AGROLAND: The Agricultural Sciences Journal
Vol. 10, No. 1 June (2023), 1 - 10
P-ISSN : 2407- 7585 & E-ISSN : 2407- 7593, Published by Tadulako University

Original Research **Open Access**

GROWTH, PHENOLOGICAL, YIELD AND YIELD COMPONENTS EVALUATION OF SWEET ORANGE (*Citrus sinensis* L.) CULTIVARS INRAYA AZEBO WOREDA OF SOUTHERN TIGRAY, ETHIOPIA

Wakuma Biratu[1], Haile Abebe[2], Mola Berhe[2], Kidane Tesfay[2], Haileslassie Gebremeskel[2] , Mulashu Tuemay[2], Haregua Feleke[2], Jhon Hardy Purba[3]

[1]Ethiopian Institute of Agricultural Research, Bako National Maize Research Center
[2]Ethiopian Institute of Agricultural Research Mehoni Agricultural Research Center
[3]Agrotechnology Study Program, Faculty of Agriculture, Universitas Panji Sakti, Bali-Indonesia

Correspondence author's: Jhon Hardy Purba
Email: jhonhardy@yahoo.com

Submit: 23 Februari 2022, Revised: 15 December 2022, Accepted: June 2023
DOI : https://doi.org/10.22487/agroland.v0i0.1206

ABSTRACT

Sweet orange (*Citrus sinensis L.*) is an important fruit produced and consumed worldwide and it's an excellent source of vitamin C. However, citrus industry in Ethiopia is at an infant stage; which is particularly due to shortage of improved and adapted cultivars and their distribution. Considering these, six sweet orange cultivars were evaluated to select adapted, high yielding and quality cultivar/s. Different growth, phenological, yield and yield component data were collected and analyzed using SAS. Days to maturity was also highly significantly ($p<0.01$)) affected by cultivars in 2017 cropping year. Fruit weight without rind (flesh weight) and juice weight were highly significantly ($p<0.05$) affected by cultivars in 2018 harvesting year. Marketable yield, unmarketable yield, and total yield tree^{-1} were significantly affected by cultivars in both 2017 and 2018 harvesting year. O. Valencia is late matured cultivars which took 1622 days from planting to first harvest. While, P.W.N. is early matured cultivars with average number of days of 1104 from planting to first harvest. In 2017, Hamlin, gave the highest marketable fruit yield tree^{-1} (68.61 kg) and total yield tree^{-1} (68.94kg). Jaffa gave significantly the maximum marketable fruit yield tree^{-1} (197.24 kg) and total yield tree^{-1} (198.81 kg) in 2018 cropping year. In 2019 harvesting year, Hamlin gave the highest marketable (63.3 kg) and total (64.02 kg) fruit yield tree^{-1}. In average Jaffa and Hamlin gave the maximum marketable fruit yield tree^{-1} from the three consecutive harvesting years with mean value of 95.38 kg and 72.24 kg respectively. So, in Raya Azebo, and other areas having similar agro-ecologies Jaffa and Hamlin cultivars are recommended. Further, studying the nutritional content and water requirements of these cultivars are suggested.

Keywords*:* Flesh weight, Juice content, Marketable fruit, Unmarketable fruit, Yield

INTRODUCTION

The genus *Citrus* (*Citrus* spp.) belong to the angiosperm of the Rutaceae family, which is widely produced and consumed worldwide. Citrus is native to Southeastern Asia, having been known in China more than 4,000 years ago (Sauls, 2008) and now produced worldwide. Citrus produced in arid, semi-arid, and even humid regions need supplemental irrigation to enhance their fruit yield (Smajstrla and Haman, 1996). Citrus is one of the most important economic tree fruit crops and include oranges, lemons, limes, tangerines and grapefruit (Davies and Albrigo, 1994; Timmer et al., 2003; Manner et al., 2006). Citrus fruits in all the shapes, sizes, and colors are attractive, fragrant, and appetizing with high nutritional values (Nawaz *et al.* 2008).

