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Evaluation of different mandarin, sweet orange, rootstock species and cultivars under mid hill conditions of Arunachal Pradesh

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ABSTRACT

A study was conducted to evaluate the different citrus species/cultivars under Arunachal Pradesh conditions. Maximum plant height and fruit weight was observed with Mediterranean orange. Zigardio mandarin recorded the highest leaf length, leaf breadth and bigger size fruit. Mandarin cultivars were devoid of thorn however very small thorns were noticed in King theppi and *Khasi* mandarin. *Khasi* mandarin recorded comparatively more segments than other mandarins. Flesh colour of the oranges varied from deep orange in *Khasi* mandarin to yellow in Wiliking orange. Nagpur mandarin recorded more number of seeds. The seeds were small, oval and yellow in colour for most of the oranges. Maximum plant height and big size fruits were observed with Washington malta sweet orange. Italian large and Vanilla malta recorded the highest leaf length and breadth while the least length was recorded with ruby blood red. The lower fruit weight was recorded with Italian large. The seed number varied from as low as one in Washington malta to as high as fifty five in *tagu*. *Tanyum* was bushy type with very long and sharp thorns. *C. jawanica* recorded the highest leaf length and breadth. Trifoliate plant with its distinct leaf characteristics was borne with very small leaves than other plants. *Karna katta* recorded comparatively bigger sized fruit while Cleopatra mandarin was smaller in size. The rind colour was deep orange for Cleopatra mandarin to light yellow for *C. latipes*. *Tanyum* had profuse seeds followed by *C. latipes.*

Key words: *Citrus* species, rootstocks, evaluation.

INTRODUCTION

Citrus occupies third place after mango and banana, grown in 0.798 million ha area to the production tune of 7.15 million tonnes per annum in India (NHB, 11). The most commercial citrus cultivars in India are the mandarin, followed by sweet orange and acid lime sharing 41, 23 and 21 per cent of area respectively. It is the second important fruit crop in world trade for fresh fruits and more than 50 countries are growing citrus commercially in different agro-climatic conditions for its diversified use and increasing demand world over. India is the sixth largest producer of citrus contributing 4.8% of the worlds, total citrus production. But has no place in world trade due to few of seedless varieties of mandarin, production of exportable quality fruit is low, colour development of fruit is inadequate etc. (Singh, 10). The diverse geographical regions characterized by varying temperature and rainfall have given rise to a wide range of variability in citrus and related genera in India. The north-eastern Himalayan region is endowed with favourable agro-climatic conditions for the growth of different citrus species and is considered the natural home of several citrus species. NE region, especially Arunachal Pradesh state is known for its quality production of *Khasi* mandarin. Among the different fruit crops grown in this state, more than 35% area is under this crop (Gogoi *et al*., 4). The wide distribution of *Sohning Riang*, *tasi, tagu* a wild sweet oranges, wild Indian mandarin, *C. assamensis*, *C. ichangensis*, *C. latipes* and *C. macroptera* in various parts of NE region gives strong indication that the region may have been the natural home for these species (Bhattacharya and Dutta, 1; Ghosh, 3). Among different citrus species, *Khasi* mandarin is the premier crop in Arunachal Pradesh, growing in over 23,360 ha area with the production of 27,251 tonnes with the productivity of modest 1.75 tonnes per ha. The crop is being grown in all sub-tropical belts of the state comprising around 60% of the total geographical area. Due to unawareness of the biodiversity some species are almost near extinct. The rich gene pools incorporating extensive variability from basic ingredients are important for improvement programmes. There is urgent need to collect all the available citrus genotypes and land races and maintain them in field gene bank (Singh and Singh, 9). Keeping the above all in mind, ICAR Research Complex for North Eastern Hill Region, AP Centre Basar, Arunachal Pradesh has collected different exotic and indigenous citrus species for evaluation and further citrus improvement programmes. The purpose of this study was to evaluate the different citrus species/ cultivars and suggest the suitable cultivars other than *Khasi* mandarin for north eastern region, especially in Arunachal Pradesh.

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MATERIALS AND METHODS

The present study was undertaken in ICAR RC NEH Region, AP Centre, Basar, Arunachal Pradesh, which extends 26° 28′ to 29° 28′ N latitude and 91° 35′ to 97° 27′ E longitude, 631 m above MSL for consecutive two seasons during 2007-08 and 2008-09. The soil in the farm is loamy clay with slightly acidic pH (5.6). Mean maximum (27.5°C) and minimum (16.7°C) temperature and relative humidity (64.7%) were recorded besides 1787.37 mm of rainfall; average of two growing seasons was also recorded during the growing period. Different citrus cultivar *viz.,* sweet oranges (13), mandarin (10), rootstock species/cultivars (9), assam lemon, pumello (2) and *khagzi* lime altogether 36 different cultivars/species are collected and growing in the research station. The trees are almost 16-year-old during the investigation. Urea, SSP and MOP were applied to tree at the constant level of 250, 200, 250 g NPK/tree/year. Urea was applied in two splits *i.e.*, immediately after harvesting and pruning (during mid January) and after fruit set (during August). Phosphorus and potassium were applied along with half the dose of nitrogen after harvesting. All the scientific package of practices was followed uniformly to all the treatments.

