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Growth, Yield, and Fruit Quality Performance of Peach Varieties

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ይህ ጥናት የተካሄደው ከውጪ የገቡ ስድስት የኮክ ዝርያዎችን ማክሬድ የተባለውን ቀደም ሲል ገብቶ በመመረት ላይ ያለ ዝርያን እንደ ማወዳደሪያ በመጠቀም በደጋማ የሀገሪቱ ክፍል በተለይም በሆለታና አካባቢው ያላቸውን የዕድገት፣ ምርት እና ጥራት ሁኔታ ለመገምገም ነው። እያንዳንዱ ዝርያ ሶስት ጊዜ በተለያየ ረድፍ ተተክለው አስፈላጊው እንክብካቤ እየተደረገላቸው አድገዋል። የተገኘው መረጃ እንደሚያመለክተው እ.ኤ.አ 2006 እና 2007 ዓ.ም በስተቀር በዛፉ ቁመት ላይ ምንም አይነት ልዩነት አለመኖሩን ሲሆን ትሮፒክ ቢዩቲ፣ 9A-35C፣ ማክሬድ፣ 88-18W እና 90-19H የተባሉት ዝርያዎች የተሻለ ቁመት አስመዝግበዋል። በተጨማሪም እ.ኤ.አ ከ 2010 ዓ.ም በስተቀር ሁሉም ዝርያዎች ተመሳሳይ የቅርንጫፍ ስፋት አሳይተዋል። መረጃው እንደሚመለከተው የግንድ ውፍረትን በተመለከተ በዝርያዎች መካከል መረጃ በተወሰደባቸው አመታት በሙሉ ልዩነት አሳይተዋል። በዚህም መሰረት ትሮፒክ ቢዩቲ እና 90-19H ከሌሎች ዝርያዎች የተሻለ የግንድ ውፍረት አስመዝግበዋል። አማካይ ለሽያጭ የሚቀርብና ጠቅላላ ምርት እንዲሁም ከአንድ ዛፍ ላይ በሚገኝ የፍሬ ቁጥር እና አማካይ የፍሬ ክብደት ላይ በዝርያዎች መካከል ከፍተኛ ልዩነት ተመዝግቧል። ዝርያዎቹ እድሜአቸው እየጨመረ ሲሄድ የምርት መጠናቸውም እንደሚጨምርና ያላቸውን የምርት አቅም እንዳሳዩ ለመረዳት ተችሏል። በተገኘው መረጃ መሰረት የትሮፒክ ቢዩቲ አማካይ ጠቅላላ ምርት 110.4 ቶን በሄ/ር ሲሆን የ90-19H ኤች ደግሞ 89.67 ቶን በሄ/ር ነው። እነዚህ ዝርያዎች ከማወዳደሪያ ዝርያው (ማክሬድ) የ 45 እና 32% ብልጫ አሳይተዋል። ከአንድ ዛፍ ላይ የሚመረት አማካይ የፍሬ ቁጥር 90-19H፣ ትሮፒክ ቢዩቲ እና 88-22C ከሌሎች የተሻለ ሲሆን የፍሬ ክብደታቸው ደግሞ በተከታታይ 78.12፣ 76.06፣ እንዲሁም 76.06 ነው። የድህረ-ምርት ጥራትን በተመለከተ በጠቅላላ ስኳርና የአሲድ መጠን፣ የፍሬ ዲያሜትር እንዲሁም የብስለት አመላካች መረጃ ላይ ልዩነት ተመዝግቧል። በመሆኑም የ9A-35C ጠቅላላ የስኳር መጠን 13.67% ሲሆን የ88-18W የአሲድ መጠን 1.03% ከሌሎቹ ዝርያዎች ሲነጻጸር ከፍተኛ እንደሆነ ለመረዳት ተችሏል።

