Evaluation of Satsuma Mandarin (*Citrus unshiu*) Varieties for Early Season Production

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Abstract

Mandarin (*Citrus reticulata* Blanco) the most important citrus species of Nepal covers nearly 58 percent of citrus area in the country. Since only mid-season local genotypes are used commercially, its harvesting duration lasts only for three months: November–January. So, to explore the possibility of early commercial production two satsuma mandarin (*Citrus unshiu* Marcvitch) varieties namely Okitsu Wase and Miyagawa Wase were evaluated for their fruit characters under screen house and open field condition at National Citrus Research Program, Dhankuta (1350 m) for two years. Total soluble solids (TSS), total acid (TA), TSS/TA ratio and sweetness of the fruits were determined from August 20 to October 10 at 10 days interval. Sweetness of the fruit was rated as sweet, slightly-sweet and sour by organoleptic test. The fruit-taste was found sweet enough for commercial use when value of TSS/TA ratio crossed 6:1 and therefore, this value was suggested as maturity index for the varieties. Under screen house condition with annual mean maximum temperature of 32^{0}C, minimum temperature of 14.4^0 C and total heat unit of 3639, the TSS/TA ratio reached to 6 in the first week of September in Okitsu Wase, and 10 days later in Miyagawa Wase. Under open field condition, where mean maximum annual temperature (25^{0}C) and heat unit (2718) were less, TSS/TA ratio hardly reached to 6 after 10th of October because of low TSS and high acid content in fruit juice. It indicated that warmer areas of 900-1000 m altitude could be the suitable locations for early production of the varieties. Further performance study at different altitude is needed to identify the best production climate. Farmers and consumers' reactions on fruit quality and taste of the varieties have been very positive, and their demand for the planting materials is high. Excepting maturity period, both varieties have been similar in fruit characters. Under screen house condition fruit weight ranged from 51 to 200 g, segment number from 8 to 14, peel content from 14 to 33 percent, TSS from 6.0 to 11.3 percent, TA from 0.88 to 2.0 percent and TSS/TA ratio from 4.9 –12.8. Fruits from both the varieties were seedless in both the conditions.

Introduction

Mandarin (*Citrus reticulata*) occupies first position among citrus fruit crops in acreage and contributes nearly 60% of total citrus production in Nepal. At present, nearly 97,478 t of mandarin-fruit is produced in Nepal from 15,987 hectare of orchards (FDD, 2002). However, in Nepal, varietal diversity is lacking in mandarin cultivation and so almost all plantations are composed of local genotypes with mid-season and narrow maturity period from November to January, which is considered as the normal season for citrus production in Nepal. During this season there is glut in the market, leading to low price as well as spoilage. On the other hand during other period of shortage prices go up and almost all the demands of citrus fruits are fulfilled from the imported ones from India (Shrestha and Shrestha, 2000). Earlier studies and surveys (Paudyal, 2004 and HDP, 1996) carried out in different parts the country could not find any local genotype that can mature prior to November. Whatever, differences in maturity period (November-January) has been noticed in local genotypes is attributed to altitude variation of production areas (environmental effect) rather than genetic diversity. Variety diversification with early, mid and late season maturity period can help to expand the availability of locally produced

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mandarin fruits in the country. Since early maturing local genotype of mandarin is lacking in the country, Horticulture Development Project introduced several exotic citrus varieties including Okitsu Wase and Miyagawa Wase from Japan during nineties ((HDP, 1996)). In Japan, these are the top early ripening cultivars of satsuma-mandarin, which covered about 30 thousands hectares of area (Omura, 1996). In recent years these varieties are also becoming popular in Italy, Spain, Australia and New Zealand for early season marketing (Gallasch, 1992). Therefore, these varieties were evaluated for their maturity period and fruit characters for two years at National Citrus Research Programme, Dhankuta to explore the potentiality of early season commercialization production in Nepalese condition.

