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Correlation studies for effect of fruit grade on fruit quality and seed traits of mandarin variants in North East India

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ABSTRACT

Field experiments were conducted during 2007-10 at ICAR Sikkim Centre, Tadong located at 1,400 m amsl to identify the suitable grade of fruits for raising nucellar nursery and fresh fruit marketing of Sikkim mandarin. Small and large sized fruits were collected from all the four districts of Sikkim. The highest fruit weight (161.25 g/fruit), waste index (1.14), TSS: acid ratio (8.00) and number of healthy seeds per fruit (19.5) were recorded. Maximum juice (53.2%), minimum waste index (0.68) and number of healthy seeds (7.1) were found in small fruits. Negative correlation between specific gravity and number of healthy seeds per fruit (-0.714) was observed. Waste index of fruits revealed significant positive correlation with healthy seeds per fruit (0.727) and total seed weight (0.721), while negative correlation with fruit shape index, specific gravity and juice content. Big sized fruits possessed high number of good quality seeds per fruit, which can be used for nursery raising as well as for fresh fruit marketing purpose, whereas small sized fruits with higher juice percentage can be recommended for fresh juice preparation.

Key words: *Citrus reticulata*, fruit grade, fruit quality, seed quality.

INTRODUCTION

Sikkim mandarin (*Citrus reticulata*) dominates the *Citrus* family and is the leading cash crop of the mid hills of Sikkim Himalayas with attractive fruit colour, size and good table and processing qualities. Presently, 95 per cent of the production is marketed as fresh fruit in India. The remaining five per cent of mandarin production only is processed, whereas the post-harvest losses, which are an estimated 25-30 per cent can also benefit the growers through creation of state-of-the-art post-harvest and value-addition infrastructure. The world market is continually making higher demand for better quality, uniform grading, presentation, and packaging of fruits. In Florida, 95 percent of commercial orange production is destined for processing, mainly as orange juice while in California; oranges are mainly produced for fresh consumption with only 21 per cent for processing (Boriss, 3). The fruit industry typically generates large volumes of effluents and solid waste (Senyi, 15). Despite the several advantages of grading growers rarely grade their fruits and vegetables through which farmer's income can increase by 30 per cent (Afshan, 1). Better quality fresh mandarin fruits with higher juice content are preferred, while fruit weight and juice percentage reflected negative correlation (Kishore *et al*., 9). Grading is the final assurance that the fruit going to the extractor is of acceptable quality (Schmidt, 14). Nucellar seedling of mandarin are raised from mature and large sized fruits selected from healthy plants (Kumar *et al*., 10). In order to raise nucellar seedlings, large quantity of seeds is required to get higher number of seedlings. Therefore, the present study was undertaken to identify the most suitable grade of mandarin for raising nucellar nursery in addition to fresh fruit marketing and juice industry of Sikkim Himalayas.

MATERIALS AND METHODS

The Experimental site is located at about 27° North and 88° East in the mid hills of Sikkim Himalaya. Fruits were collected from the trees indexed for healthiness and freedom from diseases from all the four districts of Sikkim at the altitude variation from 3,000 - 5,000' amsl in the month of November for two years. Five representative orchards were selected from each district for collection of 400 numbers of small and large fruits, respectively. Fruits were selected from 10 randomly selected plants on the basis of fruit size.

The experiment was conducted in randomized block design with three replication and 50 fruits/ replication that were categorized as West district small sized fruits (T_1), West district big sized fruits (T_2), East district small sized fruits (T_3), East district big sized fruits (T_4), South district small sized fruits (T_5), South district big sized fruits (T_6), North district small sized fruits (T_7), and North district big sized fruits

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(T_8). Uniform sized small and large sized fruits were selected for the experiment.

All the analysis was done at ICAR Res. Complex, Sikkim Centre, Tadong. TSS was measured by hand refractometer. Waste index was calculated as per Winfried and Pittroff (18). Fruit shape index was calculated following Tachibana and Yahata (17). Acidity, TSS/acid ratio and specific gravity were estimated by standard procedures. Total sugars, reducing and non-reducing sugars were determined by Shaffer-Somogyi's micro-method (Ranganna, 13). The data were analyzed statistically following the method of Panse and Sukhatme (12). The correlation between variables was calculated by partial correlation method and the test of significance was considered at 5 and 1% levels of probability.

