



## Effect of tree architecture on fruit quality and yield attributes of nectarine (*Prunus persica* var. *nectarina*) cv. Fantasia under temperate condition

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### ABSTRACT

The present study was carried out at research farm of ICAR-Central Institute of Temperate Horticulture, Srinagar during the year 2009 to 2013. The nectarine cv. Fantasia grafted on wild peach rootstock and subsequently these trees were trained in six different training systems, viz. central leader system, open center system, Y shape-tatura trellis, four scaffolds, modified central leader system and modified open leader system. These six training systems were further evaluated for plant growth, fruit quality, and yield and average data of four years have been statistically analyzed. Significant chromatic variation was recorded for fruit skin color and maximum  $a^*$  value was recorded in tatura trellis (44.13), similarly maximum trunk cross section area (TCSA) (54 cm<sup>2</sup>), fruit yield (32.72 tonnes/ha), fruit quality in terms of fruit weight (105.28 g), fruit length (65.53 mm), fruit diameter (66.85 mm), No. of fruits/plant (310) and yield efficiency (0.379 kg/cm<sup>2</sup>) were recorded in Y-shape tatura trellis system as compared to other traditional and contemporary tree architecture. Among biochemical parameters, highest TSS (14.66 °B) and ascorbic acid (15 mg/100g fresh fruit weight), titrable acidity (0.311%), TSS/acidity (60.89) was recorded in Y shape tatura trellis system, central leader system and modified open leader system respectively. Likewise total anthocyanin (6.23 mg cyanidin-3-glucoside equivalents 100/g fw), total carotenoids (8.71 mg/100 g), total phenols (575 mg GA equivalents/100 g), total flavonols (371 mg catechin equivalents/100 g), diphenyl-1-picryl hydrazyl (DPPH) (66 mg of AAE/100 g of fresh weight) and Ferric reducing antioxidant potential (FRAP) (69.16 mg of AAE /100 g of fresh weight) was recorded in Y shape tatura trellis followed by four scaffold training system. The present study emphasizes the superiority of Y shape tatura trellis system over other training system and could be exploited for higher quality and quantity nectarine production in temperate regions.

**Key words:** Fruit quality, Nectarine, Temperate, Tree architecture, Yield

The nectarine (*Prunus persica* var. *nectarine*), smooth-skinned peach of the family Rosaceae, known for more than 2000 years and grown throughout the warmer temperate regions of both the Northern and Southern hemispheres. In tree shape and leaf characteristics, the peach and nectarine are indistinguishable, but nectarine fruits look more like plums than peaches because of the smooth skin. The stones and kernels of the two fruits are alike in appearance. Nectarines have red, yellow, or white flesh (Encyclopaedia Britannica 2014). Peach and nectarine are the third most important temperate fruit crops of India consisting an area of 36.40 thousand ha, production 2.43 lakh tonnes and productivity 6.67 tonnes/ha (FAOSTAT 2014). It is favorite table fruit and highly valued for its taste and attractive color. The fruits are a rich source of sugars, vitamins and minerals and malic acid (1.2%). In modern temperate fruits orcharding, optimization of planting density and training system is

regarded as a key factor for successful orchard management (Arsov *et al.* 2013). The choice of the training system and rootstock adapted to specific agro-ecological conditions is of a great importance (Weber 2001). Tree trimming belongs to activities, which are absolutely necessary for commercial orchards (Mika 2003). The density of tree planting, their distribution, and span of the canopies decide about the orchard architecture and depend on the tree trimming, which directly or indirectly exerts an influence on the physiological processes of the trees. An appropriate canopy shaping and tree pruning system allows obtaining high yields of good quality fruit, besides ease and quick harvesting (Hrotkó 2005). The achievement of an adequate higher quality fruit yield and the setting of flower buds depends on light conditions, which can be improved through the formation of an adequate tree canopy (Sosna and Czaplicka 2008, Buler and Mika 2004). In India peaches and nectarine commonly trained in the open center training system, but this traditional training system has inherent problems like low yield and poor fruit color development. Colour is the most important indicator of maturity and quality in many fruit species. Anthocyanins represent a group of natural

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flavonoid compounds in plants and are responsible for coloration (Koes *et al.* 2005, Honda *et al.* 2002). Moreover, the nectarine also requires good skin color development for better consumer preference and higher price. Keeping this in view the present study was conducted to evaluate six training system and to analyze their effects on fruit yield and quality on nectarine cv. Fantasia.

