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Effect of Plant Density on Growth and Yield of Tomato (*Solanum lycopersicum* L.) at Thai Nguyen, Vietnam

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This study was conducted to evaluate the planting density on growth and yield of tomato fruit to determine the optimum planting density. Plant height, number of leaves per plant, fruit set, number of fruit per plant, fruit weight and fruit yield were recorded. Results indicated that treatment with 35714 plants per hectare had the highest plant height, whereas 25974 plants per hectare gave the lowest plant height. Moreover, 25974 plants per hectare had the best results in fruit set, fruit number as well as fruit weight. Planting density with 25974 plants per hectare gave the maximum fruit yield than the other treatments. It was concluded that 25974 plants per hectare significant improve fruit growth and yield of tomato fruit under field condition.

Keywords: Tomato; planting density; growth; yield.

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1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belongs to the Solanaceae family and self crossing annual crop. This family also includes other well known species such as potato, tobacco, hot pepper and egg plant [1]. Tomato is a very important vegetable cultivated and consumed in most parts of the world, from home gardens and greenhouses to large commercial farms due to its wider adaptability to various agro-climatic conditions [2]. It is grown on more than 5 million ha with a production of nearly 129 million tons. China is the world's top tomato grower, accounting for more than one-quarter of the world's tomato acreage. Egypt and India together account for more than one-fifth of the world total; Turkey and Nigeria are the other major tomato producing countries. Asia and Africa account for about 79 percent of the global tomato area, with about 65 percent of world output [3]. As it is a relatively short duration crop and gives high yield, so it is economically attractive and the area under cultivation is increasing daily all over the world [4]. Tomato was first cultivated about 100 years ago in Vietnam. Tomato area is approximately 15.000-17.000 ha annually with a yield of 15 – 17 tons/ha and more than 30 tons/ha in some intensive farming areas [5]. Tomato has a significant role in human nutrition because of its rich source of lycopene, minerals and vitamins such as ascorbic acid and b-carotene which are anti-oxidants and promote good health [6]. They can be processed into purees, juices and ketchup. Canned and dried tomatoes are economically important processed products.

In the tropics, tomato is mainly grown during the cool season, because of the adverse conditions during summer which greatly affect productivity and quality. Tomato is grown successfully on open fields varies from 52° South and 54° North latitudes, and also grown under controlled conditions in green houses [7]. The unimproved local cultivars commonly grown in the tropics, scanty plant stands, non-use of fertilizer, organic manures and other improved agricultural inputs in the management of the crops has resulted in low yield tomato fruit [8]. The management practice which greatly influence tomato fruit yield are spacing as reported by [9]. Furthermore, Lemma et al. [10] reported that plant spacing greatly influenced fruit yield in both fresh market and processed tomatoes. Likewise, Godfrey-Sam-Aggrey et al. [11] and Mehla et al. [12] also reported yield parameters in tomato to have been affected by spacing. Wider spacing on the other hand led to increase in fruit yield per plant with bigger fruits and more cracked fruits per plant. However, in Vietnam, farmers get lower yield mainly due to the fact that tomato is sensitive to a number of environmental stresses, especially extreme temperature, salinity, drought, excessive moisture and environmental pollution, diseases and pests as well as plant density. The production and productivity of the crop in the country is influenced by different factors among which improper plant spacing is the notable reason of the low productivity of this crop. Plant density is considered an important practice responsible for improving fruit setting, yield as well as quality of fruits. Thus, this study aimed to evaluate the effect of different planting density applied on growth and yield of tomato which may help in predicting the optimal spacing requirement and to improve the practices of tomato production.

2. MATERIALS AND METHODS

2.1 Plant Materials and Treatment Design

The experiment was conducted at Thai Nguyen University of Agriculture and Forestry, Vietnam during the 2013 winter-spring season. The TN 389 tomato cultivar obtained from Trang Nong company, Vietnam were used for the study. The plot size used was 1.6 m x 5 m (Plot area = 8 m^2) for the study. The experiment was design in Randomized Complete Block Design (RCBD) with three replications. The experiment consists of four treatments including the control in four planting densities: 35714; 31746; 28571; 25974 plants per hectare, respectively. Seeds of tomato cultivars were sown in separate large trays filled with top forest soil on the 5th September in 2013. Water was sprayed when necessary after seeding. After three weeks, the seedlings were transplanted to well prepare beds in the field. Fertilizer was applied @ 120 kg N, 100 kg P and 150 kg K per hectare. Mulching, weeding, insecticidal spraying, staking and other horticultural operations were done when necessary.

2.2 Data Collection

Twenty plants per plot were randomly selected from two middle rows to measure the following observations: Plant height was measured from the soil surface to the tip of the main stem and mean plant height was calculated. Number of leaves per plant: by counting the number of leaves of all sample plants and the average was

recorded. Number of fruits per plant: the total number of red ripe mature fruits which were harvested from each plant and then mean was calculated. The percentage of fruit setting was recorded. Average fruit weight was determined by weighing. Total yield for each treatment were weighted and the mean was calculated. Fruit yield ha was obtained through conversion of the net plot yield.

2.3 Statistical Analysis

The data obtained from the study were analyzed using SAS 9.1 statistical software for each cultivar separately. The least significant difference was calculated following a significance F-test (at p≤ 0.05).

