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Comparative growth, quality and yield performance study of sweet orange genotypes under rainfed vertisol of Marathwada

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Abstract
Efforts are being made to diversify the citrus industry by induction of some suitable cultivars of sweet orange, being the best choice after Nucellar in Marathwada region. Investigations were carried out at the regional Sweet Orange Research Station, Badnapur of the Vasantrao Naik Marathwada Agricultural University, Parbhani on sweet orange genotypes for growth, quality and yield performance. The results were statistically significant for all the traits studied. The variety Nucellar found significantly superior in case of plant height, Number of branches plant spread and girth of stem while incase of number of fruits/tree, weight of fruit and fruit diameter variety Valencia late found significantly superior. Peel thickness found significantly minimum in Sathgudi. TSS, titrable acidity and reducing sugar found significantly maximum in Pera Orange and Katol gold and at par with Blood red in case of titrable acidity. The maximum juice perentage was found in Sathgudi followed by Blood Red. The number of seed per fruit found significantly minimum in Blood red and Jaffa. The pH found significantly superior in Nucellar and vitamin 'C' content was found significantly maximum in case of Blood red. The sugur acid ratio was recorded significantly maximum in Katol gold and at par with Pera Orange and Nucellar. The maximum juice percentage was found in Sathgudi followed by Blood Red. The yield per tree was found significantly maximum in variety Valancia Late and which was at par with Variety Nucellar and Jaffa.

Keywords: Sweet Orange, Genotypes, Growth, Quality, yield, Vit-C, Reducing sugar, TSS

Introduction
Citrus fruits are natives of Southeast Asia (Indonesia & China), but they are now extensively grown almost throughout the world under tropical and sub-tropical conditions, where the soil and climatic regimes are quite favorable for its growth (Shah, 2004) [17]. India occupies sixth position among citrus growing countries in the world.

Maximum productivity is obtained in USA (35.11 MT/ha), Spain (19.80 MT/ha) and Italy (17.76 MT/ha). In India, citrus ranks second in area with 0.71 million hectare and third in production with 9.0 million tonnes. Lime, Lemon, Sweet orange and Mandarin cover bulk of the area under citrus fruit. Citrus fruits are grown mainly in the states of Andhra Pradesh, Maharashtra, Karnataka, Punjab, Gujarat and N.E. region of India. Kinnow is cultivated commercially in some States of Northern India particularly Punjab, Rajasthan, Haryana and Uttaranchal. Cultivation of grapefruit and pummelo introduced decade back did not catch up commercially.

In India, sweet orange is grown commercially in the states of Maharshtra, Andhra Pradesh, Punjab and Rajasthan. Mosambi in Marathwada region of Maharashtra, Sathgudi in Andhra Pradesh and Malta in Punjab are the leading commercial varieties of sweet orange in India. Marathwada region is considered have an agro-climatic situation that is very congenial for cultivation of sweet orange on a commercial scale. Successful crop cultivation in a particular region depends on several factors including varietal specification. In Marathwada, no sufficient varietal trial on sweet orange has been done to find out the best performed varieties.

Marathwada region of Maharashtra is having largest share in production of Sweet Orange (*Citrus sinensis* L. Osbeck) with an annual production of more than 7.00 lakh tones of fruits. It has also been proved that, this region is highly suitable for the cultivation of Sweet Orange. Looking to geographical situation, available inputs, annual weather condition and higher technology adoption rate among the farmers in the Marathwada, the Government of Maharashtra has sanctioned full fledged Sweet Orange Research Station, at Badnapur on 27th Feb. 2006.

In Marathwada region districts like Jalna, Aurangabad, Parbhani and Nanded, the area under Sathgudi is considerably increasing day by day due to the good demand of fruits in different markets. The excellent natural sugar acid ratio of the juice in the fruits attracts the consumers. Hence there is good price in the market. The juice of the Sathgudi is of extra ordinary quality. The sugar acid blend is natural and very pleasant, which isvery much liked by the consumer (Patil *et al*., 2007) [15]. Hence it has become very necessary to study the feasibility and suitability for cultivation of this type in the region.

Keeping in view, the importance of sweet orange genotypes, present study was planned to ascertain the best performance and suitability of sweet orange genotypes under rain fed vertisol to diversify the citrus industry of Marathwada.

