

**POULTRY MANURE AND SPACING AS IT AFFECT GROWTH PARAMETERS OF TOMATO
(*Solanum lycopersicum* L.) IN YOLA ADAMAWA STATE, NIGERIA**

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ABSTRACT

*Tomato (*Solanum lycopersicum* (L.)) is an important vegetable and cheap source of vitamin C, thus ranks number one in contribution to diet. It is widely grown in many tropical areas of the world including Nigeria. However, average yield as obtained by the local farmers in Nigeria is low, due mainly to lack of adequate information on the proper agronomic and cultural practice involve in tomato farming for optimal yield. Field experiment was conducted at the Teaching and Research Farm of the Department of Crop Production and Horticulture, Modibbo Adama University, Yola, Adamawa State, Nigeria, in the cropping seasons of 2021, 2022 and 2023 to evaluate how poultry manure and spacing affects growth Parameters of tomato (*Solanum lycopersicum* (L)). The treatment consisted of five poultry manure levels (0 tons/ha, 15 tons/ha, 20 tons/ha, 25 tons/ha and 30 tons/ha) as the main plot treatments and five spacing intervals (90x60 cm, 80x40 cm, 60x30 cm, 50x50 cm and 40x20 cm) as sub-plot treatments. The experiment was laid on a split plot design and was replicated three times. Three Tomato cultivars (Tandino, UTC and Dansiriya) were used. Appropriate agronomic practices recommended for the production of tomato were carried out to ensure optimum performance. The parameters measured were plant height, number of branches, number of leaves, stem girth. The data collected were subjected to analysis of variance and significantly different means were separated using Least Significant Difference (LSD). The result showed that 30tons/ha poultry manure significantly affected plant height (61.43 cm), number of branches per plant (5.087), 25tons/ha poultry manure performed better on stem girth (4.344 cm), 20 tons/ha poultry manure significantly affected number of leaves per plant (25.891). Plant spaced 60x30 cm performed better on stem girth. It is therefore recommended that farmers should plant Tandino cultivar and applied 30 tons/ha rate of poultry manure as well as spacing tomato 60x30 cm for optimum growth of tomato in the study area.*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetables worldwide. As it is a relatively short duration crop and gives a high yield, it is economically attractive and the area under cultivation is increasing daily (Pandey & Chandra, 2013) Moreover, tomatoes contribute to a healthy, well-balanced diet and rich in minerals, vitamins, essential amino acids, sugars, and dietary fibers. Tomato contains vitamin B and C, iron, and phosphorus. Economically speaking, tomatoes are worth a tremendous amount of money because they give more yields. Tomatoes are also one of the main ingredients in hundreds of dishes and products that are sold in supermarkets throughout the world. Tomatoes are also a popular choice by people who wish to grow fruits and vegetables in their gardens. Not only can they be used raw in salads, but they are also an essential part of many recipes as well as many produced products (Olaniyi, et al., 2010).

Nowadays the rise of food production is the major challenge to meet the food requirements of the growing population in Nigeria and it will remain essential in the future due to the pressure of inhabitants. Many factors like the cultivar used, post-harvest handling, cultural practices, weather and climate factor and soil factor influence crop quality in food production and one of the main factors is the fertilizer. Fertilizer is a natural or synthetic substance that is applied to soils to supply one or more

nutrients essential to the growth of plants. They contain main plant macronutrients like nitrogen, phosphorus and potassium. They also contain secondary plant macronutrients calcium, magnesium, and sulfur and micronutrients like copper, iron, manganese, molybdenum, zinc, and boron and are mainly known to be beneficial for the production of crops and for making way to a bountiful harvest. Soil fertility is one of the major problems limiting crop production (Martinez-Blanco, *et al.*, 2015).