Although, citrus fruits are native to Southeast Asia (Indonesia and China), but now extensively grown almost throughout the world under tropical and sub-tropical conditions where the soil and climatic regimes are favorable for its growth and yield (Shah, 2004). Sweet orange (*Citrus sinensis* L.) is one of fruits under category of citrus and an important fruit consumed all over the world as an excellent source of vitamin C, a powerful natural antioxidant that builds the body immune system (Nawaz *et al.* 2008). It also contains and important phytochemicals like liminoids, synephrine, hesperidin flavonoid, polyphenols, pectin, and sufficient amount of folacin, calcium, potassium, thiamine, niacin and magnesium are also present (Tripoli *et al*,2007; Nawaz *et al.* 2008).

In Ethiopia, citrus is one of the most economically important fruit crops grown by smallholders and commercial farmers (Seifu, 2003; Kassahun *et al*., 2006; Mohammed, 2007). So, it plays an important role in the national food and nutrition security. They can be used as raw materials for local agro- industries, save hard currency by substituting imports, and earn foreign currency by exporting fresh and processed citrus products. The development of the citrus industry also creates job opportunity (Asmare and Derbew, 2013). The country has millions of hectares of potential land for production of citrus fruits

The total area coverage and annual production of citrus fruits were estimated 5,165 ha and 38,487 tons for small-scale farms (CSA, 2018); while 2,503 ha and 33,127 tons for large-scale farms (CSA, 2015), respectively. The national average yields of citrus were estimated 6.8 t/ha for small-scale farms (CSA, 2018) and 10.5 t/ha for large- scale plantations (CSA, 2015). Large portion of citrus fruits produced are consumed locally as fresh fruit, juice and marmalade (Seifu, 2003). Some citrus fruits such as sweet orange and lime are exported to Djibouti, Europe andthe Middle East (Joosten et al., 2011).

Despite its importance, citrus productionin Ethiopia is still at its infancy, and the national average yields of citrus fruits are far less than other citrus producing countries of the world (more than 20 t/ha) (FAO, 2017). This may be attributed to shortage of improved sweet orange varieties, lack of government and/or non-government sweet orange seedling producing organs, poor extension works, disease and insect pest problems, and less attention by the government as compared to other cereal crops.

In Ethiopia, some sweet orange cultivars were evaluated at Melkassa Agricultural Research Center and registered. However, their performance may be varying with location, season and management practice like the other crops. So far, there was no study done on Sweet orange at around Raya Valley where the fruit is highly consumed and the agro-ecology favors the production of the fruit. As may the productivity of Sweet orange cultivars not consistent across the location and season, it is important to study and identify cultivar/s capable of producing high yield with goodquality.

Objective

- To evaluate the growth, yield and yield attributes of sweet orange in

Raya Azebo District of Southern Tigray Zone.

- To identify high yielding cultivar/s forfuture production

RESEARCH METHODS

Description of Study Area.

An experiment was conducted at Mehoni Agricultural Research Center (MhARC) Fachagama testing site in the Raya Azebo Woreda, Southern zone of Tigray Region, Northern Ethiopia. It is located at 668 Km from the capital Addis Abeba. Geographically, the experimental site is located at 12° 41'50" North latitude and 39° 42'08" East longitude with an altitude of 1578 m.a.s.l. Data from the meteorological class of the center shows meanannual rainfall of 539.32 mm with an average minimum and maximum temperature of 12.81 and 23.24°C, respectively. The soil textural class of the experimental area was clay loam with pH of 7.9.

Experimental Material.

Propagated seedlings of six improvedsweet orange cultivars namely: P.W. N, O. Valencia, C.Valencia, Jaffa, P.A.S.O. and Hamlin were brought from Melkassa Agricultural Research Center, and planted on pre-prepared experimental area to test the growth and yield performance of the cultivars since July 2014.

Field Preparation, Experimental Design, Planting and Field Management.

