

## Original Research Article

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## Evaluation of Tomato Cultivars for Yield, Profit and Quality Performance in an Organic Management System in North Western Himalayas, India

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### ABSTRACT

To study the performance of different tomato cultivars under organic regimes, an experiment was conducted from 2013 – 2015 at the experimental farm of the Himachal Pradesh Agricultural University, Hill Agricultural Research and Extension Centre, Kullu, India. Among different cultivars, Sioux variety took maximum days (74) from transplanting to first harvest and HeemSohna hybrid took minimum time of 67.2 days. The maximum plant height was observed in hybrid RK 123 (100.6 cm) followed by Best of all (100.3 cm). The minimum height was recorded for Sioux (83.9 cm). The Red gold hybrid recorded significantly highest number of fruits per plant (25.9) followed by RK 123 (20.0). The Red Gold hybrid had greater fruit size (29.0 cm<sup>2</sup>) followed by RK 123 (26.4 cm<sup>2</sup>), HeemSohna (24.6 cm<sup>2</sup>), Palam Pink (23.3 cm<sup>2</sup>) and Mar Globe (22.9 cm<sup>2</sup>), whereas the fruit size of Best of All (18.8 cm<sup>2</sup>) and Naveen 2000 (19.2 cm<sup>2</sup>) was minimum. Some of the entries of tomato namely RK 123, Manisha, Best of all Yash, Naveen 2000, Red Gold hybrid recorded highest but similar TSS content as compared to rest of the hybrids/varieties. All hybrids had highest but statistically similar acidity ranging from 0.54-0.58 g/100 ml of juice but varieties recorded significantly lower value of acidity (0.41-0.46 g/100 ml of juice). The ascorbic acid contents within hybrids and varieties were identical, though hybrids recorded higher ascorbic acid values (18.53-22.08 g/100 ml of juice) than varieties (11.53- 14.52 g/100ml of juice). The hybrids contained lower carotene and lycopene as compared to varieties. The hybrid Manisha recorded minimum carotene and lycopene content (5.25 mg/100 g of fruit and 3.90 mg/100 g of fruit) and highest was in Best of All variety (9.51 mg/100 g and 6.38 mg/100 g of fruit). Red Gold hybrid produced maximum tomato fruits (143.7 q/ha) and minimum fruit yield was recorded for Best of all (33.7 q/ha) and Marglobe (34.7 q/ha). Significantly higher profit and B: C was observed in case of Red Gold hybrid (rupees 259685/ha and 1.37) followed by RK 123 (rupees 186497/ha and 0.99), however, rest of the entries were found to be non-profitable.

#### Keywords

Tomato cultivars, Yield, Profit, Quality, Organic management, North western Himalayas, India

#### Article Info

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### Introduction

Tomato is grown worldwide for its edible fruits, with antioxidants benefits. It has been reported that consumption of raw tomato and

tomato based products is associated with reduced risk of cancer and cardiovascular disease (Giovannucci *et al.*, 2002). The organic production system aims at supporting and sustaining healthy eating habits,

ecosystems, soil, farmers, community, and the economy. There are rising numbers of customers who are in search of healthier, tastier and environmentally friendly food, increasing the demand for organic produce. A large proportion of commercially grown tomato have been developed and adapted to conventional agriculture systems, which employ synthetic chemicals in its culture (Brady 2011; Santos *et al.*, 2013). Performance of cultivars developed for conventional cropping systems differ in organic production system (Ahmad *et al.*, 2007; Murphy *et al.*, 2007). Organic cropping system is an alternative to develop organic tomato cultivars which can be adapted to local conditions and produce higher yields under organic management (Nandwani *et al.*, 2014; Colley and Myers, 2007; Palada and Davis, 2001). The objective of this study was to evaluate the yield performance and other agronomic characteristics of tomato cultivars grown in organic management systems.

## **Materials and Methods**

The study site, Himachal Pradesh Krishi Vishwavidyalaya Hill Agricultural Research & Extension Center, Bajaura, Kullu, India, is located at 31.8°N latitude, 77°E longitude in the Northwestern Himalayas, a part of India in Himachal Pradesh State. The area receives an average annual rainfall of 1530 mm. The area has average maximum and minimum temperatures of 26.2°C and 11.3°C, respectively. Field experiments on tomato were carried out during summer. Tomato cultivars (seven varieties and five hybrids) were used in the experiment.