#### MATERIALS AND METHODS

The present study was conducted during the year 2009 to 2013 at research farm of ICAR-Central Institute of Temperate Horticulture (CITH), Srinagar, India. The site is situated at latitude of 34° 05' N and longitude of 74° 50' E at an altitude of 1640 m above the mean sea level. Recommended package of practices followed for better and healthy crop. The average maximum temperature 19.63 °C, minimum 6.52 °C, rainfall 160.72 cm and relative humidity 58.35 %, evaporation 2.45/day, and soil characteristics, viz. pH= 6.81, EC = 0.36 dS/m were recorded during growing seasons. Tree canopies were formed from the first year itself on seedling grafted with Fantasia nectarine, which was spaced (3m × 3m) and since 2010 only corrective trimmings were done to maintain the right shape of trees. The tree architecture was developed, viz. central leader system, open center system, Y shape- tatura trellis, four scaffolds, modified central leader system and modified open center system. The trunk cross-sectional area was calculated by using formula  $TCA = Girth^2 / 4 \pi$  (Westwood *et al.* 1963). Yield efficiency was calculated as an average of yield efficiencies of three years (2010, 2011, 2012 and 2013). It is expressed as a fruit weight ratio with trunk cross-section area (TCSA). The fruit color was measured from the peel of six randomly selected nectarines. The parameters CIELab:  $L^*$ ,  $a^*$ , and  $b^*$ , were measured with a Hunter color lab. The parameter  $L^*$  indicates brightness or lightness (0 = black, 100 = white),  $a^*$  indicates chromaticity on a green (-) to red (+) axis, and  $b^*$  indicates chromaticity on a blue (-) to yellow axis (+). Numerical values of  $a^*$  and  $b^*$  were converted into hue, hue angle ( $H^\circ = \tan^{-1}(b^*/a^*)$ ) and chroma ( $C = ((a^*)^2 + (b^*)^2)^{1/2}$ ). The hue is an angle in a color wheel of 360°, with 0°, 90°, 180° and 270° representing the hues red-purple, yellow, bluish-green and blue respectively, while Chroma is the intensity or purity of the hue. The hunter color lab was calibrated using the manufacturer's standard white tile. Twenty fruits from each genotype were randomly chosen and measured. The data were collected on fruit length (mm), fruit weight (g), fruit diameter (mm), pulp thickness (mm), stone diameter (mm), stone weight (g), TSS (°Brix), acidity (%), TSS/Acid ratio and fruit yield (kg/plant). The length and diameter of the fruit were measured with a digital vernier caliper. The stone were manually separated from the fruits and stone weight and stone diameter traits were measured. Total soluble solids (TSS), titrable acidity, and sugars were determined by as per AOAC (1994). The experiment was conducted under randomized block design replicated three times as suggested by Gomez and Gomez (1984) and pooled data of

four years were analyzed using SAS 9.3 version software.

#### RESULTS AND DISCUSSION

The four-year averaged data has been analyzed statistically and the effect of different tree architecture systems on fruit skin color has been illustrated in Fig 1-3. The fruit skin color significantly differed among employed training systems. Maximum  $L^*$  value, which indicates fruits brightness or lightness (0 = black, 100 = white) was recorded in the fruits harvested from Y-shaped tatura trellis followed by four scaffold system, modified center leader system and minimum in open center system. This may be due to the overshadowing of the lower outside parts of the canopy, under the main scaffolds in all the systems except