Abstract

*The study was conducted to evaluate peach varieties for their growth, yield and quality performance under Holetta condition. The treatments consisted of six peach varieties including McRed (standard check). The trial was laid in randomized complete block design with three replications. The result indicated statistically similar tree height across the growing seasons except in 2006 and 2007. Tropic beauty, 9A-35C, McRed, 88-18W and 90-19H showed better plant height in their order. All varieties had statistically significant parity in canopy spread in all growing seasons except in 2010. However, there was significant difference in trunk cross-sectional area across all seasons. Tropic beauty and 90-19H exhibited better trunk cross-sectional area. Highly significant differences in mean marketable and total fruit yield, fruit number per tree and average fruit weight were observed. The mean total fruit yields of Tropic beauty and 90-19H were 69.03 and 56.23 t ha^{-1}, respectively. These varieties had 45.0 and 32.5% yield advantage over the standard check, McRed. Moreover, varieties 90-19H, Tropic beauty and 88-22C had better mean fruit numbers per tree and fruit weight (78.12, 76.06, and 76.06 g in aforementioned order) as compared to others. In terms of fruit quality, there were significant differences among varieties regarding total soluble solid, titratable acidity, fruit diameter and ripening index. Variety 9A-35C has the highest TSS (13.67%) while variety 88-18W has the highest TA (1.03%) and fruit diameter (5.76 cm) and followed by Tropic beauty (*0.95% and 5.46 cm, respectively*). Variety 90-19H exhibited superior ripening index and the least was obtained from 88-18W.*

Introduction

Peach (*Prunus persica* L. Batsch), belongs to the *Rosaceae* family and a species of *Prunus*, is one of the most important stone fruits in the world standing next to apple and pear (Abidi *et al.*, 2018). It is believed that the cultivated peach is native to China (Todd, 2006). Now a days, the cultivation of peach has been extended to non-traditional areas in the subtropical and tropical regions worldwide, where the climate is different from their natural habitat, with mild and dry winters and hot and rainy summers (Barbosa *et al.*, 2010) and altitude ranges from 1500 to 2700 m and average temperature of 21-24 ^{O}C (Bal, 1997). There are a number of distinct varieties of peaches in the world, which can be variously classified as melting and non-melting flesh, or hairy and smooth skin, or clingstone and freestone, *etc.* (Zhao *et al*., 2015). Although, the fruits have either yellow or white flesh color, which taste sweet, less acidic and smoother than the yellow flesh peaches, depending on the variety (Byrne *et al.*, 2000).

Peach is rich in vitamins A and C, potassium, and fiber (FAO, 2013). Besides, it contains carbohydrate, organic acids, antioxidants, phenolics, and trace amounts of proteins and lipids (Kader and Mitchell, 1989). Furthermore, production of peach has multiple uses for the farmers such as crop diversification; insure food and nutrition security (Linger, 2014; Nguyen *et al*., 2013) particularly for people who live in highland areas with cereal-based agriculture that are prone to imbalanced food habit. It is used for the establishment of small and medium scale agro-industries, reduction of unemployment, import substitution, and foreign exchange earnings (EHDA, 2012). It is friendly to the environment and can easily be incorporated in agro-forestry program of the highlands due to this it has a paramount potential for mitigation of climate change and natural resource conservation (Thorlakson and Neufeldt, 2012).

In Ethiopia, more than 46% of the total area is highland and mostly favorable for low and medium chill varieties of peach and other highland fruits production (Abayneh and Masresha, 2014). The major production season of peach in Ethiopia is from December to February when there is no production of fruits in temperate zone countries. As a result, it becomes an opportunity to export to geographically proximate countries such as Europe, the Middle- and Far-East (Joosten, 2007).

There is no clear evidence about the exact time of the introduction of peach fruits to Ethiopia. However, it was supposed to be introduced to the eastern parts of the country by the Portuguese in the 16 and 17th Centuries (Martínez, 2011). For the research purpose, the introduction of improved peach varieties to Ethiopia started in 1970/71 (Godfrey and Bereke-Tsehay, 1987). During the last 50 years, many efforts have been done to adapt and select improved varieties of introduced peach, and hence McRed, Florida red and Florida bell have been recommended so far for areas with altitudes from 2400 to 2600 m. In general, the development of fruits production in Ethiopia has been constrained by shortage of technologies to adopt, limited genetic resources available at hand, poorly developed planting materials, and orchard management techniques, lack of locally generated appropriate disease and insect pest control measures, and critical shortage of quality seedling supply (Kahasay *et al*., 2008). Now days, to solve the shortage of improved and well-adapted varieties, which is still critical problem in the country, there are evaluation of some promising varieties of peach under research that are conducted at Holetta to evaluate their suitability for the area and similar environments. However, shortage of improved and well-adapted varieties is still critical problem in the country. Therefore, the aim of this work is to evaluate the performance of peach varieties with respect to vegetative, yield and its components, and fruit quality at Holetta condition.

