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PERFORMANCE OF KHASI MANDARIN IN GARO HILLS OF MEGHALAYA

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Abstract: Khasi Mandarin (C*itrus reticulata* Blanco.) is one of the most widely cultivated and important commercial fruit crop of Meghalaya. It is widely cultivated in the Garo Hills except in the plain belt. The average productivity of mandarin orange in the Garo Hills was 3.3 t/ha which was relatively low as compared to the national average of 10.4 t/ha. In spite of favorable agro-climatic conditions the productivity of East Garo Hills (4.4 t/ha), West Garo Hills (2.7 t/ha) and South Garo Hills (2.8 t/ha) was very low and exhibited high degree of variations within the region. Hence, a study was conducted during 2011-2014 to evaluate the performance of Khasi Mandarin in the Garo Hills. The study revealed that there was significant difference in the tree characters, fruits characters and yield attributing characters among the different age groups. The trees between 21-30 years of age were found to be outstanding in terms of yield attributing characters followed by trees between the age groups of 10-20 years. Younger trees exhibited superior quality in terms of bio-chemical parameters which were inferior in older trees above 30 years. The result of the present study suggests rejuvenation or replantation of old and senile citrus orchards for improving the productivity of Khasi Mandarin in the Garo Hills of Meghalaya.
Keywords: Khasi Mandarin, *Citrus reticulata*, Garo Hills, Meghalaya.

Introduction

Khasi Mandarin (C*itrus reticulata* Blanco.) is one of the most widely cultivated and important commercial fruit crop of Meghalaya. It is widely cultivated in all the Garo Hills except in the plain belt.Fruits are depressed, globose to oblate, medium size, loosed skinned, bright orange yellow in colour, surface smooth, glossy, rind thick to medium, rind and segment easily separable, segments moderate in numbers, juice abundant, orange colour with sour-sweet blend and has good keeping quality (Ngachan *et al.*, 2010). The fruits weigh 10.31 to 109.90 g, 7-14°Brix of Total Soluble Solids (TSS), 0.67-1.31 per cent acidity, 1.83 to 3.95 pH, total sugar 2.07 to 4.65 per cent. It has been observed that mandarin orange orchards start to decline in production after satisfactory performance for few years. The decline of productivity has been attributed to various factors like plantation on unsuitable land, intercropping, inadequate nutrition, incidence of insect-pest and diseases (Ghosh, 1982). The decline of tree starts with sparsh appearance, yellowing and mottling of leaves and twig

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drying, dried-up top growth with small and less number of fruits. The branches of trees start to die from the top of downwards, ultimately resulted poor quality fruits (rough surface, thick skin, and less juice). This ultimately leads to decline of productivity to a greater extent (Yadav *et al.,* 2003).The farmers of Garo Hills cultivate mandarins extensively and produce 6426 tonnes from an area of 2088 hectares (NHB, 2015). The average productivity of mandarin orange in the Garo Hills is 3.3 t/ha which is relatively too low as compared to the national average of 10.4 t/ha. In spite of favorable agro-climatic conditions the productivity of East Garo Hills (4.4 t/ha), West Garo Hills (2.7 t/ha) and South Garo Hills (2.8 t/ha) in 2012-13 (Govt. of Meghalaya, 2015) was very low and exhibit a high degree of variations. Although Khasi Mandarin is widely cultivated in Garo Hills, information regarding tree characters, physio-chemical status and yield attributing characters is sparse and lacking. Hence, a study was conducted to investigate on these aspects.

Materials and Methods

The study was conducted in the districts of Garo Hills of Meghalaya state viz. West Garo Hills, East Garo Hills, South Garo Hills and North Garo Hills and South-West Garo Hillsdistricts during 2011-2014. For the study 160 mandarin orange growers were selected randomly. The orange growers were then stratified into four groups based on the age of plants viz., trees between 10 to 20 years of age (Group- I); trees between 21 to 30 years of age (Group- II); trees between 31 to 40 years of age (Group- III) and trees from above 40 years of age (Group- IV) respectively. Forty trees from each group were selected to study the tree characters, physio-chemical status of the fruits and yield attributing characters of the tree. The experiments were carried out at the Horticultural Laboratory of the Department of Rural Development and Agricultural Production, North Eastern Hill University (Tura Campus) situated at Tura, West Garo Hills, Meghalaya. The fruit physical characters like weight, length, diameter, specific gravity, rind thickness, number of segments, juice percentage and number of seeds were recorded using standard methods. Chemical characters of the fruit like total soluble solute (TSS), total sugar, reducing sugar, acidity, ascorbic acid, TSS/acid ratio and pH were analyzed using standard methods. Yield attributing characters like number of fruits per tree, tree height, spread of the tree (North-South and East-West) and tree volume of the trees were also recorded.

