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Influence of plant geometry on physicochemical attributes and yield of tomato (*Solanum lycopersicum* L.) under protected environment

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Abstract
The experiment was conducted at Vegetable Research Farm, Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during spring-summer 2016 and autumn-winter 2016-17 seasons to study the influence of plant geometry on physicochemical attributes and yield of tomato (*Solanum lycopersicum* L.) under protected environment. Experiment was laid out in Factorial Randomized Block Design with three replications, consisting of two treatments comprising of two plant geometries (70 × 30 cm spacing with two stems pruning and 70 × 60 cm spacing with three stems pruning). Plants spaced at 70 × 60 cm with 3 stems pruning had maximum yield/plant, total soluble solids and equatorial diameter but titrable acidity and ascorbic acid contents were maximum in those fruits whose plants were spaced at 70 × 30 cm with 2 stems.

Keywords: Plant geometry, protected environment, pruning, tomato and yield

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important "protective foods" because of its special nutritive value. It is an important source of vitamin A and C, micronutrients, certain minerals and carboxylic acids (Caputo *et al*., 2004; Hernandez-Suarez *et al*., 2007) [4, 10]. Tomatoes and tomato products are rich in antioxidant and carotenoids (George *et al*., 2004; Sahlin *et al*., 2004; Ilahy *et al*., 2011; Pinela *et al*., 2012) [7, 17, 11, 15]. Further, the consumption of tomatoes has been shown to reduce the risks of cardiovascular disease and certain types of cancer, such as cancers of prostate, lung and stomach (Canene-Adams *et al*., 2005) [3]. Tomato fruit consists of water, soluble and insoluble solids. Soluble solids are traditionally expressed as degrees Brix and mainly consist of sugars (sucrose and fructose) and salts (Salunkhe and Kadam, 1995; Beckles, 2011) [18, 2]. Higher amount of tomato solids need less amount of fruits to produce the same amount of tomato products (Beckles, 2011; Siddiqui, 2015) [2, 19]. Over the last century, tomato as an important vegetable crop has attained a tremendous popularity because it can be grown in most places all over the world, in open fields, polyhouses and net houses. In Himachal Pradesh, the growing season of tomato coincides with monsoon season thus indeterminate varieties are suitable as determinate types are more prone to diseases due to rain splashes. Among the major diseases, production of tomatoes during the rainy season is limited by late blight (*Phytophthora infestans*) and damping off caused by a complex of fungi (*Pythium spp*., *Phytophthora spp*., *Rhizoctonia spp*. and *Fusarium spp*.) reducing tomato yields and quality (Pena and Hughes, 2007) [14]. In order to produce quality and disease free fruits with enhanced productivity, tomato could be grown in polyhouse with improved management such as spacing and pruning. Pruning of leaves and side shoots contribute to enhance the ultimate yield and quality in various ways. Training maximizes the plant's ability to obtain the sunlight needed for growth and development (Guo *et al*., 1991) [9]. Relatively high perishability has made tomato plants to be more vulnerable to intensive crop management and unfavorable environmental conditions. Excessive pruning of leaves sometimes causes the plants to cease producing flowers.

Therefore, it is important to maintain sufficient foliage on the plant for adequate rates of photosynthesis. Manipulation of canopy architecture through pruning and training together with appropriate spatial arrangements has been identified as key management practices for getting quality marketable yields from polyhouse crops (Cebula, 1995; Lorenzo and Castilla, 1995) [5, 12]. Therefore, the present study was conducted to determine the influence of plant geometry on physicochemical attributes and yield of tomato (*Solanum lycopersicum* L.) under protected environment.

Material and Methods

Experiment was carried out under modified naturally ventilated polyhouse having 250m^2 area at experimental farm of Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during spring-summer 2016 and autumn-winter 2016-17 seasons in a Randomized Block Design with three replications, consisting of two treatments i.e., 70 × 30 cm spacing with two stems pruning (G_1) and 70 × 60 cm spacing with three stems pruning (G_2). For the present investigation high yielding and bacterial wilt resistant hybrid *Palam Tomato Hybrid-1* was selected and seeds were sown in plastic plug trays by using soilless media having cocopeat, perlite and vermiculite in the ratio of 3:1:1, respectively inside the growth chamber to get healthy and disease free seedlings of tomato. The observations were recorded on the traits viz., pericarp thickness, polar diameter, equatorial diameter, total soluble solids (TSS), titrable acidity, ascorbic acid and yield/plant. Observations were recorded on 5 plants taken at random in each entry. Titrable acidity was determined according to the AOAC official method 942.15 (AOAC, 2000) [1] and ascorbic acid content was recorded at marketable red ripe fruit stage by '2,6-dichlorophenol-indophenol Visual Titration Method' as described by Ranganna (1979) [16]. The data pertaining to the present investigation were statistical analyzed using the standard procedures of the Factorial Randomized Block Design (RBD) as described by Gomez and Gomez (1983) [8].