Materials and Methods

The study site

The trial was conducted at Holetta, which is located in the Oromia National Regional State and about 29 km far from Addis Ababa in west direction. The site, Holetta Agricultural Research Center, lies at 9° 00’ N latitude, 38° 30' E longitude and with an elevation of 2400 m in central Ethiopia. The daily average minimum and maximum temperatures of the area during the growing seasons (2005-2015) were 6.42 ^{O}C and 27.2 ^{O}C, respectively, and the mean annual rainfall was 918.31 mm. The soil of the experimental site is Nitisols, which is characteristically reddish to brown in color. It has soil pH of 6.67 and clay in texture with contents of 62.5% clay, 30.0% silt, and 7.5% sand. The soil has organic matter content of 2.18%, and total nitrogen, available phosphorus and exchangeable potassium contents of 0.18%, 30.58 ppm and 0.14 meq. 100 g^{-1} soils, respectively.

Experimental set-up and field management

Five peach varieties, namely 88-18W, 90-19H, 9A-35C, Tropic beauty and 88-22C introduced from Florida and a previously recommended standard check variety, McRed, were established at Holetta Agricultural Research Center in 2004. The trial was arranged in randomized complete block design with three replications using two plants per plot. The trees were spaced 4 m and 4 m between plants and rows, respectively. All field management practices such as manure and fertilizer application, irrigation water supply, weeding, and pest and disease control were performed as necessary. The trees were trained in an open center system and pruning was practiced in every growing season before the beginning of flower and leaf bud burst.

Data collection and analysis

Data were recorded on growth characteristics (plant height, canopy spread, trunk cross-sectional area), yield and yield components (marketable and total fruit yield, number of fruits per tree, mean fruit weight), and both physical fruit quality parameters (fruit length and fruit diameter) and bio-chemical fruit quality parameters like total soluble solid (TSS), ascorbic acid (AA), titratable acidity (TA) and pH.

Growth parameters

Tree height (m): was considered by measuring the height of the largest scaffold branch from the ground level.

Canopy spread: was calculated by mean measurements of the spreading of branches from North to South and from East to West.

Trunk cross-sectional area (cm^2): was also calculated based on the formula presented by (Webster and Brown, 1980):

$$TCSA\ (cm^2) = \frac{D^2}{4\pi}$$

Where, D represents the diameter measured 10 centimeter above the graft union with the help of caliper.

Yield and yield components

Marketable and total yields (t ha^{-1}): were calculated in hectare base from the yield obtained from the plot measured by using the standard sensitive balance.

Fruit numbers per tree: was taken by counting all the fruits per tree and then make the average by dividing the number of trees per plot.

Average fruit weight (g): was done by taking about 20 fruits randomly from each tree and make the average of them.

Physical and bio-chemical fruit quality

For physical quality determination, twenty fruits were randomly selected to estimate the fruit length (cm) and fruit diameter (cm) of each variety while for the bio-chemical quality procedures are stated below.

Total soluble solid (^{o}Brix): was determined by direct reading using refractometer by applying small quantity of the peach juice (2-3 drops) to fixed prism surface at 20 ºC (AOAC, 2006) from each treatment.

Ascorbic acid: was determined by volumetric method using titration (AOAC, 2000) with 2, 6-dichlorophenol-indophenol (DCPIP) which is oxidation-reduction indicator and 0.5% Oxalic acid. The preparation of oxalic acid solution was done by weighing 10 g of oxalic acid and put it in 100 mL volumetric flask and then filled up with distilled water. Following this, ascorbic acid standard solution of 1 ml was taken in to 25 mL of 0.5 oxalic acid solution containing 250 mL conical flask, and then rapidly titrated with the DCPIP solution to an end-point of light rose-pink color persists and recorded the amount of DCPIP. Similarly, 1 mL peach juice was diluted to 25 ml of 0.5% oxalic acid solution containing 250 mL conical flask. Then thoroughly mixed and titrated with DCPIP solution until the final point, light rose-pink color, persisted and the amount of DCPIP solution used to titrate the juice was recorded. The ascorbic acid content of the fruit juice was computed by the following formula and finally the result was expressed as mg per 100 g of sample (Bessey and King, 1933).