The data on growth parameters *viz.,* tree height (m), canopy coverage (m), leaf length (cm), leaf breadth (cm), presence of thorn were recorded. Ten fruits per each replication were taken randomly and analyzed for physico-chemical characteristics of fruits. The fruit characteristics like rind thickness (mm), number of segments, fruit length (cm), breadth (cm), fruit weight (g), fruit volume (ml), juice /fruit (ml), number of seeds, seed appearance , seed length (mm) and seed breadth (mm) were recorded. Chemical parameters like TSS, ascorbic acid and acidity were also analyzed as per procedure given by Ranganna (7). Flower bud initiation period and harvesting period was also recorded to know the variation among cultivars. All the treatments were executed on randomized block design (RBD) with three trees as a unit for one replication and replicated thrice. The average values were recorded for further statistical studies. Statistical analysis was carried out to know the variance for different parameters, using AGRES package and significance was identified in both 1 and 5% levels.

RESULTS AND DISCUSSION

Growth and fruit characters of mandarin cultivars are presented in Table 1. Maximum plant height was observed with Mediterranean orange which was on par with King *theppi* followed by Zigardio mandarin while the minimum plant height was observed in Wilking orange. Other cultivars did not variy significantly in their plant height. Canopy spread of the plants followed the similar pattern to that of plant height. Among the different mandarin cultivars Zigardio mandarin recorded the highest leaf length and leaf breadth than other cultivars (Table 1). *Khasi* mandarin and Mediterranean orange were at par with each other on these two parameters. Hill mandarin, Sikkim mandarin and Nagpur mandarin were smaller in length and recorded the similar leaf length whereas the leaf breadth was smaller in Hill mandarin and Nagpur mandarin followed by Sikkim mandarin. Mandarin cultivars were devoid of thorn however very small thorns were noticed in King *theppi* and *Khasi* mandarin. Zigardio mandarin recorded comparatively bigger sized fruit than other mandarins followed by King *theppi*. Nagpur mandarin and *Khasi* mandarin were similar in length and medium in size. Sikkim mandarin was comparatively smaller in size followed by Kara mandarin. However the highest fruit breadth was recorded with Nagpur mandarin followed by *Khasi* mandarin. Similar kinds of observations were recorded by Singh and Singh (9). The variation in fruit length and breadth produced flatness for *Khasi* mandarin whereas the Zigardio and Wilking orange acquired the globose shape.

Higher fruit weight was noticed in Mediterranean orange followed by *Khasi* mandarin. Zigardio mandarin and King *theppi* were at par with each other in their fruit weight. Hll mandarin and Sikkim orange were also similar in fruit weight. The lower fruit weight was recorded with Wilking orange followed by Kara mandarin. The volume of the fruit was more with Mediterranean orange followed by Nagpur mandarin. Zigardio mandarin and Kara mandarin were similar in water replacement. Least volume was recorded with wilking orange. Juice recovery per fruit was more in Mediterranean orange while the least was recorded with wilking orange. Fruit segment is the one parameter in which there was not much variation was observed among mandarins. However, *Khasi* mandarin recorded comparatively more segments than other mandarins. Flesh colour of the oranges varied from deep orange in *Khasi* mandarin to yellow in Wiliking orange. Higher rind thickness (mm) was noticed in Mediterranean orange which is at par with Zigardio mandarin. The rind was very thin for cultivars like Kara mandarin, Sikkim mandarin and Wilking orange. The most popular *Khasi* mandarin had medium level of rind thickness which gave adequate protection from bruising damage and latent infection from diseases. Nagpur mandarin recorded more number of seeds among the different mandarins evaluated followed by zigardio mandarin. No much variation in the presence of seed was observed between Hill mandarin and Sikkim orange. Very less number of seeds were recorded with Wilking orange

Table 1. Growth and fruit characteristics of different mandarin cultivars in mid hill conditions of Arunachal Pradesh.

