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Evaluation of Growth and Fruit Characteristics of Mandarin Genotypes in Dhankuta, Nepal

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Authors' contributions

This work was carried out in collaboration between both authors. The study design, implementation and data measurement were carried out in coordination of both authors. The author ABP performed the statistical analysis and prepared the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Mandarin, as an important fruit crop of Nepal, has an enormous scope of increasing production and productivity by adopting better varieties. A study on varietal selection and evaluation has been underway at National Citrus Research Programme since 2005/06. Seventeen mandarin genotypes of exotic and local origin have been evaluated in the study. This paper describes the growth and fruit physio-chemical characteristics of mandarin genotypes, observed during 2014/15 in their 10-years age. The results revealed that the plant growth for height, canopy spread and basal girth were observed at a range of 137.5 to 295.0 cm; 103.8 to 205.0 cm; and 11.8 to 22.0 cm respectively. The Local genotypes: Banskharka and Sikkime showed the highest plant growth for plant height, while exotic genotypes exhibited wide canopy growth and basal girth. The average fruit number per plant were observed at a range of 16.7 to 151.3 fruits plant^{-1}, while the fruit weight ranged from 60.0 to 133.9 g. The higher fruit number, weight and yield were observed at some exotic genotypes such as Miyagawa Wase, Fortune, Comunes Avana and Mino. Miyagawa Wase and Okitsu Wase satsuma mandarin genotypes were found extra earlier for fruit maturity as they were ready to harvest from

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early September. The better fruit size and segment weight were found again at Miyagawa Wase, Ponkan and Fortune, including Sikkime Local genotype. Moreover, the juice contents were varied from 34.24 to 55.28% among the genotypes. The higher juice content was observed at Miyagawa Wase, Fortune, Mino, Nova and Khoku Local genotypes. The fruit qualities such as TSS and TA were ranged respectively at 7.00 to 12.15 °Brix and 1.06 to 2.33%. The Local genotypes including Khoku, Sikkime and Banskharka showed the higher TSS and higher TSS/TA ratio. However, Ponkan, Fortune and Nova exhibited better fruit quality with higher TSS and TSS/TA ratio. Therefore, Miyagawa Wase, Fortune, Ponkan, Comunes, Mino, Nova, including local genotypes seems of having good characteristics in all respects for further variety improvement and selection in the future. Moreover, Miyagawa Wase and Okitsu Wase were found potential for early production.

Keywords: Mandarin; genotypes; variety selection; growth; fruit physio-chemical characteristics.

1. INTRODUCTION

Mandarin (*Citrus reticulate* Blanco) is an important fruit crop of Nepal for economic growth, grown widely in the mid hills across the country [1]. It stands the second position among the fruits, sharing 16.71% of the total fruit area in the country, comprising of the current production of 146,690 t under 26,282 ha with productivity 9.0 t ha^{-1} [2]. Traditionally, local cultivars are commonly grown throughout the country for a long period in Nepal [3,4].

These cultivars have shortcomings of similar harvesting period, and declining productivity [5,6,7]. Thus, Nepal has an enormous scope of increasing production and productivity by adopting better varieties along with improved husbandry. Furthermore, the variety diversity for fruit maturity, fruit quality and resistant to biotic and abiotic factors to be adopted are the crucial concerns of variety improvement and breeding in the future.

Therefore, with the objective of variety selection for increased productivity, including variety diversity with differed fruit maturity and quality, varietal evaluation and selection [8,9] of mandarin has been carried out at National Citrus Research Program (NCRP), Dhankuta since 2005/06 with the objectives of the better genotype selection. This paper presents the performance of evaluating genotypes with regard to growth and yield attributes including fruit physical and chemical properties.

2. MATERIALS AND METHODS

The study was undertaken during 2014/15 to assess the growth and fruit physio-chemical characteristics of mandarin genotypes. The experiment with 17 genotypes of exotic and local origin has been established (Table 1) at NCRP, Dhankuta (27°1' N and 87°18' E, 1390 m asl, south-east aspect of terrace land since 2005. The experimental location having subtropical climate with four distinct seasons (dry winter and spring, wet and humid monsoon, and autumn) receives 1500 mm annual rainfall, maximum temperature 39°C during summer, and minimum 2°C in winter. The experimental plot contained sandy loam soil.

