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Evaluation of superior Darjeeling mandarin genotypes/clones from Sikkim and Darjeeling hills

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ABSTRACT

Surveys were done in major orange growing belts of Darjeeling and Sikkim hills in the fruit ripening time which was during November till February in the year 2020-2021. Mandarin collected from Darjeeling district of West Bengal (Kurseong) showed the highest fruit weight (101.87g), juice volume (56.57 ml), pulp weight (86.40 g), and seed weight (2.31 g) whereas mandarin collected from East Sikkim showed the lowest fruit weight (72.17 g), juice volume (28.78 ml), pulp weight (45.86 g) and seed weight (1.29 g). Highest total soluble solids (TSS) of 11.69° brix was recorded in fruits collected from North Sikkim and Kalimpong. Minimum acidity of 0.65% was recorded in fruits collected from Kurseong, Darjeeling. TSS: Acid Ratio i.e. High TSS and Low Acidity which is an important qualitative characteristic for consumer acceptance and marketability was found highest in fruits collected from North Sikkim and Kurseong. Based on morphological and biochemical traits, fruits collected from Kurseong Darjeeling district were found superior for both quantitative and qualitative traits. The accession can be used for the production of quality planting material.

***Keywords*:** Acidity, Darjeeling mandarin, evaluation, superior clones, TSS

Darjeeling mandarin (*Citrus reticulata* Blanco) is one of the important cash crops for the farmers of Sikkim and Darjeeling hills. The crop is grown in hills since time immemorial. For most farmers, it is the only source of income that sustains their livelihood. The area under Darjeeling mandarin is declining at an alarming rate.In 1999-2000, the cultivated area of mandarinin West Bengal was 30,000 ha. In 2007-2008, it was 1,972 hectares (Tarafdar *et al*., 2017). Presently the area production and productivity of Darjeeling mandarin in West Bengal is 4.14 thousand ha with a production of 40.18 thousand tons and productivity of 9.71 thousand tons per ha (Anonymous, 2018).The major reasons for the decline are lack of quality planting material, poor and neglected orchards, pest and disease attacks etc. Many of the orchards of Sikkim and Darjeeling hills are poor and neglected with old diseased trees resulting in inferior quality fruits. Thus, this represents to the consumer that oranges from Darjeeling and Sikkim hills are of poor quality with small size fruits and less sugar content. However, there are orchards whose fruits are of excellent quality and of great export potential.Thus, there is a need to identify such planting material with good qualitative characteristics such as big fruit size, high juice content, high sugar: acid blend, high TSS and fewer seeds and replant the declining areas with disease-free healthy planting material so as to boost up the production in the hills and to revive the Darjeeling mandarin production. Mandarin ensures livelihood security to the farmers of the region whose marketability is determined by the increased fruit size and the ratio of total soluble solids (TSS) to acidity ratio (Dorji and Yapwattanaphun, 2011). Thus, a study was undertaken to survey, identify and evaluate superior clones of Darjeeling mandarin.

Surveys were done in major orange growing belts of Darjeeling and Sikkim hills in the fruit ripening time which was during November till February in the year 2020-2021. Details of the collection sites are given in Fig. 1. A total of 30 orchards from major orange growing belts were surveyed. From each place, 5 orchards were visited and from each orchard 10 fruit were collected. The plants were propagated through seedling with age from 10 to 20 years.

The fruit sample was brought to the IARI Regional Station, Biochemistry Laboratory for analysis. The fruit weight, pulp weight, peel weight, and seed weight were measured with the help of an electronic balance (BOECO Germany, BBL31-26406021). Volume of the fruits was measured by the water displacement method. Fruit diameter, fruit length, and peel thickness were measured using a digital vernier calliper (Mitutoyo,

Short Communication

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Table 1: Fruit morphological characterization of Darjeeling mandarin

