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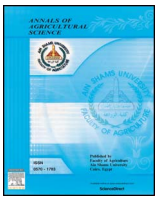

# Morphological and physico-biochemical characterization of various tomato cultivars in a simplified soilless media

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ABSTRACT

This study aimed to investigate nine commercial cultivars of tomato, in order to identify the most suitable cultivar in terms of morphological (plant height, fruit size, fruit weight and total yield) and physico-biochemical (color, firmness, total soluble solid, titratable acidity, ascorbic acid, total sugar, reducing and non-reducing sugar, β-carotene and lycopene) attributes. Plants were cultured hydroponically in the greenhouse. Results revealed that the morphological attributes of Beefsteak Group (BG) of tomatoes was significantly better than that of Cherry Group (CG). In addition, CG has higher concentration of biochemical attributes, mainly β-carotene, sugars, total soluble solids (TSS) and ascorbic acid contents. Within CG, cv. Aria was found to be the best for higher sugar contents, β-carotene and ascorbic acid contents; while, TSS was higher in the cv. Claree. Similarly in BG, cv. Sahel had the highest value of lycopene, β-carotene, TSS; whereas, lowest sugar contents were found in cv. Dirk. As far as firmness is concerned, cv. Naram (BG) was found to be more firm, than cv. Aria (CG). The highest total yield was recorded for cv. Vernal; in BG and in cv. Claree for CG, depicting that BG had significantly higher total yield, compared with CG.

## Introduction

Tomato (*Solanum lycopersicon* L.) is one of the most consumed vegetables, not only in Pakistan but also in the world, and having a unique aspect of diet. Its fruit is widely used in vegetable mixes, salads, processed goods and as an integrative part of cuisines. The processed tomatoes are available as tomato ketchup, pastes, sauces and purees. The popularity of the tomato is obvious from the fact that it is rich in phosphorus, calcium, carbohydrates, and vitamin A and C (Taylor, 1986). The diversity and standardized classification evaluation system is based on several morphological attributes (fruit weight, fruit shape and color) (Paran and Van Der Knaap, 2007), physico-chemical and sensory quality (taste, flavor) (Georgelis et al., 2004), nutritional values (Di-Mascio et al., 1989), content of vitamin C, texture, hardness, pH and acidity (Madhavi and Salunkhe, 1998).

In tomato industry, the overall production has increased due to its high demand among the consumers (Tahir et al., 2012). All over the world, the rise of the fast food industry is also having a significant impact on the demand for tomato products. It is expected, that this trend will continue in the near future and the consumption of tomato is expected to increase further (AVRDC, 1996). In the recent years, a significant increase in area and production of the tomato crop has been reported in Pakistan. In the year of 2010–11, the area was increased to 52,300 hectares and production was about 529.6 thousand tons (GOP, 2015).

The production of horticultural crops is extremely difficult in summer season due to a higher rate of infestation by pathogenic organisms. The cultivated tomato varieties in Pakistan are highly susceptible to hot climatic conditions. Moreover, due to seasonal variations (particularly in the start of summer), their production and supply

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remains far less than demand. The high temperature (above 32 °C) has adverse effects on flower formation, fruit setting, vegetative growth, development and subsequent yield (Moore and Thomas, 1952; Berry and Rafique-Ud-Din, 1988). In Pakistan, the tomato is marketed mostly during the end of winter and fruit production gradually decreases with increasing temperature. Therefore, the shortfall in demand supply chain occurs during the summer season (Hussain et al., 2001; Singh et al., 2007). Commercial scale production of tomato and other solanaceous vegetables is significantly hindered by attacks of soil-borne diseases and sudden temperature fluctuation under the open field conditions. To cope with these challenges, the hydroponic technique is considered a promising tool for commercial vegetable productions (Mavromatis et al., 2013). However, utilization capacity of the soilless system in Pakistan has not yet expanded on a commercial scale due to higher capital investment. The hydroponic culture of tomato and other susceptible vegetable crops can facilitate their successful and profitable production. Therefore, a precise detection and management of biotic and abiotic stresses should be taking into consideration for immense production.

Hydroponics is the most intensive method for crop production in the agricultural industry (Jensen, 1991). It is highly productive, as it conserves water and land, and protects the environment. Hydroponics provides optimal conditions for plant growth compared to open field production. Therefore, higher yields can be obtained through it. It also offers a means of controlling pest and soil-borne diseases, which are especially desirable in the tropics, where the life cycle and infestation of these organisms continues in un-interrupted ways (Jensen, 1991). This enables the plants to achieve higher growth of the shoot system with more vegetation, larger fruits, flowers and other edible parts. Plants in hydroponics grow up to two times faster with higher yields than with conventional soil farming methods due to higher oxygen levels around the root system, optimum pH along with increased nutrient and water uptake (Ghazvini et al., 2006).