The experiment was conducted following a randomized complete block design, with four replications, single plant per replication. The ten trees of each genotype grafted with trifoliate have been planted in one block with spacing of 4 m x 4 m. The recommended practices were adopted for the maintenance of plants under rain-fed condition. The measurements on tree growth and fruit qualities characteristics were taken from randomly selected four trees as replications of each genotype at their 10-years of age. The tree growth: height, canopy spread and trunk girth were measured as descriptor mentioned in IPGRI [10]. The fruit physical characteristics: fruit diameter and rind thickness; and fruit weight and rind weight were measured from 10 fruits per each of 4 replications, using digital calipers and micro-balance respectively. The weight of juice and fruit used to calculate the percent juice content [11]. Similarly, the fruit qualities: TSS °Brix (Total Soluble Solid) and TA% (Titratable acidity) were measured from 10 fruits per each 4 replication, respectively using refractometer and titrating 2 ml fruit juice with 0.1 M NaOH as mentioned by Hardy and Sanderson [12].

The quantitative data were analyzed by one-way ANOVA using GenStat and mean comparison was carried out with DMRT.

Table 1. The genotypes of the experiment

Genotypes	Accession No	Group	Source
1. Comunes	NCRP-99	Clementine	INRA-CIRAD, France
2. Marisol	NCRP-100	Clementine	INRA-CIRAD, France
3. Page	NCRP-94	Mandarin	INRA-CIRAD, France
4. Oroval	NCRP-98	Clementine	INRA-CIRAD, France
5. Nova	NCRP-90	Mandarin	INRA-CIRAD, France
6. URSS	NCRP-82	Satsuma mandarin	INRA-CIRAD, France
7. Mino	NCRP-81	Satsuma mandarin	INRA-CIRAD, France
8. Avana	NCRP-93	Mandarin	INRA-CIRAD, France
9. Hernandina	NCRP-97	Clementine	INRA-CIRAD, France
10. Ponkan	NCRP-08	Mandarin	ICIMOD
11. Dancy	NCRP-92	Mandarin	INRA-CIRAD, France
12. Fortune	NCRP-88	Mandarin	INRA-CIRAD, France
13. Miyagawa Wase	NCRP-05	Mandarin	JICA, Japan
14. Okitsu Wase	NCRP-06	Mandarin	JICA, Japan
15. Banskharka Local	NCRP-10	Mandarin	LAC, Lumle
16. Sikkime Local	NCRP-11	Mandarin	Tehrathum
17. Khoku Local	NCRP-01	Mandarin	Dhankuta

3. RESULTS

3.1 Growth and Yield Characteristics

The plant growth characteristics: plant height, canopy spread and basal girth were significantly ($P > 0.001$) differed among the genotypes (Table 2). The genotype Banskharka Local had the highest plant heights (295.0 cm) followed by Sikkime Local and Oroval, while the lowest height was measured with Nova (137.5 cm). The intermediate plant heights were found at par among Ponkan, Avana, Mino, Dancy, Comunes, Marisol, Furtune and Khoku Local.

The canopy spread ranged from 103.8 cm to 205.0 cm, which were significantly different among the genotypes. The genotype Hernandina had the extensive canopy spread (205 cm) followed by Comunes and Oroval, while the least spread was of Page (103.8 cm). The intermediate canopy spread was found at genotypes: Mino, URSS, Avana, and Sikkime that were statistically at par. The result showed that the plant height and canopy spread were correlated as higher plant height corresponded to the wider canopy spread (Table 2). The maximum basal girth was recorded with Miyagawa Wase (22.0 cm) followed by Banskharka Local , which were statistically at par with that of Okitsu Wase, Oroval and so on. The lowest girth was measured with Khoku Local (11.8 cm) followed by Sikkime Local (12.8 cm).