Cultivar No.*	Plant growth characteristics (Pooled mean)					Fruit characteristics (Pooled mean)								Seed characteristics (Pooled mean)			
	Tree height (m)	Canopy spread E-W x N-S (m)	Leaf length (cm)	Leaf breadth (cm)	Presence of thorn	Length (cm)	Breadth (cm)	Weight (g)	Volume (ml)	Juice/ fruit (ml)	No. of segments	Flesh colour	Rind thickness (mm)	No. of seeds	Seed length (mm)	Seed breadth (mm)	Appearance of seed
1	5.4^{bc}	4.8×4.3	6.50^{d}	2.93^{f}	A	4.63^{cde}	4.80^{abc}	97.67^{def}	105.04^{c}	49.57^{ef}	11.33^{ab}	O	3.67^{cde}	9.67^{cd}	10.66^{b}	8.00^{a}	R, Y, S
2	6.2^{a}	4.5×4.6	8.87^{ab}	4.17^{b}	P, S	4.90^{cd}	4.43^{bcd}	162.33^{a}	153.67^{a}	77.38a	10.29^{bcd}	Y	6.00^{a}	2.33^{f}	4.35^{c}	3.04^{d}	VS, Pl, I,Y
3	4.8^{c}	3.2×3.6	6.16^{d}	2.93^{f}	A	5.14^{abc}	5.14^{a}	133.61^{bc}	131.52^{b}	63.37^{c}	9.31^{d}	O	4.34^{bcd}	17.00^{a}	12.41^{b}	6.33^{abc}	S, Y
4	6.2^{a}	4.2×4.3	8.07^{bc}	3.54^{cd}	P, S	5.47^{ab}	4.76^{abc}	114.38^{cde}	108.35^{c}	52.46^{e}	9.34^{d}	Y	5.31^{ab}	8.67^{de}	13.00^{b}	8.07^{a}	I, Y-B
5	4.8^{c}	4.4×4.2	6.26^{d}	3.00^{ef}	A	3.98^{f}	3.81^{de}	97.00^{def}	93.41^{d}	57.68^{d}	10.07^{cd}	O	2.29^{e}	10.66^{cd}	7.04^{c}	4.59^{cd}	S, Pl
6	4.4^{cd}	3.3×2.7	8.50^{abc}	3.43^{de}	A	4.23^{ef}	4.09^{de}	90.14^{ef}	86.79^{e}	42.31^{f}	11.12^{abc}	O	2.28^{e}	6.68^{e}	10.38^{b}	6.42^{abc}	S, I, W-Y
7	5.9^{ab}	4.8×4.6	10.00^{a}	4.77^{a}	A	5.50^{a}	3.67^{e}	113.25^{cde}	100.18^{cd}	58.73^{d}	11.15^{abc}	DO	6.00^{a}	13.31^{b}	13.27^{b}	7.45^{ab}	I, L
8	4.2^{d}	4.2×4.1	7.23^{cd}	3.10^{def}	A	4.45^{def}	2.63^{f}	82.57^{f}	85.25^{e}	38.65^{fg}	9.33^{d}	DO	3.01^{de}	3.69^{f}	12.49^{b}	5.28^{bc}	I, Y, F
9	5.3^{bc}	3.5×3.3	9.50^{ab}	3.93^{bc}	P, S	4.93^{bcd}	4.98^{ab}	141.62^{ab}	138.61^{b}	72.89^{ab}	11.66^{a}	DO	4.67^{abc}	11.57^{bc}	16.52^{a}	5.12^{cd}	S, Ov
10	4.6^{cd}	3.4×3.8	7.31^{cd}	3.1^{def}	A	4.48^{def}	4.23^{cde}	123.68^{bcd}	128.27^{bc}	64.38^{c}	10.35^{bcd}	Y	3.59^{cd}	9.85^{cd}	11.82^{b}	7.33^{ab}	Y, R
CD at 5%	0.87	-	1.50	0.49	-	0.57	0.69	26.71	19.86	5.94	1.24		1.61		0.31	0.21	

P = Present; A = Absent; S = Small; L = Long; M = Medium; VS = Very Small; VL = Very Long; B = Big; O = Orange; Y = Yellow; G = Green; DO = Deep Orange; LG = Light Green; R = Round; I = Irregular; Pl = Plumpy; B = Brown; W = White; F = Flat; Ov = Oval

*1. Hill mandarin; 2. Mediterranean orange; 3. Nagpur mandarin; 4. King *theppi*; 5. Sikkim mandarin; 6. Kara mandarin; 7. Zigardio mandarin; 8. Wilking orange; 9. *Khasi* mandarin; 10. Kinnow mandarin; Means 'i' in a column with similar letters are non-significant.

