ISSN (Online): 2091-2609
DOI Prefix: 10.3126/ijasbt
International Journal of Applied Sciences and Biotechnology (IJASBT)

Research Article

Performance of Exotic Sweet Orange Genotypes at Dhankuta, Nepal

Amar Bahadur Pun[1]*, Manish Kumar Thakur[2]
[1]Nepal Agricultural Research Council (NARC), Agricultural Research Station, Pakhribas, Dhankuta, Nepal
[2]NARC, Regional Agricultural Research Station, Tarahara, Nepal

Abstract
The study was conducted to evaluate the varietal performance of sweet orange genotypes at National Citrus Research Program, Dhankuta, Nepal during 2015. Twenty exotic as well as local genotypes planted in 2005 were evaluated for their fruit physio-chemical characteristics at their 10-years aged. Three genotypes: Malta Blood Red, Dhankuta Local and Valencia Late have resulted as superior genotypes for fruit yield characteristics. Some genotypes Delicious Seedless, Salustiana and Hamlin also exhibited excellent performance for their fruit size and weight; however these genotypes produced lower fruit number per plant. Pineapple, Meisheu-9, and Washington Navel had higher TSS. There was similar fruit maturity period commenced from 14 November to 28 December among the genotypes. Based on the results, the genotypes showing distinct characteristics of fruit yield and quality including fruit maturity period should be promoted to make variety diversity in Nepal.

Keywords: Genotypes; diversity; characteristics; quality; evaluation; sweet orange

Introduction
Sweet orange (*Citrus sinensis* Osbeck) is the high-value fruit crop in the global trade that world production was estimated at 47.8 million metric tons in 2016/17 (USDA, 2018; Grace et al, 2012). It occupies the second position after mandarin in production value among citrus fruits in Nepal (NCRP, 2017; NCDP, 2016; AEC, 2014). The annual production of fresh sweet orange was estimated at 33, 558 t under 5131 ha with 9.7 t/ha productivity in 2016/17 (MoAD, 2016). Nepal has a huge potential of growing sweet orange for area expansion with appropriate varieties. As of now, the cultivars adopted in Nepal are of local origin and exotic varieties have not been adopted. The existing local cultivars have excellent fruit qualities including physio-chemical properties (NCRP, 2016). Nevertheless, nearly all existing cultivars have similar fruit maturity period that the domestic harvesting of the existing local cultivars coincides for three months from November to January. So, Nepal has to import fresh fruit beyond this period (GoN, 2011). Thus, the citrus industry needs diverse varieties having dissimilar fruit maturating traits for expanding the fruit harvesting period. In this context, evaluation and selection of exotic including local genotypes has been underway for few years to put forth varietal diversity.

Materials and Methods
The study on the varietal evaluation of sweet orange including 20 exotics as well as local genotypes has been underway at National Citrus Research Program (NCRP),

Cite this article as:
A.B. Pun and M.K. Thakur (2018) Int. J. Appl. Sci. Biotechnol. Vol 6(4): 308-312. DOI: 10.3126/ijasbt.v6i4.16023

[1]*Corresponding author
Amar Bahadur Pun,
Nepal Agricultural Research Council (NARC), Agricultural Research Station, Pakhribas, Dhankuta, Nepal
Email: amarppun@gmail.com

Peer reviewed under authority of IJASBT

Dhankuta, Nepal since 2005. The genotypes were collected from different sources including INRA-CIRAD, France; ICAR, India and ICIMOD. The experiments were conducted following a randomized complete block design, with four replications, single plant per replication. The ten trees of each genotype grafted with trifoliate orange have been planted in one block with spacing of 4 m x 4 m. The recommended practices were adopted under rain-fed condition. The experimental site was located between 27°1' north latitude and 87°18' east longitudes with the elevation of 1250 m asl facing south-east aspect. The experimental site comprises sandy loam soil, receiving average annual rainfall at the range of 940-1350 mm. The observations on fruit physio-chemical characteristics were measured from the randomly selected four trees as replications of each genotype at their 10-years of age in 2015. The fruit diameter and fruit weight were measured from 10 fruits per 4 replications, using digital callipers and micro-balance respectively as mentioned in the citrus descriptor (IPGRI, 1999). Similarly, the weight of fruit pulp, juice weight and volume (Cantuarias-Avilés, 2010), TSS °Brix (Total Soluble Solid) and TA% (Titratable acidity) were measured from 10 fruits per 4 replications, respectively using refractor-meter and titrating 2 ml fruit juice with 0.1 M NaOH as mentioned by Hardy and Sanderson (2010). The data were analysed using GenStat and DMRT software.