The growth and yield of vegetable crops mainly depend on the quality and quantity of fertilizers used (Chang, *et al.*, 2010). So, to increase soil fertility and yield, inorganic/chemical fertilizers are often used. Frequent and high rate uses of inorganic fertilizer have been associated with some environmental pollution, alteration in soil textures, and physical property of the soil. Moreover, the nutritional value of the crops will be affected seriously by the continuous use of synthetic fertilizers (ketama & Bauer, 2011) also inorganic fertilizers will increase the cost of crop production. Now, throughout the world, the demand for organic foods that are good for health and the environment is increasing among the consumers. Furthermore, consumers often look upon the taste of organic products and they should be healthier than the conventional one (Ekehund & Tjamemo, 2004). Apart from the release of nutrients in a slow manner, the application of organic fertilizers made from animal excreta or other agricultural wastes improves structure and stability of the soil and in addition to enhancing the yield and quality of the crop plants (Chang, *et al.*, 2010; Marzauka & Kassem, 2011). Organically produced fruits, vegetables, food crops get much higher value not only in the international market but also in our domestic market. Crop produced using chemicals may not be acceptable by the consumers because they are conscious about the residues, which have negative impact on human health and the environment. Chemical fertilizers can cause problems with the heavy metals that can be found in it. These include Lead, Mercury, Cadmium, and Uranium, which can have a negative impact on the kidneys, liver, and lungs. These heavy metals are also associated with other human health hazards. (Almulla, *et al.*, 2012; Gondek, *et al.*, 2020).

Organic manure such as compost and vermin compost improve texture, structure, color, water holding capacity, microbial activity, anion and cat ion exchange capacity, organic matter, and carbon content of soil and, it also promotes the vegetative growth, flowering, fruit set, yield and quality of tomato (Guo, *et al.*, 2020; Someri, *et al.*, 2017; Kachave, *et al.*, 2021 & Tonfack, *et al.*, 2009). The application of organic fertilizer is an important means of maintaining soil fertility status and is also environmentally friendly. This is because nutrients contained in organic manures are released more slowly and are stored for a longer time in soil, thereby ensuring a long residual effect (Singh, *et al.*, 2020). In many tropical soils, organic manure has been reported to be the major source of nitrogen phosphorus, potassium, calcium as well as magnesium. Generally, fertilizers are applied to the soil for enhancing the ability to supply adequate nutrients and for getting a higher yield of the crops (Biswas, *et al.*, 2015).

Plant population is an important agronomic factor that modulates the crop microenvironment and affects the growth, development and yield formation of crops. Within certain limits, an increase of Plant Population Density (PPD) decreases the growth and yield per plant but the reverse occurs for yield per unit area (Hussen, *et al.*, 2013). The effect of plant population on growth, plant characters, and yield could vary due to varietal characters and growing seasons in the same geographical areas. Thus, the relationship of seed yield with different growth parameters and yield components under variable planting density is very important to understand the basic mechanism of the yield-plant density relationship and this would also help in optimizing plant population for improving the yield of tomato. (Rahman & Hossain, 2011). Spacing plays a vital role in the proper growth and development of the plant. Yield is the result of interplant and intra plant competition. Optimum plant spacing utilizes maximum natural resources, such as nutrients, sunlight, soil moisture, etc. and ensures satisfactory yield and proper use of land (Wagayehu, *et al.*, 2015; Abrha, *et al.*, 2015). The correct spacing for

tomato plants depends partly on how they are grown. When stakes are used or tomato cages to support the plants, allow 1.5 to 3 feet of space between plants should be allowed. When grown without support plants should rest on the ground as they grow, with 3 to 4 feet between plants. If planting in rows, allow 3 to 4 feet between rows. In addition, consider planting fast-growing, early-season crops, such as lettuce or spinach, in this space. These plants mature and are ready for harvest before your tomatoes become large enough to overshadow them (Kirimu, et al., 2011).

Properly spaced tomato plants are likely to be healthier and produce a larger harvest than those that are overcrowded or too widely spaced. The distance between tomato plants depends on the types of tomatoes and how you intend to support them (Menberu, et al., 2012) Outdoors tomato farmers usually plant their seedlings in single rows. A common pattern for single rows planting is 0.3 m to 0.6 m (12-24 inches) distance between plants on the row and 0.8 m to 1.3 m (2.6-4.3 ft.) distance between rows. For twin rows planting, growers maintain the same distance between plants on the row, 0.45 m (1.48 ft.) distance between rows and 1.2 m (3.94 ft.) between two couples. Following these patterns, there will be approximately 15000-30000 plants per hectare. The exact distances and the number of plants depend on the tomato variety, environmental conditions, the irrigation system, and the yield goals of the producer. (1 hectare = 2, 47 acres = 10,000 square meters) (Kirimu, et al., 2011).

