Evaluation of Exotic Mandarin Germplasm under Mid-Hills of Sikkim Himalayan Region

K Kishore[1*], N Monika, D Rinchen, B Pandey, R Singh[2], H Rahman and A Kumar
ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok-737102, Sikkim
[1]*Directorate of Research on Women in Agriculture, Khandagiri Road, P.O. Baramunda, Bhubaneshwar-751003, Odisha*
[2]*Indian Institute of Vegetable Research, Varanasi-221005, Uttar Pradesh*

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Eight exotic mandarin germplasm were evaluated on the basis of physico-chemical properties of fruit at ICAR Research Complex, Sikkim Centre, Tadong, Gangtok, during 2009 and 2010. Cultivar 'Dancy' had the longest fruit development period and maximum oil gland density, whereas, Thorny showed precocity in fruit development. Except 'Page', all mandarin germplasm had loosely adhered flavido which is the desired character for table type variety. 'Kinnow' and 'King' mandarins have relatively bigger and heavier fruit, whereas, 'Page' has the smallest and 'Fortune' has medium size fruit. Except 'Fortune', other cultivars could not develop deep orange colour in their fruit. Fortune had maximum juice content (51.3%), TSS (10.4° Brix), TSS/acid ratio (11.07), sugar content (7.86%) and sugar/acid ratio (8.45). It also had intermediate number of seeds/fruit (10.2). Whereas, 'Dancy' has the minimum juice content (42.6%), TSS (8.2° Brix), TSS/acid ratio (5.77), sugar/acid ratio (4.45%) and seeds/fruit (7.3). Physico-chemical properties of mandarin germplasm clearly indicated that 'Fortune' mandarin possesses desired qualities for table type cultivar and hence deserves adoption after further field evaluation trial.

Key Words: Fruit, Juice content, Mandarin, Sugar/acid ratio

Introduction

Citrus is cultivated under varied latitudes of tropical and subtropical regions of the world as well as of India. India ranks forth in world citrus production (Anon., 2010) and citrus industry is mainly dominated by sweet orange (*Citrus Sinensis* Osbeck), mandarin (*Citrus Reticulata* Blanco), lemon (*C. limon*) and lime (*Citrus Rurantifoli*a Swingle), however, other citrus groups are cultivated at limited scale (NHB, 09-10). The northeastern region is rich treasure of various Citrus species and varieties (Bhattacharya and Dutta, 1956). Manipur and Assam are major citrus producing state, accounting for more than 60 % of citrus production in the region (NHB, 09-10). Among citrus, mandarin is considered as the most important horticultural fruit crop of the regions, which plays vital role in sustaining the livelihood of farmers. Mandarin shows minor variation in physico-chemical properties due to its adaptability under different climatic conditions (Singh *et al.*, 2001). In Sikkim, mandarin (*Citrus reticulata* Blanco) is mainly cultivated in the mid hills under the subtropical temperate humid climatic conditions with the altitudinal variations of 3000 -4200 feet.

The North-eastern region is recognized globally as an area of citrus diversity but the genetic erosion of valuable citrus species warrants for an urgent step for conservation of exceptionally well performing germplasm under specific climatic conditions. Sharma *et al.* (2004) studied in detail the genetic resources of citrus of north eastern India and put emphasis on their systematic conservation and potential use. Furthermore, Malik *et al.* (2006) characterized the endangered potential citrus root stocks of northeastern region and perceived the potential threat of erosion if not conserved. Many potential exotic citrus species/varieties have been introduced and some of them have well adapted and some has the potential to be grown at larger scale. Initially germplasm should be characterized, evaluated and screened against biotic and abiotic stresses for future utilization for improvement. Other strategies include *ex-situ* conservation facilities such as gene banks. The later has received considerable importance after perceiving the threat of rapid genetic erosion.

The physico-chemical and sensorial attributes of mandarin cultivated in different areas of Sikkim has been studied (Kishore *et al*., 2009) however, evaluation of performance of exotic mandarin germplasm under mid hills of Sikkim has not been done so far. This study will be helpful not only in giving an overview of the potential of exotic mandarin germplasm but also in conserving them.

**Author for Correspondence: E-mail: kkhort2003@yahoo.com*

Moreover, the potential germplasm may be suggested for step-wise adoption in the region due to poor productivity of Sikkim mandarin.