Results and Discussion

Fruit Yield Characteristics

The results revealed that variation on the fruit yield characteristics: number of fruits, fruit diameter, fruit weight and fruit yield per plant were highly significant ($P < 0.001$) among the genotypes (Table 1). The 10-year old trees gave the average fruit number ranging from 5.50 to 67.00 fruits/plant. The genotype Malta Blood Red produced the significantly maximum number of fruits (67.00/plant) among the genotypes. The second highest fruit number was recorded at Dhankuta Local (53.75/plant) followed by Valencia Late (44.75/plant), which were at par. The least fruit number was observed at Meisheu-9 (5.50/plant). The intermediate fruit numbers were observed at Venelle (29.50/plant), White Taker (29.25/plant), Tamango (24.50/plant), Hamlin (24.00/plant), Shamauti (21.50/plant), Salustiana (21.50/plant), Succari (20.25/plant), Blood Red (19.00/plant), and Lue Gim Gong (18.25/plant), which were at par.

The fruit diameter was significantly varied ($P < 0.01$) among the genotypes, which was ranged from 52.80 to 92.44 mm (Table 1). The genotype Delicious Seedless had the significantly highest fruit diameter (92.44 mm) among the genotypes, while the least fruit diameter was observed at genotypes Tamango (52.80mm). The intermediate fruit diameter was statistically at par among other genotypes. The fruit weight was varied, ranging from 75.44 to 165.28 g among the genotypes. The genotypes: Salustiana, Hamlin, Succari, Lue Gim Gong, Shamauti and Skage Bananja had the excellent fruit weight, while Delicious Seedless, White Taker, and Tamanga had the lowest fruit weight among the genotypes. Genotype: Malta Blood Red produced the significantly highest fruit yield (9.49 kg/plant) followed by Dhankuta Local (6.47 kg/plant) and Valencia Late (5.14 Kg/plant). The genotype Meisheu-9 produced the least fruit yield (0.60 Kg/plant).

Table 1: Fruit yield characteristics of sweet orange genotypes evaluated at NCRP, Dhankuta, 2015

Genotypes	Number of fruits/plant	Fruit diameter (mm)	Fruit weight (g)	Fruit yield (Kg/plant)
1. Tamango	24.50 cd	52.80 c	94.19 fg	2.03 cdefg
2. Venelle	29.50 c	60.40 bc	109.42 ef	3.16 c
3. Malta Blood Red	67.00 a	64.50 bc	143.14 abcd	9.49 a
4. Shamauti	21.50 cde	63.65 bc	152.69 abc	3.19 c
5. Hamlin	24.00 cd	63.75 bc	164.99 a	2.46 cde
6. Skages Bananja	15.00 defgh	65.59 bc	154.49 abc	2.28 cdef
7. White Taker	29.25 c	53.16 bc	90.27 fg	3.34 c
8. Blood Red	19.00 cdefg	58.84 bc	111.10 ef	2.12 cdefg
9. Lane Late	11.25 efgh	65.72 bc	151.26 abc	0.82 efg
10. Delicious Seedless	12.50 defgh	92.44 a	75.44 g	1.70 cdefg
11. Caracara Navel	6.75 gh	57.97 bc	113.48 def	0.67 fg
12. Valencia Late	44.75 b	60.42 bc	114.85 def	5.14 b
13. Lue Gim Gong	18.25 cdefg	60.96 bc	160.48 abc	2.81 cd
14. Washington Navel	8.00 fgh	64.62 bc	133.62 bcde	1.17 defg
15. Salustiana	21.50 cde	69.76 b	165.28 a	2.32 cdef
16. Succari	20.25 cdef	69.63 b	162.77 ab	3.16 c
17. Pinepple	12.75 defgh	65.35 bc	135.84 abcde	2.44 cde
18. Meisheu-9	5.50 h	61.74 bc	113.39 def	0.60 g
19. Sevelle Common	10.25 efgh	67.37 bc	130.59 cde	1.26 defg
20. Dhankuta Local	53.75 b	69.08 b	141.98 abcd	6.47 b
F test	***	*	***	***
CV%	38.33	16.44	16.59	41.66
LSD (0.05)	12.35	14.91	30.77	1.67