Materials and Methods

Two satsuma mandarin varieties namely Okitsu Wase and Miyagawa Wase grafted on trifoliate orange rootstock and grown under screen house and open field condition were evaluated for fruit characters for two years at National Citrus Research Programme, Dhankuta (1130 m altitude). The roof of the screen house was covered by Silpoulin (a durable plastic). The daily minimum and maximum temperature under both conditions were recorded and total heat unit was calculated as the annual sum of the (average monthly temperature – 13) x (number of days per month). To determine the maturity period 5 fruit samples were evaluated for total soluble solids (TSS), total acids (TA), TSS/TA ratio, juice content and sweetness at 10 days interval from 20th August (5th Bhadra) to 10th October (25th Aswin). TSS was recorded by hand Refracto meter. Two ml fruit juice was titrated with 0.1 N sodium hydroxide (NaOH) solution to Phenophthalein end point and percentage of TA was calculated using formula of Rangana (1995). Sweetness of the fruit was also categorized as sweet, slightly sweet and sour by organoleptic test during chemical test and corresponding TSS/TA ratio at which fruits were sweet enough for commercial consumption was determined. To determine the detailed fruit characters of the varieties, a total of 21 fruit samples were collected on 30th September (15th Aswin) from screen house grown plants and evaluated for fruit weight, fruit size, segment number, seed number, peel weight, juice content, TSS, TA and TSS/TA ratio. Juice and peel content was calculated based on total fruit weight. Means of two years data with standard deviations within variety were used for comparison.

Result and Discussion

Maturity Period

Change in TSS, TA, juice content was evaluated from 10th August to 10th October at 10 days interval to determine the maturity periods. In variety Okitsu Wase TSS was higher inside screen house grown plants than in open field condition throughout the evaluation period. Increase in TSS content was found faster after 20th September (Fig.1-a). In case of Miyagawa Wase, TSS content in fruit juice was almost equal in both conditions until 10th of September but after that TSS increased at faster rate under screen house condition (Fig. 2-a). In both condition TSS content was higher in Okitsu Wase than in Miyagawa Wase. In California, TSS in Okitsu Wase was recorded 9.3 during 3rd week of September and increased to 11.4 by second week of December (CCPP, 2004).

Acid content in the fruit juice is the other parameter of fruit quality and maturation. Decrease in acid percentage in fruit juice indicates the initiation of maturity of fruits. Until September 20, acid content in Okitsu Wase was almost equal inside the screen house and in open condition but after this period it decreased rapidly under screen house condition and reduced to 0.95% on October 10 which was 1.5% on August 20 (Fig. 1-b).