RESULTS AND DISCUSSION

Observations on various characteristics of Sikkim mandarin showed significant effect of location and fruit size on morphological as well as chemical properties (Table 1). Fruit weight was significantly different for both small and large fruits at all the locations. The highest fruit weight recorded for big fruits collected from North Sikkim (161.25 g/fruit) was significantly different from all other treatments and at par with the fruits of East district. The lowest fruit weight was observed for small fruits collected from South Sikkim (71.25 g/fruit). Maximum specific gravity was observed in small fruits of South Sikkim (0.95) and was at par with T_1, T_2, T_3 and T_7 but significantly different from other treatments. Minimum specific gravity was found in big fruits of South Sikkim (0.73). Large sized fruits exhibited minimum specific gravity was earlier reported by Gill *et al.* (7). The big sized fruits of South Sikkim had the maximum fruit shape index (203.8), with the minimum in big sized fruits of West Sikkim (79.8). The highest fruit hollowness observed in big fruits from East Sikkim (1.91 cm) was at par with big fruits of North Sikkim, however, the lowest fruit hollowness was found in small fruits of North Sikkim (0.88 cm). Small fruits of North Sikkim contained the maximum juice (53.2%) that was statistically at par with big size fruits of the same location and the small fruits of East Sikkim but significantly different from all other locations. The big sized fruits from East Sikkim recorded the lowest juice content (40.9%). Big fruits of West and North Sikkim revealed the highest waste index (1.14) and lowest (0.68) was recorded in small sized fruits of East Sikkim. TSS: acid ratio observed in big size fruits of West Sikkim (8.00) was the highest as compared to all others, while the lowest was in big size fruits of South Sikkim. Highest juice content, TSS: acid ratio and palatability rating were observed for small sized fruits by Gill *et al.* (7). TSS: acid ratios for small fruits are not in agreement with that of Gill *et al.* (7). Amongst all the treatments, total sugars content of small fruits of West Sikkim recorded the highest (10.06%), which was significantly different from other treatments. The lowest total sugars content was in the big size fruits of South Sikkim (7.50 %), which was at par with small and big sized fruits of North Sikkim. Reducing sugar was the highest in small sized fruits of West Sikkim (6.52%), which was at par with the small fruits of East Sikkim (6.25%) and the small sized fruits of North Sikkim but significantly different from other treatments. Reducing sugar was the lowest in the big sized fruits of South Sikkim (4.41%). The small size fruits from South Sikkim revealed the

Table 1. Effect of fruit grade and orchard location on fruit quality parameters.

Treatment	Fruit weight (g)	Fruit shape index	Fruit hollowness (cm)	Specific gravity	TSS: acid ratio	Juice (%)	Waste index	Total sugars (%)	Reducing sugar (%)	Vit. C (mg/100 ml)
T_1	110.00	169.8	1.10	0.93	7.63	50.9	0.85	10.06	6.52	40.00
T_2	137.50	79.8	1.65	0.92	8.00	47.9	1.14	8.57	5.76	36.00
T_3	89.25	116.9	1.36	0.92	5.66	51.6	0.68	9.09	6.25	44.00
T_4	158.25	118.4	1.91	0.82	7.57	40.9	1.05	8.57	5.76	42.00
T_5	71.25	118.9	1.07	0.95	4.56	50.5	0.93	9.37	5.55	50.00
T_6	141.50	203.8	1.65	0.73	3.92	48.0	1.00	7.50	4.41	40.00
T_7	88.75	121.0	0.88	0.91	5.42	53.2	0.77	7.50	6.25	42.00
T_8	161.25	115.7	1.75	0.84	5.45	51.3	1.14	7.50	6.00	40.00
$LSD_{(P = 0.05)}$	1.96	-	0.18	0.04	-	1.9	-	0.200	0.559	1.065

Treatments: West district small sized fruits (T_1), West district big sized fruits (T_2), East district small sized fruits (T_3), East district big sized fruits (T_4) South district small sized fruits (T_5), South district big sized fruits (T_6) North district small sized fruits (T_7) and North district big sized fruits (T_8).

maximum vitamin C content (50.00 mg/100 g), which was significantly different from other treatments with minimum in the big size fruits of West Sikkim (36.00 mg/100 g). Similar findings were reported by Arzani *et al.* (2), and Singh and Singh (16).

The location and fruit size significantly influenced the seed quality. All the seed quality parameters showed significant variation amongst all the treatments (Table 2). The big sized fruits of North Sikkim exhibited the best seed shape index (60.83), while the small sized fruits of South Sikkim had the lowest (42.980). Aborted seeds were lowest in small fruits of West Sikkim (1.75) with highest recorded in small size fruits of South Sikkim (13.00). Maximum number of healthy seeds per fruit was found in big size fruits of South Sikkim, which was at par with the big size fruits of West and North Sikkim but significantly different from the other fruits. The big size fruits of North Sikkim had the heaviest seeds (3.14 g), which was at par with big size fruits of West Sikkim (3.01 g) and significantly different from the other fruits. The lightest seed weight was observed in small size fruits of South Sikkim (0.68 g). Number of seeds per fruit was significantly correlated with fruit size; fruit weight and peel thickness (Ketsa, 8; Demirkeser *et al.*, 5). Large fruit size may be because of local climatic conditions coupled with higher number of seed, cytokinin and gibberellin levels in the relevant tissues (Erner *et al.*, 6). The size of seeded fruits was larger but less soluble solids content was reported by Zhang (19). Finding of our present study is in agreement with Zhang (19) for fruit size and seed number but it differs for the soluble solids content.