The interaction effect of inter-and intra-row spacing significantly affects both marketable and unmarketable yields of tomatoes. Spacing of tomato 10 to 50 cm intra-row spacing and 60 to 120 cm inter-row row spacing were reported for different tomato varieties in different locations and years. The importance of recommending inputs and management practices that are central to producing a good yield and quality of tomato fruit which was also affected by varieties and growing region (Getachew & Gebremedhin, 2020, Abrha *et al.*, 2015).

Madisa, et al., (2015) reported that narrower plant spacing significantly increased the plant height, while wider plant spacing significantly increased the plant weight, number of branches, and leaves. They also reported that stem girth was statistically significant due to different plant spacing. The widest spacing produced the maximum stem girth and it gradually decreased with decreasing spacing. The plants planted at the widest spacing produced profuse branching without lodging Prodhan et al., 2011. Islam et al., (2011) reported that the number and weight of fruits per plant, as well as the vegetative branches per plant decreased significantly with increase in population density from 61×30.5 cm to 61×91.5 cm.

Spacing of closer cm produced not only the highest number of productive branches and fruits per plant but also the highest fruit weight per plant and together with a spacing of 40×30 cm they produced the highest fruit yield ha⁻¹. Fruit size for spacing 40×30 cm, 40×35 cm, and 40 cm × 40 cm which was essentially similar was larger than that of 40×25 cm spacing which produced the lowest number of productive branches and fruits per plant and the lowest fruit weight per plant and fruit yield ha⁻¹. Spacing plays a vital role in the proper growth and development of the plant Maboko, et al., (2011). Yield is the result of interplant and intra plant competition. Optimum plant spacing utilizes maximum natural resources, such as nutrients, sunlight, soil moisture, etc. and to ensure satisfactory yield and proper use of land. Wider row spacing tended to produce stronger plants that did not require any support unlike at closer spacing where the plants were thinner and weaker (Maurya, et al., 2013; Wegayehu, et al., 2015).

Experimental design: The study is an experimental study that was laid in split plot design in a factorial fashion replicated three times. The experimental layout was a split-split plot design and each plot was 2m x 2m having 1m space between the block and 0.5 m between plots. The experiment consist of nine blocks and each block has twenty-five plots. The land was cleared using cutlass, local hoe, and rake.

The field was spray with herbicide. The field was plowed mechanically using a tractor. The field was divided into blocks and plots of equal size.

Experimental site: The field experiment was conducted at the Teaching and Research farm of the Department of Crop Production and Horticulture, Faculty of Agriculture, Modibbo Adama University, Yola, Adamawa State in Northeast Nigeria. The farm lies between Latitude N 9° 20' 38" and Longitude 12° 30' 51" East of the equator at an altitude 232.3m above sea level. The cropping history of the experimental site was taken, the farm attendant detailed the researcher on the type of crop cultivated on experimental site year before the experiment.

Planting Materials: The experimental materials used were tomato using Cultivars Tandino, UTC, and Dansiriya Cultivars which were obtained from local tomato farmers in Yola. The implement used for the experiment includes a Knapsack sprayer, herbicide, cutlass, local hoe, rake, garden fork, measuring tape, measuring ruler, rope, watering can, and poultry manure.

Nursery Preparation: Nursery beds were prepared and raised to 15 cm above the ground level to avoid erosion. The seed of all the Cultivars that were sown underwent a viability test using the floatation method to be sure of the viability of the seeds. This was done by putting the seed in a container and pouring water on it to observe all the seeds that float above to be discarded. The seeds also underwent germination tests where ten seeds from each cultivar was sown and observed its germination to be sure of the germination capability of the seeds. The seeds were sown by drilling at 10cm deep and covered with fine sand and some dry grasses. Watering was done twice daily morning and evening by using a watering can to ensure sufficient moisture for seed germination. As soon as the seeds germinate the dry grasses were removed for proper seedlings establishment. Other cultural practices were observed until the seedlings are ready for transplanting.

Transplanting: Transplanting of the tomato seedlings to the experimental plots was done when the seedlings are four weeks old after sowing when the seedlings had 3 to 4 true leaves (Kisetu & Heri (2014)). The transplanting was done in the evening in order to reduce transplanting shock. One seedling was transplanted per hole.

