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Effect of Intra-Row Spacing on Growth and Development of Tomato (*Solanum lycopersicum* L.) Variety Roma-VF under the Irrigated Conditions of East Gojjam Zone, Ethiopia

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Abstract: A field experiment was conducted on Nitrosol at Debremarkos University research field during March to June 2016 under irrigated conditions. The objectives were to identify the effect of intra-row spacing on growth and development of tomato plant and to determine the optimum intra-row spacing that gives comparatively the best growth and development. The experiment was therefore carried out using a randomized complete block design (RCBD) with three replications using one commercial variety Roma-VF with four treatments combination of 20, 25, 30 and 35cm spacing between plants having a constant inter-row spacing of 50cm. Data were collected on plant height, number of flowers plant^{-1}, number of primary braches plant^{-1} and leaf area plant^{-1}. The analysis of variance (ANOVA) indicated that there were highly significant differences among the measured parameters except number of flower plant^{-1} which was not significant at 5% probability level. The result revealed that tomato variety Roma-VF planted at intra-row spacing of 25cm had comparatively higher in two measured growth parameters i.e. number of primary branches and number of flower plant^{-1}. The highest plant height was recorded from lowest intra-row spacing (20cm) due to the severe competition among plants in the row looking for light and air. The result also indicated that the largest leaf area plant^{-1} was obtained from the intra-row spacing of 35cm which was the widest spacing among the treatments due to reduced competition for nutrients and water. Thus, based on the results of this experiment, the optimum intra-row spacing for better growth and development performance was obtained from the treatment combination of 25cm by 50cm intra and inter row spacing, respectively. Finally, this research is done using only one variety in one season, thus further research should be done including additional varieties over time and space to determine the best intra-row spacing.

Key words: Intra-row · Inter-row · Tomato · RCBD · ANOVA and Roma-VF

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belongs to the *Solanaceae* family and self-pollinated crop. It is very important vegetable crop which is cultivated and consumed in most parts of the world, from gardens and green houses to large commercial farm [1]. It is fairy adapted and grows well in warm condition. It requires optimum temperature of 20-25°C during the day and 15-17°C at night. It requires moisture or rain fall about 600mm well distributed throughout the growing season and well drained soil, light loam with high organic matter content with 5 to 7.5 soil pH [2].

Tomatoes are very important for human health as they are good source of vitamin A and C. It is important for bone formation and growth, cell division and differentiation, for helping the regulation immune system since it contain vitamin A. In addition, tomato is important forming collagen, a protein that gives the structure to bones, cartilage, muscle and blood vessels. This crop contains lycopene which is very power full antioxidants that help to prevent the development of cancer.

Tomato is grown on more than 5 million hectare of land with production of nearly 129 million tons. China is the world top growers accounting for more than one-quarter of the world's tomato acreage. India produce

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about 7.6 million metric ton of tomato from about 540, 000 ha of land [2]. It is one of the most popular & important vegetables crop used for fresh consumption as well as for processing. Thus, tomato varieties are popular and economically important vegetables produced in the country [3]. In recent year the total area of land covered by tomato farms in the Ethiopian 2014/15Meher/main cropping season was 5011 ha with an estimated yield of 307, 000 tons [4, 5].

Plant spacing has a profound effect on the growth performance and yield of tomato. Several scholars reported that tomato produced fewer fruit plant^{-1} but more fruit per hectare as a plant density increased in field where as fruit size was an affected [6]. Melkasa agriculture research center has developed a number of varieties and agronomic packages for tomato to and recommended different plant spacing's to different parts of Ethiopia. However, investigating the context of other parts of Ethiopia such study lacks considering edaphic and climatic conditions of other areas. Since the spacing requirement of tomato depend on soil type and fertility, types of cultivar, the use of blanket recommendation would be in appropriate and it would be indispensible to identify appropriate recommendation for a specific soil type and cultivar grown in the country [7].

Improper spacing is among the notable reasons for low productivity of this crop. According to [8] plant spacing greatly influenced fruit yield in both fresh market and processing of tomato. The importance of plant spacing on yield and quality parameters in tomato crop and yield variation observed due to diseases infestation and other factors were also reported [9].