$$Ascorbic\ acid = \frac{DCPIP\ (\text{mL})used\ to\ totrate\ the\ juice}{DCPIP\ (\text{mL})used\ to\ titrate\ the\ standard\ ascorbic\ acid}\ x\ 1\ mg/\text{mL}$$

Titratable acidity and pH: was determined by titrate each sample of the peach fruit juice, which has 6 ml volume and diluted it in 50 ml distilled water to make the slurry easier to stir during titration, with 0.1 N NaOH until the pH rises to 8.2 and record the volume (mL) of NaOH used to reach the end point. Then, the titratable acidity was calculated in terms of malic acid, which is the predominating acid in peach with milli-equivalent factor 0.067, and was expressed as percent of juice according to Garner *et al*. (2008).

$$Acid\ (\%) = \frac{[\text{mL}\ NaOH\ used]x[0.1\ N\ NaOH]x[miliequivalent\ factor]}{\text{mL}\ of\ sample}\ x\ 100$$

The pH value of the sample were measured using a glass electrode pH meter subsequent to it was calibrated by buffer solution 7 and 4 according to the method (AOAC, 2005). The ripening index was calculated as the ratio of TSS to TA.

Data were subjected to analysis of variance (ANOVA) according to the Generalized Linear Model (GLM) of SAS version 9.0 (SAS, 2010) and interpretations were made following the procedure of Gomez and Gomez (1984). Significant differences between treatment means were separated using the Least Significance Difference test at 5% level of significance.

Results and Discussion

Growth parameters

The analysis of variance indicated that there was no significantly difference in tree height among the peach varieties in all years except in 2006 and 2007, which showed significant differences ($P < 0.05$), respectively (Table 1). Even though, the tree height showed a significant result, the variety McRed, Tropic beauty, 90-19H and 9A-35C had statistically similar plant height performance in 2006 and 2007 growing seasons (Table 1). In all cropping season, the variety 88-18W showed less growth in height. The result revealed that there was a significant difference ($P<0.01$) in trunk cross-sectional area among the varieties over the growing years (Table 1). In general, varieties Tropic beauty and 90-19H exhibited statistically parity trunk cross-sectional area in all growing seasons except 2007 and 2010, and these varieties had higher trunk cross-sectional area as compared to others while the least trunk cross-sectional area was recorded on variety 88-22C in all growing season except 2007 and 2010. The analysis also showed that all varieties had no any statistical difference in canopy spread except in 2010 ($P<0.01$), during this year varieties Tropic beauty, 90-19H, 88-18W and McRed, were observed to have larger canopy and no significant difference with each other (Table 2).

Tree vigor, is expressed by different parameters like plant height, trunk cross-sectional area, and canopy spread/volume, affected the photosynthetic rate and productivity and hence ultimately affected the biomass or economic yield (Almeida *et al.*, 2016). The ratio between canopy height, thickness, and width must be considered to ensure adequate light levels inside the canopy (Corelli and Sansavini 1989). Previous finding indicated that taller plants are more productive than shorter trees due to light interception favored by taller plant (Day *et al*, 1999). The relative growth rate of trees in particular slow with increasing size due in part to the large allocation of assimilate to structural material of the trunk required to hold photosynthetic material up in the canopy and as a result biomass accumulates more slowly as total biomass increases (Paine *et al*., 2012). Tree trunk cross-sectional area is the most common surrogate measurement to determine the plant size and indirectly the capacity of a plant to produce fruits (Jimenez and Diaz, 2004). Trunk cross-sectional area, is a good indicator of tree fruit cultivar growth and adaptability in a given area (Daniel *et al.*, 2001), was positively correlated with transport of nutrients from root to different aerial parts of the plant and the distribution of photosynthates from site of production to site of utilization, which ultimately influence the vegetative growth and also fruit yield (Hartmann and Kester, 2002). Although, previous investigation also stated that there is a positive relation between canopy volume, leaf area, yield, and production efficiency with the trunk cross-sectional area of a plant (Dalal and Brar, 2012). Canopy spread is affected by different factors such as pruning, training and rootstock used (Basile *et al.*, 2007). Caruso *et al* (1999) also reported that decline in tree spread with increase in planting density may be due to excess crowding of trees and mutual competition at higher densities. Dyankov (1998) observed that vegetative growth was more vigorous at wider spacing in peach.