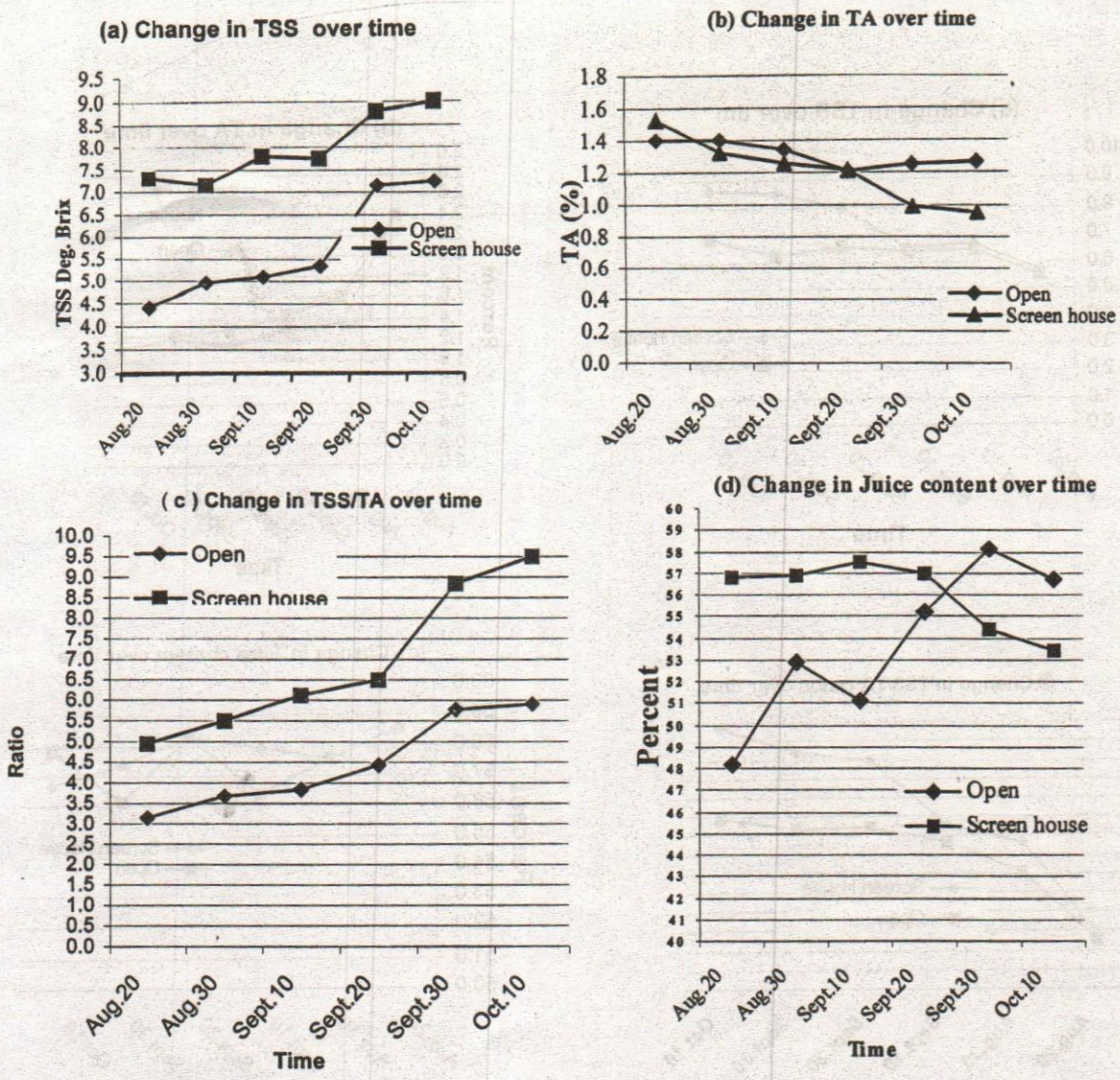

Fig. 1. Internal fruit characters of Okitsuwase over time during maturity.

However TA content of the fruits grown in open field did not decrease below 1.2% even on October 10. Acid content in the fruit juice of Miyagawa Wase decreased rapidly over the period of August 20 to Aug 30 in both conditions and after that the rate of acid break down was slow (Fig. 2-b). In all the dates of observation percentage of acid was found less in the fruits harvested from screen house than those from open field. Acid content in Okitsu Wase was less than in Miygawa Wase in all the dates of evaluation (Fig. 1-b & Fig.2-b). Okitsu Wase was found sweeter than Miyagawa Wase in sensory test. Most possibly it is because of low acid content on Okitsu Wase.

Ratio of TSS to TA is the most important factor to determine the maturity period of sweet type citrus fruits. Trend in TSS/TA change in Okitsu Wase and Miyagawa Wase has been presented in Fig. 1-c and Fig. 2-c respectively. Under screen condition TSS to TA ratio of Okitsu Wase crossed 6:1 on 10th of September (Fig. 1-c) whereas in Miyagawa Wase it crossed 6:1 ratio 10 days later (Fig. 2-c).