The production, productivity and the national average yield of tomato in Ethiopia is as low as compared to neighboring countries like Kenya and Tanzania. Besides, the national average of tomato fruit yield under farmer's condition is 6.13 tons ha^{-1} [4] which is very low compared to 25 to 40 tons ha^{-1} at demonstration and experimental research plots, respectively [3]. Tomato production in Ethiopia has different problems, among those plant spacing is the first and foremost bottle neck problem that limits tomato production and productivity in East Gojjam zone in particular and in Amahara regional state in general. Typical farmers produce tomato using broad casting and inter closing methods. These types of methods has many problems such as high plant population, difficult to manage, increasing computation to water and nutrients, harbor diseases and pets leads that to low quality product. Moreover, small fruit, low quality and reduced yield is due to improper plant spacing including inter-row and intra-row spacing [10]. Therefore, this experiment was conducted to identify the effect of intra-row spacing on the growth and development of tomato plant variety Roma-VF and to determine the optimum intra-row spacing that gives comparatively the best growth and development in the experimental area

MATERIALS AND METHODS

Description of the Study Site: The experiment was conducted under field condition on *Nitrosol* at Debre Markos University College of Agriculture and Natural Resources, horticulture department experimental site on-station during the year 2016 under irrigation condition. The area is geographically located 300 km Northwest of Addis Ababa and 265 km Southeast of Bahir Dar at an about 10°20' N latitude and 37°43' E longitude at an altitude of 2446 m.a.s.l, with mean annual rain fall of 1380 mm and the average temperature of the area is ranging from 14 – 24°C.

Experimental Materials and Treatments: A single tomato variety named Roma-VF was used for the experiment because of its availability and commercially produced in farmers' fields. This variety was collected from horticulture department. The treatments used in the experiment were intra-row spacing with combinations of 50 x 20, 50 x 25, 50 x 30cm (control) and 50 x 35cm which are assigned as T_1, T_2, T_3 and T_4, respectively.

Experimental Design: The experiment was laid in randomized complete block design (RCBD) with three replications. Four treatments were used with intra-row spacing of tomato plant. The experiments were assigned to the experimental plot randomly by using card drawing method and the net area of the experiment was 66m^2. The area of a single plot was 3.6m^2 (2m length x 1.8 widths). Each plot contains four rows. The spacing between two adjacent plots and blocks was kept as 40cm and 50cm, respectively. The number of plants per plot was dependent on the treatments (intra-row spacing). The inter-row spacing was common for all treatment i.e. 50cm.

Experimental Procedures: The land was cleared, ploughed (disked), leveled and large clods was broken down the remains of roots stalks, non-decomposed crop residues, weeds and other unwanted materials was removed. Then the soil was smoothed, fined and the land was laid out for nursery establishment. Seed were sown in nursery at February 05-07-2008 E.C. Then during three leaf stages seedling was transplanted to the main field for the experiment. Urea was applied in split form twice during the

Table 1: List intra-row spacing

Treatments	Intra-row (cm)	Number of plants/plot	Total number of plants
T_1	50 x 20	36	3 x 36=108
T_2	50 x 25	28	3 x 28=84
T_3	50 x 30	24	3 x 24=72
T_4	50 x 35	20	3 x 20=60

whole season, the first after two weeks from emergency of the seedling and the second 50days from transplanting. Weeding and watering were practiced manually as frequently as needed.

Data Collection: Data were collected on plant basis from the two middle rows by tagging five randomly selected plants excluding the remaining side of the rows as borders. The parameters recorded were:

Plant Height (cm): Plant height of five randomly selected plants per plot was measured from the bottom of the plant up to the end of the main stem using ruler in centimeter and average mean of it were used to analyze this data.

Number of Primary Branches Plant^{-1}: Number of primary branches of five randomly selected plants was counted from the same plant where the plant height was measured.

Number of Flower Plant^{-1}: Actual count of flowers from five randomly selected plants was recorded and average mean of it were used for data analysis.

Leaf Area Plant^{-1}: Leaf area of five randomly selected plants were calculated by measuring the highest width in centimeter and multiplied with the highest length of the leaf from a single plant.