Table 1. Plant height and trunk cross-sectional area of peach varieties

Variety	Plant height (m)							Trunk cross-sectional area (cm^2)					
	2005	2006	2007	2008	2009	2010		2005	2006	2007	2008	2009	2010
Tropic beauty	1.79	2.40a	2.61a	2.65	2.58	2.68		0.69a	4.43a	4.65a	5.65ab	6.49a	6.78a
88-18W	1.33	2.21ab	2.32b	2.43	2.48	2.58		0.25bc	3.29b	3.70b	5.05abc	4.26b	5.79ab
88-22C	1.33	1.82b	2.08c	2.17	2.28	2.3		0.19c	2.68b	2.91bc	4.03c	4.33b	4.34c
90-19H	1.53	2.41a	2.42ab	2.38	2.52	2.83		0.53a	5.12a	3.32bc	6.43a	6.10a	5.02bc
9A-35C	1.64	2.44a	2.40ab	2.37	2.43	2.79		0.54a	3.39b	2.66c	4.15c	4.61b	5.26bc
McRed	1.20	2.22a	2.43ab	2.42	2.54	2.69		0.35b	3.36b	3.50b	4.29bc	4.94b	5.33bc
Mean	1.47	2.25	2.38	2.4	2.47	2.64		0.43	3.71	3.46	4.93	5.12	5.42
Level of sig.	NS	*	*	NS	NS	NS		**	**	**	*	**	**
LSD (5%)	0.57	0.40	0.24	0.47	0.38	0.38		0.16	0.84	0.83	1.50	0.90	1.08
CV (%)	21.49	9.67	5.53	10.83	8.39	7.87		21.15	12.51	13.16	16.72	9.63	10.97

*Means within a column followed by the same letter(s) are not significantly different from each other at 0.05 probability level; Ns- non-significant; *-significant at P < 0.05, **-significant at P<0.01 probability levels.*

Table 2. Mean canopy spread of peach varieties

Variety	Canopy spread (m)				
	2006	2007	2008	2009	2010
Tropic beauty	2.7	1.79	3.32	3.35	3.75a
88-18W	2.19	1.60	3.12	3.08	3.33ab
88-22C	2.26	1.28	2.98	2.51	2.80c
90-19H	2.8	1.68	3.78	3.07	3.73a
9A-35C	2.21	1.43	2.93	2.69	2.88bc
McRed	2.32	1.54	3.26	3.25	3.63a
Mean	2.42	1.55	3.23	2.99	3.35
Level of sig.	NS	NS	NS	NS	**
LSD (5%)	0.75	0.53	0.74	0.75	0.53
CV (%)	17.11	18.74	12.52	13.69	8.67

*Means with the same letter along the column are not significantly different; Ns- non-significant; *-significant at P < 0.05, **-significant at P<0.01 probability levels.*

Yield and yield components
Marketable and total fruit yield

The analysis revealed that both the marketable and total fruit yield of the evaluated peach varieties showed the presence of statistically significant difference (*P<0.01*) in all fruiting seasons except in 2010 (Table 3). Accordingly, marketable and total fruit yield of variety Tropic beauty was significantly higher than the other varieties in all years (21.96/37.01, 28.71/44.00, and 113.50/142.20 t ha^{-1}, with the respect to the order mentioned above) except 2010 in which the marketable and total fruit yield did not show significant difference even if it produced more yield (19.10 and 52.92 t ha^{-1} in the aforementioned order). Following Tropic beauty, variety 90-19H had significantly higher marketable and total yield in the 2008 (17.39 and 24.47 t ha^{-1}, respectively) and 2015 (110.97 and 140.50 t ha^{-1}, respectively) years; however, it was beat by the standard check, McRed, (16.30 and 27.98 t ha^{-1}, in the order mentioned in the above) in 2013 cropping year. When we see the total fruit yield potential progress from first year to the last fruiting year; i.e., 2008-2015, varieties were expressed their relative maximum yield performance from 74.0% (variety Tropic beauty) to 88.6% (McRed). Based on the cumulative average marketable and total fruit yield of the four harvesting seasons, variety Tropic beauty (45.82 and 73.97 t ha^{-1}, respectively) was the leading and followed by variety 90-19H (39.62 and 56.23 t ha^{-1}, in the aforementioned order) and the least mean marketable fruit yield was obtained from McRed (22.69 and 37.97 t ha^{-1}, respectively) (Table 3). Regarding to the yield advantage, varieties Tropic beauty and 90-19H had showed 45 and 32% total fruit yield advantage, respectively, over the standard check, McRed.