The experimental plots were laid out in a randomized block design (RBD) with three replications. The seeds of all varieties were obtained from the germplasm collections maintained at Centre and hybrids were purchased from the local market.

The study was conducted under irrigation during the 2013, 2014 and 2015 cropping seasons. Seedlings of tomato were raised in nursery beds of 2 m × 1 m in size, raised 5 cm from the soil surface to provide good drainage for the removal of surplus irrigation water. The seeds were sown in rows spaced 15 cm apart and covered lightly with fine soil before irrigation.

The beds were irrigated every day until germination then twice a week. After germination, seedlings were thinned until an intra-row spacing of 3 cm was achieved.

Seedlings were carefully transplanted after 6 weeks to the experimental plots which were prepared with 2.0 m × 3.2 m dimensions to accommodate 28 plants per plot (four rows) at a recommended spacing of 90 cm between rows and 30 cm between plants. The spacing between two plots in each replication and between adjacent blocks was 0.5 m and 1 m, respectively as an aisle.

The crop was supplied with a mix of FYM and vermicompost equivalent to recommended NPK fertilizers. Standard agronomic practices such as weeding, cultivation, irrigation, organic fertilizer application and staking were carried out uniformly during the growing season for all plots. Diseases and insects were managed using bio agents. Fruits were harvested at the mature green stage.

Field data were collected in this experiment including growth parameters, plant characters, yield components, fruit yield and fruit quality as indicated next.

### **Plant height**

Plant height was recorded by measuring the height of five randomly selected plants in each plot from the ground level to the main apex; mean values were expressed in cm.

### **Number of fruits per plant**

The total number of fruits per plant was counted from each five pre-tagged plant in each plot having.

### **Marketable fruit yield**

At each harvest, fruits were categorized as marketable or unmarketable fruits.

Fruits with cracks, damaged by insects, diseases, birds, small fruits and those with sunburn were considered as unmarketable and fruits free from visible damage were considered as marketable and yield was expressed in terms of q/ha.

### **Average equatorial fruit diameter**

The same fruit which was used for polar diameter was measured for their equatorial (trans-verse diameter) diameter; values were expressed in cm.

### **Produce quality**

#### **TSS**

The TSS content of fruits was measured on Refractometer.

#### **Titrateable acidity**

Two milliliter of juice was titrated against 0.1 N sodium hydroxide (NaOH) using phenolphthalein as an indicator. Appearance of pink colour was taken as end point of titration.

Titrateable acidity was expressed in terms of mg anhydrous citric acid in 100 ml of juice and calculated as follows:

Titrateable acidity = Vol. of NaOH/Vol. of juice taken  $\times$  0.0064  $\times$  100

### **Ascorbic acid (mg/100 ml)**

It was estimated by 2,6-dichlorophenol indophenol method of AOAC (1975). Two milliliter juice sample was added to an equal volume of 6% metaphosphoric acid in a conical flask and titrated with standard dye solution. The end point was indicated by the appearance of pink colour, which persisted for about 15 s. The dye was standardized with standard stock solution (1 mg/1 ml) of ascorbic acid. The results were expressed as milligrams ascorbic acid/100 ml of tomato juice and calculated as follows:

$$\text{Ascorbic acid} = Y/X \times 100$$

Where, Y is the volume of dye used (ml) in titrating 2 ml juice and X the volume of dye used (ml) in titrating 2 ml standard stock solution.

### **Lycopene (mg/100 g)**

Two gram fruit sample was taken and pigment was extracted with 10 ml acetone in portions, using 2 ml at a time until a colourless residue was obtained. The acetone was evaporated to dryness. The volume was brought to 25 ml with petroleum ether. The optical density was read at 505 nm (since  $\beta$  carotene has negligible absorbance at this wavelength) using a Systronics Spectrophotometer. Petroleum ether was used as blank. Lycopene content was calculated as:

$$\text{Lycopene content} = \text{Final vol. (ml)} \times \text{Optical density} / 2 \times \text{Wt. of sample (g)}$$

### **Statistical analysis**

The data were subjected to ANOVA for a randomized block design and means were compared using significant difference at 5% probability using CPCS-1 data analysis package.