Data Analysis: The data collected was analyzed after the average mean values of the above growth and development parameters were calculated using Microsoft-Excel program and data were subjected to ANOVA using SAS program 2002 version. The mean separation was done by using the least significant difference (LSD) at 5% and1% significant levels.

RESULTS AND DISCUSSION

The ANOVA indicated that there is highly significance difference among the measured parameters except number of leaf plant^{-1} which was non-significant at 5% probability level.

Table 2: ANOVA of mean growth parameters of tomato variety Roma –VF

SV	DF	PLH	N 1° B	NFPPL	LAPPL
Rep.	2	2.58^{ns}	3.08^{ns}	345.33^{ns}	0.0013^{ns}
Tret.	3	468.56^{**}	35.33^{**}	302.97^{ns}	0.066**
Erro.	6	4.81	2.75	4012.56	0.0037
Mean		36.83	8.67	38.92	1.81
CV(%)		5.95	19.13	52.19	3.39

where, SV=source of variation, PLH = Plant height, N1^0 B= Number of primary branches, NFPPL= Number of flowers per plant, LAPPL= leaf area per plant and **- highly significant at 1% significant level, *Significant at 5% and ns= non-significant at 5% probability level

Plant Height: Plant height of tomato was significantly affected by the intra-row spacing treatments but there is non-significant difference between treatment T_3 (30 x 50cm) and T_4 (35 x 50cm) as indicated in Table 3. The tallest plant height was obtained from the treatment T_1 (20 x 50cm) which gave a height of 52.67cm. The shortest plant height (26.33cm) was recorded from the treatment T_4 (35 x 50cm). This result is in agreement with [11] who reported that maximum plant height was observed from lower spacing due to maximum competition for light and air.

Number of Primary Branches: ANOVA indicated that there were highly significant differences among treatments for number of primary braches. The maximum number of primary branches recorded from T_2 (25 x 50cm), but not statistically different from T_1 (20 x 50cm) whereas the minimum number of primary braches recorded from the treatment T_3 (25 x 50cm). This result in line with [12] who reported that increased plant intra-row spacing decreased the number of branches plant^{-1}. This is due to more nutrient, moisture and space become available for the other vegetative growth than branches.

Number of Flower Plant^{-1}: Intra-row spacing was non-significantly different at ($p<0.05$) for number of flower plant^{-1} as shown in Table 3. But the maximum number of flower per plant were obtained from T_2 (25 x 50cm) and T_1 (20 x 50cm) with average counted number 51.67 and 42.00, respectively. The mean separation conducted using LSD indicated there were no-significant differences occurred among all intra-row spacing. This result contradicted to report presented by [11] that the highest number of flower per plant^{-1} recorded from the wider spacing (30cm) and he states that increasing plant spacing more than 30cm had little addition of flower number plant^{-1}, so based on his findings increasing intra-row spacing greater than 30cm is not needed.

Table 3: Mean values of growth parameter of tomato Roma –VF

	Mean values			
Treatments	PLH (cm)	N 1° B (No.)	NFPPL (No.)	LAPPL (cm^2)
T_1 (50x20cm)	52.67[a]	10.33[a]	42.00[a]	1.67[b]
T_2 (50x25cm)	41.00[b]	12.67[a]	51.67[a]	1.89[a]
T_3 (50x30cm)	27.33[c]	5.33[b]	32.67[a]	1.71[b]
T_4 (50x35cm)	26.33[c]	6.00[b]	29.33[a]	1.98[a]
Mean	36.83	8.67	38.92	1.81
LSD(0.05)	4.38	3.31	40.00	0.123
CV (%)	5.95	19.13	52.19	3.39

Mean values sharing similar letter in a column are statistically non-significant at P<0.05.

Leaf Area Plant^{-1}: Intra-row spacing significantly affect leaf area plant^{-1} at ($p<0.05$). The highest leaf area obtained from the wider spacing T_4 (35 x 50cm) with mean values of 1.98cm^2 while the lowest recorded from T_1 (20 x 50cm). This result is in line with [13] and [3], they reported that the wider area allow to have high amount of moisture, nutrient, air and light available from the wider spacing thus the surface of the leaf is increases and more photosynthesis takes place.