Weeding was done to control weeds to avoid competition for nutrients between the plants and the weeds. The weeding was done using local hoe and handpicking. Pest and diseases were controlled by the use of pesticide the reason is that wood ash may affect the treatment which eventually will affect the result of the study. On the event of advert temperature water was spread around the experiment site to reduce the effect of high temperature on the growing plants. On the event of moisture stress water was sprinkle on the plots using watering can.

Method of Data Collection: Five plants per plot were consecutively selected and tagged for determination of plant height, stem girth, number of leaves, and number of true branches from two weeks, four weeks, and six weeks after transplanting. The days to 50 % flowering, days to 50% fruiting, number of fruits, fruit diameter, fruit length, fruit weight, number of marketable fruits and number of unmarketable fruits were evaluated after each harvest.

Plant height (cm): The plant heights were measured at 2 WATP, 4 WATP and 6 WATP from the base of the plants to the terminal growing point of the main stem. The average plant height of 5 selected plants per plot were measured using meter rule in centimeters (cm)

Number of leaves: The numbers of leaves excluding the cotyledon from the 5 selected plants in each plot were counted at 2 WATP, 4 WATP and 6 WATP manually.

Number of primary branches: The number of primary branches of 5 selected plants at 2, 4 and 6 WAT from each plot were counted and the mean was calculated to determine the number of branches per plant for each treatment.

Stem girth: The stem girth of the 5 selected plants in each plot were measured in centimeter using a thread and meter rule at 2 WATP, 4 WATP and 6 WATP.

Method of Data Analysis: The data generated from the research were organized using Microsoft Excel (MS Excel) and then were subjected to Analysis of Variance (ANOVA) using SPSS version 22. The differences among the treatment mean for significant result was performed using Least Significant Difference at 0.05 confidence level.

RESULT AND DISCUSSION

The result on table 1 indicated that in the 2021 rainy season, 30 tons/ha PM recorded the tallest (44.44cm) plant which was statistically at par with 25 tons/ha PM (44.11cm), followed by 20 tons/ha PM (43.14cm) which was significantly at par with 15 tons/ha PM (42.20cm). The shortest (28.20cm) plant was recorded from control. Similarly, in the 2022 rainy season, 30 tons/ha PM produced the tallest (28.94cm) plant though was statistically at par with 20 tons/ha PM (28.82cm), followed by 15 tons/ha PM (27.25cm) which also is at par with 25 tons/ha PM (26.78cm). The shortest (18.16cm) plant height at 6WAT in the 2022 rainy season, in respect to nutrient was recorded from control. In the 2023 rainy season 30 tons/ha PM recorded the tallest (61.43cm) plant which was statistically at par with 15 tons/ha PM (61.31cm), followed by 25 tons/ha PM (59.95cm) which was equally at par with 20 tons/ha PM (59.57cm). The control recorded the shortest (36.23cm) plant. The combined analysis indicated that 30 tons/ha PM recorded the tallest (44.7704cm). The least (27.5289cm) plant was recorded from the control. This result accords with findings of Adekiya & Agbedeb (2017) who reported that tomato growth is influenced by increase in poultry manure application.

In the spacing treatment in 2021 rainy season, the 60 x 30 cm spacing recorded the tallest (41.40cm) plant, followed by 50 x 50 cm (40.66cm) which was statistically at par with 40 x 20 cm spacing (40.15). The shortest (39.90cm) was recorded from 80 x 40 cm spacing though statistically at par with 90 x 60 cm spacing (39.98cm) plant height. In 2023 rainy season at 6WAT 40 x 20 cm spacing recorded the tallest (29.62cm) plant height, followed by 60 x 30 cm spacing (26.68cm) which was at par with 50 x 50 cm spacing (26.54cm). 90 x 60 cm spacing recorded the shortest (20.70cm) plant height. In 2023 rainy season there was no significance ($P > 0.05$) difference on the effect of spacing on plant height. The combined analysis showed that 40 x 20 cm spacing recorded the tallest (41.6674cm). The least (38.3978cm) plant height was recorded from 90 x 60 cm spacing. This result is in line with the findings of Abriham & Kefale (2020) who reported that the growth of tomato plant is influenced by spacing.