Values are the means of four replications. Means in the column with different letters indicate significantly differences ($P \leq 0.05$); *** indicates very highly significant differences at $P \leq 0.001$ level; * indicates significant differences at $P \leq 0.05$ level.

Fruit Quality Characteristics

There was significant variation (P≤ 0.001) on the fruit pulp, juice weight and juice content among the genotypes (Table 2). The fruit pulp was ranged from 56.37 to 124.98 g. The genotype Shamauti has the highest fruit pulp (124.98 g/fruit) followed by Salustina (112.17 g/fruit), Lue Gim Gong (110.51 g/fruit), Hamlin (109.82 g/fruit) and Skages Bananja (109.72 g/fruit). The fruit juice weight was not widely varied that it ranged from 30.09 to 49.23 g/fruit. The juice content was observed at the range of 33.61 to 60.36% among the genotypes. The genotype Venelle was found to have the highest juice content (60.36%), while genotype Pineapple contained the least juice (33.62%). However, it was statistically at par among the most genotypes except few ones. Moreover, genotypes: Venelle, Tamango, Sevelle Common and Succari were found to have higher juice content among genotypes.

Fruit TSS, TA and TSS to TA ratio

The results revealed that there was highly significant variation on TSS, TA and TSS to TA ratio among the genotypes (Table 2). The significantly higher TSS was observed at Pineapple (11.18 °B), Meisheu-9 (11.16 °B) and Washington Navel (11.13 °B) compared to other genotypes. The least TSS content was observed at Hamlin (8.58 °B), Lue Gim Gong (8.63 °B), and Salustiana (9.28 °B). The Titratable Acidity (TA) was varied, ranging from 1.23% to 4.24%. The highest TA was observed at Caracara Navel (4.24%) followed by Venelle (4.08%) and Malta Blood Red (3.57%). The lowest TA was recorded with Succari (1.25%), corresponding the highest TSS to TA ratio (8.77).

Fruit Maturity

The fruit maturity period commenced from 14 November to 28 December among the genotypes that Tamango, Hamlin and Sevelle Common were found earlier for fruit maturity. Valencia Late, Lue Gim Gong, Blood red and Washington Navel were matured late among the genotypes that they became ready to harvest on 6 December onward. The results revealed that the maturity period among the genotypes was found very short (Fig. 1).

Table 2: Fruit physio-chemical properties of sweet orange genotypes evaluated at NCRP, Dhankuta, 2015