Results and Discussion

Data presented in Table 1 indicated that plant geometries had significant influence on equatorial diameter of tomato under protected environment. The use of plant geometry of 70 × 60 cm spacing with 3 stems pruning (G_2) resulted highest equatorial diameter (6.5 cm) being statistically superior to plant geometry of 70 × 30 cm spacing with 2 stems pruning (G_2). It may be due to less competition among plants for growth factors in wider spacing as reported by Singh (2004) [20]. It was also observed from Table 2 that with the increase in plant spacing 70 × 60 cm with 3 stems pruning (G_2) the total soluble solids (5.6 º Brix) increased as compared to 70 × 30 cm spacing with 2 stems pruning (G_1). Increase in total soluble solids could be due to effective utilization of sunlight at wider spacing. Titrable acidity was enhanced with decrease in plant spacing and was highest (1.6 per cent) at plant geometry of 70 × 30 cm spacing with 2 stems pruning (G_1) being statistically superior to 70 × 60 cm spacing with 3 stems pruning (G_2) (Table 2 and Fig. 1). Pandita and Bhatnagar (1981) also recorded high titrable acidity because of smaller size of fruit at closer plant spacing. Similar observations were also reported by Singh and Parmar (2004) [21]. Plant geometry had also significant effect on ascorbic acid contents of fruits. Plant geometry of 70 × 30 cm spacing with 2 stems pruning (G_1) registered significantly higher ascorbic acid (19.8 mg/100g) over plant geometry 70 × 60 cm spacing with 3 stems pruning (G_2). These results are in agreement with Fehr (1979) and Pandita and Bhatnagar (1981) [13] also recorded high ascorbic acid because of smaller size of fruit at closer plant spacing. A cursory glance at Table 2 and Fig. 1 clearly indicates that plant geometry significantly affected fruit yield/plant. The crop planted at a spacing of 70 × 60 cm with 3 stems pruning (G_2) produced significantly higher fruit yield/plant (2.3 kg) than the crop planted at closer spacing 70 × 30 cm with 2 stems pruning (G_1). The reasons for the higher fruit yield/plant may probably be due to less competition for light, nutrients, water and space in wider row-spacing compared to closer one.

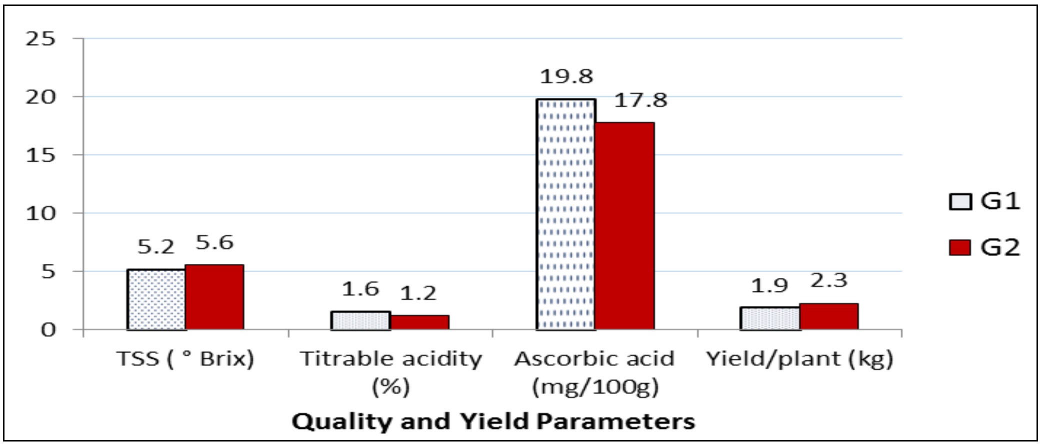

Fig 1: Effect of different plant geometry on total soluble solids (° Brix), titrable acidity (%), ascorbic acid (mg/100g) and yield/plant (kg)

Table 1: Effect of plant geometry on pericarp thickness (mm), polar diameter (cm) and equatorial diameter (cm)

Treatment	Pericarp thickness (mm)			Polar diameter (cm)			Equatorial diameter (cm)		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Plant geometry									
G_1	7.2	8.1	7.6	5.9	6.2	6.1	5.9	6.5	6.2
G_2	7.4	8.5	7.9	6.1	6.3	6.2	6.3	6.7	6.5
S.Em±	-	-	-	0.1	-	-	0.1	0.1	0.1
CD(P=0.05)	NS	NS	NS	NS	NS	NS	0.3	0.1	0.1

NS = Non-significant

Table 2: Effect of plant geometry on total soluble solids (°Brix), titrable acidity (per cent), ascorbic acid (mg/100g) and yield/plant (kg)

Treatment	Total soluble solids (° Brix)			Titrable acidity (per cent)			Ascorbic acid (mg/100g)			Yield/plant (kg)		
	2016	2017	**Pooled**	2016	2017	**Pooled**	2016	2017	**Pooled**	2016	2017	**Pooled**
Plant geometry												
G_1	4.5	5.9	5.2	1.7	1.5	1.6	20.0	19.7	19.8	2.0	1.9	1.9
G_2	4.9	6.2	5.6	1.3	1.1	1.2	17.9	17.7	17.8	2.3	2.3	2.3
S.Em±	-	0.1	0.1	0.0	0.1	0.0	0.3	0.5	0.3	0.0	0.0	0.0
CD(P=0.05)	NS	0.4	0.2	0.1	0.1	0.1	0.9	1.5	0.8	0.1	0.1	0.1

NS = Non-significant

Based upon present results, it can be concluded that use of plant geometry G_2 i.e. 70 × 60 cm spacing with 3 stems pruning significantly increased yield/plant and total soluble solids in tomato under the protected environment. Plants under G_1 i.e. 70 × 30 cm spacing with 2 stems pruning had maximum titrable acidity and ascorbic acid content.

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