Conclusion and Recommendations: Tomato is the most important vegetable crop in Ethiopia, providing a higher income to small scale farmers compared to other vegetable crops. However, tomato production in Ethiopia is highly constrained by several factors. Improper plant spacing is among the notable reason of low productivity of this crop.

The study was therefore mainly conducted to investigate the effect of different level of intra-row spacing on the growth of tomato under Debre Markos condition. It was carried out under field condition of Debre Markos University College of Agriculture and Natural Resource, Department of Horticulture Research station site in 2016 off season using irrigation. The experiment is one factor and with four treatments (20, 25, 30 and 35cm) by 50cm intra-row spacing on Roma-VF variety arranged in RCBD with three replications.

From the study conducted, intra row spacing had valid effect on growth and development of tomato. Plants at intra-row spacing of 25cm had comparatively higher number of branches and flowers than other treatments. While the tallest plant height was obtained from intra-row spacing of 20cm and the plant spacing at intra-row 35cm had large leaf area.

Generally, this research indicates that higher plant density (narrow spacing less than 25cm) greatly affected plant growth and as a consequence it also affect final yield of tomato plant. Increasing plant spacing more than 25cm reduced the number of branches, plant height and number of flower plant^{-1}. To produce higher fruit yield, tomato grower in the study area should be encouraged to use intra-spacing of 50 x 25cm for Roma-VF variety. Finally, this research is a one season research and it did not consider yield and yield attributes due time constraint, thus such type of research should be repeated over time and space to determine the best intra-row spacing for tomato variety Roma-VF.

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REFERENCES

1. Agyema, K., B. Osei, I. Berchie, J.N. Mochiah and B. Mee, 2014. Effect of poultry manure and different combination of in organic fertilizer on growth and yield of four tomato varieties in Ghana, Agriculture Science, 2(4): 27-34.
2. Tuan, N.M. and N.T. Mao, 2015. Effect of plant density on growth and yield of tomato at Thai Nguyen, Vietnam. International Journal of Plant & Soil Science, 7(6): 357-361.
3. Lemma, D., 2002. Tomato research experiences and production prospects, Ethiopian Agricultural Research Organization Research report, No. 43.
4. CSA, 2015. The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey 2014/15, Addis Ababa, Ethiopia: Statistical Bulletin 578, 1: 13-14.
5. Parmar, P., R.B. Subramanian and A.K.K. Achakzai, 2012. Optimization of growth regulators for shoot induction and regeneration of Tomato (*Lycopersicum esculentum* Mill.). Acad. J. Plant Sci., 5(4): 114-118.
6. David, Son H., 2000. Nursery management administration and culture, 2nd Ed, prentice hall, Eagle wood cliff, New Jersy, pp: 275-257.
7. FAO, 1989 and 2004. Production year book: tomato! Voe-4, pp: 85-94.
8. Lemma, D., Z. Yayeh and E. Heralth, 1992. Agronomic studies on tomato and capsicum vitamin content of horticulture crops postharvest biology and technology, pp: 153: In 20: 207-220.
9. Mehla, C.P., V.K. Srivastava, S, Jage, R. Mangat, J. Singh and M. Ram, 2000. Response of tomato varieties to N and P fertilization and spacing. Indian Journal of Agricultural Research, 34(3): 182-184.

10. Abu, T. and T. Teddy, 2013. Production of tomato in Ethiopia challenged by pest. USDA foreign Agricultural Science. Addis Ababa, Ethiopia, 13(5): 1-3.
11. Seid, H., K. Merema and W. Mestawat, 2013. Effect of intra row spacing on the growth and development of tomato. Intrnational Journal of Science, 10(1): 19-24.
12. Khushk, A.M., M.M. Miano, A.H. Ansari and M.I. Mosi, 1990. Influence of inter row and intra row spacing onthe yield and yield components of onion (Allium cepaL.). Sarhad J. Agri., 6: 147-50.
13. Mohammad, A. and A. Singh, 2007. Intra-row spacing and pruning effects on fresh tomato yield in Sudan Savannah of Nigeria. Journal of Plant Sciences, 2: 153-161.