant growth. Good vegetative growth will lead to good generative growth. The taller a plant, the greater the fruit weight it will produce. A higher number of leaves will affect the photosynthesis process, as leaves are the site of photosynthesis. According to Rinasari et al. (2016), an increasing number of leaves enhances the plant's food reserves stored in the form of fruit, provided that the plant's water and nutrient needs are adequately met.

CONCLUSION AND SUGGESTIONS

Research results show that the treatment of various planting distances does not have a significant effect on all parameters. The ideal planting distance for tomato plants is found in the following treatments: spacing J3: 40 x 30 cm for plant height, spacing J2: 50 x 50 cm for flowering age, spacing J1: 50 x 40 cm for harvest fruit count, and spacing J4: 40 x 40 cm for fresh fruit weight. This study suggests that further research is needed on the effects of planting distances for tomatoes (Solanum lycopersicum L.) with different varieties in varying land conditions to provide recommendations for ideal planting distances.

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