Pits or holes (60cmx60cm) for planting was prepared at both intra and inter spacing of6m on two months before planting and the subsoil and top soil were kept separately. six plants plot^{-1} were considered. A well decomposed manure with the top soil was mixed and fill back the prepared pits. Planting was done since August 2014 on well prepared hole as per the recommended agronomic practice. A completely randomized block designs (RCBD) was used for the experiment and each cultivar was replicated three times. Seedlings were planted at spacing of 6*6 (1 seedling = 36m^2) and on the net plot area 6*6*4 (144m^2) and experimental area of 144*3*6(2592m^2). Then, all the necessary agronomic practices like, irrigating, cultivation, insecticide spray, weeding and harvesting were done at standard time. Special fruit orchard management practices like training at the early stage of tree growth and pruning was undertaken.

Data Collected

Growth, developmental and yield related data were collected as listed as follows beginning from 2016:

Tree Height: Plant height was measured from each plants from the soil surface to the top most growth points of plant part at first harvest. At the later, the average of all the treewere taken for analysis

Average Canopy Diameter: It was measured from each plant on the plots both north to south and east to west direction and the average of the plants and measured direction be taken.

Fruit Diameter and length (cm): The diameter and length of randomly sampled five Sweet Orange fruits were measured using Caliper on the second harvesting cycle. These parameter were also taken plant based.

Average Fruit Weight (Kg): This indicate weight of a single fruit at harvest. This data was taken from eight representative Sweet Orange fruits and then divided for eight.

Fruit Flesh Eight (Kg): Also, it was weight ofsingle fruit without rind (Weight without rind in Kg). Similarly, this data was taken from eight representative Sweet Orange fruits by removing the rind from each fruit and then divided for eight.

Average Juice Weight (gm): Juice of ten representative Sweet Orange fruits were extracted and measured using Cylinder

Marketable Yield: Marketable yield was yield taken per tree at the time the fruits developed yellowish to full yellow color

as illustrated on (Figure 1). At this stage, yellowish to yellow colored fruits were pickedand acceptable size, healthy, free of insect infestation and un injured fruits were selected and weighed using Hanging balance.

Unmarketable Yield: These were undersizedand damaged fruits.

Total fruit yield (kg): Is summation of marketable and unmarketable fruit fruits.

Figure 1. Sweet Orange performance and appropriate stage for harvesting c

Data Analysis

Collected data were subjected to analysis of variance (ANOVA) following a procedure appropriate to a randomized complete block design. LSD was used for comparison of means at *P<0.05.*

RESULTS AND DISCUSSION

Plant Growth Characters

Plant height and Canopy diameter

In both 2017 and 2018, plant height was significantly (*p<0.05*) affected by sweet orange cultivars (Table 2). In 2017 Jaffa gave the highest plant height (3.27m); however, it is significantly different from only O. Valencia and P.W.N. cultivars. P.A.S.O gave the maximum plant height (3.73m) which is significantly similar with the rest all cultivars except O. Valencia which gave the lowest plant height (Table 1). The average of two years data indicated that Jaffa gave the tallest (3.48m) plant height, while, P.W.N. gave the shortest (Table 1). In agreement with this Khan *et al*. (2015) revealed significant differences among the means of sweet orange cultivars. Whereby Mineola gave the tallest plant heightwhile Moro attained minimum height.

The variation plant height among cultivars might be due to the genetic potential of the cultivars on apical dominance and growth. Canopy spread was not significantly ($p \geq 0.05$) affected by sweet orange cultivars in both 2017 and 2018 cropping year (Table 2).

Phenological Characters Days to Frist Harvest

Days to first harvest (maturity) from planting was significantly (*p<0.05*) affected by sweet orange cultivars (Table 2). Whereby O. Valencia cultivar was matured late with average number of days to first harvest of 1622.06. Whereas the rest cultivars were significantly similar and considered as early matured one (Table 1). This phenological character is highly influenced by the genetic constituent of the cultivar.