The data was statistically analyzed by applying Fisher's analysis of variance (Panse and Sukhatme, 1989). The level of significance employed in 'F' test was P=0.05. Critical differences were calculated for comparison wherever the 'F' tests were found significant. The

factors affecting various physico-chemical properties and productivity of mandarin orange were determined by using the multiple regression analysis. Correlation coefficients of various factors affecting the physico-chemical properties and productivity of mandarin orange was determined.

Results and Discussion

***Tree character*:** The data presented in Table 1 reveals that the height of the plant was highest in group-IV (6.48 m) followed by group-III (5.70 m), group-II (5.42 m) and lowest in group-I (4.60 m). The spread of the tree from East to West was longest in group-IV (5.25 m) than group-III (5.17 m), group-II (4.83 m) and group-I (3.56 m) respectively. Similarly the spread of the tree from North to south was largest in group-IV (4.82 m) followed by group-III (4.5 m), group-II (3.88 m) and smallest in group-I (3.5 m). Accordingly Tree volume was largest in group-IV (16.9 m^3), which was followed by group-III (15.5 m^3) than group-II (12.5 m^3) and lowest in group-I (8.3 m^3). These results show that the size of the tree in terms of height, spread and volume was highest in group-IV comparing to others age groups. This may be due to the higher age of the group-IV trees and age differences of ten years between each group.

***Yield attributing characters*:** The pooled data in Table 2 shows that the maximum number of fruit was recorded in group-II (124), followed by group-I, group-III and group-IV with 107, 91.50 and 66.67 respectively. Similarly the productivity was highest in the group-II (4.70 t/ha), which was followed by group-I, group-III and group-IV with 3.87, 2.48 and 1.47 metric tonnes per hectare respectively. From these result it is clear that group-II trees bear maximum numbers of fruit as well as heaviest fruits while group-IV trees were lowest in number of fruits and fruit weight. This may be due to the ideal productive age of the trees in group-II while low yield of group-IV may be because of old tree affected by diseases and pests.

***Physical characters of mandarin orange*:** The physical characters of mandarin orange fruits of the four age groups were recorded and presented in Table 3, 4 and 5. The weight of the fruit was highest in group-II (130.69 g), followed by group-I (125.48 g), group-III (101.87 g) and group-IV (80.59 g) respectively. The weight of the fruits differs significantly among the groups. The length of the fruit significantly varied among the groups and the pooled data shows that the group-II fruits had maximum length (66.42 mm), followed by group-I (53.22 mm), group-III (50.92 mm) and group-IV (49.25 mm) in descending order. Similarly, the diameter of the fruit was largest in group-II (68.41 mm), which was followed by group-I (65.04 mm) than group-III (59.06 mm) and minimum in group-IV (55.25 mm). There was a significant difference in the diameter of the fruits between the groups. Among the different

groups, the group-II fruits exhibit thickest peel (2.81 mm) followed by group-IV (2,45 mm) than group-I (2.33 mm) and least in group-III (2.17 mm) respectively. The different groups showed significant difference in the thickness of the fruit peel. In contrast the peel weight was heaviest in group-I (43.15 g), followed by group-II (35.39 g), group-III (22.72 g) and lightest in group-IV (20.77 g) and it was significantly different among the groups. The number of segments was however not significantly different from among the groups with group-II (10.40) having the highest number of segments, while group-III (9.00) had the least number of segments. There was significant difference among the different age groups with respect to the number of seeds. From the pooled data it was observed that the maximum number of seeds was found in group-I (16.20) followed by group-II (15.00), group-III (10.80) and finally group-IV (10.60) in descending order respectively. The above presented result shows that group-II was highest in all characters i.e. length of fruit (66.42 mm), diameter of fruit (68.41 mm), peel thickness (2.81 mm) and number segment (10.40) except in peel weight (43.15 g) and number of seed (16.20) where group-I was highest. The group-II trees may be at the prime production stage producing bigger fruits with more number of segments than other group.

Yadav *et al.*, (2003) comparing the physico-chemical characters between healthy and decline tree of Khasi Mandarin in Meghalaya of different age groups found that the fruit length ranges from 5.14 to 5.82 cms (51.4 to 58.2 mm), fruit diameter ranges from 5.42 to 6.93 cms (54.2 to 69.3 mm) and peel thickness ranges from 0.21 to 0.24 cms (2.1 to 2.4 mm) which was comparable to the present finding. Das *et al.,* (2004) reported fruit length of 5.28 cms (52.8 mm), fruit diameter of 5.22 cms (52.2 mm), peel thickness of 1.46 mm, number of segments was 9 and number of seeds was 16.8 on Khasi Mandarin in Meghalaya, which was also corroborate with the present finding. Medhi*et al*., (2007) reported fruit weight (113.3 to 159.6 g) of Khasi Mandarin in Assam.