and Mediterranean orange. Presence of less number of seed is one of the pre-requisite for processing industries of citrus. Therefore this low seed value character of Wilking orange may be used in future breeding programmes. *Khasi* mandarin recorded the highest seed length among the mandarins. Sikkim mandarin and Mediterranean orange recorded the least seed length while all other mandarins studied in this experiment were similar in seed length and no much variation was recorded. Seed breadth was more with Hill mandarin followed by King *theppi*. Zigardio and Kinnow mandarin were medium in their seed breadth and were at par with each other. Least seed breadth was observed in Mediterranean orange. The seeds were small, oval and yellow in colour for most of the oranges. King *theppi* and wilking orange recorded comparatively irregular, flat shaped seeds. *Khasi* mandarin recorded more TSS than other mandarins while the higher acidity was recorded with Mediterranean orange (Fig. 1). Ascorbic acid content in the fruits did not vary much among mandarins. However the content was more in king *theppi* followed by *Khasi* mandarin. It was observed that Zigardio mandarin and King *theppi* were similar in most of the characters studied. Zigarrdio mandarin was the last in harvest followed by King *theppi*. These two mandarins could be exploited to extend the availability of orange during the off-season, *i.e.* April-May. Sikkim orange and Hill mandarin were similar in most of the physico-chemical characters. It could be concluded that among the different mandarins the Zigardio mandarin, Hill mandarin and Sikkim orange cultivation can be promoted to this region to increase the cropping season.

Maximum plant height was observed with Washington malta followed by Valencia Newton while the minimum plant height was observed in Vanilla malta (Table 2). Other cultivars did not vary significantly in their plant height. Canopy spread of the plants followed the similar pattern to that of plant height. Among the different sweet orange cultivars and races Italian large and Vanilla malta recorded the highest leaf length and breadth while the least length was recorded with Ruby Blood Red followed by *tasi* which was par with Washington malta. Mosambi Australia, Daccus malta and *Sohning riang* were medium in their leaf length. It was observed from the table that not much variation was recorded among different sweet oranges and were at par with each other on their leaf breadth. Washington malta recorded comparatively bigger sized fruit than other sweet oranges followed by Vanilla malta. Daccus malta, *Sohning riang*, *Tagu* and mosambi Australia similar in length and were medium in size. Excelier malta was comparatively smaller in size. The performance of sweet orange cultivars were also studied under Punjab conditions (Sharma and Josan, 8). However, the highest fruit breadth was recorded with daccus malta which was at par with Vanilla malta and Washington malta. The fruit breadth was little for Excelier malta. Higher fruit weight was noticed in Washington malta followed by Vanilla malta. Mosambi Australia and *tasi* were at par with each other in their fruit weight. It was observed from table that unlike mandarin greater variation is weight of the fruit within cultivar and among the cultivars was observed in sweet orange. Exotic cultivars like Para malta, Excelier malta and Ruby Blood Red were also similar in fruit weight and their fruit volume. The lower fruit weight was recorded with Italian large. The volume of the fruit was more with Vanilla malta which was par with *tasi* and Washington malta. Least volume was recorded with Italian large. Fruit segment is the one parameter in which there was not much variation observed among sweet orange cultivars which were lucid from the not significant result from the statistical analysis. Similarly variations among sweet oranges were studied by Kalra *et al*. (5). Sweet oranges in general had thicker rind than mandarins. Washington malta was observed with the thicker rind followed by local race *sohning riang*. *Tasi* and daccus malta were at par on their rind thickness. Rest of the sweet orange cultivars was clustered together as no significant difference was recorded with each other on rind thickness of cultivars.

Sweet oranges showed of variations in the presence of seed in the fruit. The seed number vary from as low as one in Washington malta to as high as fifty five in *tagu* which is the local race concentrated much in Along belt West Siang district of Arunachal Pradesh. *Sohning riang*, Italian large and mosambi Australia were par in their seed number. Seed length was highest in Vanilla malta followed by *tagu*. Excelier malta, Washington malta, mosambi Australia and *tagu* were at par with each other and medium in length. Least seed length was recorded with Italian large followed by *Sohning riang* which was par with Para malta and Ruby Blood Red while the seed breadth was more with *tasi* followed by Ruby Blood Red. The lower seed breadth was recorded with Excelier malta. Not much variation was recorded in TSS of different sweet orange cultivars (Fig. 2). Vanilla malta recorded more ascorbic acid followed by excelier malta. Higher and lower acidity was expressed in excelier malta and Whittawar malta respectively. Given the importance in processing industries, the cultivation of sweet orange could be exploited in the region. Cultivars like Washington malta could be improved and introduced due to their less seed content and higher juice recover per fruit.