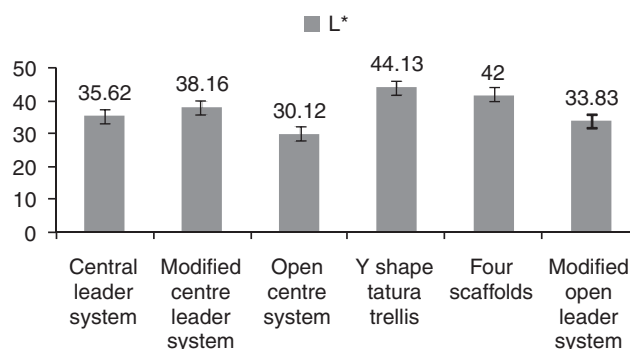


Fig 1 Effect of six training systems on fruit skin color ( $L^*$ ) in nectarine cv. Fantasia. Vertical bars represent  $\pm$  SE (LSD: 1.27)

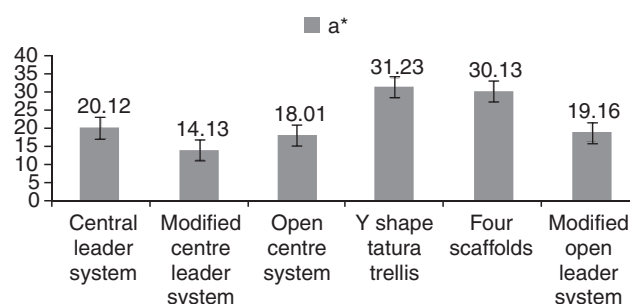


Fig 2 Effect of six training systems on fruit skin color ( $a^*$ ) in nectarine cv. Fantasia. Vertical bars represents  $\pm$  SE (LSD:0.53)

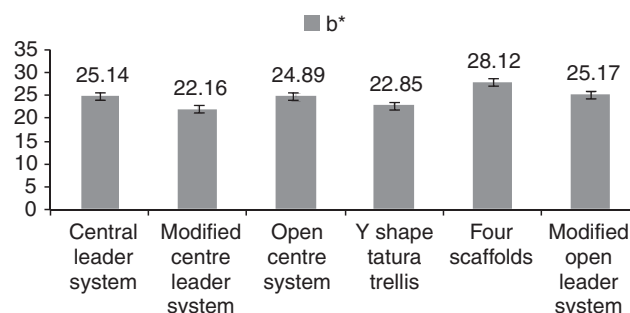


Fig 3 Effect of six training systems on fruit skin colour ( $b^*$ ) in nectarine cv. Fantasia. Vertical bars represent  $\pm$  SE (LSD:0.97)

Y-shaped tatura trellis. Because the trees are broader at the top, the top over shadow the bottom part of the canopy (Dejong *et al.* 1999, Marini and Sowers 2000). The  $a^*$  value, which indicates fruit chromaticity on a green (-) to red (+) axis, was also recorded highest in Y shape tatura trellis followed by four scaffolds and lowest in modified central leader system, however,  $b^*$  value, which indicates chromaticity on a blue (-) to yellow axis (+) estimated highest in four scaffolds followed by modified open leader system and lowest in tatura tellies. Chroma value was recorded maximum in Y-shaped tatura trellis followed by the open centre system, four scaffolds and minimum in centre leader system, whereas hue value determined highest in modified centre leader system followed by the open centre system and lowest in Y shape tatura trellis but hue angle for the training system found non-significant. In Y shape tatura trellis system deep red color fruit percentage was higher (lower  $L^*$ ,  $b^*$  and hue values and higher  $a^*$  values) compared to four scaffolds or modified center leader system light and pink in color (intermediate  $L^*$  and  $b^*$  values; higher  $a^*$  values; and lower hue values). The bi-colored peel fruits, red with green and yellow patches (intermediate  $L^*$ ,  $a^*$ ,  $b^*$  and hue values) were higher in center leader system and open center system. Similar results were also reported by Caruso *et al.* (2001) and emphasized that the total yield a free standing Y-shaped system produced 74% first-grade fruit compared to 63% produced by a central leader system.