The Table 4 shows that juice recovery was highest in group-II (53.81 %) and lowest in group-IV (38.22 %) and showed a significant difference among the groups. Similar to juice recovery, the pulp weight was heaviest in group-II (40.14 g) and lowest in group-IV (24.72 g), while group-I (39.89 g) and group-III (29.14 g) was second and third respectively. The data presented in Table 5 exhibit a significant difference in pulp weight among the groups. The specific gravity of the fruits among the groups was not significantly different from each other and it was highest in group-II (1.044) followed by group-III (1.043) and the least was group-I and-IV (1.042). In peel to fruit ratio group-V (26.43 %) show highest percentage,

which was followed by group-II (24.75 %) than group-I (23.99 %) and least was in group-III (21.84 %) and there was a significant difference in the percentage of peel to fruit ratio among the different age groups. Das *et al.,* (2004) reported pulp weight of 11.5 g which was much lower than present findings and juice recovery of 75.62 per cent slightly higher than the above result. Yadav *et al.,* (2003) found fruit juice ranging from 37.94 to 47.78 per cent comparable to the present findings. Medhi *et al*., (2007) reported juice recovery of 45.18 to 50.51 per cent in Assam.

***Chemical characters of mandarin orange*:** The chemical parameters of mandarin orange fruits were analyzed, recorded and is presented in Table 6 and 7. The pooled data on Table 6 shows that the total soluble solids (TSS) was recorded highest in group-I (10.98 ^{0}Brix) followed by group-III (10.62 ^{0}Brix), group-IV (10.52 ^{0}Brix), group-II (10.36 ^{0}Brix) and the four groups showed a significant difference in the level of TSS. The pH of the fruit juice among the groups did not show any significant differences and the pH was highest in group-I (4.2) and lowest in group-IV (3.74). The pH of group-II and group-III were 3.66 and 3.54 respectively. The data on Table 27 showed that the acidity of the fruits was significantly different among the different age groups and it was highest in group-I (0.81), which was followed by group-IV (0.78) than group-II (0.76) and least in group-III (0.73) respectively. The TSS: acid ratio presented in Table 26 showed that the ratio was highest in group-I (14.43) and lowest in group-IV (11.61) than group-II and group-III had 14.12 and 13.30 TSS: acid ratio respectively. There were significant differences among the different age groups in relation to the TSS: acid ratio. From the above result fruits of group I found to be superior as compared to all other groups, while, group-II was found to be second in quality parameter as compared to group-III and group-IV. These results were similar to the finding of Yadav *et al.,* (2003) with TSS ranging from 9.30 to 10.65 ^{0}Brix, acidity ranging from 0.69 to 1.06 per cent and TSS: acid ratio ranging from 9.43 to 14.79. Similar result was also reported by Das *et al.,* (2004) with TSS (10.43 ^{0}Brix) and acidity (0.840 %). Medhi *et al*., (2007) reported fruit acidity ranging from 0.42 to 0.48 per cent and TSS range of 9.28 to 10.80 ^{0}Brix of Khasi Mandarin in Assam.

The data presented in Table 7 showed that the percentage of reducing sugar present in the different age groups were significantly different from each other. The reducing sugar percentage was highest in group-I (7.84 %) followed by group-II (6.56 %) than group-III (6.51 %) and lowest in group-IV with 6.44 per cent. In the non-reducing sugar the percentage was highest in group-II (2.76 %) than group-III, group-IV and group-I with 2.49, 1.15 and

