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Review on Effects of Planting Density on Growth Performance of Tomato (*Lycopersicon esculentum* MILL.)

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Abstract

This paper is to review the effect of planting density on growth performance of tomato which is the most important vegetable crops in Ethiopia, providing a higher income to small-scale farmers compared to other vegetable crops. Tomato production in Ethiopia is highly constrained by several factors. Farmers get lower yields mainly due to disease, pests and inappropriate agronomic practice and lack of improved variety. Improper plant spacing is among the notable reason of low productivity of this crop.

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Tomato, Planting density, Growth and performance

Introduction

Tomato (*Lycopersicon esculentum*) belongs to the *Solanaceae* family and self-crossing annual crop. This family also includes other well-known species such as potato, hot pepper, tobacco and eggplant (aubergine). The centre of origin of the world tomato is considered to be Andean Zone, whereas it is considered that the tomato was domesticated in Mexico (Ara *et al.*, 2007).

Presently the tomato is one of the vegetables with the highest production in the world and its production is increasing all over the world, primarily in Asia. The production area in Europe, North and Latin America, tends to stop increasing of yield per hectare, probably using high yielding varieties. Tomato is the most third important crop in the world next to potato and sweet potato (FAO, 2005). In 2009 the world's total cultivated area under tomato was 4.89 million ha, with a production quantity of 141.14 million tons (FAOSTAT, 2011).

China is the world leading tomato producer with a production of 34.12 million tons followed by the United States and turkey (FAOSTAT, 2011). China is not only the world largest fresh tomato producer, but also the world largest tomato paste producer, followed to Europe and United States. In 2008, the export quantity reached 818,512 tones a sharp increase from 106,667 ton in the previous year (Zhang *et al.*, 2010).

Tomato is the most widely grown vegetable in the world being recognized as a reach source of vitamins and minerals. Tomatoes are extremely beneficial to human health for they are rich in minerals, vitamins, essential amino acids, sugars and dietary fibers. Tomato fruit are consumed fresh in salad or cooked in sauces, soup and

meat or fish dishes. They can be produced in to purees, juices, and ketchup. It is also among the most important vegetable crops in Ethiopia. The total production of this crop in the country has shown a marked increase (Lemma *et al.*, 1992)

Since it becomes the most profitable crop providing a higher income to small scale farmers compared to other crops. Tomato was first domesticated in the Central America as early as 700B.C. Tomato plants are dicots, and grow as a series of branching stems, with a terminal bud at the tip that does the actual growing. When that tip eventually stops growing, whether because of pruning or flowering, lateral buds take over & grow in to other, fully functional, vines. Tomato plant vines are typically pubescent (covered with fine short hairs). These hairs facilitate the veining process, turning in to roots where ever the plant is in contact with the ground and moisture, especially if there is some issue with vines contact to its original root.

The leaves are 10-25cm long, odd pinnate, with 5-9 leaf lets on petioles, each leaf lets up to 8cm long, a serrated margin ; both the stem and leaves are densely glandular-hairy (David, 2010).

Tomatoes can be grown both in temperate and tropical zone. Its fruit is fleshy berry globular to oblate in shape and 2-25cm in diameter. The immature fruit is green and hairy. Ripe fruits range from yellow, orange to red. It is usually round, smooth or furrowed. Tomato fruits mature in about 25-30 days after fertilization (Giovannoni, 2006). According to the author maturity is correlated with increased fruit size, weight, specific gravity, total acidity and hydrogen concentration. Time from transplant to first harvest is 70-75 days for cherry type, 75-80 days for the plum type & 80-90 for the large fruited type tomatoes. The ripening phase of tomato fruit is also characterized by fruit softening, coloring sweating MoARD (2009).

Reported that in Ethiopia, tomato is produced in altitude between 700-2000, which is characterized as warm and dry day and cooler night, are favorable for optimum growth and development of tomatoes. A temperature range 21-27^{o}c day and 10-20 night is favorable for plant development, and fruit set in the country. It grows better at a constant day and night temperature. A different of 6^{o}cbetween day and night temperatures was found sufficient for good plant growth and development.