Place	Fruit weight (g)	Fruit volume (ml)	Juice volume (ml)	Pulp weight (g)	Peel weight (g)	Peel thickness (mm)	No. of segment	Segment weight	Fruit diameter (mm)	Fruit length (mm)	No. of seeds	Seed weight (g)
I	93.73^{ab}	88.67^{a}	39.27^{b}	84.00^{a}	16.58	63.99	9.20	7.45	46.58	87.57^{a}	11.26^{b}	1.66^{b}
II	73.80^{cd}	78.67^{ab}	34.53^{bc}	54.83^{b}	16.50	64.07	8.47	7.46	45.04	86.17^{b}	10.60^{b}	1.70^{b}
III	72.17^{cd}	80.42^{ab}	28.78^{c}	45.86^{b}	17.20	64.10	8.84	7.06	42.20	86.14^{b}	10.03^{b}	1.29^{c}
IV	84.07^{bc}	73.27^{b}	37.33^{bc}	60.53^{b}	15.53	64.15	10.93	7.46	45.69	86.40^{ab}	10.80^{b}	1.67^{b}
V	67.50^{d}	45.33^{c}	30.67^{bc}	54.25^{b}	14.08	64.18	8.75	6.95	44.49	84.28^{c}	10.50^{b}	1.46^{bc}
VI	101.87^{a}	79.53^{ab}	56.67^{a}	86.40^{a}	15.27	63.85	9.87	8.58	46.38	86.69^{ab}	15.80^{a}	2.31^{a}
CV	**9.13**	**9.42**	**13.62**	**14.89**	**22.97**	**0.23**	**9.56**	**9.68**	**4.19**	**08.24**	**14.98**	**10.82**
CD@1%	**19.42**	**18.12**	**13.35**	**24.78**	**NS**	**NS**	**NS**	**NS**	**NS**	**3.68**	**NS**	**0.47**
CD@5%	**13.66**	**12.74**	**9.38**	**17.42**	**NS**	**NS**	**NS**	**NS**	**NS**	**2.59**	**3.14**	**0.33**

I-Suntaley,S.Sikkim, II-Lingee, S.Sikkim,III-East Sikkim,IV-Kalimpong, W.B,V-Dzongu, N.Sikkim,VI-Kurseong, Darjeeling

Table 2: Component loading of five principal components of Darjeeling mandarin based on fruit characters

Characters	*PC1*	*PC 2*	*PC 3*	*PC 4*	*PC 5*
Frtwt	0.54	-0.08	0.22	0.62	0.13
Frt vol	0.40	0.89	0.00	-0.12	-0.06
Juice vol	0.35	-0.24	0.73	-0.37	-0.19
Pulp wt	0.65	-0.34	-0.60	-0.20	0.05
Peel wt	0.01	0.09	-0.02	-0.04	0.12
Peel thickness	0.00	0.00	0.00	0.02	-0.02
Sgm	0.02	-0.01	0.06	0.27	-0.22
Sgmwt	0.02	-0.01	0.06	-0.04	-0.03
frtdia	0.05	-0.05	-0.07	0.01	-0.68
Frt Len	0.04	0.05	-0.03	0.05	-0.07
NoS	0.07	-0.06	0.19	-0.15	0.26
seed wt	0.01	-0.01	0.03	-0.03	-0.06
TSSR" Brix	-0.02	-0.01	0.01	0.16	-0.01
Acidity	0.00	0.00	0.00	0.04	-0.03
Ascorbic acid	0.00	0.01	0.11	0.31	0.44
TSS:Acid	0.02	0.02	0.01	-0.44	0.39
Eigen Value	612.92	161.62	24.65	6.93	1.38
Variance (%)	75.903	20.015	3.053	0.8580	0.1710

Frtwt-Fruit weight,Frt vol- Fruit volume, Juice vol- Juice volume, Pulpwt- Pulp weight, Peel wt- Peel weight, Peel thickness, Sgm- Number of Segment, Sgmwt- Segment weight, frtdia- Fruit DiameterFrt Len-Fruit Lengthseed wt- Seed weight, TSSR" Brix,AcidityAscorbic acid,TSS:Acid Ratio

Model number-500-196-20). Total acidity (%) was estimated through a volumetric procedure. In 5ml of filtered juice and 5ml of distilled water, a few drops of phenolphthalein indicator were added and titrated against standard alkali solution (1N NaOH) and expressed as percentage acidity (AOAC, 2000). Ascorbic acid content of the fruit juices was estimated by using 2, 6 dichlorophenol-indophenol dye titration method (Ranganna, 2003). TSS was measured by Electronic Refractometer (Hanna instrument, HI96801). Statistical analysis was done by applying Fisher's analysis of variance (Panse and Sukhatme, 1989).