Yield and Yield Related Parameters Single Fruit Weight

An average of single fruit weight was significantly affected by sweet orange cultivars in all 2017, 2018 and 2019 harvesting years regardless of the degree of significance level (Table 4). In 2017, Hamlin gave significantly the highest (0.49 kg) average single fruit weight; while the rest cultivars were statistically similar and considered as the lowest. In 2018, Jaffa gave significantly the maximum single fruit weight (0.0.56 kg); whereas the lowest single fruit weight (0.12 kg) was recoded on Hamlin cultivar which is statistically similar with P.A.S.O. cultivar. The highest average single fruit weight was observed on P.W.N. (0.27kg) which is significantly at par with C. Valencia and P.A.S.O. cultivars. The average single fruityield obtained from the consecutive three years indicated that the maximum average single fruit weight

(0.36 kg) was recorded on Jaffa cultivar (Table 3). Nawaz *et al. (2012)* found the significance difference among sweet orange cultivars on fruit weight whereby the maximum average fruit weight (218.2 g) was observed in Salustiana, followed by Blood Red, Hamlin, Pineapple, Valencia Late, Musambi and Succari. Also, Ishfaq *et al*. (1999); Mohar *et al*. (2011) and Khan *et al*. (2015) reported the maximum fruit weight on Blood red followed by Jaffa. This indicated that the average fruit weight which is chiefly influenced by the fruit size and juice content of the fruit is differed throughout the harvesting year. This indicated that the fruit weight is greatly affected by not only the cultivars but also the production year.

Table 1. Mean of Growth and Phenological characters of Sweet Orange Cultivars.

Cultivars	PH (m)			CS (m)			DM
	Years		Mean	Years		Mean	2017
	2017	2018		2017	2018		
O. Valencia	2.87^{b}	3.20^{b}	3.03	3.44	3.22	3.33	1622.06^{a}
C. Valencia	3.14^{a}	3.65^{ab}	3.40	3.46	3.64	3.56	1120.05^{b}
Jaffa	3.27^{a}	3.70^{a}	3.48	3.45	3.74	3.59	1119.16^{b}
Hamlin	3.23^{a}	3.60^{ab}	3.42	3.20	3.52	3.36	1116.00^{b}
P.A.S.O	3.09^{a}	3.73^{a}	3.41	3.19	3.23	3.21	1108..04^{b}
P.W.N.	2.74^{b}	3.27^{ab}	3.01	3.36	3.53	3.45	1104.01^{b}
Mean	3.06	3.52		3.35	3.48	3.42	1198.32
LSD $_{(0.05)}$	0.18	0.46		ns	ns		201.649

PH = Plant height, CS = Canopy spread, DM = Days to maturity
Means within columns for each variable followed by different letters are statistically different at($p < 0.05$), Least significant difference at 5%.

Marketable, Unmarketable and Total Yield Tree^{-1}

The result indicated that there is the significant difference ($p<0.05$) among sweet orange cultivars on marketable and total fruit yield tree^{-1} in 2017 harvesting year. Also, cultivars exerted highly significant difference ($p<0.01$) on marketable and total fruit yield tree^{-1} in 2018 and 2019 harvesting Year (Table 4). The maximum marketable (68.61 kg) and total fruit yield tree^{-1} (68.94 kg) were recorded on Hamlin cultivar in 2017 harvesting year; however, it was not significantly different from P.A.S.O, O. Valencia, and C. Valencia on both yield components. P.W.N. gave the lowest marketable and total fruit yield tree^{-1} in both 2017 and 2018 cropping year. In 2018 cropping season, Jaffa gave the maximum marketable (197.24 kg) and total fruit yield tree^{-1} (198.81 kg). In 2019 harvesting year, Hamlin gave the highest marketable (63.3 kg) and total (64.02 kg) fruit yield tree^{-1} which is significantly the same with O.Valencia, C. Valencia, and Jaffa cultivars. P.A.S.O and P.W.N. cultivar gave significantly the lowest marketable and total fruit yield tree^{-1} (Table 3).