Nine different rootstock species were also collected, growth characters and physico-chemical characteristics observed during the study is presented

Table 2. Growth and fruit characteristics of different sweet orange cultivars in mid hill conditions of Arunachal Pradesh.

Cultivar No*	Plant growth characteristics (Pooled mean)					Fruit characteristics (Pooled mean)								Seed characteristics (Pooled mean)			
	Tree height (m)	Canopy spread E-W x N-S (m)	Leaf length (cm)	Leaf breadth (cm)	Presence of thorn	Length (cm)	Breadth (cm)	Weight (g)	Volume (ml)	Juice/ fruit (ml)	No. of segments	Flesh colour	Rind thickness (mm)	No. of seeds	Seed length (mm)	Seed breadth (mm)	Appearance of seed
1	6.5^{c}	4.6x5.1	9.53^{ab}	4.30^{bc}	P, L	5.13^{bcd}	5.63^{cd}	93.25^{fg}	88.66^{de}	32.25^{de}	9.66	Y	5.64^{c}	5.12^{d}	12.61^{de}	6.66^{bcd}	I,M,P
2	5.3^{d}	4.6x4.6	7.24^{de}	3.13^{d}	P, S	4.47^{d}	4.87^{e}	93.67^{fg}	87.28^{de}	31.37^{e}	10.32	Y	5.61^{c}	2.67^{e}	14.37^{cd}	5.41^{d}	I,F,Y
3	5.2^{d}	4.6x3.7	8.80^{bc}	3.87^{cd}	P, M	4.93^{cd}	5.32^{cde}	99.14^{efg}	103.42^{cd}	37.76^{d}	10.28	Y	6.57^{bc}	4.33^{de}	13.16^{cde}	7.67^{bc}	R, Y
4	4.3^{e}	4.1x4.2	10.20^{a}	5.17^{a}	P, S	5.80^{ab}	6.57^{a}	144.21^{ab}	150.03^{a}	45.52^{c}	9.66	Y	5.00^{c}	2.69^{e}	18.64^{a}	8.91^{bc}	B, Ov
5	8.2^{a}	6.3x6.7	6.63^{ef}	3.43^{d}	A	6.32^{a}	6.64^{a}	157.73^{a}	152.42^{a}	62.75^{a}	10.45	Y	9.85^{a}	1.29^{f}	13.41^{cde}	6.33^{bcd}	M,I,F
6	7.3^{ab}	6.2x6.7	9.56^{ab}	4.88^{ab}	A	5.27^{bcd}	5.87^{bc}	99.63^{efg}	96.66b^{cd}	34.58^{d}	9.66	Y	5.34^{c}	4.42d^{e}	15.67^{bc}	8.03^{bc}	I,L,Br
7	6.4^{c}	5.8x6.2	7.82^{cde}	3.64^{cd}	P	5.49^{bc}	6.51^{a}	116.42^{de}	117.25^{bc}	40.83^{cd}	10.05	Y	9.03^{ab}	10.84^{c}	12.52^{de}	6.37^{bcd}	B,P,R
8	6.6^{c}	4.5x3.2	10.65^{a}	5.19^{a}	P, L	4.90^{cd}	5.52^{bc}	84.29^{g}	86.51^{ef}	30.37^{e}	11.06	Y	6.46^{bc}	9.45^{cd}	12.04^{e}	6.42^{bcd}	L,Pl
9	5.8^{cd}	3.8x4.6	8.00^{cd}	3.84^{cd}	P, S	5.23^{bc}	5.75^{c}	134.75^{abc}	130.86^{abc}	55.94^{b}	11.25	Y	5.72^{c}	9.48^{cd}	13.73^{de}	7.51^{bc}	Ov,Y
10	5.6^{d}	4.8x4.4	6.53^{ef}	3.09^{d}	A	5.18^{bcd}	5.69^{c}	130.76^{abc}	135.93^{abc}	53.49^{b}	9.89	Y	7.66^{b}	15.04^{b}	14.17^{d}	15.74^{a}	M,R
11	5.9^{cd}	5.2x5.6	7.06^{de}	3.11^{d}	A	5.27^{bc}	5.36^{cde}	109.28^{defg}	98.62^{e}	34.85^{d}	9.95	Y	5.85^{c}	50.42^{a}	18.06^{ab}	8.06^{bcd}	B,R
12	6.3^{c}	4.3x3.7	5.87^{fg}	3.76^{cd}	A	5.14^{bcd}	5.87^{cde}	85.46^{fg}	83.85^{f}	30.71^{e}	10.64	LG	6.13^{bc}	4.03^{de}	12.48^{de}	9.46^{b}	I,L,F
13	6.2^{c}	4.4x4.1	7.83^{cde}	3.12^{d}	P	5.50^{bc}	6.62^{a}	128.41^{bcd}	134.92^{ab}	42.53^{c}	11.53	W	7.21^{b}	4.96^{d}	12.53^{de}	7.37^{bcd}	R,Y
CD at 5%	0.74	-	1.31	0.74	-	0.79	0.66	31.18	36.38	12.87	NS	-	2.73	3.10	2.87	1.23	-