Table 1 depicts the morphological characteristics of Darjeeling mandarin fruits. Mandarin collected from the Darjeeling district of West Bengal (Kurseong) showed the highest fruit weight (101.87g), juice volume (56.57 ml), pulp weight (86.40 g), and seed weight (2.31 g) whereas mandarin collected from East Sikkim showed the lowest fruit weight (72.17 g), juice volume (28.78 ml), pulp weight (45.86 g) and seed weight (1.29 g). Higher fruit weight generally had high juice volume, pulp weight, and seed weight, and vice versa. There were no significant differences for peel weight, peel thickness, number of segment, segment weight, fruit diameter

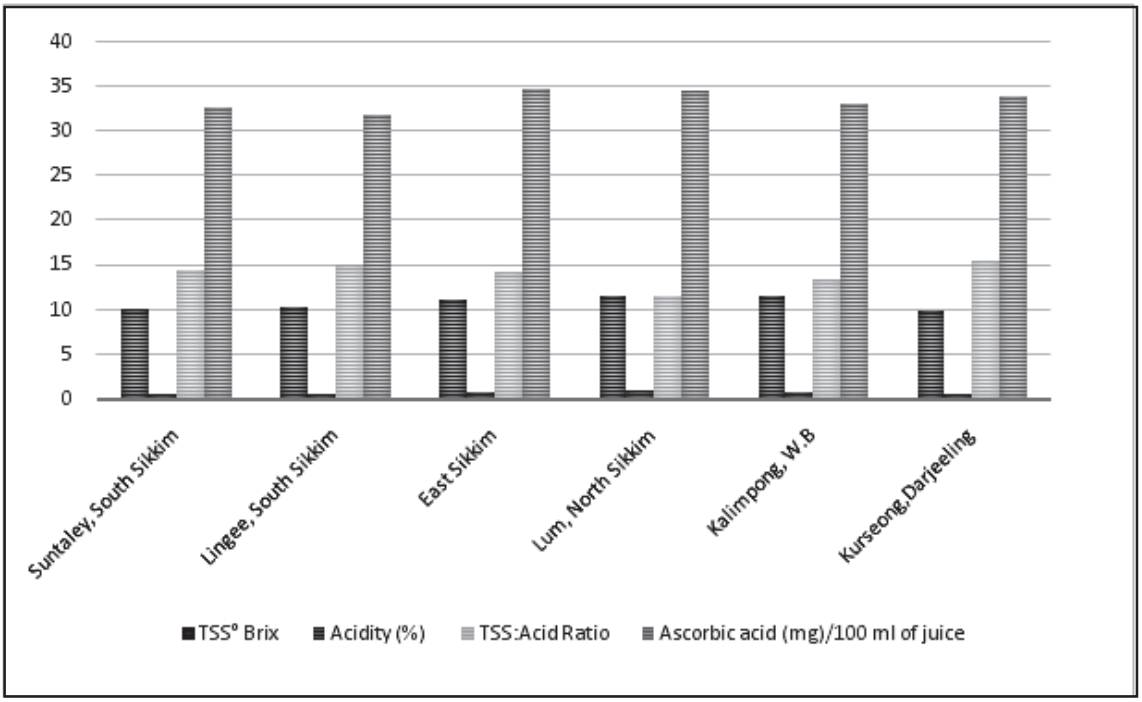

Fig. 1: TSS, Acidity and ascorbic acid of Darjeeling mandarin

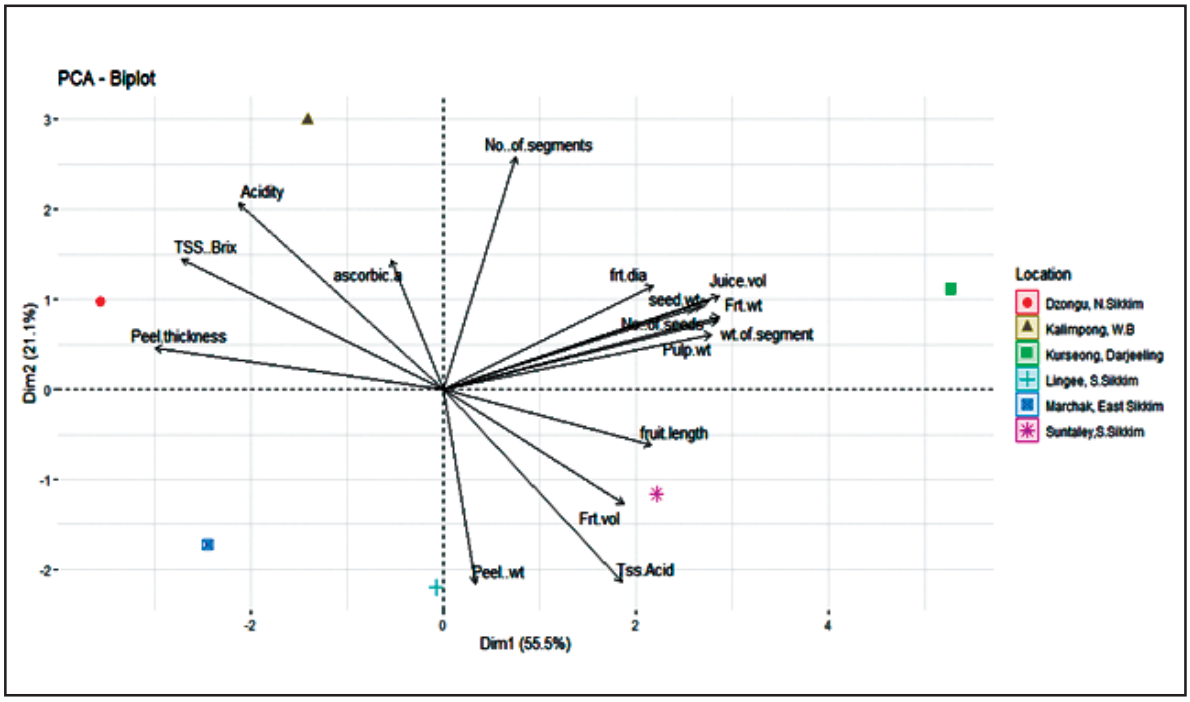

Fig. 2: Biplot analysis using first two principal component (PC1 and PC2)

among all the mandarin accessions.Dorji and Yapwattanaphun (2011) reported wide variations in quantitative characters in Bhutanese mandarin. Many researchers have already reported significant variations in fruit morphological and physico-chemical traits of mandarin germplasm (Khan *et al*., 2008; Josan and Kaur, 2006 ; Longkumer and Kabir, 2014; Singh *et al*., 2017). The results were in accordance with the observations of Moore (2001) and Reuther *et al.* (1967) who reported that mandarins are a highly heterogeneous group in citrus and showed higher phenotypic variation than any other citrus group.