## Results and Discussion

### Days to harvest

Analysis of data showed significant differences among the varieties/hybrids for number of days taken to first harvest (Table 1). The Sioux variety of tomato took maximum days (74) from transplanting to first harvest and HeemSohna hybrid was bit early and took minimum time of 67.2 days. However, other cultivars had similar period to first harvest. Other studies (Abrar *et al.*, 2011 and Falak *et al.*, 2011) showed that the time taken from transplanting to first harvest for tomato cultivars ranged between 70 and 120 days. Moraru *et al.*, (2004) also indicated a wide range of variability in days to first harvest.

### Plant height

In the present study, maximum but similar plant height was observed in hybrid RK 123 (100.6 cm) and Best of all (100.3 cm). However, their height was statistically at par with other varieties/hybrids except Sioux which had minimum height (83.9 cm) (Table 1). These findings agreed with that of Jamala *et al.*, (2011), who reported that taller okra plants were obtained at maximum temperature of 25 to 35°C. High maximum temperature was experienced during the vegetative growth and consequently more assimilates production occurred which probably induced better plant growth and yield in hot season. Similar opinion was put forwarded by Hossain *et al.*, (2002) in brinjal and Mehraj *et al.*, (2014) in tomato who reported that growth and development of crops can be influenced by season.

### No. of fruits/plant

The Red gold hybrid recorded significantly highest number of fruits per plant (25.9)

followed by RK 123 (20.0). The Mar Globe, Manisha, Best of all and Yash hybrids bear minimum and similar fruits per plant (13.0, 13.5, 13.6 and 14.5). Hybrid namely 7730, Roma, Sioux, Naveen 2000 had similar number of fruits per plant but significantly lower than Red Gold and RK 123 but higher than Mar Globe, Manisha, Best of all and Yash hybrids (Table 1). Organic regimes having many nutrients (balance nutrients), which are responsible for development of flowers and fruits, while inorganic only NPK. The number of fruits per plant may increase due to the more number of flowers remained on the plant and increased the chances to form more fruits by the plants treated with organic manures and also due to varietal differences among the different cultivars. According to Tonfack *et al.*, (2009), the increase in number of fruits in tomato may be due to carbon contents, and increase cation exchange capacity of soil, which added to the development of fruit formation and also less pest and disease attack on plants treated with organic fertilizers.

### Fruit size

The tomato fruit size varied significantly among different varieties/hybrids (Table 1). The Red Gold hybrid had greater fruit size (29.0 cm<sup>2</sup>) followed by RK 123 (26.4 cm<sup>2</sup>), HeemSohna (24.6 cm<sup>2</sup>), Palam Pink (23.3 cm<sup>2</sup>) and Mar Globe (22.9 cm<sup>2</sup>), whereas the fruit size of Best of All (18.8 cm<sup>2</sup>) and Naveen 2000 (19.2 cm<sup>2</sup>) was minimum. Except two hybrids namely Red Gold and RK 123, all other varieties/hybrids were statistically at par with each other. The increment in the fruit size may be due to organic fertilizer that provided calcium and potassium in proper amount with appropriate water absorbed by the plants, which caused elongation in the size of tomato fruits. Masarirambi *et al.*, (2009) observed similar results while working on tomato plant and concluded that the enlargement of tomato

fruit size might be due to physiological fitness and manure application, which influenced all growth parameters. In addition organic fertilizers were found better than application of inorganic fertilizer because inorganic provided NPK while manures provided full supplement.

### Fruit quality

#### TSS

Some of the entries of tomato namely RK 123, Manisha, Best of all Yash, Naveen 2000, Red Gold recorded highest but similar TSS content as compared to rest of the hybrids/varieties (Table 2). The organic manures have been proved beneficial in enhancing the fruit quality of tomato. Similar results were also observed by Zhu-wei Min *et al.*, (2003) that tomato cultivar ‘Puhong 909’ had maximum TSS content (4.5%) under the multispan greenhouse. Singh (2011) also reported that maximum TSS was present in ‘Naveen’ (5.60)

under naturally ventilated polyhouse. The value of total soluble solids content varied from 4.79% to 6.02% (Hossain *et al.*, 2010). Durvesh and Singh (2006); Ahmad *et al.*, (2012); Gupta *et al.*, (2011) reported that quality attributes like total soluble solids of the fruit ranged from 3.67 to 6.0 °Brix.