P = Present; A = Absent; S = Small; L = Long; M = Medium; VS = Very Small; VL = Very Long; B = Big; O = Orange; W = White; Y = Yellow; G = Green; DO = Deep Orange; LG = Light Green; R = Round; I = Irregular; Pl = Plumpy; Br = Brown; W = White; F = Flat; Ov = Oval

*1. Para malta; 2. Excelier malta; 3. Whittawar malta; 4. Vanilla malta; 5. Washington malta; 6. Valencia Newton; 7. *Sohning Riang*; 8. Italian Large; 9. Mosambi Australia; 10. *Tasi*; 11. *tagu*; 12. Ruby Blood Red; 13. Daccus malta; Means 'i' in a column with similar letters are non-significant.

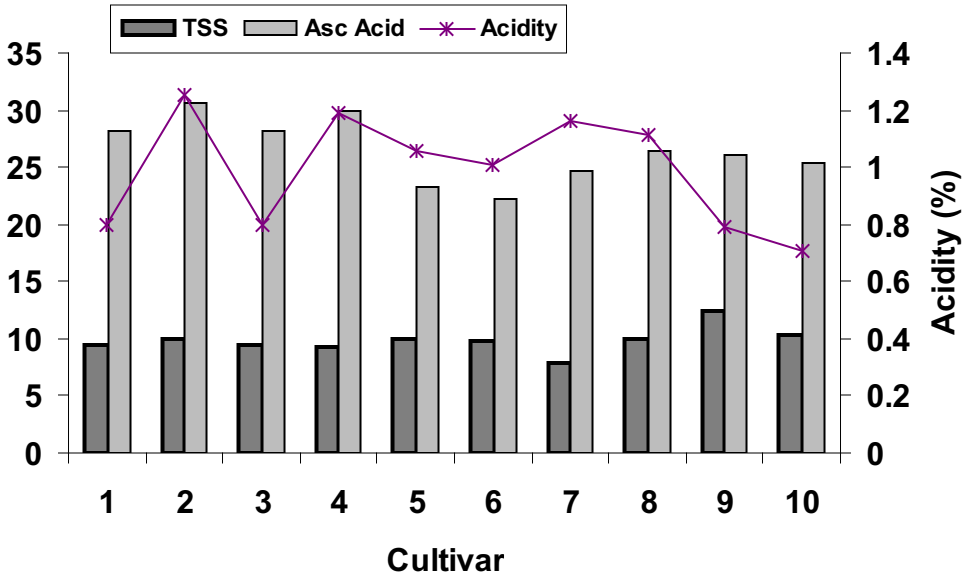

Fig. 1. Chemical characteristics of different mandarin cultivars in Arunachal Pradesh
*Ascorbic acid (mg/100 g); TSS (°B); Cultivar names are mentioned under Table 1.