Similarly, significant variation on number of fruits, fruit weight and yield plant^{-1} was observed among the genotypes (Table 2). The 10-year old trees gave the average fruit number ranging from 19.5 to 147.1 fruits plant^{-1}. The maximum number of fruit plant^{-1} was recorded at Comunes (147.1) followed by Avana (134.1), Mino (133.0), Miyagawa Wase (118.0), and Fortune (114.1) which were at par. The least fruit number was observed with Khoku Local Ponkan (19.5). The fruit weights were ranged from 60.0 g to 133.9 g. The genotypes: Ponkan, Furtune, Miyagawa Wase and Sikkime had excellent fruit weight, while Page, Avana and Comunes had lowest fruit weight among the genotypes.

Miyagawa Wase showed the highest fruit yield (13.0 kg plant^{-1}) followed by Fortune (11.6 kg plant^{-1}), Nova (9.2 kg plant^{-1}), Avana (9.1 kg plant^{-1}), and Comunes (9.0 kg plant^{-1}). The two genotypes: Miyagawa Wase and Fortune were found promising for bearing the excellent fruit weight with the higher yield. The Dancy and Khoku Local exhibited the least fruit yield among the genotypes.

3.2 Fruit Maturity

The genotype Miyagawa Wase was found earliest for fruit maturity followed by Okitsu Wase and Mino that the fruits were ready to harvest on 21st September, 1st October and 27th October respectively. The Local genotypes: Khoku, Sikkime and Banskharka were matured late among the genotypes that they became ready to harvest on 1st December onward. The results revealed that the Satsuma mandarin genotypes: Miyagawa Wase and Okitsu Wase were found 7 to 8 weeks earlier than the Local genotypes Fig. 1.

Table 2. Growth and fruit yield characteristics (2014/15)

Genotypes	Plant height (cm)	Canopy spread (cm)	Basal girth (cm)	Number of fruits/plant	Fruit weight (g)	Fruit yield (kg/plant)
1. Comunes	220.0 cde	190.0 ab	19.0 abcd	147.1 a	67.7 fg	9.0 abc
2. Marisol	218.1 cde	146.7 cd	17.8 abcde	51.8 efg	87.4 def	3.1 fg
3. Page	172.5 efg	103.8 e	13.7 efg	41.8 efg	60.0 g	3.5 efg
4. Oroval	235.0 bc	190.0 ab	19.7 abc	87.5 bcde	105.3 bcd	8.8 abcd
5. Nova	137.5 g	117.0 de	15.7 cdefg	97.2 bcd	98.6 cde	9.2 abc
6. URSS	162.5 fg	166.3 abc	17.2 bcde	96.3 bcd	95.8 cde	7.9 bcde
7. Mino	223.0 c	167.8 abc	15.0 defg	133.0 ab	97.9 cde	6.6 cdef
8. Avana	222.5 cd	163.8 bc	18.7 abcd	134.1 ab	65.6 fg	9.1 abc
9. Hernandina	212.5 cde	205.0 a	18.0 abcde	56.1 defg	104.2 cde	4.0 defg
10. Ponkan	225.0 c	118.8 de	15.2 defg	22.4 g	133.9 a	2.3 g
11. Dancy	222.5 cd	151.3 bcd	17.0 bcdef	42.7 fg	82.2 efg	1.7 g
12. Fortune	215.0 cde	136.3 cde	18.0 abcde	114.1 ab	127.8 ab	11.6 ab
13. Miyagawa Wase	175.0 defg	143.8 cde	22.0 a	118.0 ab	112.2 abc	13.0 a
14. Okitsu Wase	162.0 fg	161.3 bc	20.0 abc	93.5 bcde	102.7 cde	7.2 bcdef
15. Banskharka Local	295.0 a	155.0 bcd	21.0 ab	108.0 abc	102.6 cde	8.8 abcd
16. Sikkime Local	277.5 ab	147.5 cd	12.8 fg	66.0 cdef	110.3 bc	5.1 cdefg
17. Khoku Local	210.0 cdef	138.0 cde	11.8 g	19.5 g	100.9 cde	1.7 g
F Test	***	***	***	***	***	***
LSD (0.05)	48.07	40.33	4.35	43.80	21.77	4.33