Tree growth, fruit yield, and physico-chemical attributes also recorded and presented as Table 1. High performances and yield can be achieved early in the lifetime of an orchard by adopting the appropriate orchard design. Tree growth significantly influenced by tree architecture and maximum trunk cross-sectional area (TCSA) was measured in Y shape tatura trellis system followed by four scaffolds, open centre, centre leader and minimum in modified open leader system. Maximum fruit length was recorded in Y shape tatura trellis system followed by modified open leader and open centre

system, whereas fruit diameter recorded highest in Y shape tatura trellis system followed by modified open leader and open centre system. The heaviest fruit was obtained in tatura trellis followed by four scaffolds, central leader system and lightest in modified central leader system. The present findings are in accordance to Dejong *et al.* (1999) and Caruso *et al.* (2001) those reported while working on Stark Redgold nectarine. The free standing Y system can produce higher yield at full bearing than the traditional open vase system and a central leader system. 'Y' shape systems also have better light interception and distribution within the canopy than a central leader system (Singh *et al.* 2004) and the traditional open vase system (Grassman and Dejong 1998).

The number of fruits/plant and yield/plant also varied significantly among the training system and maximum final fruit retention and yield/plant recorded highest in Y shape tatura trellis followed by four scaffolds, open center and minimum in modified open centre system. The yield efficiency is a complex index, which includes the vegetative growth of the tree and its productivity (Gjamovski and Kiprijanovski 2011). Yield efficiency expressed by means of the trunk development and crown volume is an important indicator of the tree's productivity (Kiprijanovski *et al.* 2009). In the present study, yield efficiency was obtained highest in Y- shape tatura trellis followed by four scaffolds, open center, modified central leader lowest in central leader system. The current outcomes justify the statement that planting system and tree shapes within a given density positively influence on high yield and quality of the fruits (Wertheim *et al.* 2001). Furthermore, the results also confirmed by Corelli *et al.* (1986) for medium-early ripening cultivars, show that in full field conditions and for early-ripening low-chill cultivars, Y system gave high performance both in terms of yield and fruit quality.

Fruit quality characteristics were also significantly influenced by the tree architecture (Table 2). Maximum

Table 1 Effect of six training systems on yield and yield related attributes in nectarine cv. Fantasia

Training system	TCSA * (cm <sup>2</sup> )	Fruit length (mm)	Fruit diameter (mm)	Fruit weight (g)	No. of fruits/plant	Yield (t/ha)	Yield efficiency (kg/cm <sup>2</sup> )
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Central leader system	44 ± 0.63	55.75 ± 0.56	54.30 ± 0.60	83.79 ± 0.74	210.84 ± 2.54	17.67 ± 0.260	0.257 ± 0.003
Modified centre leader system	47 ± 0.56	56.36 ± 0.69	53.01 ± 0.88	91.87 ± 0.28	225.60 ± 1.52	20.73 ± 0.256	0.254 ± 0.003
Open centre system	49 ± 0.76	55.90 ± 0.70	59.03 ± 0.38	87.14 ± 0.88	249.67 ± 1.90	21.76 ± 0.154	0.278 ± 0.003
Y shape tatura trellis	54 ± 1.07	65.53 ± 0.91	66.85 ± 0.217	105.28 ± 1.26	310.76 ± 4.60	32.72 ± 0.093	0.379 ± 0.006
Four scaffolds	51 ± 0.28	55.60 ± 0.45	57.94 ± 0.624	77.07 ± 0.37	297.07 ± 2.33	22.90 ± 0.08	0.305 ± 0.003
Modified open leader system	43 ± 0.45	60.40 ± 1.22	60.45 ± 1.33	88.97 ± 0.52	154.00 ± 1.90	13.70 ± 0.04	0.195 ± 0.003
CD P=0.05)	2.3	2.69	2.46	2.62	8.74	0.55	0.012

SE: Standard error, \*TCSA: Trunk cross-sectional area of tree

Table 2 Effect of six training systems on fruit quality attributes in nectarine cv. Fantasia