Genotypes	Pulp weight (g/fruit)		Juice weight (g/fruit)	Juice content (%)		TSS (°Brix)		TA (%)		TSS to TA ratio	
1. Tamango	56.37	h	31.02	55.86	a	10.13	defg	2.48	f	4.12	efg
2. Venelle	63.06	gh	37.77	60.36	a	10.50	cd	4.08	a	2.57	i
3. Malta Blood Red	92.72	bcde	41.31	45.96	bc	10.56	bcd	3.57	b	2.97	hi
4. Shamauti	124.98	a	43.96	35.18	def	10.00	defgh	2.60	ef	3.85	fgh
5. Hamlin	109.82	abc	41.61	37.89	cdef	8.58	k	1.48	ij	5.79	cd
6. Skages Bananja	109.72	abc	43.09	39.00	cdef	10.19	defg	1.51	ij	6.76	bc
7. White Taker	88.29	bcdef	34.16	38.03	cdef	9.72	fghij	3.10	c	3.14	ghi
8. Blood Red	66.97	fgh	30.93	46.21	bc	10.00	defgh	1.50	ij	6.68	bc
9. Lane Late	98.59	bcd	34.11	34.51	ef	9.63	ghij	2.62	def	3.70	fgh
10. Delicious Seedless	92.02	bcde	37.62	44.66	bc	10.25	def	2.17	g	5.02	de
11. Caracara Navel	74.34	efgh	32.60	43.93	bcd	10.88	abc	4.24	a	2.56	i
12. Valencia Late	87.02	cdef	34.13	38.85	cdef	9.50	hij	2.91	cd	3.27	ghi
13. Lue Gim Gong	110.51	abc	38.16	35.10	def	8.63	k	2.80	cde	3.10	hi
14. Washington Navel	106.24	abcd	43.38	40.70	cdef	11.13	ab	1.68	hi	6.78	b
15. Salustiana	112.17	ab	49.01	43.05	cde	9.28	j	1.90	gh	4.94	de
16. Succari	94.26	bcde	49.23	52.38	ab	10.44	cde	1.23	j	8.77	a
17. Pineapple	91.39	bcde	30.64	33.61	f	11.18	a	2.50	ef	4.52	ef
18. Meisheu-9	67.11	fgh	30.09	44.74	bc	11.16	a	2.98	c	3.75	fgh
19. Sevelle Common	84.28	defg	46.32	55.28	a	9.38	ij	2.51	ef	3.82	fgh
20. Dhankuta Local	84.19	defg	33.70	40.02	cdef	9.88	efghi	2.12	g	4.66	ef
F test	***		ns	***		***		***		***	
CV%	18.62		21.62	14.66		4.05		8.71		15.31	
LSD (0.05)	23.92		11.67	8.98		0.58		0.31		0.98	

Values are the means of four replications. Means in the column with different letters indicate significantly differences (P≤0.001); *** indicates very highly significant differences at P≤0.001 level; ns indicates non-significantly differences.