This finding was corresponding with the result expressed by Fathi *et al.* (2012) who discussed about fifteen genotypes of peach with the minimum and maximum fruit yield of 13.75 and 73.75 t ha^{-1}, respectively. However, the maximum fruit yield is ultimately limited by light interception and economic fruit yield is a function of the efficiency of light use and light distribution within the canopy (Bosa *et al*., 2016). When we compared the productivity of peach in Ethiopia to the productivity of the top three producers of peach; namely, China, Spain and U.S.A, with their average productivity of 16.76, 16.25 and 20.17 t ha^{-1}, respectively (USDA, 2016), all the above evaluated varieties in Ethiopia showed advanced productivity than the above top peach producing countries. This indicates that Ethiopia has a great potential to produce peach fruits for both local and export markets. The evaluated peach varieties displayed irregular or alternate fruit bearing behavior throughout the trial seasons, which might be due to high fruit loads are reported to strongly suppress vegetative growth (Martínez-Alcántara *et al*., 2015). Furthermore, varieties displayed irregular fruit bearing behavior throughout the trial seasons, which might be due to its nature of biennial bearing. As we observed from this evaluation, the cultivars showed an increase in yield with age and expressed its maximum genetic potential as the age increases, in 2015, since the fruit potential of a tree depends on its size (Treder *et al*., 2010) and this will be achieved with age and similar findings was obtained by Czynczyk *et al*. (2009).

Table 3. Marketable and total fruit yield of peach varieties

Variety	Marketable yield (t ha^{-1})					Total yield (t ha^{-1})				
	2008	2010	2013	2015	Mean	2008	2010	2013	2015	Mean
Tropic beauty	21.96a	19.1	28.71a	113.50a	45.82	37.01a	52.92	44.00a	142.20a	69.03
88-18W	13.26bc	16.41	10.61c	78.32b	29.65	16.06bcd	39.96	16.51c	97.65bc	42.45
88-22C	12.71bc	16.15	17.08b	52.96c	24.72	18.45bc	34.16	28.86bc	73.98c	38.86
90-19H	17.39ab	15.49	14.63bc	110.97a	39.62	24.47b	35.86	24.10bc	140.50a	56.23
9A-35C	10.00cd	11.76	12.74bc	65.41bc	24.98	14.10d	45.03	22.13bc	106.83b	47.02
McRed	5.37d	9.72	16.30bc	59.37bc	22.69	8.66d	39.51	27.98bc	75.72c	37.97
Mean	13.45	14.77	16.68	80.09		19.79	41.24	27.26	106.15	
Level of sig.	**	NS	**	**		**	NS	**	**	
LSD (5%)	6.62	6.45	6.17	21.75		9.35	16.06	11.53	30.66	
CV (%)	27.03	24.01	20.32	14.93		25.97	21.41	23.25	15.88	

*Means within a column followed by the same letter(s) are not significantly different from each other at 0.05 probability level; Ns- non-significant; *-significant at P < 0.05, **-significant at P<0.01 probability levels*

Number of fruits per tree and fruit weight

The result revealed that the average number of fruits per tree of the six peach varieties had been varied statistically in all cropping years except in 2010 while for fruit weight, the varieties showed significance difference only in 2013 ($P<0.05$) and 2015 ($P<0.01$) only (Table 4). Tropic beauty produced a significant higher number of fruits per tree until 2013 but later in 2015, the varieties 90-19H and 9A-35C were produce relatively a statistical similar fruit number with Tropic beauty. However, the mean maximum fruit number was obtained from 9A-35C while variety 88-18W exhibited mean lower number of fruits per tree. Varieties 88-18W, 90-19H and Tropic beauty showed statistically parity average fruit weight in 2013 and they relatively produced fruits with larger weight (102.67, 86.75 and 85.93 g, in the aforementioned order); however, in cropping season 2015, only varieties 88-18W and Tropic beauty were produced statistically larger fruit weight (66.23 and 57.64 g, respectively) as compared to others. In general, the largest average fruit weight was obtained from variety 88-18W (332.87) followed by 90-19H (307.98 g) while the least was obtained from variety 88-22C (231.24 g) (Table 4).