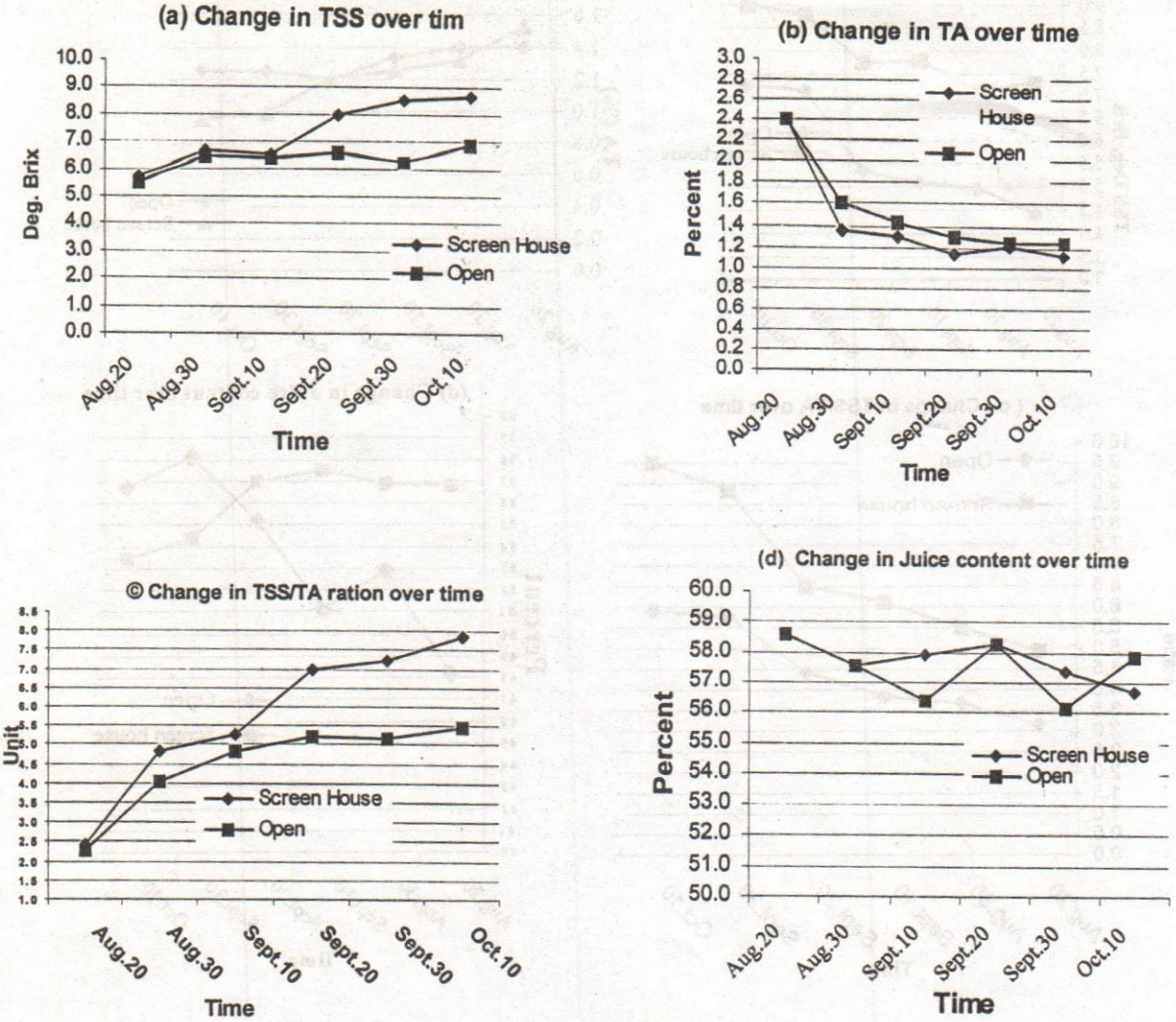

Fig. 2 Change in internal fruit quality of Miyagawa Wase over time during maturity.