Keeping in view the importance of tomato, it was imperative to carry out an experiment on different varieties of tomatoes (*Solanum lycopersicon*) under greenhouse conditions by using hydroponics in Pakistan. The research evaluation was based on morphological, qualitative and analytical parameters, which are imperative for the development of rapid screening techniques and proper selection method of different tomato varieties. Therefore, the objective of this study was to explore the best variety under a hydroponic system and to evaluate its performance in terms of growth/yield and fruit quality.

## Material and methods

The experimental study was carried out at Farmers Market Private Limited owned by PMAS-Arid Agriculture University of Rawalpindi, during 2012–2013. The nine tomato cultivars of two major groups, Beefsteak (cvs. Grandy, Naram, Dirk, Sahel and Vernal) and Cherry (cvs. Cheramy, Aria, Nactar and Claree) were selected, and their seeds were purchased from “EnzaZaden and Rijkzwaan” Holland. These seeds were germinated in sowing trays (240 cell/holes filled with rockwool) and kept in an automatically controlled biological condition. Hydroponic sowing media consisted of rockwool plug and vermiculite. The seedlings were ready within a month and transplanted to another hydroponic growing media, referred to as coir (coconut fiber 100 × 20 × 7 cm/four plants/slabs). All of the tomato cultivars were kept under identical climatic conditions (25–30 °C, humidity 65–80%, high air circulation and level of carbon dioxide 1300 ppm) controlled through a computer (computational data), in the automated greenhouse.

### *Morphological parameters*

Morphological parameters, such as plant height (cm), fruit diameter (cm), fruit weight (g) and total yield (g/plant) were recorded according to Shah et al. (2011).

### *Physico-biochemical parameters*

The physico-biochemical analyses of nine different cultivars of tomatoes were performed after harvesting.

#### *Firmness*

The trait fruit firmness was checked by Penetrometer (FT-327). The tomato pulp was gently removed and placed over the plunger tip. The values were taken in kgf.

#### *Total soluble solids (TSS)*

TSS of selected cultivars were determined by Atago RX 500 digital refractometer (Barrett et al., 1998). The drop of tomato juice was placed on the prism of the refractometer and then the reading was recorded in °Brix (AOAC, 1990).

#### *Titratable acidity (TA)*

Acidity was determined by titrating 10 g of a homogenized sample of tomato juice, after dilution with 50 mL distilled water, 0.1% NaOH solution at a pH of 8.17 (Thakur et al., 1996), and the result was reported as g/L.

#### *Ascorbic acid (AA)*

Ascorbic acid concentration for selected tomatoes was measured following the method of Tareen et al. (2012). The procedure involved making a homogenized mixture of fruit pulp (5 g), 5 mL of 0.1% HCl (w/v) and then the mixture was centrifuged for 10 min at 10,000 rpm and the supernatant was collected. Then the absorbance of the supernatant solution was measured by a spectrophotometer (SP 3000 plus) at 243 nm.

#### *Total sugar contents*

Estimation of total sugar contents was calculated by following the method of (Hortwitz, 1960). An aliquot of 25 mL was prepared for reducing sugars into a flask. 20 mL of distilled water and 5 mL of HCl was poured into it to convert the non-reducing sugars into reducing sugars. This reaction mixture was kept at room temperature for overnight so that complete hydrolysis could take place. Then, 1 N NaOH was poured into the reaction mixture to neutralize the solution using phenolphthalein as an indicator. Titration was performed against Fehling's solution by slow boiling up to brick red color appearance then, again few drops of methyl blue were added. This titration method was repeated until the appearance of brick red color. The values of sugars were taken by the giving formula:

$$\text{Total Sugar } (\%) = 25 \times (X/Y)$$

where:

x = mL of standard sugar solution used against 10 mL Fehling’s solution.

Y = mL of sample aliquot used against 10 mL Fehling’s solution.

### *Analytical parameters*

#### *Lycopene & β-carotene*

The lycopene and β-carotene (mg/100 mL) were evaluated in hydroponically grown tomatoes (Nagata and Yamashita, 1992). One gram of tomato sample was taken in a test tube; poured acetone: hexane (4:6) in the test tube and then the mixture was homogenized. The optical density of the homogenized mixture was measured at 663, 645, 505 and 453 nm. The values of lycopene and β-carotene were calculated by following formula:

$$\text{Lycopene(mg/100mL)} = -0.0458A_{663} + 0.204A_{645} + 0.372A_{505} - 0.0806A_{453}$$

$$\beta\text{-carotene(mg/100mL)} = 0.216A_{663} - 1.22A_{645} - 0.304A_{505} + 0.452A_{453}$$