In consistent to the presented finding, Marini (2003) who also found the fruit number per tree was negatively related to the fruit size in weight basis. Fruit size and total fruit yield were all affected by crop load, although there were differences between cultivars, and affect negatively the mean fruit weight (Embree *et al.*, 2007). This is due to the fact that fruit size is mainly determined by the number of cells per fruit and their subsequent enlargement (Harada *et al*., 2005), and both factors are affected by the competition for carbon between developing fruits as crop load increases (Ho, 1992). This fact accounts for both the increase in the total fruit yield per tree and the decrease in the mean fruit size with increases in crop load. Thus, higher total fruit yield under increased crop load is due to an increase in fruit number (Inglese *et al*., 2002). According to the CPVO (2012), UPOV (2010) guidelines and ECPGR descriptors for peach (Giovannini *et al*., 2013), all the six varieties were produced with mean fruit size ranging from larger (200-240 g) to very large (>240 g).

Table 4. Average fruit number per tree and fruit weight of peach varieties

Variety	No of fruits per tree					Average fruit weight (g)				
	2008	2010	2013	2015	Mean	2008	2010	2013	2015	Mean
Tropic beauty	683.5a	556.5	468.0a	2740.7ab	1112.18	96.75	63.85	85.93ab	57.64ab	304.17
88-18W	164.5cd	577.7	98.8c	1401.5c	560.63	93.05	70.92	102.67a	66.23a	332.87
88-22C	275.0c	783.0	300.8b	2093.8bc	863.14	75.00	43.27	76.95b	36.02d	231.24
90-19H	419.7b	753.2	293.2b	2778.0ab	1061.01	115.00	57.48	86.75ab	48.75c	307.98
9A-35C	295.3bc	823.5	249.3b	3339.3a	1176.87	87.83	47.31	72.11b	34.50d	241.75
McRed	103.7d	773.3	291.0b	1429.0c	768.66	56.94	57.65	83.49b	53.75c	251.83
Mean	323.6	711.2	283.5	2297.1		87.43	56.75	84.65	49.48	
Level of sig.	**	NS	**	*		NS	NS	*	**	
LSD (5%)	132.3	375.5	130.1	1215.1		42.13	18.40	17.51	8.88	
CV (%)	22.5	29.0	25.2	29.1		26.49	17.82	11.37	9.87	

*Means with the same letter along the column are not significantly different; Ns- non-significant; *-significant at P < 0.05, **-significant at P<0.01 probability levels.*

Physical and biochemical fruit qualities

The varieties were differed significantly according to fruit diameter (*P<0.01*), total soluble solid (*P<0.05*), titratable acidity (*P<0.05*), and ripening index (*P<0.01*) while the other fruit quality parameters such as fruit length, pH and ascorbic acid were not varied statistically (Table 5). Regarding the fruit diameter, one of the physical fruit quality parameter, 88-18W and Tropic beauty were statically uniform in fruit diameter but they were produced larger fruit size. Variety McRed had the smallest fruit diameter (4.62 cm) and the largest one was obtained from 88-18W (5.76 cm). Varieties 9A-35C, 88-18W and Tropic beauty were had a relatively higher TSS and their content showed statically parity among each other. In general, the TSS of peach fruits varied from 10.27 (McRed) to 13.67 ^{o}Brix (9A-35C). In case of TA content, our results indicate that varieties 88-18W (1.03), Tropic beauty (0.95) and 90-19H (0.93) were produced significantly higher TA content. The lowest TA content was obtained from McRed (0.80). With regard to ripening index, the higher ripening index was obtained from variety 90-19H (16.67) while the lowest one was obtained from variety 88-18W (12.06) depending on their TSS and TA values (Table 5).

