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

Harmanjeet Singh, Parveen Sharma and Pardeep Kumar

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 titratable 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 splash. 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 250m² 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 (G₁) and 70 × 60 cm spacing with three stems pruning (G₂). For the present investigation high yielding and bacterial wilt resistant hybrid Palam Tomato Hybrid-I 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 5 plants taken at random in each entry. Titratable acidity was determined according to the standard procedures of the Fact (1979) and 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 (G₁) registered significantly higher ascorbic acid (19.8 mg/100g) over plant geometry 70 × 60 cm spacing with 3 stems pruning (G₂). 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 (G₂) produced significantly higher fruit yield/plant (2.3 kg) than the crop planted at closer spacing 70 × 30 cm with 2 stems pruning (G₁). 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)](image)

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

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pericarp thickness (mm)</th>
<th>Polar diameter (cm)</th>
<th>Equatorial diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant geometry</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>G₁</td>
<td>7.2</td>
<td>8.1</td>
<td>7.6</td>
</tr>
<tr>
<td>G₂</td>
<td>7.4</td>
<td>8.5</td>
<td>7.9</td>
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<tr>
<td>S.Em±</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>CД(р=0.05)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total soluble solids (°Brix)</th>
<th>Titrable acidity (per cent)</th>
<th>Ascorbic acid (mg/100g)</th>
<th>Yield/plant (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant geometry</td>
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<tr>
<td>G&lt;sub&gt;1&lt;/sub&gt;</td>
<td>4.5</td>
<td>5.9</td>
<td>5.2</td>
<td>1.7</td>
</tr>
<tr>
<td>G&lt;sub&gt;2&lt;/sub&gt;</td>
<td>4.9</td>
<td>6.2</td>
<td>5.6</td>
<td>1.3</td>
</tr>
<tr>
<td>S Em +</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>CD(P&lt;0.05)</td>
<td>NS</td>
<td>0.4</td>
<td>0.2</td>
<td>0.1</td>
</tr>
</tbody>
</table>

NS = Non-significant

Based upon present results, it can be concluded that use of plant geometry G<sub>2</sub> 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<sub>1</sub> i.e. 70 × 30 cm spacing with 2 stems pruning had maximum titrable acidity and ascorbic acid content.

References
2. Beckles DM. Factors affecting the postharvest soluble solids and sugar content of tomato (Solanum lycopersicum L.) fruit. Postharvest Biology and Technology 2011; 63(1):129-140.