The average yield obtained throughout the three consecutive harvesting years (2017,2018 and 2019) indicated that Jaffa and Hamlin cultivar gave the highest marketable fruit weight plant^{-1} with average yield of 95.38 kg and 72.24 kg respectively. In 2017, P.W.N. gave significantly the maximum unmarketable fruit yield tree^{-1} (2.10 kg); whereas, Hamlin gave the highest unmarketable yield tree^{-1} (1.75 kg) in 2018 cropping year (Table 3). In line with finding, Chahal and Gill (2015) reported as the yield efficiency was affected by

different sweet orange varieties whereby Hamlin recorded highest yield efficiency followed by Trovita and Rhode Red. In 2019 cropping year, the yield recorded was lower ascompared to yield obtained in 2017 and 2018, which is due to serious theft problem and heavy pruning done to reduce the infestation of leaf miner and cottony cushion scales insect pest.

The highest marketable and total fruit yield tree^{-1} might be attributed to the large number of fruit number tree^{-1} and larger fruit size. Yearly, cultivars were not performed consistently which might be attributed to the alternate and biennial bearing habit of the cultivars. The highest unmarketable yield tree^{-1} obtained might be attributed to heavy insect infestation and smaller fruit size.

Fruit Quality

Fruit Diameter and Length

Regardless of the level of significance difference fruit diameter and length were significantly (*p<0.05*) influenced by sweet orange cultivars (Table 6). The maximum fruitlength (8.37 cm) was recorded on P.W.N. cultivar which is significantly the same with C. Valencia and O. Valencia. P.W.N. also gave the highest fruit length (7.25 cm) in 2018 harvesting year which is statistically at par with O. Valencia. However, P.A.S.O. and Hamlin gave significantly the same fruit length which considered as the lowest fruit length in this cropping year. In 2019 harvesting year, C. Valencia gave the maximum (7.74 cm) fruit length. The average fruit length obtained from the consecutive three years harvesting indicated that P.W.N. gave the highest (7.46 cm) fruit length (Table 5).

P.W.N. cultivar gave the highest fruit diameter in 2017 and 2018 year with respective average fruit diameter of 7.96 cm and 7.03 cm respectively. But P.W.N.is significantly the same with C. Valencia in 2017 and C. Valencia and O Valencia in 2018. In 2019, C. Valencia gave the widest (7.73 cm) fruit diameter which is statistically the same with O. Valencia and Jaffa cultivars. The mean value of the three consecutive harvesting years showed that P.W.N. gave the maximum fruit diameter (Table 5). Khan *et al*. (2015) reported that the presence of significance difference on fruit diameter among sweet orange cultivars. Similarly, Khan *et al*. (2010) reported Tarocco-N and Salustiana better fruit size. From the result, fruit size is highly influenced by cropping year and genetic constituents of the cultivars.

Flesh Weight and Juice Content

Flesh weight (weight without rind) was not significantly ($p \geq 0.05$) affected by sweet orange cultivars in 2017 but in 2018 and 2019 harvesting years (Table.6.). In both 2018 and 2019, the maximum flesh weight was recorded from P.W.N. cultivar which is significantly the same with C. Valencia and O. Valencia cultivars in 2018 and with P.A.S.O. and C. Valencia in 2 019 cropping year (Table 5).

Table 2. Mean square of Growth and phenological characters of Sweet Orange Cultivars

Source of Variation	DF	PH		CS		DM
		Years		Years		Year
		2017	2018	2017	2018	2017
Replication	2	0.17	0.17507	0.1307	0.04895	1407.4
Cultivars	5	0.13**	0.15709	0.0493	0.13750	129526
Error	10	0.01	0.06307	0.3478	0.08178	12286
CV (%)		3.2	7.1	17.6	8.2	9.2

ns= non significant, *=significant, **= highly significant at P<0.05, CV = Coefficient of Variation

Table 3. Mean of Growth and Phenological Characters of Sweet Orange Cultivars.