1.05 per cent respectively, and the different age groups showed significant differences in the percentage of non-reducing sugar. The total sugar, however, was highest in group-II (8.99 %) followed by group-III (8.68 %), group-I (8.50 %) and least in group-IV (7.27 %). The total sugar was also significantly different among the different age groups. The data in Table 28 showed that the amount of vitamin C was not significantly different in the different age groups. The highest amount of vitamin C was found in group-I (31.46 mg $100ml^{-1}$ of juice), which was followed by group-III (30.20 mg $100ml^{-1}$ of juice) than group-II (28.49 mg $100ml^{-1}$ of juice) and the least was found in group-IV (28.10 mg $100ml^{-1}$ of juice) respectively. The above result shows that reducing sugar percentage was highest in group-I (7.84 %), non-reducing sugar was highest in group-II (2.76 %), total sugar was highest in group-II (8.99 %) and highest amount of vitamin C was found in group-I (31.46 mg/100 g of pulp). A similar result was reported by Das *et al.,* (2004) with total sugar (6.102 %) and non-reducing sugar (2.192 %) while lower in ascorbic acid (21 mg 100 ml^{-1} of juice) and reducing sugar (3.910 %) respectively. Yadav *et al.,* (2003) also reported comparable ascorbic acid (28.40 – 35.50 mg $100ml^{-1}$ of juice) content to the present finding. Medhi *et al*., (2007) found total sugar range of 6.29 to 6.76 per cent and ascorbic acid range 43.82 to 50.44 mg 100 g^{-1} of Khasi Mandarin fruits in Assam.

Conclusion

There was significant difference among the groups in the tree characters and Group IV trees were largest while Group I were smallest. Yield attributing characters also differ significantly among the groups. The trees between 21-30 years of age were found to be outstanding in terms of yield attributing characters followed by trees between the age groups of 10-20 years. These younger trees also exhibited superior quality in terms of bio-chemical parameters which were poor in older trees, i.e. above 30 years. In the Garo Hills trees belonging to the age group of 21-30 years exhibited highest productivity of best quality fruits. Trees above 40 years were poor yielders. These facts warrants for rejuvenation or replantation of old and senile orchards for enhanced productivity.

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Table 1: Tree characters of mandarin orange trees in Garo Hills, Meghalaya.

Groups	Height of tree (m)			Spread of tree East – West (m)			Spread of tree North – South (m)			Tree Volume (m^3)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
Group-I	4.17	5.03	4.60	2.92	4.20	3.56	3.01	3.98	3.50	7.51	9.08	8.30
Group-II	5.13	5.71	5.42	4.26	5.40	4.83	3.59	4.17	3.88	11.89	13.11	12.50
Group-III	5.50	5.90	5.70	4.75	5.58	5.17	4.37	4.63	4.50	15.05	15.94	15.50
Group-IV	6.40	6.56	6.48	4.91	5.58	5.25	4.71	4.93	4.82	16.74	17.07	16.90
C.V.	17.42	10.85	13.96	21.46	12.82	15.56	19.56	9.76	14.14	31.71	25.80	27.48
S.Em±	0.32	0.12	0.17	0.22	0.09	0.11	0.27	0.22	0.13	0.86	0.54	0.47
C.D.$_{(P=0.05)}$	1.09	1.20	0.43	0.38	0.23	0.27	0.78	0.54	0.31	1.45	1.23	1.17

Table 2: Yield attributing characters of mandarin orange fruits in Garo Hills, Meghalaya.

Groups	Number of fruits/tree			Productivity (t/ha)		
	2012	2013	Pooled	2012	2013	Pooled
Group-I	107.34	106.66	107.00	3.92	3.92	3.87
Group-II	123.81	124.18	124.00	4.60	4.79	4.70
Group-III	91.13	91.88	91.50	2.37	2.59	2.48
Group-IV	67.08	66.25	66.67	1.55	1.40	1.47
C.V.	24.85	25.21	23.33	44.93	46.91	39.23
S.Em±	3.95	3.62	3.34	0.15	0.14	0.08
C.D.$_{(P=0.05)}$	9.13	10.34	8.25	0.43	0.29	0.20

Table 3: Weight, length, diameter and peel thickness of Khasi Mandarin fruits in Garo Hills.

Groups	Weight of fruit (g)			Length of fruit (mm)			Diameter of fruit (mm)			Peel thickness (mm)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
Group I	125.60	127.90	125.48	51.24	55.20	53.22	64.20	65.87	65.04	2.62	2.04	2.33
Group II	138.09	136.07	130.69	66.74	66.10	66.42	68.31	68.50	68.41	2.70	2.91	2.81
Group III	97.10	98.79	101.87	49.32	52.52	50.92	58.43	59.68	59.06	2.21	2.12	2.17
Group IV	78.50	80.80	80.59	48.45	50.24	49.35	55.18	55.31	55.25	2.53	2.36	2.45
C.V.	24.61	23.14	19.84	15.97	12.54	12.82	9.52	9.58	8.80	8.54	16.65	12.57
S.Em±	0.47	0.21	0.73	0.13	0.41	0.64	0.50	0.64	0.72	0.07	.12	0.09
C.D. $_{(P=0.05)}$	1.23	1.76	1.80	1.88	1.45	1.58	1.76	1.34	1.78	0.17	0.31	0.22

Table 4: Peel weight, number of segment, number of seeds and juice percentage of Khasi Mandarin fruits in Garo Hills.