#### Acidity

Acidity of tomato fruits has great significance from processing point of view. According to Guold and Berry (1972), a tomato variety for processing should have acid contents ranging from 0.35% to 0.55%. High acidity prevents microbial activities in processed products.

During three years of study, all the hybrids have highest but statistically similar acidity ranging from 0.54-0.58 g/100 ml of juice but varieties recorded significantly lower value of acidity (0.41-0.46 g/100 ml of juice) (Table 2). Similar results were also reported by Hossain *et al.*, (2010) and Singh (2011).

**Table.1** Mean growth, yield attributes, fruit quality and yield of tomato hybrids/varieties (average of 3 years)

Hybrid/variety	Plant height (cm)	No. of fruits/plant	Days taken to harvest	Fruit size (cm <sup>2</sup> )
Yash**	95.6	14.5	70.7	21.1
Naveen2000**	99.6	18.3	70.9	19.2
Manisha**	99.6	13.5	71.1	20.7
Red Gold**	99.0	25.9	71.7	29.0
Hybrid 7730**	98.7	18.0	68.7	23.5
Roma*	93.8	18.5	70.9	22.0
Sioux*	83.9	18.3	74.0	20.9
Best of all*	100.3	13.6	71.0	18.8
Palam Pink*	99.1	14.1	69.9	23.3
Mar Globe*	94.7	13.0	70.0	22.9
RK 123**	100.6	20.0	69.8	26.4
HeemSohna**	99.7	18.6	67.2	24.6
CD (5%)	5.0	2.1	2.01	1.3

\*Variety, \*\* Hybrid

**Table.2** Mean Fruit quality of tomato hybrids/varieties

Hybrid/variety	TSS ( <sup>0</sup> Brix)	Acidity (g/100 ml of juice)	Ascorbic acid (g/100 ml of juice)	Carotene (mg/100 g of fruit)	Lycopene (mg/100 g of fruit)
Yash**	4.3	0.58	20.15	6.54	4.14
Naveen2000**	4.1	0.58	18.53	6.35	3.90
Manisha**	4.3	0.57	21.57	5.25	4.48
Red Gold**	4.2	0.56	22.08	6.15	4.15
Hybrid 7730**	3.8	0.54	20.05	6.40	4.36
Roma*	4.8	0.46	14.52	8.34	5.38
Sioux*	4.6	0.42	12.45	8.47	5.95
Best of all*	5.1	0.44	13.58	9.51	6.88
Palam Pink*	4.8	0.41	12.20	6.56	5.90
Mar Globe*	4.8	0.44	11.53	8.27	6.64
RK 123**	4.4	0.56	21.30	5.38	5.24
HeemSohna**	4.1	0.58	21.45	6.00	5.40
CD (5%)	0.40	0.10	4.11	1.04	1.03

\*Variety, \*\* Hybrid

**Table.3** Mean tomato yield and profitability of hybrids/varieties under organic nutrient management

Hybrid/variety	Yield (q/ha)	Gross Returns	Cost of Cultivation	Net Returns	B:C
Yash**	79.0	246875	185628	61247	0.33
Naveen2000**	60.3	188438	187128	1310	0.01
Manisha**	110.3	344688	186183	158505	0.85
Red Gold**	143.7	449063	189378	259685	1.37
Hybrid 7730**	117.3	366563	185703	180860	0.97
Roma*	64.6	201875	184458	17417	0.09
Sioux*	47.6	148750	184458	-35708	-0.19
Best of all**	33.7	105313	184458	-79146	-0.43
Palam Pink*	60.7	189688	184458	5230	0.03
Mar Globe*	34.7	108438	184458	-76021	-0.41
RK 123**	119.8	374375	187878	186497	0.99
HeemSohna**	115.7	361563	189378	172185	0.91
CD (0.05)	9.2	-	-	61247	0.31