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

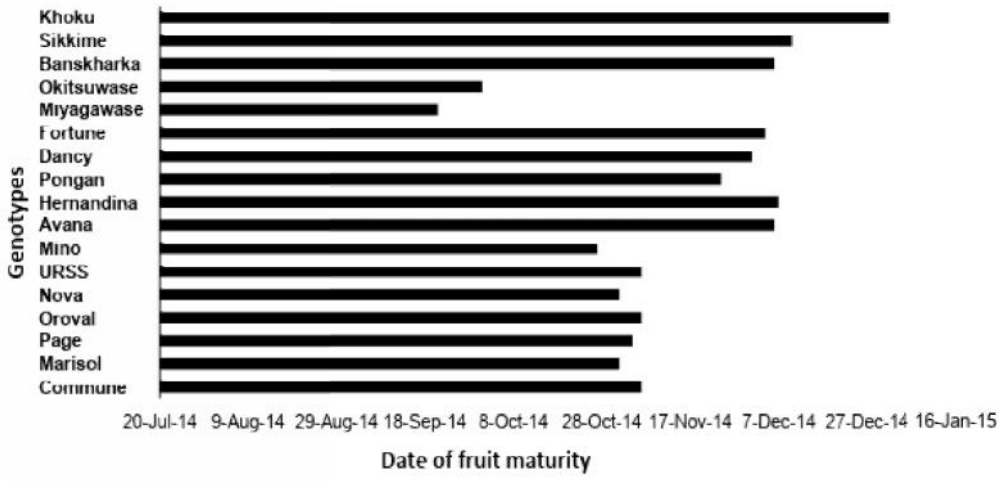

Fig. 1. Fruit maturity period of different genotypes

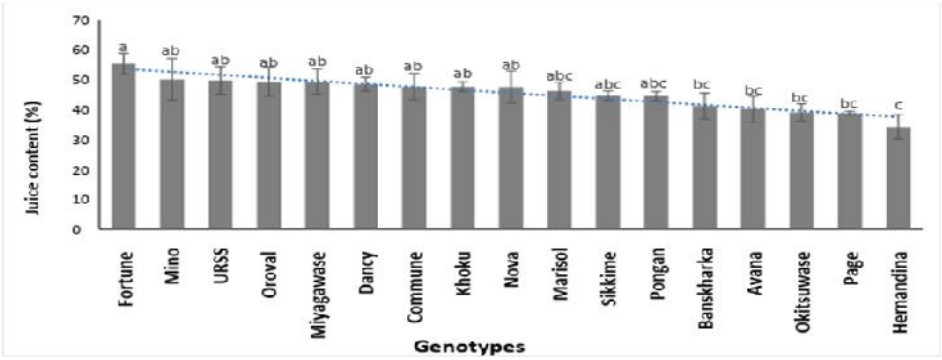

Fig. 2. Fruit juice content%. It was expressed as the percentage of weight of extracted juice to fruit weight. Values are the means of four replications from ten pooled fruits for each genotypes (n=10). Means ± SEM with different letters indicates significance at P<0.05 level.

3.3 Fruit Physical Characteristics

There was significant variation (P≤ 0.001) on the fruit diameter among the genotypes. It was ranged from 44.0 mm to 69.2 mm. The highest fruit diameter was recorded with Ponkan (69.2 mm) followed by Sikkime Local (65.1 mm), Fortune (63.7 mm), Miyagawa Wase (63.7 mm) and Khoku Local (63.3 mm). The rind thickness and rind weight were also varied significantly (Table 3).