Table 2 shown that in 2021 rainy season 30 tons/ha PM produced the highest (4.000) number of branches per plant though statistically not significantly different from 20 tons/ha PM (3.840), followed by 20 tons/ha PM (3.702) which also was at par with 15 tons/ha PM (3.669) number of branches per plant. The least (2.591) number of branches per plant was recorded from the control. Similarly, in 2022 rainy season 30 tons/ha PM recorded the highest (4.067) number of branches per plant though not significantly different from 15 tons/ha PM (3.969) number of branches per plant, followed by 20 tons/ha PM (3.802) which was at par with 25 tons/ha PM (3.740) number of branches per plant. The least

(2.584) number of branches per plant was obtained from the control. In 2023 rainy season also 30 tons/ha PM recorded the highest (5.087) though statistically not significantly different from 15 tons/ha PM (5.044) number of branches per plant, followed by 25 tons/ha PM (4.942) which was also at par with 20 tons/ha PM (4.920) number of branches. The least (3.211) was recorded from the control. The combined analysis indicated that 30 tons/ha PM produced the highest (4.36222) number of branches. The least (2.79556) number of branches per plant was recorded from the control. The result of this study agrees with the findings of Alhrout et al. (2018) who reported that application of poultry manure significantly enhanced the growth character of tomato.

Regards to Plant spacing in 2021 rainy season the result showed that the 60 x 30 cm spacing produced the highest (3.893) and is at par with 50 x 50 cm spacing (3.773) number of branches per plant, followed by 80 x 40 cm, 40 x 20 cm and 90 x 60 cm spacing producing 3.578, 3.467 and 3.384 respectively which were not significantly different. In 2022 rainy season 60 x 30 cm spacing recorded the highest (3.874) number of branches per plant, followed by 50 x 50 cm spacing (3.667) number of branches per plant. The least (3.378) number of branches was obtained from 90 x 60 cm spacing which was at par with 80 x 40 cm and 40 x 20 cm spacing (3.478 and 3.473 respectively). In 2023 rainy season at 6WAT 80 x 40 cm spacing recorded the highest (4.784) number of branches though not significantly different with 60 x 30 cm spacing (4.744) followed by 90 x 60 cm spacing (4.609) which was also not significantly different from 50 x 50 cm spacing (4.598) number of branches per plant. The least (4.409) number of branches was obtained from 40 x 20 cm spacing. The combined analysis indicated that 60 x 30 cm spacing produced the highest (4.17704) number of branches per plant, while 90 x 60 cm spacing recorded the least (3.81037) number of branches per plant. This study disagrees with findings of Madisa et al. (2015) who reported that wider spacing of tomato plant significantly increase number of branches.

In table 3, the result shown that in 2021 rainy season 30 tons/ha PM produced the highest (23.847) number of leaves per plant though not significantly different from 25 tons/ha (23.757) followed by 20 tons/ha (23.333) number of leaves. The least (17.911) number of leaves per plant was recorded from control. In 2022 rainy season 30 tons/ha PM produced the highest (13.213) number of leaves per plant, followed by 20 tons/ha and 25 tons/ha PM which were significantly not different (13.124 and 13.086 respectively). The least (7.878) number of leaves was recorded from control. In 2023 rainy season 20 tons/ha PM recorded the highest (25.891) number of leaves per plant, followed by 30 tons/ha (25.584) which was at par with 15 tons/ha (25.504) number of leaves per plant. The least (18.247) number of leaves per plant was recorded from the control. The combined analysis indicated that 30 tons/ha PM produced (20.8830) number of leaves per plant. The least (14.6785) number of leaves per plant was recorded from was recorded from the control. This result is in line with the findings of Olaniyi et al. (2010) who reported that application of poultry manure significantly increased the vegetative growth of tomato plant.

Concerning plant spacing in 2021 rainy season, 60 x 30 cm spacing produced the highest (22.944) number of leaves per plant, followed by 80 x 40 cm (22.431) and the least (21.957) number of leaves per plant was recorded from 40 x 20 cm spacing. In 2022 rainy season there was no significant ($P>0.05$) effect of spacing on number of leaves per plant of tomato. In 2023 rainy season 60 x 30 cm spacing recorded the highest (24.473) number of leaves per plant, followed by 80 x 40 cm and 50 x 50 cm spacing which was not significantly different (24.340 and 24.076 respectively). 40 x 20 cm spacing produced the least (23.627) though at par with 90 x 60 cm (23.980) number of leaves per plant. The combined analysis indicated no significant ($P>0.05$) difference.