Materials and Methods

The present experiment was conducted at the field of Sweet orange research station Badnapur during the years 2015-16. The experiment consisted of nine varieties Viz. Washington Naval, Valancia Late, Hamline, Jaffa, Blood Red, Pera Orange, Katol Gold, Nucellar and Sathgudi as treatments replicated for three times under randomized block design consisting of three plants of each variety. The field consisted of nine genotypes planted in year 2011-12 at the spacing of 6 x 6 m. Totals twenty seven plants were selected for investigation. Observations on growth, fruit yield and physio-chemical parameters were recorded as per standard specifications. The fruits of Mrug bahar from each tree were selected to study in detail the physical and chemical composition of sweet orange genotypes. Following observations were recorded during the course of investigation viz, height of plant, spread of plant, girth of stem, number of fruits per tree, weight of fruits, fruit diameter, yield of the tree, peel thickness, pH, acidity, juice percent, number of seeds per fruit, reducing sugar, sugar acid ratio, T.S.S. and ascorbic acid.

The vegetative behavior of the experimental trees was assessed by recording height of the plants that was measured by telescopic pole. It was measured from soil level to highest top branch of the tree. To measure the spread of the tree, two observations were taken from East to West and North to South at right angle with the help of measuring tape in a cross section up to the maximum out growth of the plant in each direction and average spread was calculated. Stem girth was measured by a measuring tape, just above the rootstock and scion joint. Fruit weight and total number of fruits per plant (yield) were recorded by weighing and counting total number of fruits per tree atthe time of harvest. Fruit diameter was measured by measuring the 10 fruits per cultivar with the help of digital verneir caliber and average fruit diameter was calculated (Nawaz *et al*., 2008) [13]. Average fruit weight was calculated by weighing ten fruits per tree on digital electric balance and average was calculated at the time of harvest. To determine number of seeds per fruit, ten fruits was taken as a sample from each tree of the respective cultivar, fruits were circumcised and the seeds were extracted, counted and average number of seeds per fruit was calculated. Peel thickness for every fruit was measured in millimeters by using vernier caliber for selected ten fruits from each treatment and then average peel thickness was calculated.

Sampling

Mature Mrug bahar fruits were collected because it contains absolute proportion of nutrients (Riaz *et al*., 2015) [12] in the month of February 2016. Fruit samples were collected in polythene bags early in the morning and transported for analysis to laboratory of department of Horticulture, VNMKV, Parbhani. Samples were processed within five hours after receiving laboratory.

Processing

Fruits were washed with distilled water to remove dust particles. There after juice was extracted with the help of fruit juice extractor for physio-chemical analysis i.e. percent juice content (%), total soluble solids (T.S.S.), pH, percent acidity, reducing sugar, vitamin C content and sugar : acid ratio of all collected sweet orange fruit samples.

Determination of fruit juice content (%)

The juice content were weighed and recorded in grams by using methods given by Lacey *et al*., 2009 [10] and Grewal *et al*., 2000 [9]. The percent juice content was calculated by using the following formula.

$$\% \text{ juice content} = \frac{\text{Juice weight}}{\text{Fruit weight}} \times 100$$

Determination of pH

The juice pH for each sample was determined by using calibrated pH meter.

A. O.A. C. (1985) [1].

Determination of Acidity

Acidity of juices was determined by acid base titration given by Lacey *et al*., (2009) [10].

Percentage acid = titration value x acid factor x 10/10 (ml juice) Factor for citric acid = 0.0064 (citrus fruits)

Determination of Sugar: Acid ratio

To determine the sugar / acid ratio you need to divide the sugar concentration (°Brix) by the citric acid concentration.

Determination of Total soluble solids

Total soluble solids of fruit juicew ere determined as *Brix by using Refractometer (A.O.A.C. 1985) [1]

Determination of Reducing sugar

The reducing sugar was estimated by using Benedict's chemical estimation method (Sethi, 2003).

Determination of Vitamin C

Vitamin C content in fruit juice was determined by iodine titration. (A.O.A.C.1985) [1].

Statistical Analysis

The response of experimental trees to different parameters studied was evaluated by statistical analysis of data using ANOVA technique with Randomized Block design given by Panse and Sukhatme, 1985 [14].

Results and Discussion

Performance and suitability of sweet orange genotypes were investigated for important growth, yield and quality traits in Marathwada region. The results showed statistically significant for all the traits studied.