Likewise, the rind thickness was found highest at Ponkan followed by Mino, Oroval and Nova, while the minimum rind thickness was observed with Comunes, Marison, Avana, Banskharka Local, Sikkime Local and Miyagawa Wase. The higher rind weights were observed at the genotypes in order with their corresponding higher rind thickness that the highest weight was found with Ponkan (53.2 g), while the least weight at Page (11.4 g). The number of segments and segment weight

Table 3. Fruit quality characteristics (2014/15)

Treatments	Fruit diameter (mm)	Rind thickness (mm)	Rind weight (g)	No of segments	Segment weight (g)
1. Comunes	47.9 gh	1.9 h	17.0 gh	8.8 gh	50.9 ef
2. Marisol	50.4 fgh	2.1 h	16.9 gh	11.5 a	68.2 cd
3. Page	44.0 h	3.5 def	11.4 h	9.6 defg	46.3 f
4. Oroval	56.1 ef	4.5 ab	24.4 def	8.1 h	71.8 c
5. Nova	50.4 fgh	4.2 abc	20.5 efg	10.1 cde	76.0 bc
6. URSS	50.3 fgh	3.7 cd	27.3 bcde	10.6 abcd	65.7 cde
7. Mino	47.9 gh	4.6 a	26.0 cdef	11.0 abc	65.4 cde
8. Avana	51.5 fg	2.5 gh	12.3 h	11.1 ab	48.7 f
9. Hernandina	61.5 bcde	3.5 de	26.4 cdef	9.0 fgh	71.3 cd
10. Ponkan	69.2 a	4.7 a	53.2 a	10.4 bcd	80.3 abc
11. Dancy	56.2 def	2.9 efg	20.1 fg	10.5 abcd	56.0 def
12. Fortune	63.7 abc	3.9 bcd	30.6 bcd	10.9 abc	94.5 a
13. Miyagawa Wase	63.7 abc	2.7 g	22.6 efg	10.4 bcd	73.5 bc
14. Okitsu Wase	57.1 cdef	2.8 fg	25.0 cdef	10.4 bcd	93.1 ab
15. Banskharka Local	61.4 bcde	2.7 g	34.1 b	9.2 efg	67.1 cd
16. Sikkime Local	65.1 ab	2.7 g	31.6 bc	9.1 fgh	75.4 bc
17. Khoku Local	63.3 abcd	3.4 def	33.6 b	9.8 def	67.8 cd
P value	0.001	<0.001	<0.001	<0.001	<0.001
LSD (0.05)	7.19	0.63	7.11	0.97	15.53

*Values are the means of four replications of the pooled from 10 fruits per replication. Means in the column with different letters indicate significantly differences (P≤0.05); *** indicates very highly significant differences at P≤0.001 level.*

Table 4. Fruit qualities

Treatments	TSS °Brix	TA%	TSS/TA ratio
1. Comunes	7.88 fg	1.35 ef	5.92 cdef
2. Marisol	8.21 defg	1.42 def	6.08 cdef
3. Page	9.55 cd	1.77 cde	5.44 cdef
4. Oroval	7.49 g	1.25 f	6.19 cde
5. Nova	9.00 cdef	1.26 f	7.40 abc
6. URSS	7.00 g	1.06 f	6.83 bcd
7. Mino	7.19 g	1.40 def	5.21 def
8. Avana	9.40 cde	2.33 a	4.05 f
9. Hernandina	12.15 a	1.31 f	9.32 a
10. Ponkan	12.06 a	1.32 f	9.42 a
11. Dancy	11.02 ab	1.82 bcd	6.14 cdef
12. Fortune	11.50 a	2.23 ab	5.42 cdef
13. Miyagawa Wase	8.12 efg	2.02 abc	4.05 ef
14. Okitsu Wase	8.19 efg	1.87 bc	4.62 ef
15. Banskharka Local	11.35 a	1.36 ef	8.79 ab
16. Sikkime Local	10.00 bc	1.27 f	8.67 ab
17. Khoku Local	11.31 ab	1.36 ef	8.46 ab
F test	***	***	***
LSD (0.05)	1.35	0.44	2.13

*Values were the means of four replications of the pooled juice from 10 fruits per replication. Means in the column with different letters indicate significantly differences (P≤0.05); *** indicates very highly significant differences at P≤0.001 level.*

were differed significantly (P<0.001). The number of segments was varied from 8.1 to 11.5 fruit^{-1} that the highest segment number was recorded with Marisol followed by Oroval. Similarly, the segment weight was ranged from 46.3 g to 94.5 g fruit^{-1} and the highest weight was exhibited with Fortune and the least weight with Page.