Table 2. Effect of fruit grade and orchard location on seed quality parameters.

Treatment	Total No. of healthy seeds/ fruit	No. of aborted seeds fruit	Total seed weight (g)	Seed shape index
T_1	7.1	1.75	2.10	54.55
T_2	19.0	4.50	3.09	50.00
T_3	12.0	2.50	1.42	46.77
T_4	17.0	3.52	2.29	50.41
T_5	7.0	13.00	0.68	42.98
T_6	19.5	4.50	2.37	47.97
T_7	8.5	8.00	1.65	53.76
T_8	19.0	6.50	3.14	60.83
$LSD^{(P=0.05)}$	1.23	1.13	0.23	-

Treatments: West district small sized fruits (T_1), West district big sized fruits (T_2), East district small sized fruits (T_3), East district big sized fruits (T_4) South district small sized fruits (T_5), South district big sized fruits (T_6) North district small sized fruits (T_7) and North district big sized fruits (T_8)

The correlation co-efficient (Table 3) between different variables of Sikkim mandarin revealed that fruit hollowness was positively correlated with waste index (0.723*), number of healthy seed/fruit (0.909**), total seed weight (0.693*) and negatively to specific gravity (-0.650*) of fruits, which showed hollowness as important contributor towards waste index. Data also indicated that there was negative correlation between specific gravity and number of healthy seeds per fruit (-0.714*). Waste index of fruits recorded significant positive correlation with healthy seeds per fruit (0.727*) and total seed weight (0.721*), which showed that seeds and total seed weight

Table 3. Correlation studies between fruit and seed qualities in mandarin.

Parameter	Fruit shape index	Fruit hollowness (cm)	Specific gravity	TSS/ acid ratio	Juice (%)	Waste index	Total healthy seeds	No. of aborted seeds	Total seed wt. (g)
Fruit shape index									
Fruit hollowness (cm)	-0.082								
Specific gravity	-0.567	-0.650*							
TSS: acid	-0.425	0.222	0.338						
Juice (%)	-0.073	-0.423	0.168	-0.433					
Waste index	-0.183	0.723*	-0.409	0.217	-0.510				
Total healthy seeds	-0.048	0.909**	-0.714*	0.054	-0.500	0.727*			
No. of aborted seeds	-0.236	-0.389	0.253	-0.540	0.277	0.079	-0.321		
Total seed weight (g)	-0.081	0.693*	-0.445	0.415	-0.282	0.721*	0.795*	-0.488	
Seed shape index	-0.031	0.172	-0.145	0.260	0.186	0.296	0.234	-0.279	0.669*

*, **Significant at 5 & 1% levels

contributed significantly to waste index. Total number of seeds per fruit was also positively correlated with total seed weight per fruit (0.795*). Total-seed weight per fruit was positively correlated with seed shape index (0.669*). Highest juice content, total soluble solids (TSS), TSS: acid ratio and palatability rating for large sized fruits has been also reported by Gill *et al.* (7). This data showed the role of seed numbers in controlling the final size of fruit. Developing seeds are active sites of auxin, cytokinin and gibberellins synthesis. The physiological role of endogenous hormones produced in developing seeds are able to pass out of the seed either along the vascular system or by diffusion through the testa, which in turn directly stimulate the growth of surrounding tissues of the fruit and indirectly by directing the metabolic transport of photosynthates required for fruit growth (Crane, 4). Ovaries contain a greater number of fertilized ovules hence; greater seed number may automatically accompany larger fruit size. Similarly, there is direct relationship between seed number and peel thickness of Sikkim mandarin. The role of endogenous hormones in normal and abnormal (rough) thickness of mandarin fruits has been extensively reviewed (Moneselise and Goren, 11). There is direct correlation between the development of rough peel and the presence of higher cytokinin and gibberellin levels in the relevant tissues (Erner *et al.*, 6)

The fruit and seed quality revealed significant variation in all the four districts of Sikkim. However, the big sized fruits that possessed good quality and high number of good quality seeds can be recommended for raising mandarin nursery and fresh fruit market, while the smaller fruits with higher juice content and low waste index may be processed for value-addition fetching higher returns to the resource poor farmers of Sikkim, since they are normally sold in market at very low price.

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