The results of present investigation with respect to physico-chemical characteristics of peach fruits showed marked variations, which may be attributed to genetic variability of peach cultivars and environment (Chadha *et al.*, 1968), canopy position, crop load and fruit maturity (Crisosto *et al.*, 1997). Consistence with that of Crisosto and Crisosto (2005) study, all varieties showed values over 10 ^{o}Brix, which is considered the minimum value for consumer acceptance for peaches and nectarines. The variability found in TSS among varieties can be explained by the quantitative performance of this quality trait as stated by Quilot *et al.* (2004). However, there are varieties with TA values were lower than 0.9%, which is considered the maximum limit for low acidity peaches (Hilaire, 2003). Because acidity of fruit decreases and total soluble solids increases during maturity and ripening stage of fruit (Padda *et al.*, 2011). In peaches, the ripening index is a major organoleptic quality trait of the mature fruit and is used as a quality index (Bassi and Selli 1990).

Table 5. Biochemical and physical fruit qualities of peach varieties evaluated under Holetta condition

Variety	Fruit length (cm)	Fruit diameter (cm)	Total soluble solid (°Brix)	Ascorbic acid	Fruit pH	Titratable acidity (%)	Ripening index
Tropic beauty	5.36	5.46ab	11.87abc	9.78	3.48	0.95ab	12.47cd
88-18W	5.33	5.76a	12.33ab	8.89	3.42	1.03a	12.06d
88-22C	5.15	4.98cd	11.13bc	8.00	3.49	0.74c	15.13b
90-19H	5.18	5.19bc	11.40bc	10.67	3.44	0.93ab	16.67a
9A-35C	4.85	4.87cd	13.67a	10.22	3.57	0.82bc	12.30cd
McRed	5.11	4.62d	10.27c	9.11	3.41	0.80bc	12.90c
Mean	5.16	5.15	11.78	9.45	3.47	0.88	13.59
Level of sig.	NS	**	*	NS	NS	*	**
LSD (5%)	0.45	0.39	1.97	3.73	0.14	0.17	0.77
CV (%)	4.83	4.18	9.21	21.68	2.30	10.71	3.13

*Means within a column followed by the same letter(s) are not significantly different from each other at 0.05 probability level; Ns- non-significant; *-significant at P < 0.05, **-significant at P<0.01 probability levels.*

Conclusions and Recommendations

Peach is one of the most important temperate fruits and has the next position after apple in popularity in Ethiopia. All peach varieties showed almost similar tree growth in all growing seasons except in 2006 and 2007. In all cropping season, the variety 88-18W showed less growth in height. From this study, McRed had highest relative growth rate followed by 88-18W while the least relative growth rate was observed on Tropic beauty. In general, varieties Tropic beauty and 90-19H exhibited higher trunk cross-sectional area. While in terms of canopy spread, varieties Tropic beauty, 90-19H, 88-18W and McRed were observed to have larger canopy.

Regarding with the fruit yield, marketable and total fruit yield of Tropic beauty was significantly higher than the other varieties in all years and followed by variety 90-19H. Even these two varieties have 45 and 32% total fruit yield advantage, in aforementioned list. Concerning the total fruit yield potential progress from first year to the last fruiting year; i.e., 2008-2015, varieties were expressed their relative maximum yield performance from 74.0% (variety Tropic beauty) to 88.6% (McRed). The highest average number of fruits per tree was obtained from variety 9A-35C followed by Tropic beauty while the least was obtained from 88-18W. As to the average fruit weight, varieties 88-18W produced the relatively large average fruit weight and followed by 90-19H and Tropic beauty while the least average fruit weight was obtained from 88-22C.

Variations of fruit quality parameters in terms of fruit diameter, total soluble solid, titratable acidity and ripening index were observed among the varieties. Regarding the fruit diameter, 88-18W and Tropic beauty were produced larger fruit size while variety McRed had the smallest fruit diameter. The TSS of peach fruits varied from 10.27 to 13.67 °Brix; however, varieties 9A-35C, 88-18W and Tropic beauty were had a relatively higher TSS. In case of TA content, our results indicate that varieties 88-18W, Tropic beauty and 90-19H were produced significantly higher TA content. With regard to ripening index, the higher ripening index was obtained from variety 90-19H followed by

88-18W while the lowest one was obtained from variety 88-18W depending on their TSS and TA values.

In general, this evaluation gives a clue for their performance at Holetta and similar conditions. However, still there is shortage of improved technologies to be adopted, limited genetic resources available at hand; crop load, irrigation, fertilizer, orchard management techniques, disease and insect pest control measures, and critical shortage of quality seedling supply should be given emphasis for future works.

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