Groups	Peel weight (g)			No. of segment			No. of seeds			Juice recovery (%)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
Group I	43.06	43.24	43.15	9.96	10.04	10.00	15.60	16.80	16.20	48.68	48.31	48.50
Group II	35.25	35.53	35.39	10.30	10.50	10.40	14.97	15.03	15.00	53.59	54.02	53.81
Group III	22.08	23.35	22.72	9.03	8.96	9.00	10.50	11.10	10.80	41.38	41.96	41.67
Group IV	21.05	20.48	20.77	9.00	9.40	9.20	10.40	10.80	10.60	37.35	38.86	38.11
C.V.	35.09	34.68	31.03	6.88	7.00	12.11	21.79	22.03	20.79	16.07	14.75	13.82
S.Em±	0.69	0.46	0.29	0.97	0.77	0.48	0.35	0.38	0.48	0.83	0.54	0.44
C.D. (P=0.05)	0.89	0.97	0.72	N.S	N.S	N.S	1.45	1.32	1.18	1.36	1.13	1.09

N.S = Not Significant.

Table 5: Pulp weight, specific gravity and peel to fruit ratio of Khasi Mandarin fruits in Garo Hills.

Groups	Pulp weight (g)			Specific gravity			Peel to fruit ratio (%)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
Group I	40.62	39.15	39.89	1.02	1.06	1.04	23.61	24.37	23.99
Group II	41.97	38.30	40.14	1.01	1.07	1.04	24.53	24.96	24.75
Group III	30.03	28.24	29.14	1.04	1.04	1.04	21.46	22.21	21.84
Group IV	25.15	24.29	24.72	1.04	1.06	1.05	26.72	26.14	26.43
C.V.	23.74	22.71	29.59	1.46	1.19	0.25	9.05	6.74	16.62
Se.M.	0.42	0.23	0.58	0.02	0.01	0.01	0.79	0.07	0.36
C.D. (P=0.05)	1.18	1.43	1.44	N.S	N.S	N.S	1.56	1.34	0.90

N.S = Not Significant.

Table 6: Chemical characters of mandarin orange fruits in Garo Hills, Meghalaya

Groups	TSS (Brix)			pH of fruit juice			Acidity (%)			Reducing sugar (%)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
Group-I	11.01	10.95	10.98	4.26	4.15	4.20	0.84	0.77	0.81	7.78	7.91	7.84
Group-II	10.32	10.40	10.36	3.59	3.73	3.66	0.80	0.71	0.76	6.65	6.48	6.56
Group-III	10.57	10.66	10.62	3.52	3.56	3.54	0.76	0.80	0.78	6.47	6.54	6.51
Group-IV	10.46	10.58	10.52	3.77	3.72	3.74	0.72	0.74	0.73	6.35	6.53	6.44
C.V.	2.81	2.15	3.48	8.82	6.66	4.52	6.62	5.13	8.93	9.64	10.16	8.75
S.Em±	0.10	0.08	0.14	0.25	0.18	0.07	0.02	0.03	0.01	0.06	0.09	0.03
C.D. (P=0.05)	0.23	0.12	0.34	N.S	N.S	N.S	0.01	0.06	0.02	0.14	0.21	0.07

N.S = Not Significant.

Table 7: Chemical characters of mandarin orange fruits in Garo Hills, Meghalaya

Groups	Non-Reducing sugar (%)			Total sugar (%)			Vitamin C (mg 100ml^{-1} of juice)			TSS/Acid ratio		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
Group-I	1.08	1.04	1.05	8.48	8.52	8.50	31.54	31.37	31.46	14.62	14.24	14.43
Group-II	2.78	2.75	2.76	8.95	9.04	8.99	28.25	28.72	28.49	14.27	13.97	14.12
Group-III	2.81	2.72	2.49	8.57	8.79	8.68	29.98	30.42	30.20	12.93	13.13	13.30
Group-IV	1.19	1.12	1.15	7.10	7.44	7.27	28.34	27.86	28.10	11.53	11.69	11.61
C.V.	48.83	50.13	43.12	9.78	8.34	8.15	5.28	5.38	9.87	10.56	8.65	9.00
S.Em±	0.67	0.73	0.41	0.13	0.11	0.06	1.09	1.14	1.25	0.32	0.28	0.20
C.D. (P=0.05)	1.12	1.26	1.00	0.35	0.29	0.15	N.S	N.S	N.S	0.52	0.22	0.48

N.S = Not Significant.