The juice content was observed at the range of 34.2 to 55.3% among the genotypes. The Fortune was found to have the highest juice content (53.3%), while genotype Hernandina contained the least juice. However, it was statistically at par among the most genotypes except few ones (Figure 2). Moreover, these two genotypes also were reported to have higher juice and acid content among the tested genotypes (Fig. 2).

3.4 Fruit Quality Attributes

The TSS content of Hernandina was the highest (12.15 °Brix) followed by Ponkan (12.06 °Brix), and Fortune (11.50 °Brix). However, Banskharka Local, Khoku Local and Dancy had TSS content respectively at 11.35, 11.31 and 11.02 °Brix, which were statistically at par. The least TSS content was observed at URSS, Mino and Oroval, respectively with 7.00, 7.19 and 7.49 °Brix (Table 4). The titratable acidity (%) was differed significantly among the genotypes that ranged from 1.06% to 2.33%. The highest acidity was observed at Avana (2.33%) followed by Fortune (2.23%) and Miyagawa Wase (2.02%). The lowest acidity was recorded with Oroval (1.25%), Nova (1.26%) and Sikkime Local (1.27). The higher TSS/TA ratio was observed at Ponkan and Hernandina, including Local genotypes: Banskharka Local, Sikkime Local and Khoku Local.

4. DISCUSSION

The growth of 10-years aged plants differed significantly among the genotypes. The results showed that the plant heights, which ranged from 137.5 to 295.0 cm. The two local genotypes: Banskharka and Sikkime attained the maximum tree height, but tree canopy spread and basal girth were observed higher in the exotic genotypes (Table 2). The tallest plant height of Banskharka Local differed to the lowest plant height of Nova genotypes by 157.5 cm. But, the exotic genotypes were found more spreading growth than local genotypes including higher basal girth that Hernandina had the extensive tree canopy followed by Comunes and Oroval genotypes. Saua et al. [13] found the maximum basal girth of Nagpur mandarin at 40.23 cm, fruit size of 70 to 81 mm and the highest yield of 37.52 kg tree^{-1}.

The exotic genotypes showed the maximum fruit number plant^{-1} and the highest fruit yield compared to local genotypes, except Banskharka Local (Table 2). The fruit number at 108.0 plants^{-1} of Banskharka Local observed at the present study, which was the lowest as compared to 5000-5500 fruits plant^{-1} of same genotype as observed by Budathoki et al. [3].

Budathoki et al. [3] also observed the higher fruit weight of Banskharka Local, ranging from 100-200 g fruit $^{-1}$ as compared to 102.6 g fruit^{-1} of the present study. Shrestha and Paudyal [14] found the fruit weight of Khoku Local at 100.23 g fruit^{-1}. In the another study, the fruit weights of Okitsu Wase and Miyagawa Wase were observed at 51 to 200 g fruit^{-1} respectively [6].

The present study showed the highest yield of Miyagawase (13 kg plant^{-1}) followed by Fortune (11.6 kg plant^{-1}). In the study, the fruit yield of local genotypes is relatively very low compared to those varieties adopted in many countries. Paudyal et al. [1] presented the similar results of the local varieties that Khoku Local of 25-years aged, giving fruit yield of 25-131 kg plant^{-1}, fruit weight of 66.5-87.8 g, acid content of 0.81-1.40%.

The fruit maturity in the study varied from mid-September and mid-January. The Satsuma mandarin genotypes: Miyagawa Wase and Okitsu Wase found the earliest for fruit maturity, while Khoku Local became ready to harvest later in mid-January. Budathoki et al. [3] also observed variation in fruit maturity, ranging from December to February.

The highest fruit diameter was observed at Ponkan genotype followed by Sikkime Local, Fortune and Miyagawa Wase. However, the fruit size of local genotypes was also found higher. The rind thickness that expresses the fruit quality as most of the exotic genotypes has thick rind as compared to local genotypes. The number of segments fruit^{-1} in the study ranged from 8.1 to 11.5, which is similar to the finding of Paudyal & Chalise [6].