3. RESULTS AND DISCUSSION

3.1 Effect of Plant Density on Plant Height and Number of Leaves Per Plant of TN 389 Tomato Cultivar

Plant height at maturity had significant relationship among the treatment means. The results summarize in Table 1 showed that there was significant different in plant height among treatments. In the present study plant height ranged between 140.4 to 174.9 cm, in which the lowest plant height with value of 140.4 cm was obtained in 25974 plants per hectare, followed by 28571 plants per hectare with value of 152.8 cm, whereas the highest plant height of 174.9 cm was recorded in control treatment (35714 plants per hectare). It seems that plant height at maturity decreased with higher planting density which is in agreement with the finding of [8]. Gupta and Shukla [13] also reported increased plant height in tomato at high plant density than at low plant density which is in line with the present result. Therefore, the data present in Table 1 showed that low plant density has resulted in higher plant height than high plant density. Too low a plant density is a common cause of poor fertilizer response [14]. However, plant densities had no significant effect on number of leaves per plant (Table 1). These results agree to those of Mahmoud [15] and Ahmed [16].

3.2 Effect of Plant Density on Fruit Set, Fruit Number, Fruit Weight and Fruit Yield of TN 389 Tomato Cultivar

3.2.1 Fruit set (%)

For the fruit set, the results in Table 2 showed that there were significant different fruit set among treatments. In term, the maximum fruit set with value of 54.7% was achieved in 25974 plants per hectare, whereas the lowest fruit set was obtained 35714 plants per hectare with value of 49.1%. It seems that low plant density gave the higher fruit set than the control treatment. The remaining treatment in this study showed the higher fruit set than the control treatment, although the difference was not statistically significant (p≤0.05) was showed in Table 2.

Table 1. Effects of planting density on mean of plant height, number of leaves per plant of TN 389 tomato cultivar in winter spring season 2013

Planting density	Plant height (cm)	No. of leaves/ Plant
35 714 (control)	174.9^{ab1}	30.4^{a}
31 746	161.4^{bc}	32.0^{a}
28 571	152.8^{cd}	31.9^{a}
25 974	140.4^{d}	32.1^{a}

[1]Mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan's multiple range test

Table 2. Effect of planting density on fruit set, fruit per plant, fruit weight and fruit yield of TN 389 tomato cultivar in winter spring season 2013

Plant density	Fruit set (%)	Number of fruit per plant (fruit)	Fruit weight (g)	Fruit Yield (ton/ha)
35714 (control)	49.1^{bc1}	12.7^{b}	85.5^{a}	28.1^{cd}
31746	54.3^{ab}	14.9^{a}	90.8^{a}	29.3^{bc}
28571	53.4^{ab}	15.3^{a}	90.9^{a}	30.9^{b}
25974	54.7^{a}	15.9^{a}	91.4^{a}	33.3^{a}

[1]Mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan's multiple range test

3.2.2 Number of fruits per plant

The number of fruits per plant for all treatment in this study is presented in Table 2. In term, treatment with 25974 plants per hectare produced the highest fruit number per plant (15.9 fruit number), followed by treated with 28571 plants per hectare, 31746 plants per hectare with values of 15.3; 14.9 fruit number, respectively, whereas the lowest fruit number per plant of 12.7 fruit number was recorded in control treatment (35714 plants per hectare). The total number of fruits plant decreased as planting density increase, this might be due to the effect of competition. This arisen due to the fact that competition is less in low planting density than at high planting density. The competition might be high for nutrients, physical spaces and water. These results are in agreement with the finding of Balemi [17] who indicated that fruit number per plant was also significantly influenced by plant density, the low plant density resulting in significantly more fruit number as compared to high plant density.

3.2.3 Fruit weight

The results summarized in Table 2 indicated that treatment with 25974 plants per hectare had the maximum fruit weight (91.4 g), whereas the lowest fruit weight 85.5 g was recorded in control treatment (35714 plants per hectare), although the difference was not statistically significant ($p \leq 0.05$), which is in accordance with the finding of Law-Ogbomo and Egharevba [8]. It seems that low plant density gave the highest fruit weight compared to high plant density. This result is in agreement with the report of Ali [18].

3.2.4 Fruit yield

Data in Table 2 indicated that fruit yield was significantly influenced by the planting density. The mean total fruit yield of the tomato ranged between 28.1 and 33.3 ton/ha. In the case of this study, the highest fruit yield was found in 25974 plants per hectare with 33.3 ton/ha, followed by treatment with 28571 plants per hectare, 31746 plants per hectare, whereas the control treatment 35714 plants per hectare showed the lowest value of 28.1 ton/ha, which is in agreement with the repotted of Law-Ogbomo and Egharevba [8] who similarly reported the highest total fruit yield of tomato at low plant density than at high plant density

4. CONCLUSION

From the experiment results, it can be concluded that 25974 plants per hectare clearly decrease plant height. Moreover, fruit set, fruit number, fruit weight as well as fruit yield markedly increased in low planting density (25974 plants per hectare). From the results, we can concluded that application of 25974 plants per hectare may be recommended as practical tools for improving fruit set, fruit number, fruit weight and fruit yield of tomato fruit under field conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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