The date when the value of TSS/TA ratio crossed 6 was considered as the initiation of maturity period because the fruits having ≥ 6:1 TSS/TA ratio were found sweet enough for commercial use in organoleptic test. Under relatively warmer condition of screen house receiving 3640 heat unit (Table 2) Okitsu Wase started to mature on first week of September (3rd week of Bhadra) and Miyagawa Wase about 10 days later. However, under open field condition where total heat unit was less (2718), TSS/TA ratio reached hardly up to 6:1 only after 10th of October (25th Aswin) because of low TSS and high TA in fruit juice. Under field condition of California, Okitsu Wase achieved legal internal maturity 6.5 Brix/acid ratio by third week of September but did not achieve requisite 75% colour break until two weeks later and it produced good yields with high percentage of large seedless fruits at the time when no other citrus fruits are available and hence have market potential (Feryson, 1999). About 4% of the Satsuma mandarins have been cultivated under plastic coverage or green house for off-season shipment in Japan (Nito, 2000). Under such conditions good quality fruits of Satsuma can be harvested four months earlier than normal cultivation with high sugar (>12^0 Brix), low acid (<1.0%) and attractive appearance. The average yield is almost double of that in normal cultivation. These results support the findings of our study that under plastic house condition maturity was earlier with better quality fruits.

Table 1. Fruit characters of Okitsu and Miyagawa Wase under screen house condition

Fruit Characters	Okitsu Wase		Miyagawa Wase	
	Mean ± SD	Range	Mean ± SD	Range
Weigh (gm)	100.7 ± 34.1	58.5-190	122.3 ± 49.0	51.7-210
Diameter (mm)	62.5 ± 7.1	51.1-78.5	35.9 ± 10.5	48.5-77.5
Height (mm)	48.9 ± 7.0	37.5-61.1	54.5 ± 12.6	38.7-84.1
Segment number	11.1 ± 1.5	8.0-13.0	11.0 ± 1.3	8-14
Peel (%)	18.1 ± 5.0	12.8-32.8	18.6 ± 4.3	13.9-31.1
Juice (%)	57.7 ± 5.9	37.8-66.5	58.2 ± 5.9	48.7-74.2
TSS (° Brix)	8.6 ± 1.4	6.75-11.3	8.6 ± 1.3	6.0-11.2
Total acid (%)	1.16 ± 0.16	0.88-1.4	1.24 ± 0.25	0.96-2.0
TSS/TA ratio	7.5 ± 1.8	5.38-12.83	7.1 ± 1.3	4.9-9.4

In screen house condition percentage of juice in the fruit started to decline from 20th September in both varieties indicating the full maturity of the fruits. On the other hand in open field condition fruit juice did not show any decreasing trend until October 10 (Fig. 1d and 2d)

Table 2. Temperature (^{0}C) and heat unit under screen house and open field condition

Month	Screen house condition				Open field condition			
	Max	Min	Mean	Heat unit (total)	Max	Min	Mean	Heat unit (total)
Jan	27.0	8.8	17.9	147.0	19.5	6.9	13.2	6.2
Feb	29.6	12.1	20.4	219.3	23.2	11.6	17.4	123.2
Mar	33.6	13.0	23.3	319.3	23.4	13.3	19.4	196.9
Apr	33.4	15.2	24.2	347.2	28.5	18.3	23.4	312.0
May	33.1	17.8	25.5	385.9	26.5	18.6	22.6	296.1
Jun	32.4	18.6	25.5	387.5	27.2	20.3	23.8	322.5
Jul	34.2	20.2	26.7	424.7	26.9	21.1	24.0	341.0
Aug	33.2	19.6	25.9	399.9	26.7	20.9	23.8	334.8
Sept	32.5	17.5	24.5	356.5	27.4	19.6	23.5	315.0
Oct	30.5	12.2	21.4	242.2	26.5	17.7	22.1	282.1
Nov	31.3	9.6	20.0	208.5	23.7	12.0	19.7	145.5
Dec	31.9	7.9	19.9	200.1	20.9	8.8	14.4	43.5
Mean	31.9	14.4	23.1	3639.0	25.0	15.8	20.4	2718.6