Growth behavior

The data obtained from present investigation showed that the plant height (12.83 m), Number of branches (33.66), Plant spread (4.87, 4.73 m) and girth of stem (50 cm) found significantly maximum in variety Nucellar over rest all genotypes. The semi arid tracks of Marathwada region are highly suited for the cultivation of Nucellar. The results of present studies are coinside with those of Patil *et al*., 2007 [15]. Plant height is important vegetative characteristic of citrus trees, as there will be more height, there will be more number of branches and total number of leaves and the leaves serve as the food manufacturing factories of plant. Similarly stem girth, which is another important indicator of vegetative performance of plants.

Vegetative growth has a profound impact on the reproductive growth of citrus because citrus bears on current season growth emerging from one year old branches (Ahmed *et al.*, 2006) [2]. The reason of better performance of Nucellar and Valancia Late might be due to their better compatibility with soil and environmental conditions and better absorption of the various nutrients from the soil, as the optimum concentration of the nutrients in plant body is much more important for proper growth and development of plants (Malik, 1994) [11]. Nutrients affect the photosynthetic rate, production of carbohydrates and proteins, which in turn control plant growth and development (Taiz & Zeiger, 2002) [18].

Yield and yield components

The yield data obtained from studies showed that the number of fruits per tree were significantly maximum in genotype Valancia Late (565). Weight of fruit (gm) was recorded significantly higher with Valancia Late and Blood Red (285.67 gm). The significantly maximum fruit diameter was recorded with genotype Valancia Late (30.76). The fruit yield per tree was found significantly maximum with genotype Valancia Late. The findings of present studies are in agreement with those of Frost and Cameron (1951) [7], Aziz (1963) [6] and Patil *et al*., 2007 [15]. The results for number of fruits per plant indicated significant differences among cultivars. Our findings were found to be in close consonance with that of Augusti *et al*. (2002) [5].

Fruit quality characters

Citrus fruit are important source of some essential dietary micronutrients. The quality of citrus can be evaluated on the basis of commonly used and accepted worldwide indicators of fruit quality i.e., TSS, acidity, Sugar: Acid ratio, juice contents and Reducing sugar contents. Different physiochemical characters were evaluated i.e., juice contents, TSS, acidity, Sugar; Acid ratio, pH, ascorbic acid contents and Reducing sugars.

Among the fruit quality traits, peel thickness found significantly less in genotype Sathgudi over rest all genotypes. Peel thickness of citrus fruit is also important fruit quality parameters and in citrus cultivars it varies from cultivar to cultivar. The results for peel thickness depicted significant differences among various cultivars of sweet oranges.

TSS and reducing sugar found significantly maximum in Pera orange and Katol Gold over rest all genotypes. Total soluble solids (TSS) are an important measure of the sugar contents of the fruits as sugars constitute approximately 85% of the soluble solids in citrus fruits (sweet oranges & mandarins) (Wardowski *et al*., 1979) [19]. Significant differences of TSS were observed among various sweet orange cultivars. In sweet orange, it is observed that sugar level increased with fruit maturity. Such increase has been attributed to concurrent increase in the sucrose content which is then hydrolyzed to simple sugars that affect both the taste and the texture of the fruits and rise in the sugar makes the fruit much better (Riaz *et al*., 2015) [12].

In case of Titrable acidity, Valancia Late was recorded with significantly lowest value over rest of all. The data pertaining to acidity showed significant effect of cultivars on acidity. Titrable acidity in sweet orange fruits is one of the quality traits. In sweet orange genotypes, fruit quality will be better if acidity is on lower side. In most cases, it is present in excess of total titrable acidity of fruits (Riaz *et al*., 2015) [12].

The number of seeds per fruit was found significantly lowest in genotype Blood Red and Jaffa. Generally citrus fruits with less number of seeds per fruit are processed,

because most efficient processing machines fail to extract juice from highly seeded citrus fruits. Processing machines separate seed core from fruits, but even then, some seeds are crushed in juice that requires de-bittering, which is a costly process and makes the juice expensive (Anwar & Ibrahim, 2004) [3]. Internationally, the citrus fruits having less than five seeds per fruit are considered seedless, if we follow these criteria then out of nine sweet orange cultivars tested five cultivars (Blood Red, Jaffa, Valancia late, Pera Orange and Nucellar) were seedless in present study.