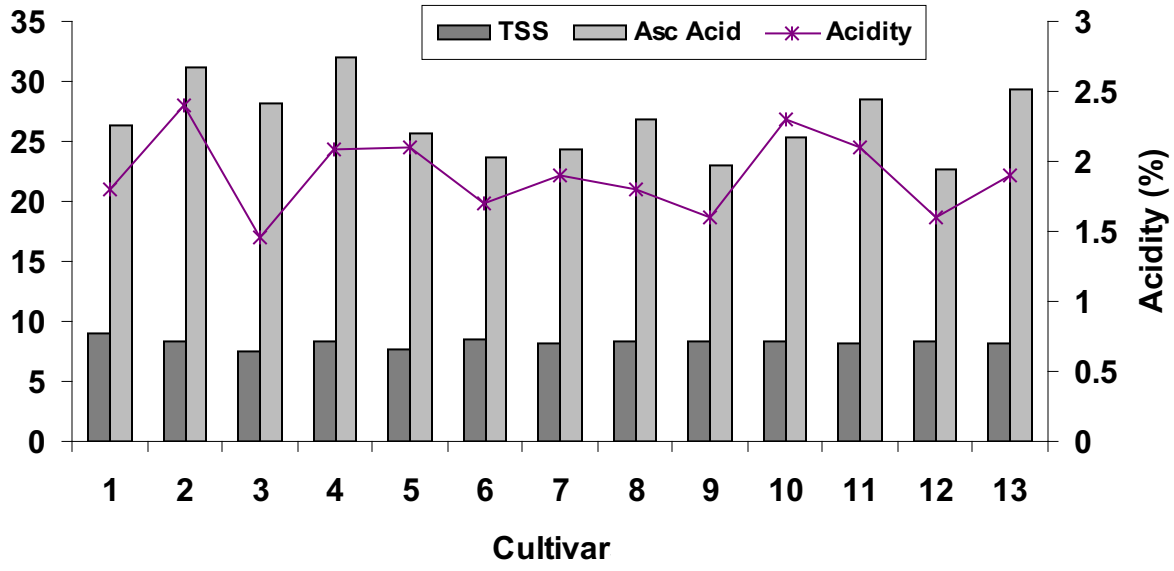

Fig. 2. Chemical characteristics of different sweet orange cultivars in Arunachal Pradesh
*Ascorbic acid (mg/100 g); TSS (°B); Cultivar names are mentioned under Table 1.

(Table 3). *Tanyum* was bushy type with very long and sharp thorns (Dubey and Singh, 2). Flowers were very big and had creepy branches. *C. jawanica* recorded the highest leaf length and leaf breadth followed by *C. latipes* which was on par with *Karna katta* on leaf length. However, the leaf breadth was very little for *C. latipes*, resulted in to very narrow pointed shape to leaves. Further, the presence of distinct petiolar wings made this species a separate identity among the group of rootstocks. Obviously, trifoliate plant with its distinct leaf characteristics has borne very small leaves than other plants. *Tanyum* (*C. medica*) and *C. volkamariana*, two native rootstocks of this region were similar in their leaf length. *C. volkamariana*,

Table 3. Growth and fruit characteristics of different rootstock genotypes in mid hill conditions of Arunachal Pradesh.

Cultivar No.*	Plant growth characteristics (Pooled mean)					Fruit characteristics (Pooled mean)								Seed characteristics (Pooled mean)			
	Tree height (m)	Canopy spread E-W x N-S (m)	Leaf length (cm)	Leaf breadth (cm)	Pre-sence of thorn	Length (cm)	Breadth (cm)	Weight (g)	Volume (ml)	Juice recovery (ml)	No. of seg-ments	Flesh colour	Rind thickness (mm)	No. of seed	Seed length (mm)	Seed breadth (mm)	Appear-ance of seed
1	5.45^{bc}	5.15x5.27	8.46^{b}	4.50^{b}	P, L	8.62^{a}	8.93^{a}	311.34^{a}	290.14^{a}	85.43^{a}	10.13^{b}	Y	19.33^{a}	7.33^{bc}	9.28^{bcd}	6.28	R,P,I,I, Y
2	7.56^{a}	7.63x6.57	8.52^{b}	2.63^{de}	A	5.05^{bc}	5.42^{b}	150.00^{b}	143.37^{b}	47.87^{b}	11.47^{a}	LG	13.68^{b}	38.62^{a}	11.67^{b}	6.57	Ov, Pl
3	4.87^{d}	6.54x7.25	5.13^{d}	3.07^{d}	P, L	4.14^{cd}	3.87^{bcd}	77.45^{cd}	71.65^{de}	29.46^{d}	9.03^{c}	Y	7.35^{c}	13.28^{bc}	8.53^{cd}	5.89	S , Ov , Pl
4	4.92^{d}	4.45x4.36	10.07^{a}	6.14^{a}	P, S	4.03^{d}	4.76^{bc}	85.62^{c}	92.34^{cd}	38.65^{bc}	11.26^{a}	Y	6.06^{cd}	8.07^{bc}	8.21^{d}	6.66	M , Pl
5	6.67^{b}	6.15x5.89	4.95^{de}	3.12^{d}	P, M	4.17^{cd}	4.25^{bcd}	80.38^{cd}	86.69^{cd}	36.14^{bc}	9.14^{c}	G	5.62^{cd}	4.15^{c}	15.46^{a}	6.05	B, Pl, O
6	3.28^{e}	4.87x4.95	7.48^{c}	3.72^{c}	P, VL	6.78^{b}	5.08^{bc}	155.29^{b}	145.05^{b}	46.34^{b}	10.33^{b}	Y	6.00^{cd}	42.69^{a}	9.39^{bcd}	5.74	S , Ov
7	6.17^{b}	6.14x6.68	7.71^{bc}	3.09^{d}	A	1.96^{f}	2.86^{d}	30.69^{d}	27.49^{e}	9.38^{f}	10.54^{b}	DO	3.37^{d}	11.53^{bc}	11.74^{b}	5.92	G, S, Ov , Pl
8	5.08^{c}	4.65x4.93	4.25^{e}	2.35^{e}	P, L	3.31^{e}	3.84^{cd}	57.81^{cd}	60.02^{de}	22.43^{e}	7.85^{d}	Y	5.69^{cd}	17.04^{b}	8.63^{cd}	5.93	Y , R
9	6.25^{b}	7.36x6.18	10.34^{a}	5.23^{b}	P	4.86^{c}	3.75b	72.73^{d}	83.14^{cd}	36.23^{bc}	10.28^{b}	Y	11.32^{bc}	6.28^{c}	10.34^{bc}	6.29	S, Ov
CD at 5%	1.04	-	0.93	0.58	-	1.48	1.56	50.71	46.16	10.54	0.97	-	3.41	9.84	2.46	NS	-

