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*Research Article*

# Survey, Selection and Evaluation of Elite Khasi Mandarin (*Citrus reticulata* Blanco.) Genotypes for Growth, Yield, Quality and Biotic Stress Tolerance under Climatic Conditions of North-Eastern Region

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**ABSTRACT**

*Khasi mandarin (Citrus reticulata Blanco.) is one of the most widely cultivated and important commercial fruit crop of North Eastern region. During 2005-2010, a survey was conducted for identification of superior Khasi mandarin genotypes in relation to growth, yield, quality, pest and disease tolerance from different places of North Eastern region. After thorough survey, eight elite Khasi mandarin genotypes were selected and collected for maintaining at Citrus Research Station, AAU, Tinsukia in 2011. Among the growth characters, CRS-4 was found to be the highest for most of the characters viz., plant height (4.37m), stem girth (13.47cm), N-S plant spread (4.67m), E-W plant spread (5.10m) and crop canopy volume (49.67m$^3$). CRS-4 recorded highest for most of the yield and yield attributing characters viz., fruit length (7.13cm), fruit width (8.57cm), fruits per plant (782.67), fruit yield per plant (146.33kg), fruit yield (35.63t/ha) and fruit weight (172.67g). In quality parameters also, CRS-4 exhibit the best for most of the characters viz., juice content, TSS content, ascorbic acid, TSS:Acid, reducing sugar, non-reducing sugar, total sugar and shelf-life. Further, CRS-7 was observed to be comparatively tolerant to biotic stresses.*

***Key words:*** *Khasi mandarin, Fruit, Growth, Yield, Quality, North East*

## INTRODUCTION

North-Eastern Region of India is one of the homelands of numerous citrus species[4,1]. Out of the 27 species reported in India, 23 belong to North-Eastern region of India[6,1]. Khasi mandarin (*Citrus reticulata* Blanco.) is the most economically important Citrus crops available in North-Eastern region and plays a vital role in the socio-economic development of the people. Currently, in *India citrus* is cultivated over an *area* of about 1,055 thousand hectares with a *production* of 12,746 thousand metric tons and the productivity of 12.08 MT/ha. Out of this, Mandarin alone occupies an area of 429 thousand hectares with a *production* of 4754 thousand metric tons and the productivity of 11.08 MT/ha.

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However, in North Eastern states mandarin occupies an area of about 117.96 thousand hectares with a *production* of 691.26 thousand metric tons and the productivity of 5.86 MT/ha.

Khasi mandarin is well known for its quality, fruit colour, unique sugar acid blend and shelf life which make it the most popular citrus cultivar in North-Eastern region. Though Khasi mandarin is widely cultivated in this region, there is lack of high yielding, good quality, pest and disease tolerant clones for commercial cultivation. Hence, a study was done to identify the best clones for commercial cultivation of Khasi mandarin which gives better results for ensuring food security and increasing the farm income of North Eastern region.

At present CRS, AAU, Tinsukia have been maintained eight elite Khasi mandarin genotypes with following objectives:

1. To evaluate the growth, yield and quality of Khasi mandarin
2. To assess the biotic stress tolerant genotypes
3. To identify the best genotypes for releasing the farmers field