Cultivars	MFWtPP				UMFWtPP				TY (kg)				FWt (kg)			Mean
	Years			Mean	Years			Mean	Years			Mean	Years			
	2017	2018	2019		2017	2018	2019		2017	2018	2019		2017	2018	2019	
O.Valencia	56.27^{ab}	17.37 ^{d}	52.46^{a}	42.03	1.17^{b}	0.66^{d}	0.270^{b}	0.7	57.43^{ab}	18.04^{d}	52.73^{a}	42.73	0.26^{b}	0.16^{c}	0.19^{bc}	0.20
C. Valencia	50.77^{abc}	9.49 ^{d}	53.37^{a}	37.87	0.56^{c}	0.71^{d}	0.32^{b}	0.53	51.33^{abc}	10.20^{d}	53.68^{a}	38.40	0.29^{b}	0.17b^{c}	0.22^{ab}	0.23
Jaffa	38.87^{bc}	197.24^{a}	50.03^{a}	95.38	0.23^{c}	1.24^{b}	0.26^{b}	0.577	39.10^{bc}	198.81^{a}	50.3^{a}	96.07	0.28^{b}	0.56^{a}	0.20b^{c}	0.34
Hamlin	68.61^{a}	84.81^{b}	63.3^{a}	72.24	0.33^{c}	1.75^{a}	0.72^{a}	0.93	68.94^{a}	86.56^{b}	64.02^{a}	73.17	0.49^{a}	0.12^{d}	0.17^{c}	0.26
P.A.S.O	57.60^{ab}	91.22^{b}	15.5^{b}	54.77	1.40^{b}	1.06^{bc}	0.27^{b}	0.91	59.00^{ab}	92.28^{b}	15.77^{b}	55.68	0.25^{b}	0.14^{cd}	0.22^{abc}	0.20
P.W.N.	30.41^{c}	53.67^{c}	16.97^{b}	33.68	2.10^{a}	0.87^{cd}	0.29^{b}	1.08	32.51^{c}	54.53^{c}	17.26^{b}	34.76	0.32^{b}	0.20^{b}	0.27^{a}	0.26
Mean	50.42	75.63	41.94	55.99	0.97	1.05	0.35	0.79	51.39	76.74	42.3	56.81	0.32	0.22	0.21	0.25
LSD $_{(0.05)}$	21.69	16.05	19.3		0.44	0.32	0.23		21.61	15.97	19.22		0.14	0.03	0.055	

MFWtPP = Marketable fruit weight plant^{-1}, UMFWtPP = Unmarketable fruit weight plant^{-1}, TY = Total Yield Means within columns for each variable followed by different letters are statistically different at ($p < 0.05$)

Table 4. Mean square of Growth and Phenological characters of Sweet Orange Cultivars.

Source of Variation	DF	MFWtPP			UMFWtPP			TY (kg)			FWt		
		Years			Years			Years			Mean		
		2017	2018	2019	2017	2018	2019	2017	2018	2019	2017	2018	2019
Replication	2	623.8	28.80	131.1	0.01	0.01	0.0445	621.5	27.75	131.4	0.003	0.001	0.001
Cultivars	5	570.4*	14020.08**	1251.4	1.57**	0.49**	0.097	546.0*	14163.55**	1263**	0.024*	0.083**	0.004*
Error	10	142.1	77.82	112.4	0.06	0.03	0.152	141.2	77.08	111.6	0.006	0.0004	0.001
CV (%)		23.6	11.7	25.3	25.3	16.6	34.8	23.1	11.4	25.0	24.6	8.4	14.4

ns= non significant, *=significant, **= highly significant at P<0.05.