Fruit setting is poor when the temperature is either high or low. Extreme temperature cause flower drops and poor fruit set. Tomato is grown on about 4.5 million hectares worldwide, the largest producer being china with 32 million metric tons. India produces 7.6 million metric tons of tomatoes from about 540,000ha (Daniel, 2007). Now a day's tomato is grown in most of the countries around the globe except Colden region. It can be grown on small scale in the kitchen garden where a few plants yielding fruits for the whole family and a commercial scale as cash crop by the vegetable growers (David, 2010).

In the tropics tomato is mostly produced by transplanting. Good quality of seedling usually leads to better growth, higher yields and earlier maturity. Tomato is among the most important vegetable crops in Ethiopia. Both fresh and processed tomato varieties are popular and economically important vegetable crops produced in the country (Geleta *et al.*, 1995). Lemma *et al.*, (2003) indicated that the total production of tomato in the country has shown as a marked increase since it become the most profitable crop providing high income to small scale farmers' compared to other vegetable crops. However, the production and productivity of the crop in the country is influenced by different factors among which improper plant spacing is the notable reasons of the low productivity of this crop.

Objective

To review the effects of planting density on growth performance of tomato.

Literature review

The tomato crop

The tomatoes though commonly classified as a vegetable is real a fruit, berry in fact. Tomato fruit exhibit all of the common characteristics of berries the fruit develops from the ovary of the flower and its flesh due to the pericarp walls and skin (Gold man *et al.*, 1999)

Origin and Distribution of Tomato

Tomato is originated in Peru, Ecuador and Bolivia with the availability of numerous wild and cultivated relatives in those areas. It is taken by Mexico for the domestication and cultivation in the farm. From Mexico it is moved to Europe in 16th century (RAM, 2006).

The first moutons of the tomato in America were made in 1710 by 1830 it become popular in USA. It was also reported that the crop arrived in West Africa parts via Portugal's traders more over it brought across the continent from Egypt or the Sudan (Ali, 2008).

Botany of crop

Tomato is a true diploid with 2n=24. Plant is annual with herbaceous prostrate stem having determinate or indeterminate growth habit. In the determinate growth, terminal bud ends in a floral bud and further growth in arrested resulting in dwarf and bushy stature. In indeterminate growth, terminal bud is a leafy bud and terminal and lateral buds continue to grow and there are less production of flowers and fruits on mainstem.

Flowers are borne in racemose cyme and flower cluster is known as 'truss' and its position is extra axillary. Flowers are hermaphrodite, pendulous, pentamerous and hypogenous. Stamens are six in number and inserted on throat of corolla tube and anthers are convent around style Tomato is a self pollinated crop due to hermaphrodite flowers, introvert stigma, internal and synchronized anther dehiscence, and stigma receptivity.

Self fertilization occurs when pollen grains are shedding during growth of style through anther corn. In warm regions of the country, some amount of crossing wasobserved when stigma protrudes out the level of anthers.

Tomato Taxonomy

The tomato which is also known as love apple in English (Moore, 1985) is one of the most popular vegetable as well as one of the most important cash crops. It is the third most important vegetable crop next to potato and sweet potato. The resent world production is about 4 million tones fresh fruit from 2 million hectar. It is also known to be one of the most important crops which can grow in green house fallowed by pepper and cucumber (Moore, 1985 and Ali, 2008).

Tomato belongs to the family *Solanaceae* and genus *Lycopersicum*. At present time nine species are recognized with in this genus it is herbaceous the herds grow up to 2m in height. It has vigorous tap roots with extensive fibrous root (Ram, 2006). According to Ali 2008), stems is solid hairy rooting at nodes spirally arrange is-30cm petiole 3-6cm long. Mainly oval irregularly toothed flowers barn apposite of between about 2cm in diameter calyx tube short, hairy sepal persistent, petals visually 6cm up to 10cm in length yellow reflexes when matured and anthers have bright yellow color.

Tomato flowers are normally perfect and there are 4-8 flowers in each compound inflorescence there is a light protective anther surrounding the stigma leading to self-pollination on not possess the ideal climate for tomato crop and have less land area devoted to tomato production (FAO, 2002).

Ecology of tomato

In tropics, tomato mostly produced by transplanting good quality seedlings usually leading to higher yield and earlier maturity. Tomato that matures early could only receive higher price on fresh market but also could reduce the risk involved in growing tomato in the tropics (June, 1987).