Table 3 indicated that in 2021 cropping season, 25 tons/ha PM produced the highest (4.344cm) stem girth which was at par with 20 tons/ha (4.311cm) stem girth, followed by 30 tons/ha (4.189cm). The least (3.136cm) stem girth was produced from control. In 2022 cropping season 25 tons/ha

produced the highest (4.296cm) stem girth which was at par with 20 tons/ha (4.261cm) stem girth, followed by 30 tons/ha (4.139cm) stem girth. The least (3.085cm) stem girth was recorded from control. In 2023 cropping season 20 tons/ha produced the highest (4.136cm) stem girth, followed by 25 tons/ha (4.062cm) stem girth. The least (2.938cm) stem girth was obtained from the control. The combined analysis indicated that 20 tons/ha produced the highest (3.643cm) stem girth. The least (2.65926cm) stem girth was obtained from the control. This result accords with the findings of Ogundare et al. (2015) whose findings revealed that growth parameters of tomato performed better with the increased application of poultry manure.

Regards to spacing in 2021 cropping season, 60 x 30 cm spacing recorded the highest 4.169cm) stem girth though not significantly different from 50 x 50 cm spacing (4.073cm) stem girth, followed by 80 x 40 cm spacing (3.964cm) which was at par with 40 x 20 cm spacing (3.947cm) stem girth and 90 x 60 cm (3.911cm) stem girth. In 2022 cropping season 60 x 30 cm spacing produced the highest (4.019cm) stem girth though at par with 80 x 40 cm and 50 x 50 cm spacing (3.915cm and 3.913cm) stem girth respectively. The least (3.055cm) stem girth was obtained from 90 x 60 cm spacing. In 2023 cropping season similarly 60 x 30 cm spacing recorded the highest (3.904cm) stem girth, followed by 50 x 50 cm spacing (3.891cm) stem girth and the least (3.740cm) stem girth was obtained from 90 x 60 cm spacing which was not significantly different from 40 x 20 cm spacing (3.744cm) stem girth. The combined analysis indicated no significant ($P>0.05$) effect of spacing on stem girth of tomato.

CONCLUSION

It is clear that the use of poultry manure and spacing is useful for enhancing the growth and development of tomato crop production. The result of this study affirms that the application of poultry manure at the rate of 30tons/ha and spacing tomato 40 x20 cm significantly resulted in enhancing an optimum growth of tomato.

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LIST OF TABLES

Table 1: Mean effects of spacing and PM on plant height at 2WAT, 4WAT and 6WAT in 2021, 2022 and 2023 Growing Season

Treatment	2WAT			4WAT			6WAT			Com
	2021	2022	2023	2021	2022	2023	2021	2022	2023	
Cultivar										
Tandina	17.881b	13.951c	23.643b	21.768c	19.615a	38.06c	39.20b	25.80b	53.60b	24.234b
UTC	19.171a	15.323a	23.980b	27.143a	18.347b	43.23a	41.09a	25.59b	56.81a	25.432a
Dansiriya	17.551b	14.201b	24.252a	22.697b	19.513a	41.26b	40.97a	26.28a	56.69a	24.765b
P [^] F	0.090	0.015	0.127	0.342	0.059	0.016	0.739	0.462	0.426	0.453
PM										
15 tons/ha	18.809b	15.280b	25.092a	25.418a	21.044a	43.04b	42.20b	27.25b	61.31a	43.5889a
20 tons/ha	18.542c	14.949c	25.582a	25.576a	19.593b	42.31b	43.14b	28.82a	59.57b	43.8444a
25 tons/ha	19.760a	15.427b	25.411a	24.418b	20.389b	45.14a	44.11a	26.78b	59.95b	43.6126a
30 tons/ha	18.969b	16.087a	25.962a	23.702b	21.731a	45.89a	44.44a	28.94a	61.43a	44.7704a
Control	14.924d	10.716d	17.933b	20.233c	14.033c	27.86c	28.20c	18.16c	36.23c	27.5289b
P [^] F	0.001	0.001	0.001	0.018	0.001	0.001	0.001	0.001	0.001	0.001
Spacing										
90x60	17.933c	12.429b	23.967b	23.484b	15.322c	38.86c	39.98	20.70	54.52	38.3978b
80x40	18.078b	14.780a	24.373a	23.611b	19.978b	39.25b	39.90	25.91	56.88	40.8970a
60x30	18.584a	14.849a	24.287a	24.460a	19.580b	40.85b	41.40	26.68	56.69	41.5244a
50x50	18.260b	14.829a	23.798b	23.902b	20.042a	41.69a	40.66	26.54	55.38	40.8585a
40x20	18.149b	15.571a	25.367a	23.889b	20.869a	43.58a	40.15	29.62	55.22	41.6674a