The Nucellar genotype found significantly superior in case of pH. The pH of sweet orange juices provides the information about the state of acidity and basicity. The findings are in line with the findings of Anwar *et al*., (1999) [4].

In case of Vit- C content, Blood Red recorded with highest amount of Vit-C content. Vitamin C is highly bioavailability and therefore the most important water- soluble antioxidant in cells and efficient scavenger of reactive oxygen species. The slightly higher values in the literature may due to the genotype, environmental conditions or analytical methods used. These findings are in agreement with Frost and Cameron (1951) [7].

The Sugar: Acid ratio was recorded significantly maximum in Katol Gold and at par with Pera Orange and Nucellar. The sugar-acid ratio contributes to the unique flavour of citrus. At the beginning of the ripening process the sugar-acid ratio is low, because of low sugar content and high fruit acid content this makes the fruit taste sour. During the ripening process the fruit acids are degraded, the sugar content increases and the sugar acid ratio achieves a higher value. (http://www.agric.wa.gov.au/PC_93298.html).

The maximum juice perentage was found in Sathgudi followed by Blood Red. Juice percentage in the citrus fruit is considered to be very important. The ultimate demand of customer is higher juice percentage in the fruit. Results regarding the juice percentage revealed significant differences among different cultivars. These findings of juice content are in agreement with Anwar *et al*., (1999) [4].

Table 1: Comparative growth and yield performance of sweet orange genotypes

Treatment	Height of plant (m)	No. of Branches	Plant spread (m)		Girth of Stem (cm)	No. of fruits / tree	Weight of fruit (g)	Fruit Diameter (cm)	Fruit yield (kg) / tree
			E-W	N-S					
T1	12.13	32.00	3.33	3.48	44.33	468.33	215.33	22.73	100.75
T2	11.83	25.33	3.48	3.23	42.66	565.00	285.67	30.76	162.25
T3	10.40	25.66	3.95	3.55	44.00	471.66	236.00	24.20	111.31
T4	12.00	26.66	3.27	3.48	41.33	511.66	252.67	21.03	129.21
T5	10.83	26.66	3.68	3.72	47.43	383.33	285.67	24.95	108.93
T6	11.16	31.00	3.15	3.35	44.66	416.66	238.00	23.86	99.15
T7	11.50	29.00	4.58	3.57	47.26	418.33	193.33	21.10	80.90
T8	12.83	33.66	4.87	4.73	50.00	523.33	259.67	23.26	135.80
T9	10.50	25.00	3.02	2.93	37.66	325.00	196.00	21.23	63.68
SE ±	0.489	0.855	0.04	0.04	1.731	38.683	3.98	0.232	11.64
CD at 5 %	1.478	2.586	0.13	0.13	5.234	116.97	12.02	0.70	35.19

Table 2: Evaluation of quality parameters of Sweet Orange genotypes

Treatment	Peel thickness (mm)	TSS (Brix *)	No. of seeds / fruit	pH	Titrable Acidity (%)	Sugar : Acid Ratio	Reducing sugar %	Vit 'C' mg/ 100 g	Juice percentage (%)
T1	5.30	10.00	11.00	2.99	1.34	7.44	4.87	52.80	36.77
T2	6.98	9.23	4.66	2.86	1.25	7.40	4.70	53.73	38.78
T3	6.46	9.03	6.00	2.80	1.34	6.73	4.53	52.63	37.21
T4	6.78	10.13	1.33	2.75	1.40	7.25	5.00	53.60	36.90
T5	7.31	10.03	1.33	2.92	1.46	6.87	4.93	58.76	39.29
T6	4.77	11.86	2.66	2.71	1.50	7.88	5.17	52.93	35.51
T7	4.76	12.10	7.66	3.02	1.50	8.05	5.17	52.40	36.69
T8	5.15	10.16	3.66	3.30	1.32	7.68	4.87	51.22	38.29
T9	3.58	9.10	10.33	3.17	1.28	7.11	4.53	51.70	39.77
SE ±	0.018	0.112	0.539	0.017	0.021	0.136	0.05	0.35	0.18
CD at 5 %	0.055	0.339	1.629	0.051	0.063	0.41	0.16	1.06	0.55

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