Materials and Methods

A total of eight mandarin germplasm; Dancy, Thorny, Fox, Fortune, Afourer, Page, King (Citrus nobilis Lour.) and Kinnow (*C. nobilis* Lour. x *C. deliciosa* Ten.) were collected under Sikkim Foundation Programme from Catherin Research Institute, Australia. Germplasm were planted in 2001 in the research farm of ICAR Sikkim Centre, Tadong, Gangtok located at latitude of 27°20' N, longitude of 88° 4' E and altitude of 1300m amsl. The prevailing climate is temperate humid with annual rainfall of 2850 mm and mean minimum and maximum temperature ranges of 11.5 and 24.6°C, respectively. Plants were planted in randomized block design with three replications and evaluated in 2009 and 2010 on the basis of their yield attributes and fruit characters. Data on flower and fruit characters were recorded as per the descriptor for Citrus (IPGRI, 1999). Physical characters of fruit were measured by considering mean value of ten fruits; however, data on chemical characters were calculated by taking mean value of five fruits under different replications during 2009 and 2010. The juice percentage was calculated by dividing the juice content with fruit weight and by multiplying the resultant with 100. The total soluble solids (TSS) were recorded by hand refractometer (0-32° Brix), whereas, titrable acidity, vitamin C, reducing sugar and total sugar were determined by following the methods of Ranganna (1991). The TSS/acid ratio was calculated by dividing TSS and titrable acidity and similarly sugar/acid ratio was calculated by dividing sugar and acid. Data collected on various attributes during 2009 and 2010 were averaged and subjected to analysis of variance (ANOVA) to test the significance among variables and Duncan multiple range test at $P<0.05$ to compare the means by using SPSS statistical package (11.5 version).

Table 1. Physical characters of mandarin germplasm

Citrus species	Variety	IC No.	Time of flowering	Duration from flower to fruit maturity (days)	Fruit base	Fruits apex	Fruit shape	Flavido colour	Flavido adherence	Nature of oil glands	Oil glands/ mm^2	Albedo colour
C. reticulata	Dancy	586981	Feb. 1st fortnight	287.5[a]	Convex	Flat	Obloid	Light orange	Loose	Conspicuous	6.3[a]	White with yellow tinge
C. nobilis	King	586982	Feb. 2nd	278.3[b]	Truncate	Flat	Spherical	Light orange	Loose	Conspicuous	5.4[ab]	Creamish
C. reticulata	Thorny	586983	Mar. 1st fortnight	252.7[e]	Convex	Flat	Spherical	Orange	Slightly tight	Conspicuous	5.7[a]	White with orange tinge
C. reticulata	Fox	586984	Feb. 2nd fortnight	270.3[c]	Truncate	Flat	Obloid	Greenish with yellow tinge	Loose	Conspicuous	4.2[bc]	Creamish
C. reticulata	Fortune	586985	Feb. 2nd fortnight	265.3[d]	Convex	Convex	Obloid	Deep	Slightly tight	Highly Conspicuous	5.6[a]	Creamish
C. reticulata	Afourer	586986	Feb. 1st fortnight	267.7[d]	Convex	Flat	Spherical	Orange	Slightly tight	Conspicuous	5.1[ab]	Creamish
C. reticulata	Page	–	Feb. 2nd fortnight	277.7[b]	Convex	Flat	Spherical	Orange	Strong	Conspicuous	5.4[ab]	White with orange tinge
C. nobilis x *C. deliciosa*	Kinnow	–	Mar. 1st fortnight	271.7[c]	Truncate	Flat	Obloid	Orange	Slight tight	Conspicuous	4.6[bc]	White with orange tinge
CD at 5%			–	6.6	–	–		–	–	–	0.8	

Data with the same superscripted letter in a column are statistically non-significant (p=0.05)