The genotypes: Fortune, Mino, URSS, Miyagawa Wase, and Oroval had the excellent juice content of about 50% with corresponding higher segment weight and fruit size. Shrestha and Paudyal [14] also have observed the higher juice content (46.37%) of Khoku Local at Dhankuta district. In the present study, TSS was ranged from 7.00 to 12.15 °B that the highest TSS was observed at Hernandina followed by Ponkan genotypes. The TSS of local genotype Khoku Local was observed at 11.31 °B, where Paudyal et al. [1] also observed the TSS of Khoku Local, ranging from 10.7 to 12.9 °B. Most of the exotic genotypes including Miyagawa Wase and Okitsu Wase had lower TSS in the study.

The lowest TA value was found at genotype URSS (1.06%), including local genotypes: Khoku Local, Banskharka Local, and Sikkime Local. Paudyal et al. [1] also observed the TA of Khoku Local genotype, ranging from 0.81 to 1.40%.

In this study, the highest TSS/TA ratio was observed at Ponkan followed by Hernandina. Similarly, the local genotypes: Khoku Local, Banskharka Local and Sikkime Local had also higher TSS/TA ratios. Shrestha and Paudyal [14] observed the higher TSS/TA ratio of 9.25 at Khoku Local. In another study, Paudyal and Chalise [6] found the TSS of Khoku Local, ranging from 6 to 11.3%, TA from 0.88 to 2.00% and TSS/TA ratio from 4.9 to 12.8. The results revealed that the acid content was observed higher in the exotic genotypes as compared to the local genotypes. De Ancos et al. [15] showed the ascorbic acid bio-accessibility higher in pulp (75.8%) than in juice (46.0%). Ummarat et al. [16] revealed that mandarin taste is influenced by the levels of sugars and acids and relative ratios among them, while a mixture of different aroma volatiles, including alcohols, aldehydes, ketones, terpenes and esters affect aroma and overall flavor.

The study has the objective to select the genotypes of diverse characteristics, including multiple fruit harvesting periods. Furthermore, improvement and selection of good quality traits are important steps in the variety development program. Budathoki et al. [3] found mandarin diversity with distinct variation in Banskharka, Parbat and Karendanda, Syangja districts of Nepal, observing the variation in fruit maturity from December to January-February. Shrestha et al. [17] reviewed that despite of wide citrus diversity in Nepal, the work on evaluation and characterization of genetic materials including mandarin is limited as it would be a basis for breeding, conservation and varietal development. Breeding of good quality traits requires selection of parents with a wider genetic diversity [18,19]. Nepal needs to introduce the early or late harvesting cultivars [6] for off-season production.

5. CONCLUSION

The study has given the current picture of genotypes performance. The results clearly indicated the superiority of some introduced exotic genotypes over the Local genotypes. Of the 17 genotypes evaluated, Local genotypes: Banskharka and Sikkime showed the highest plant growth for plant height, while exotic genotypes Hernandina, Oroval and Comunes, including Miyagawa Wase exhibited wide canopy growth and basal girth. The exotic genotypes such as Miyagawa Wase, Furtune, Comunes Avana and Mino performed better for yielding higher fruit numbers, including fruit weight and yield. Miyagawa Wase and Okitsu Wase satsuma mandarin genotypes were found extra earlier for fruit maturity. The better fruit size and segment weight were found again at Miyagawa Wase, Ponkan and Fortune, including Sikkime Local genotypes. Moreover, higher juice content including higher fruit yield were observed at Miyagawa Wase, Fortune, Mino, Nova and Khoku Local genotypes. The fruit quality as determined by TSS and TA and their ratio, Local genotypes including Khoku, Sikkime and Banskharka showed the higher TSS and higher TSS/TA ratio. However, Ponkan, Fortune and Nova exhibited better fruit quality with higher TSS and TSS/TA ratio.

Therefore, Miyagawa Wase, Fortune, Ponkan, Comunes, Mino, Nova, including Local genotypes seems of having good characteristics in all respects for further variety improvement and selection in the future. Moreover, Miyagawa Wase and Okitsu Wase were found potential for early production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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