Bio-chemical characteristics such as TSS, acidity and ascorbic content are presented in Fig. 1. The highest TSS of 11.69° Brix was recorded in fruits collected from North Sikkim and Kalimpong. Minimum acidity of 0.65% was recorded in fruits collected from Kurseong, Darjeeling. TSS:Acid ratio i.e.high TSS and low acidity which is an important qualitative characteristic for consumer acceptance and marketability was found highest in fruits collected from North Sikkim and Kurseong, Darjeeling.The level of TSS/acidity indicates the sweetness of an orange (Kishore *et al*., 2010).The accession showed no significant variation in ascorbic acid content. Variation in TSS in the accessions maybe due to the variation in the elevations. The highest TSS (11.69° Brix) was observed in the accession collected from more than 1200m MSL. Lowest TSS(10.09° Brix) was observed from accession from elevation of less than 800m MSL.

Principal Component Analysis

PCA revealed five component for 100 % of the total variations (Fig. 2 and Table 2). Fruit characteristics such as fruit weight, fruit volume, juice volume, pulp weight were the most important traits that contributed to the variation of 75.90 % in PC1. Fruit volume, peel weight, fruit length, TSS:Acid and ascorbic acid were the most important traits accounting for 20.02% variation in PC2.PC3,PC4 and PC5 accounted for 8.35%, 7.28% and 6.50% of the total variation respectively.

CONCLUSION

The study revealed that based on morphological and biochemical traits fruits collected from Kurseong of Darjeeling district were found superior for both quantitative and qualitative traits. This accession can be used for the production of quality planting material.

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