Table 2. Physico-chemical characterization of mandarin germplasm

Citrus species	Variety	IC No.	Fruit size (mm)	Fruit wt. (g)	Peel thick-ness (mm)	Fruit firm-ness (lb/ inch$^{2)}$	No. of seg-ments	Juice (%)	TSS (^{o}B)	Acidity (%)	TSS/ acid ratio	Vit. C (mg/ 100 g)	Red. sugar (%)	Total sugar (%)	Sugar/ acid ratio	Seeds/ fruit
C. reticulata	Dancy	586981	63 x 54	98.5^{c}	3.5 ^{a}	5.6^{c}	10^{a}	42.6^{c}	8.2^{b}	1.42^{a}	5.77^{d}	62.5^{a}	4.82^{c}	6.32^{d}	4.45^{e}	7.3^{c}
C. nobilis	King	586982	65 x 57	108.6 ^{b}	3.2 ^{b}	6.2^{a}	10^{a}	43.4^{c}	8.8^{b}	1.12^{b}	7.85^{c}	55.2^{b}	5.10^{b}	6.54^{c}	5.83^{c}	18.3^{b}
C. reticulata	Thorny	586983	62 x 52	90.3^{d}	3.2 ^{b}	5.5^{c}	11^{a}	47.5^{b}	9.3^{a}	0.98^{c}	9.48^{b}	47.3^{d}	5.24^{a}	6.84^{c}	6.97^{b}	7.9^{c}
C. reticulata	Fox	586984	63 x 53	95.6^{d}	3.6 ^{a}	5.8^{b}	10^{a}	46.2^{b}	8.4^{b}	0.96^{c}	8.75^{b}	48.2^{d}	4.65^{c}	6.23^{d}	6.48^{b}	21.4^{a}
C. reticulata	Fortune	586985	60 x 52	87.6^{e}	3.2 ^{b}	5.6^{c}	8^{b}	51.3^{a}	10.4^{a}	0.93^{c}	11.07^{c}	45.3^{d}	5.62^{a}	7.86^{a}	8.45^{a}	10.2^{c}
C. reticulata	Afourer	586986	58 x 51	82.6^{f}	3.2 ^{b}	5.6^{c}	9^{ab}	47.6^{b}	8.5^{b}	1.21^{b}	7.02^{c}	48.4^{d}	4.75^{c}	6.21^{d}	5.13^{d}	17.4^{b}
C. reticulata	Page	–	56 x 50	64.5^{g}	3.5 ^{a}	5.7^{c}	10^{a}	44.3^{c}	10.2^{a}	1.22^{a}	8.36^{b}	52.7^{c}	5.12^{b}	7.42^{b}	6.08^{bc}	16.6^{b}
C. nobilis x *C. deliciosa*	Kinnow	–	66 x 58	113.5 ^{a}	3.7^{a}	6.1^{b}	10^{a}	50.6^{a}	9.8^{a}	1.28^{a}	7.65^{c}	56.4^{b}	4.95^{c}	7.30^{b}	5.70^{c}	18.1^{b}
CD at 5%				3.4	0.2	0.3	1.4	1.9	1.6	0.2	0.8	3.5	0.4	0.4	0.6	3.1

Data with the same superscripted letter in a column are statistically non-significant (p=0.05)

Results and Discussion

The qualitative and quantitative traits varied with germplasm (Table 1 and 2). The flowering time varied from February to March, however, Dancy and Afourer showed precocious flowering, whereas, Kinnow and Thorny were late in flowering under the temperate humid climate of Sikkim. Thorny mandarin had the shortest fruit development cycle and got matured in 252.7 days whereas, Dancy had the longest fruit development period of 287.5 days. Most of the germplasm had oblate fruit shape with convex fruit base and flat apex, however, the fruit base of King and Fox mandarin was truncate. Flavido colour of germplsm varied from light orange to deep orange colour except Fox mandarin which had greenish colour flavido with yellow tinge , whereas, albedo colour of germplasm varied from creamish to whitish. As regard to adherence of flavido with albido, except Page other mandarin germplasm were loosely adhered. Nature and density of oil gland are considered important variables for germplasm characterization. All germplasm had conspicuous oil gland the maximum oil gland density recorded in Dancy (6.3/ mm^{2}) and minimum in Fox mandarin (4.2/mm^{2}), whereas other germplasm had intermediate density.

Physical properties of fruits of different germplasm clearly indicate that King and Kinnow bear relatively bigger and heavier fruits, whereas Page mandarin has the smallest and lightest fruits. Peel thickness varied marginally with germplasm and the maximum peel thickness was recorded in Kinnow followed by Fox mandarin. Thorny had the maximum segments, whereas Fortune had the minimum. Juice content varied from 42.5-51.3% and the highest percentage of juice was recorded in Fortune (51.30%), whereas Dancy had the minimum.

The chemical analysis of fruit showed that Fortune had the highest TSS and lowest acidity that resulted highest TSS/acid ratio (11.8), whereas fruit of Dancy had the lowest TSS, highest acidity and consequently lowest TSS/acid ratio. The highest vitamin C content was recorded in Dancy and lowest in Fortune. In contrast, Fortune had the highest reducing sugar, total sugar and sugar acid ratio followed by Thorny mandarin, whereas, Dancy had the minimum reducing sugar, total sugar and sugar acid ratio. The highest sugar acid ratio suggests high sweetness and preferred variety for table purpose. Varietal preference is also based on the number of seeds/fruit and generally fruits with less seed are preferred. Fox had the maximum number of seeds/ fruit (21.4) and Thorny had the minimum number (7.9). Preliminary evaluation studies clearly indicated that Fortune mandarin has potential to become the table variety of this region, as its fruit possesses most of the required physicho-chemical properties. However, before suggesting for adoption further multilocational field evaluation is required to be undertaken. Citrus diversity of northeastern region has been studied by various workers (Hore *et al*., 1997; Malik *et al*., 2006; Singh *et al*., 2001) and they suggested proper exploitation of potential germplasm in crop improvement. This effort will further strengthened by more concentrated efforts to characterize document and conserve the native and exotic species of citrus in North-eastern India.

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