P[^]F 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.231 0.001

Means values in a column followed by the same letter(s) are not significantly different by LSD (P<0.05)

Table 2: Mean effects of spacing and PM on Number of Branches at 2WAT, 4WAT and 6WAT of Tomato in 2021, 2022 and 2023 Growing Season

Treatment	2WAT			4WAT			6WAT			Com
	2021	2022	2023	2021	2022	2023	2021	2022	2023	
Cultivar										
Tandina	1.600b	1.617b	1.575c	2.544b	2.547b	3.151c	3.657a	3.649a	4.488b	3.543a
UTC	1.932a	1.932a	1.660b	2.783a	2.784a	3.524b	3.649a	3.749a	4.676a	3.546a
Dansiriya	1.293c	1.313c	1.856a	2.545b	2.565b	3.787a	3.359b	3.459b	4.759a	3.534a
P [^] F	0.244	0.222	0.491	0.158	0.136	0.213	0.084	0.079	0.686	0.543
PM										
15 tons/ha	1.693b	1.873a	1.876a	2.524b	2.927a	3.816a	3.669b	3.969a	5.044a	4.32741a
20 tons/ha	1.638b	1.838a	1.891a	2.351c	2.751c	3.722b	3.702b	3.802b	4.920b	4.17481b
25 tons/ha	1.749a	1.749b	1.858a	2.531b	2.831b	3.811a	3.840a	3.740b	4.942b	4.14074b
30 tons/ha	1.784a	1.884a	2.011a	2.671a	2.871b	3.880a	4.000a	4.067a	5.087a	4.36222a
Control	0.778c	0.840c	0.849b	1.776d	1.780d	2.207c	2.591c	2.584c	3.211c	2.79556c
P [^] F	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.0001
Spacing										
90x60 cm	1.438d	1.468d	1.671b	2.189d	2.384d	3.513b	3.384b	3.378d	4.669b	3.81037c
80x40 cm	1.584b	1.600c	1.809a	2.478c	2.582c	3.624a	3.578b	3.478c	4.784a	3.98000b
60x30 cm	1.800a	1.818a	1.716b	2.849a	2.869a	3.547b	3.893a	3.874a	4.744a	4.17704a
50x50 cm	1.682b	1.711b	1.671b	2.669b	2.769b	3.449c	3.773a	3.667b	4.598b	4.04815b
40x20 cm	1.538c	1.458d	1.616b	2.549c	2.556c	3.302d	3.467b	3.473c	4.409c	3.78519c

P^F 0.001 0.001 0.312 0.001 0.001 0.110 0.001 0.001 0.013 0.0001

Means values in a column followed by the same letter(s) are not significantly different by LSD (0.05)

Table 3: Mean effects of Spacing and PM on Number of Leaves at 2WAT, 4WAT and 6WAT of Tomato in 2021, 2022 and 2023 Season