Fruit characters

External and internal fruit characters of both varieties were evaluated from the trees grown under screen house on 30th of September (15th Aswin). Table 2 presents the mean, standard deviation and range value of these characters. Fruits of Miyagawa Wase were slightly bigger (122 ± 49 gm) than that of Okitsuwase (101 ± 34.0 gm) and they were oblate in shape (height < diameter), peel (skin) was thin (18%) and fruits were very juicy (58%) in both varieties. Unlike our results, bigger fruits (142-194 gm) of Okitsuwase with less juice content (31-36%) were produced in California condition (CCPP, 2000). Segment number ranged from 8-13 in Okitsuwase and 8-14 in Miyagawa Wase. Likewise TSS in fruit juice was 8.6 ^{0} Brix in both varieties but Okitsuwase had less acid content (1.16%) than in Miyagawa Wase (1.24%). TSS/TA ratio was also slightly higher in Okitsuwase in comparison to Miyagawa. Okitsuwase was sweeter than Miyagawa Wase due to less acid

content and higher TSS/TA ratio. Most other fruit characters were very similar in both varieties.

Conclusion and Recommendation

Mandarin is the major fruit crop of Nepal with about 60 percent share on area coverage and total production of citrus fruit crops. Since this crop gives 5-6 times higher income in comparison to cereal crops it is considered as a high value commodity for mid-hill farmers. However, one of the major constraints faced by the farmers for further commercialization is the seasonality of its production. At present almost all mandarin plantations of the country are composed of local genotypes of midseason (November-January) maturity period. In other months of the year all demands of citrus are fulfilled by import from India. Numerous varieties have been developed for early, mid and late season production in many developed countries of the world. Introduction of exotic varieties with diversity in maturity period can help to expand the production period of mandarin fruits in Nepal. In this context, newly introduced early maturing Satsuma mandarin varieties namely Okitsu Wase and Miyagawa Wase were evaluated under screen house and open field conditions for their maturity period and fruit quality.

Following conclusion can be drawn from the results of the study:

- Taste of fruit was sweet enough for commercial use when TSS/TA ratio was at least 6:1. So, this ratio is considered as maturity index for these varieties.
- Under screen house condition (with 3640 heat unit) Okitsu Wase started to mature on 10th of September (3rd week of Bhadra) and Miyagawa wase 10 days later.
- Under open field condition (2718 heat unit) maturity started only after 10th of October.
- Both varieties are suitable for early season (Aswin-Kartik) commercially production.
- Fruit quality and taste (sweetness) was better under screen house condition than that in open field condition which indicates that the areas warmer than Paripatle farm (1350 m altitude) could be suitable places for early fruit production.
- Since these varieties can be harvested from last week of Bhadra, they can fetch the high demand and price incurred during Dasain and Tihar festival.

It was also realized that following studies need to be further carried out to develop complete production technologies:

- Multilocation production studies at different altitudes to find out best production environment.
- As growth on trifoliate rootstock was found slow, plants grafted on this rootstock should be grown in high density planting
- Performance evaluation on fast growing rootstocks such as citrange and citrumelo is also recommended.
- Peel colour of the fruit remains green while fruits mature internally. So, de-greening will improve the market acceptability.

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[Queries from the participants of the seminar:

Dr. Y.H. Shrestha and Mr. D.B. Thapa commented on the altitude the research was carried out. As the sweetness and color of satsuma-mandarin improved and fluffiness of fruit decreased with increasing altitude, they suggested for further study at higher altitude. Dr. R.C. Bhusal suggested for selection of appropriate rootstock for that trifoliate was not compatible with satsuma mandarin. For selection of early varieties, Mr. L.N. Dewaju suggested to work on local mandarin for that he had observed local trees ripening even in Ashwin and Kartik. Based on Japanese reports those showed an increase of TSS in unshiu grown inside plastic house, the presenter, in response to the queries, added that the response of the mandarin at lower or higher altitudes should be observed through field researches. To conclude the paper, the chairperson of the session suggested verifying not only the variety but also the locations producing early crops, and developing alternative approaches of degreening.]