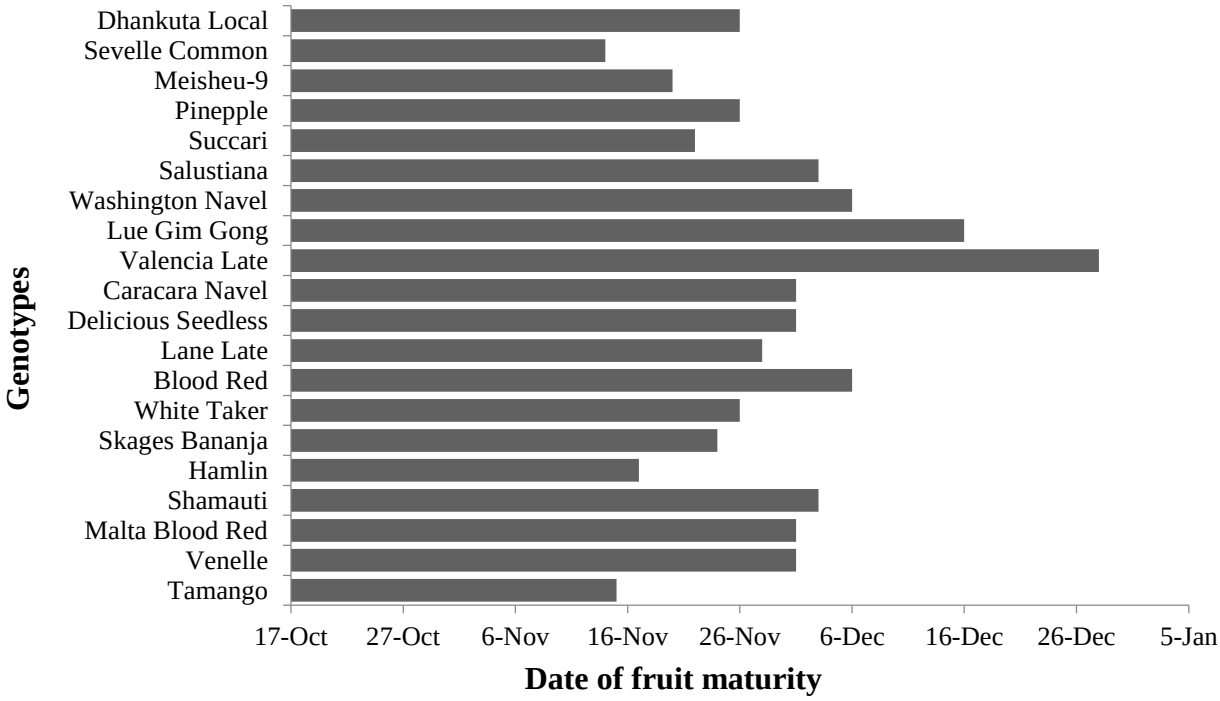

Fig. 1: Fruit maturity period of sweet orange genotypes

Discussion

There was significant variation on the fruit yield characteristics among the genotypes. The number of fruits per plant was recorded at the range of 5.50 to 67.00 fruits that Malta Blood Red produced the highest fruit number (67.00/plant) followed by Dhankuta Local (53.75/plant) and Valencia Late (44.75/plant). Similar result was observed by Khalid et al. (1993) that number of fruits per plant was 154 in Pineapple, 154 in Hamlin, 203 in Salustiana and 131 in Blood Red from 7-years-aged plants in Pakistan.

The fruit diameter among the genotypes was recorded at the range of 52.80 to 92.44 mm that Delicious Seedless had the highest fruit diameter (92.44 mm), while the least was recorded at Tamango (52.80 mm). Khalid et al. (1993) had found similar result as the fruit diameter was found at the range of 62 to 75 cm among the tested varieties of sweet orange. The fruit weight observed at this study was ranged from 75.44 to 165.28 g and this was very lower than those of Khalid et al. (1993)' finding as it was found at the range of 155.00 to 226.70 g.

Similarly, the fruit yield recorded at the present study was very lower than those of other studies. The highest fruit yield recorded at this study was 9.49 kg/plant, while it was 42.7 kg/plant in the observation of Khalid et al., (1993). The juice content observed at the range of 33.61 to 60.36% in this study was similar to those of Chahal and Gill (2015). The genotype Venelle was found to have the highest juice content (60.36%), while genotype Pineapple contained the least juice (33.62%). However, it was statistically at par among the most genotypes except few ones. Moreover, genotypes: Venelle, Tamango, Sevelle Common and Succari were found to have higher juice content among genotypes. The TSS of the following varieties: Pineapple, Blood Red, Salustiana and Hamlin were observed respectively at 11.18, 10.00, 9.28 and 8.58 °B. Khalid et al. (1993) also reported the similar TSS values of the same varieties that were 9.67, 9.53 10.30 and 8.00 °B respectively The genotypes with higher TA% were Caracara Navel (4.24%), Venelle (4.08%) and Malta Blood Red (3.57%).

The similar fruit maturity time of the existing local cultivars is making short harvesting period of sweet orange in Nepal. The harvesting period of sweet orange in Sindhuli and Ramechhap remains only for three months during November to January and beyond this period, Nepal imports fresh fruits in huge amount (AEC/FNCCI, 2014). This brings necessary of adopting distinct varieties of having diverse characteristics including fruit harvesting period. Chahal and Gill (2015) showed that cultivation of narrow genetic pool in citrus may impose market glut including threat in term of diseases and pests outbreak. The findings of Malik et al. (2012) on the study of genetic diversity of sweet orange cultivars have put forth the prospect of developing new varieties. Furthermore, Budathoki et al. (2004) found wide diversity with distinct variation in sweet orange cultivars in Banskharka, Parbat and Karendanda, Syangja districts of Nepal, observing the variation in fruit maturity from December to January-February that it would be a basis for breeding, and varietal development. Nepal needs to introduce the early as well as late harvesting cultivars.

Conclusion

Based on the results, Malta Blood Red, Dhankuta Local and Valencia Late have resulted as superior genotypes for fruit yield characteristics including fruit number, weight and yield. Some genotypes like Delicious Seedless, Salustiana and Hamlin exhibited excellent for their fruit size and weight; however these genotypes produced lower fruit number per plant. The Venelle, Tamango, Sevelle Common and Succari contained higher juice percentage among genotypes. The Pineapple, Meisheu-9, and Washington Navel had higher TSS, while Caracara Navel, Venelle and Malta Blood Red contained higher TA. The genotypes Succari, Washington Navel, Skages Bananja, Blood Red and Hamlin found excellent for fruit quality. There was similar fruit maturity period among the genotypes. However, Valencia Late, Blood Red and Washington Navel appeared four to five weeks late for fruit harvesting than the earliest genotypes; Sevelle Common and Hamlin. Based on the results, the genotypes showing distinct characteristics of fruit yield and quality including fruit maturity period should be promoted to make variety diversity in Nepal.