Treatment	2WAT			4WAT			6WAT			Com
	2021	2022	2023	2021	2022	2023	2021	2022	2023	
Cultivar										
Tandina	11.116b	7.461a	12.89a	16.152b	10.833b	17.912a	21.960b	12.349a	23.621b	19.546a
UTC	11.733a	7.453a	13.05a	16.023b	10.924a	17.951a	22.001a	12.471a	24.280a	19.876a
Dansiriya	11.456b	6.973b	12.51b	16.972a	9.943c	16.885b	22.043a	11.171c	24.396a	19.987a
P^F	0.362	0.090	0.958	0.423	0.426	0.765	0.725	0.396	0.052	0.0654
PM										
15 tons/ha	11.707b	7.756a	13.75a	16.858b	11.089b	19.756a	22.827c	12.729d	25.504b	20.3533b
20 tons/ha	11.829b	7.844a	13.60a	16.916b	11.533ab	17.589c	23.333b	13.124b	25.891a	20.7839a
25 tons/ha	12.371a	7.667a	13.65a	17.844a	11.689a	18.960b	23.757a	13.036c	25.269b	20.6867b
30 tons/ha	12.132a	7.756a	13.53a	17.633a	11.667a	17.711c	23.847a	13.213a	25.584a	20.8830a
Control	9.133c	5.458b	9.54b	12.660c	6.856c	13.898d	17.911d	7.878e	18.247c	14.6785c
P^F	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Spacing										
90x60 cm	11.176c	7.378a	14.08a	15.907c	10.447d	17.782a	22.078d	11.836c	23.980cb	19.2496b
80x40 cm	11.393c	7.189c	12.65b	16.416b	10.629b	17.827a	22.431b	12.104a	24.340a	19.6252ba
60x30 cm	11.947a	7.353a	12.60b	17.098a	10.589c	17.753b	22.944a	11.944b	24.473a	19.7874a
50x50 cm	11.484b	7.282b	12.18c	16.402b	10.493d	17.400c	22.267c	11.931b	24.076b	19.4244ba
40x20 cm	11.176d	7.278b	12.56bc	16.089bc	10.676a	17.151c	21.957e	12.169a	23.627d	19.2496b
P^F	0.001	0.804	0.001	0.001	0.676	0.006	0.001	0.446	0.001	0.1440

Means values in a column followed by the same letter(s) are not significantly different by LSD (P<0.05)

Table 8: Mean effects of Spacing and PM on Stem Girth of Tomato (*Solanum lycopersicum* L) at 2WAT, 4WAT and 6WAT in 2021, 2022 and 2023 Growing Season

Treatment	2WAT			4WAT			6WAT			Com
	2021	2022	2023	2021	2022	2023	2021	2022	2023	
Cultivar										
Tandina	2.333a	1.769a	2.168b	3.151b	2.509a	2.871b	3.919a	3.419a	3.744a	3.231a
UTC	2.331a	1.565b	2.233a	3.156b	2.276b	3.000a	4.060a	4.010a	3.875a	3.245a
Dansiriya	2.364a	1.505b	2.324a	3.220a	2.163b	2.987a	4.059a	4.009a	3.833a	3.321a
P [^] F	0.722	0.409	0.495	0.934	0.178	0.662	0.571	0.521	0.732	0.034
PM										
15 tons/ha	2.460b	1.222c	2.409a	3.322a	2.502a	3.091a	4.084c	4.054b	3.909c	3.4952b
20 tons/ha	2.440a	1.702a	2.410a	3.364a	2.424a	3.171a	4.311a	4.261a	4.196a	3.64370a
25 tons/ha	2.502a	1.753a	2.404a	3.413a	2.407ba	3.096a	4.344a	4.296a	4.062b	3.60444a
30 tons/ha	2.547a	1.784a	2.342a	3.389a	2.342b	3.033b	4.189b	4.139a	3.982c	3.50444b
Control	1.764c	1.604b	1.638b	2.389b	1.904c	2.371c	3.136d	3.085c	2.938d	2.65926c
P [^] F	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0001
Spacing										
90x60	2.258	1.614	2.207a	3.080c	2.307	2.882	3.911b	3.051c	3.740c	3.31926c
80x40	2.360	1.624	2.222a	3.149b	2.351	2.936	3.964b	3.915a	3.804b	3.37407b
60x30	2.424	1.603	2.298a	3.322a	2.324	3.031	4.169a	4.019a	3.904a	3.46593a
50x50	2.340	1.612	2.289a	3.322a	2.313	3.009	4.073a	3.913a	3.891b	3.42593a
40x20	2.331	1.612	2.193a	3.104bc	2.284	2.904	3.947b	3.876b	3.744c	3.32519c
P [^] F	0.012	0.991	0.161	0.001	0.578	0.010	0.001	0.001	(0.05)	0.0023

Means values in a column followed by the same letter(s) are not significantly different by LSD (P<0.05)