\*Variety, \*\* Hybrid

### Ascorbic acid

High ascorbic acid in tomato aids in better retention of natural colour and flavour of the

products (Thamburaj, 1998). There were significant differences for ascorbic acid content in hybrids and varieties (Table 2). However, the ascorbic acid contents within

hybrids and varieties were identical, though hybrids recorded higher ascorbic acid values (18.53-22.08 g/100 ml of juice) than varieties (11.53- 14.52 g/100 ml of juice). Singh (2011) also reported that 'ARTH-128' recorded maximum ascorbic acid content (20.63) and 'To-Ind-Hyb/4' recorded minimum ascorbic acid content (14.03) under net/poly house. Similar to this study Gupta *et al.*, (2011) reported that ascorbic acid content ranged from 19.88 to 27.68; 19.50 to 30.06 and 27.82 to 31.33 mg per 100 g in different tomato genotypes.

### **Carotene**

As far as carotene content is concerned, there were significant differences among hybrids and varieties (Table 2). The hybrids have low value of carotene as compared to hybrids. Best of all variety a recorded maximum carotene content (9.51 mg/100 g of fruit) and lowest was in Manishahybrid (5.25 mg/100 g of fruit). Singh (2011) observed maximum carotene content in 'NP-1001' (4.11). Data corresponds to earlier study by Gupta *et al.*, (2011), who reported  $\beta$ -carotene content range from 4.80 to 5.30 and 5.40 and 6.78 mg per 100 g in different tomato genotypes.

### **Lycopene**

Lycopene is one of major character controlling the fruit colour which affects the quality of tomato. There were significant differences for lycopene content among hybrids and varieties (Table 2).

The highest value for lycopene was observed in Best of all variety (6.38 mg/100 g of fruit) and lowest in hybrid Naveen (3.90 mg/100 g of fruit). Data corresponds to earlier study by Gupta *et al.*, (2011), who reported lycopene content range from 1.40 to 4.15 and 3.23 to 4.03 mg per 100 g in different genotypes of tomato.

## **Yield and net profit**

### **Fruit yield**

The data demonstrated that Red Gold hybrid produced maximum tomato fruits (143.7 q/ha) and minimum fruit yield was recorded for Best of all (33.7 q/ha) and Marglobe (34.7 q/ha). The next highest fruit yield was observed for RK 123 (119.8 q/ha) followed by 7730 (117.3 q/ha), HeemSohna (115.7 q/ha) and Manisha (110.3 q/ha) were however, statistically similar to each other (Table 3). The increase and decrease in tomato yield may be due to the genetic potential of each cultivar and also the application of organic manure might have brought about positive change in the total yield by supplementing the essential elements for tomato plants. According to Palm *et al.*, (1997), recommended dose of organic manure can be used by plants for contributing effectively to all growth parameters and enhance the growth and yield of tomatoes.

The result of Akanbi *et al.*, (2005) is of primary importance to these findings as they concluded that application of organic manure and compost was responsible for achieving desirable growth and yield parameters in tomato plants. The gain in fruit weight may be due to the genetic attributes of different tomato cultivars and may also be due to formation of fruit on healthy plants, which utilized more nutrients, water and light according to requirement for more production. Unlu and Padem (2009) reported that farm yard manure was better than NPK as more fruit weight was recorded in tomato plants treated with organic manure as compared to inorganic fertilizer because organic manure have more water-holding capacity and provide continuous nutrients, which is in accordance with these result for more accumulation of weight in tomato plants treated with organic fertilizer.

## Net returns

The net returns and benefit cost ratio for different hybrids/varieties varied significantly and maximum profit and B: C was observed in case of Red Gold hybrid (rupees 259685/ha and 1.37) followed by RK 123 (rupees 186497/ha and 0.99), 7730 (rupees 180860/ha and 0.97), HeemSohna (rupees 172185/ha and 0.91) and Manisha (rupees 158505/ha and 0.85). The rest of the entries were found to be non-profitable (Table 3).

It is concluded that different tomato cultivars behaved significantly different from each other concerning various parameters. Among tested cultivars, Red Gold and RK 123 resulted in the highest production. Varieties were found superior in terms of fruit quality as compared to hybrids. The results concluded that organic regime gave the best production and quality produce and also organic tomato management is encouraged due to various advantages such as food safety, free from any chemical fertilizers and environment friendly.

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