Training system	TSS (°B)	Acidity (%)	TSS/ Acidity	Ascorbic Acid (mg/100g of fresh fruit)	Total anthocyanin (mg cyanidin-3-glucoside equivalents 1100 gfw)	Total carotenoids (mg/100 g)	Total phenols (mg GA equivalents/ 100 g)	Total flavonols (mg catechin equivalents/ 100 g)	DPPH (mg of AAE/ 100 g of fresh weight)	FRAP (mg AAE/ 100 g of fresh weight)
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Central leader system	13.00 ± 0.16	0.311 ± 0.001	41.90 ± 0.42	12.00 ± 0.14	2.13 ± 0.03	6.53 ± 0.04	400.06 ± 5.90	315.11 ± 3.89	51.06 ± 0.46	24.10 ± 0.17
Modified centre leader system	14.10 ± 0.22	0.303 ± 0.004	46.73 ± 0.29	11.00 ± 0.13	2.11 ± 0.04	6.43 ± 0.02	415.7 ± 4.98	212.25 ± 4.34	40.57 ± 0.67	44.23 ± 0.19
Open centre system	14.30 ± 0.06	0.235 ± 0.005	60.89 ± 1.21	13.00 ± 0.12	1.52 ± 0.07	5.52 ± 0.07	378.01 ± 6.23	252.47 ± 3.90	31.32 ± 0.49	38.52 ± 0.23
Y shape tatura trellis	14.66 ± 0.16	0.247 ± 0.002	58.91 ± 0.83	15.00 ± 0.12	6.23 ± 0.08	8.71 ± 0.06	575.1 ± 8.98	371.46 ± 4.78	66.13 ± 0.57	69.16 ± 0.18
Four scaffolds	13.43 ± 0.06	0.289 ± 0.002	46.38 ± 0.29	14.00 ± 0.19	2.91 ± 0.07	6.85 ± 0.04	505.21 ± 6.90	305.78 ± 4.23	55.13 ± 0.62	54.23 ± 0.22
Modified open leader system	14.20 ± 0.05	0.202 ± 0.002	69.70 ± 0.26	12.00 ± 0.17	1.09 ± 0.001	5.67 ± 0.03	352.02 ± 5.89	262.04 ± 4.48	15.61 ± 0.34	27.13 ± 0.16
CD P=0.05)	0.17	0.010	2.27	0.42	0.23	1.56	20.72	12.89	4.89	6.21

TSS: Total soluble solids, GA: Gallic acid, DPPH: Diphenyl-1-picryl hydrazyl, FRAP: Ferric reducing antioxidant potential, AAE: Ascorbic acid equivalents

TSS recorded in fruits harvested from Y shape tatura trellis as compared to modified open centre and modified central leader system and minimum in central leader system, whereas fruit titrable acidity estimated highest in modified central leader system and least in open centre system. The TSS/acidity ratio was significantly higher in modified open centre as compared to rest of the training systems. Ascorbic acid contents also significantly differed in modified center leader, open centre, tatura trellis and four scaffolds, however, centre leader and modified open leader were found at par. The highest ascorbic contents were recorded in Y shape tatura trellis and lowest in four scaffold system. Trellis systems are an alternative to the traditional central leader system, especially in medium- to high-density orchards, and allow trees to be fully exposed to sunlight, and growers can use platforms for picking, thinning, and pruning (Weber 2001). Among antioxidants traits, highest total anthocyanin (6.23 mg cyanidin-3-glucoside equivalents/100 g), total carotenoids (8.71 mg/100 g), total phenols (575.10 mg GA equivalents/100 g), total flavonols (371.46 mg catechin equivalents /100 g), DPPH (66.13 mg of AAE /100 g of fresh weight) and FRAP (69.16 mg of AAE /100 g of fresh weight) content was recorded in Y shape tatura trellis system however in four scaffolds system the content of total anthocyanin (14.00 mg cyanidin-3-glucoside equivalents/100 g), total carotenoids (6.85 mg/100 g), total phenols (505.21 mg GA equivalents/100 g), total flavonols (262.04 mg catechin equivalents/100 g), DPPH (55.13 mg of AAE/100 g of fresh weight) and FRAP (54.23mg of AAE/100 g of fresh weight) was recorded. Our results suggest that Y shape trellis

trained trees would likely allow a better light distribution to the fruits in the inner and lower part of the canopy than another training system. This conclusion is also supported by the findings of DeJong *et al.* (1994) and Waldo (2006) reported for Flavorcrest peach cultivar, a 35% increase of sunlight distribution into the Y Shape tree canopy compared to the Central Spindle. However, to fully clarify these aspects, additional studies including light penetration and distribution are needed.

The present study showed that the Y shape tatura trellis tree architecture is better than other traditional tree architecture systems and could be potentially utilized for higher yield and quality commercial nectarine cultivation.

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