Tomato is warm season crop. It requires warm clear dry condition and altitude range from 700-2000 masl. The optimum temperature in the central lowlands of Ethiopia (lift valley area) range between 21-28c^{o} during day time and 10-20c^{o} at night (tindal, 1983). In addition to temperature, friable and sandy loam soils with PH of 5.6-7 is favorable for high yield and better seed set the exact type and dosage of fertilizer will depend on the nature of the soil and cultivars excessive nitrogen should be avoided since it delays fruit formation (June, 1987).

Low soil temperature, retard the growth of seedling and absorption of minerals also be affected well drained fertile soils with good moisture retaining capacity and high level of organic material is reported to be preferable (Ram, 2006).

Effects of spacing patterns on tomato growth performance

Plant population and spacing are important plant management practices that greatly influence yield and quality of fruit. The distance between plants and between rows depends on the methods and purpose of production, soil fertility, plant structure vine type and farm equipment (Lamma, 2000).

Optimum spacing improves performance of tomato. It has been reported that while wider spacing increased mean fruit size, mean fruit weight and fruit weight per plant, closer spacing increased fruit number per plant and

total fruit yield per hectare (Rawshan, 1996; Rafi, 1996; Myanmar, 1999).

According to Wuster and Nganga (1970), appropriately spaced and properly pruned plants produce larger, earlier and relatively reasonable fruit yield than non-pruned tomato of the same variety. Therefore, farmers need information on the beneficial effects of integrating proper spacing and appropriate pruning on performance of tomato. Tomato yield could be increased substantially through improved cultural practices. Two of such practices that greatly influence tomato yield are planting density and pruning. Rafi (1996), Myanmar (1999), Chen and Lal (1999) and Abdel-Al *et al.,* (1962).

Effects of spacing patterns on yield and yield traits of tomato

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).

Table.1 Effects of planting density on mean of plant height, number of leaves per plant of TN389 tomato cultivar in winter spring season 2013

Planting density	Plant height	No. of leaves/plant
35714(control)	174.9^{ab1}	30.4^{a}
31746	161.4^{bc}	32.0^{a}
28571	152.8^{cd}	31.9^{a}
25974	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'smultiple range tests

Table.2 Effect of planting density on fruit set, fruit per plant, fruit weight and fruit yield of TN389 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}

1Mean in each column followed by the same letters are not significantly different at P≤ 0.05 according to Duncan'smultiple range tests

Economic importance of tomato

Tomatoes are considered to be one of the most economical crops of all those that exist in the world. 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 super markets throughout the world.

Tomato is an important vegetable in the world presently its importance is increasing and its widely accepted and commonly consumed in variety of dishes as row cooked or processed products more than any other vegetables tomato is rich source of vitamins and minerals (lemma 2002).

Tomato supply is rich in different kinds of nutrients with high amount of water and low in calories is consumed as fresh and Juice farm both are good source of vitamin A

and C but the juice has only about contain only 3-4 times vitamin C than the ripe tomato (Moare, 1935).

Summary

Tomato is the most important vegetable crops 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. Farmers get lower yields mainly due to disease, pests and inappropriate agronomic practice and lack of improved variety. Improper plant spacing is among the notable reason of low productivity of this crop. The review was to summarize the effect of different levels of intra row spacing on growth and development of tomato.

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.

Plant population and spacing are important plant management practices that greatly influence yield and quality of fruit. The distance between plants and between rows depends on the methods and purpose of production, soil fertility, plant structure and farm equipment. Optimum spacing improves performance of tomato. While wider spacing increased mean fruit size, mean fruit weight and fruit weight per plant, closer spacing increased fruit number per plant and total fruit yield per hectare. Appropriately spaced plants produce larger, earlier and relatively reasonable fruit yield than inappropriately spaced tomato of the same variety. Therefore, farmers need information on the beneficial effects of integrating proper spacing and appropriate pruning on performance of tomato. Tomato yield could be increased substantially through improved cultural practices. Two of such practices that greatly influence tomato yield are planting density and pruning.Spacing also depends on the growth habit (determinate, indeterminate or semi determinate). Spacing between plants and rows depends on the cultivar growth habit, soil type, cropping system and also whether the plants are to be supported by stakes or left on the ground so by observing different parameters we have to decide the optimum required spacing for tomato.

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