References

AEC/FNCCI (2014) *Study on achievements access of OVOP Junar program in Ramechhap district.* Agro Enterprise Centre (AEC), Secretariat of One Village One Product (OVOP), Federation of Nepalese Chamber of Commerce and Industry, Kathmandu, Nepal.

APP/MoAD (2011) *Study Report on Status of Sweet-orange Cultivation and Processing Industries in Sindhuli District.* Agribusiness Promotion Program (APP), Agribusiness Promotion and Marketing Development Directorate, Ministry of Agriculture and Co-operatives, Government of Nepal.

Budathoki K, Regmi HN, Pradhan NG, Gotame TP, and Poudyal KP (2004) Citrus diversity, their characterization and evaluation in Nepal. In: Khatri BB, Sharma BP, Khatiwada PP, Paudyal KP, Khadge BR and Regmi HN (Eds.) *Proceeding of the Forth National Workshop on Horticulture, March 2-4, 2004, Kathmandu*. Nepal Agricultural Research Council, National Agriculture Research Institute, Horticulture Research Division, Khumaltar, Lalitpur, Nepal: 116-122.

Cantuarias-Avilés T, Mourão Filho F, Stuchi ES, Silva SR, and Espinoza-Núñez E (2010) Tree performance and fruit yield and quality of Okitsu Satsuma mandarin grafted on 12 rootstocks. *Scientia Horticulturae* ***123*** (3): 318-322. DOI: https://doi.org/10.1016/j.scienta.2009.09.020.

Chahal TS and Gill PPS (2015) Performance of Exotic Sweet Orange (*Citrus sinensis* Osbeck) cultivars on Different Rootstocks under North Western India. *Indian Journal of Science and Technology* ***8***(16): 59391. DOI: 10.17485/ijst/2015/v8i16/59391

Grace JK, Sharma KL, Seshadri KV, Ranganayakulu C, Subramanyam KV, Raj GB, Madhavi M (2012) Evaluation of Sweet Orange (Citrus sinensis L. Osbeck) cv. Sathgudi Budded on Five Rootstocks for Differential Behavior in Relation to Nutrient Utilization in Alfisol. *Communications in Soil Science and Plant Analysis* ***43*** (7): 985-1014. DOI: https://doi.org/10.1080/00103624.2012.656164

Hardy S, and Sanderson G (2010) *Prime Fact 980, Citrus maturity testing*. Department of Industry and Investment, State of New South Wales, Australia: 1-6. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0020/320294/Citrus

IPGRI (1999) Descriptors for Citrus. International Plant Genetic Resources Institute (IPGRI), Rome, Italy.

Khalid M, Qureshi M, Laghari H, Khokhar KM and Shah AH (1993) Comparative evaluation of some sweet orange varieties at Islamabad. Pak. *J. Agri. Sci.* ***30*** (1).

Malik SK, Rohini MR, Kumar S, Choudhary R, Pal D and Chaudhury R (2012) Assessment of Genetic Diversity in Sweet Orange [Citrus sinensis (L.) Osbeck] Cultivars of India Using Morphological and RAPD Markers. *Agric Res* ***1***(4):317–324. DOI: https://doi.org/10.1007/s40003-012-0045-3

MoAD (2016) *Statistical Information on Nepalese Agriculture 2072/73 (2015/16).* Government of Nepal, Ministry of Agricultural Development, Singha Durbar, Kathmandu, Nepal.

NCDP (2016) *Annual Program and Statistic 2015/16.* National Citrus Development Program (NCDP), Kirtipur, Kathmandu, Nepal.

NCRP (2017) *Annual Report 2073/74 (2016/17).* National Citrus Research Program, Paripatle, Dhankuta, Nepal, NARC Publication Serial No 00549-362/2017/18.

USDA (2018) *Citrus: World markets and trade.* Foreign Agricultural Service/USDA, Office of Global Analysis. Retrieved from https://apps.fas.usda.gov/psdonline/circulars/citrus.pdf