Table 5. Mean of Growth and phenological characters of Sweet Orange Cultivars

Cultivars	FL			Mean	FD			Mean	FlWt			Mean	JWT		Mean
	Years				Years				Years				Years		
	2017	2018	2019		2017	2018	2019		2017	2018	2019		2018	2019	
O. Valencia	8.02^{a}	6.83^{ab}	7.37^{ab}	7.4	7.30^{b}	6.72^{ab}	7.40^{abc}	7.14	0.2	0.14^{ab}	0.16^{bc}	0.17	85.01^{a}	125.4^{ab}	105.2
C. Valencia	8.09^{a}	6.51^{bc}	7.74^{a}	7.44	7.50^{ab}	6.62^{abc}	7.73^{a}	7.13	0.20	0.14^{ab}	0.19^{ab}	0.17	88.71^{a}	141^{a}	114.8
Jaffa	7.21^{b}	6.15^{cd}	7.3^{ab}	6.89	6.98^{b}	6.26^{bcd}	7.41^{ab}	6.88	0.23	0.11^{bc}	0.16^{bc}	0.166	65.57^{b}	120.3^{abc}	92.9
Hamlin	6.95^{b}	5.81^{d}	6.58^{c}	6.44	7.19^{b}	5.86^{d}	6.71^{bc}	6.56	0.21	0.09^{c}	0.13^{c}	0.145	49.25^{b}	80.8^{d}	65.02
P.A.S.O	6.57^{b}	5.98^{d}	6.62^{c}	6.39	6.98^{b}	6.22^{cd}	6.94^{bc}	6.71	0.1	0.10^{c}	0.18^{abc}	0.15	54.68^{b}	107.2^{bc}	80.94
P.W.N.	8.37^{a}	7.25^{a}	6.76^{bc}	7.46	7.96^{a}	7.03^{a}	6.68^{c}	7.22	0.21	0.16^{a}	0.23^{a}	0.2	90.02^{a}	99.8^{cd}	94.91
Mean	7.54	6.42	7.07	7.01	7.32	6.45	7.14	6.97	0.21	0.12	0.17	0.17	72.21	112.41	92.31
LSD $_{(0.05)}$	0.730	0.53	0.714		0.629	0.48	0.717		ns	0.052	0.055		18.3	25.6	

FL= Fruit length, FD= Fruit diameter, FlWt = Flesh weight, JWT = Juice weight, Means within columns for each variable followed by different letters are statistically different at ($p < 0.05$).

Table 6. Mean square of Growth and phenological characters of Sweet Orange Cultivars.

Source of Variation	DF	FL			FD			FLWt			JWT	
		Years			Years			Years			Years	
		2017	2018	2019	2017	2018	2019	2017	2018	2019	2018	2019
Replication	2	0.08	0.08	0.001	0.06	0.04	0.06	0.005	0.0001	0.0006	55.40	142.60
Cultivars	5	1.58**	0.90**	0.693*	0.41*	0.52**	0.55*	0.00^{ns}	0.002**	0.0036*	979.40**	1343.90**
Error	10	0.16	0.08	0.154	0.12	0.07	0.16	0.003	0.0002	0.0009	101.30	198.0
CV (%)		5.3	4.5	5.6	4.7	4.1	5.5	24.8	11	17.5	13.9	12.5

ns= non significant, *=significant, **= highly significant at P<0.05

The average fruit juice weight obtained from sample of ten fruits was highly significantly ($p<0.01$) affected by sweet orange in 2018 and 2019 harvesting years (Table 6). In both 2018 the maximum juice weight (90.02 g) was recorded from P.W.N. cultivar which is significantly the same with C.Valencia and O. Valencia cultivars (Table 5).

C. Valencia which is significantly the same with O. Valencia and Jaffa gave the highest juice weight (141 g) which is significantly at par with O. Valencia and Jaffa cultivars. While the lowest juice weight was recorded from Hamlin cultivar which is significantly the same with P.W.N. In average C. Valencia also gave the highest juice weight (Table 5). In agreement with this finding, Chahal and Gill (2015) reported significantly the highest juice percentage on Olinda variety followed by Rhode Red. Similarly, Nawaz *et al. (2012)* revealed the significant difference on juice content percentage among sweet orange cultivars.

In general, yield components and fruit quality indicators are highly influenced by season of harvesting (production), cultivarsand pests.

CONCLUSION AND RECOMMENDATION

From this study, the result indicated that virtually all the growth, phenology and, yield and fruit quality were significantly affected by sweet orange cultivars. Not only the influence of cultivars on the above growth, phenological, yield and fruit quality, but also, season (year) of fruiting also affected these characters. Fromthe result**,** Jaffa and Hamlin gave the maximum marketable fruit yield tree^{-1} from the three consecutive harvesting years with average value of 95.38 kg and 72.24 kg respectively. Thus, in and around the study area as well as other areas having similar agro-ecologies Jaffa and Hamlin cultivars arerecommended.

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