P = Present; A = Absent; S = Small; L = Long; M = Medium; VS = Very Small; VL = Very Long; B = Big; O = Orange; Y = Yellow; G = Green; DO = Deep Orange; LG = Light Green; R = Round; I = Irregular; Pl = Plumpy; B = Brown; W = White; F = Flat; Ov = Oval

1. *Karna katta*; 2. *C. latipes*; 3. *C. volkamariana*; 4. *C. jawanica*; 5. Citrange; 6. *Tanyum*; 7. Cleopatra mandarin; 8. Trifoliate orange; 9. Rough lemon.

citrange and Cleopatra mandarin were similar in their leaf breadth. Greater variation in fruit length and breadth was noticed among the rootstock plants. The importance of rootstock on crop growth of lemon was also studied (Mishra and Singh, 6). *Karna katta* recorded comparatively bigger sized fruit than other rootstocks followed by *Tanyum*. *C. latipes*, citrange, *C. jawanica* and *C. volkamariana* were at par with each other for fruit length and had medium to big size fruits. Cleopatra mandarin was comparatively smaller in size followed by trifoliate orange. However, the highest fruit breadth was also recorded with *Karna katta* followed by *C. latipes*. Rough lemon had a peculiar suppression in their naval region. Other rootstocks *viz., Tanyum*, *C. jawanica*, citrange and *C. volkamariana* were recorded the similar value in fruit breadth whereas the fruit breadth was little for Cleopatra mandarin followed by trifoliate orange. Higher fruit weight was noticed in *Karna katta* followed by *Tanyum* which was on par with *C. latipes*. *C. jawanica* bear medium sized fruits while the fruit size and weight was very small for Cleopatra mandarin. The fruit volume of the plants followed the similar pattern to that of fruit weight. However little variation that *C. latipes* recorded the second higher fruit volume followed by *Tanyum*. *C. latipes*, *C. jawanica*, *Tanyum* and Cleopatra mandarin were on par with each other on their fruit segments. Trifoliate orange recorded the less number of segments followed by *C. volkamariana*. *Karna katta*, hardy rootstock plants bear a fruit with thick rind. Very thin rind was found in Cleopatra mandarin. The rind colour was deep orange for Cleopatra mandarin to light yellow for *C. latipes*.

Number of seeds present in the fruits is the very important character for rootstock spieces. Local *Tanyum* plant had profuse seeds followed by *C. latipes*. *C. volkamariana*, *C. jawanica* , *Karna katta* and Cleopatra mandarin were on par and was good in their seed content. However, citrange recorded the least number of seeds among the rootstock plants. It may be due to their hybrid nature. Seed length was highest in citrange followed by *C. latipes.* Cleopatra mandarin, *Karna katta*, *Tanyum* and *C. volkamariana* were at par with each other and medium in length. Least seed length was recorded with trifoliate followed by *C. jawanica*. No significant change in seed breadth was noticed among rootstocks. However from the visual appearance of seed, citrange and trifoliate has the plumpy, round seed which are pointed towards one end and yellow in colour. Dieback is the main problem in this region due to citrus trunk borer and development of hard pan in the soil. Rootstocks like *Tanyum* and *C. volkamariana* could be exploited to overcome these problems. The *Khasi* mandarin could be budded/grafted with trifoliate orange or Cleopatra mandarin to induce earliness and lateness to the mandarin crop respectively.

India has the richest wealth of citrus and north eastern region of the country is known to be exploited for the betterment of citrus industry in the country. New potential areas for expansion of citrus cultivation needs to be exploited in order to get global commercial status to citrus industry in India. Further the diversity from the world should be collected and evaluated for its future use in all the breeding programmes. In addition to conventional evaluation procedures, there is need to develop molecular markers so that a particular gene of interest can be identified and transferred to a desirable cultivar in the future breeding programmes.

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