## METHOD AND MATERIALS

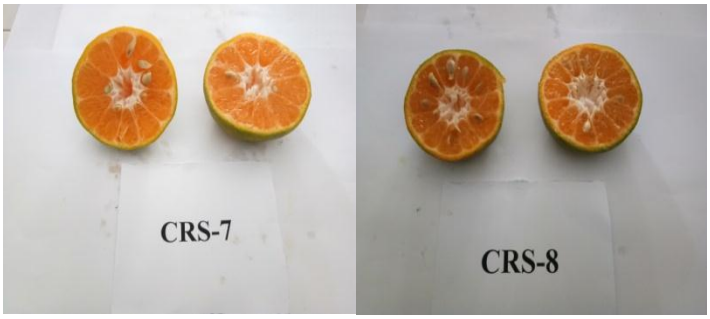
**Survey, identification and selection of genotypes:** The survey was conducted during 2005-2010 from different places of North Eastern region for identification of superior genotypes of Khasi mandarin. Eight superior genotypes were identified and selected in respect of health, vigour, yield and tolerant to biotic stress from the farmer's field of different places of North Eastern region and data were recorded according to their performance during the period of survey. In 2011, selected Khasi mandarin genotypes were collected to maintain at Citrus Research Station, AAU, Tinsukia for conservation and better performance in future generation in relation to yield, quality, pest and disease tolerance. The selected clones were named as: CRS-1, CRS-2, CRS-3, CRS-4, CRS-5, CRS-6, CRS-7 and CRS-8.

**Evaluation of genotypes:** Eight elite Khasi mandarin genotypes were evaluated for morphological and biochemical characters. Data were recorded according to their performance and analyzed statistically by applying Fisher's method. Data on growth characters like plant height (m), stem girth (cm), leaf lamina length (cm), leaf lamina width (cm), N-S plant spread (m), E-W plant spread (m), crop canopy volume ($m^3$) and yield attributing characters like fruit length (cm), fruit diameter (cm), number of fruits per plant, fruit yield per plant (kg), fruit yield (t/ha), average fruit weight (g), time taken for maturity (days), Trunk borer, Leaf miner, Lemon butterfly, Citrus looper, Mealy bug, Twig blight, *Phytophthora* root rot, Citrus Tristeza Virus and Citrus Greening infestations were recorded after five years of planting.

**Fig.1. Khasi mandarin genotypes**


**CRS-1** **CRS-2** **CRS-3**


**CRS-4** **CRS-5** **CRS-6**




**CRS-7** **CRS-8**

## RESULTS AND DISCUSSIONS

**Growth parameters:** The results on growth characters showed highly significant variations among the selected Khasi mandarin genotypes (Table 1). Data revealed that the highest plant height (4.37m) was recorded in CRS-4 which was at par with CRS-2 (4.13m) and the lowest plant height was recorded in CRS-1 (3.20m). The highest stem girth was recorded in CRS-4 (13.47cm) which was at par with CRS-2 (13.20cm) and the lowest was recorded in CRS-6 (12.53cm). The leaf lamina length and leaf lamina width was recorded highest in CRS-4 (8.27cm) and (4.17cm) which was at par with CRS-2 (8.13cm) and (4.13cm). Further, CRS-4 also results higher N-S (4.67m) and E-W (5.10m) plant spread which was followed by CRS-2 (4.53m) and (4.83m) and the lowest was recorded in CRS-5 (3.40m) and (3.57m). Regarding canopy volume, CRS-4 also recorded highest (49.67$m^3$) which was at par with CRS-2 (48.00$m^3$) and the lowest was recorded in CRS-5 (38.67$m^3$). From these results it was clear that CRS-4 recorded highest for most of the growth attributing characters which was similar with CRS-2.

**Yield parameters:** The highest fruit length (7.13cm) and fruit width (8.57cm) was recorded in CRS-4 which was at par with CRS-2 and the lowest fruit length and fruit width was recorded in CRS-8 (5.40cm) and (6.57cm). Maximum number of fruits per plant was recorded in CRS-4 (782.67) which was followed by CRS-2 and the lowest number of fruits per plant was recorded in CRS-5 (656.00). Similarly, the maximum fruit yield per plant and fruit yield were recorded in CRS-4 (146.33kg and 35.63t/ha, respectively) which was followed by CRS-2 and the lowest was recorded in CRS-5. Again, CRS-4 also recorded highest fruit weight (172.67g) followed by CRS-2. The lowest fruit weight was recorded in CRS-6 (123.00g). In case of time taken for maturity, CRS-2 recorded minimum days (231.00 days) followed by CRS-4 and CRS-7 recorded maximum days for maturity (249.00 days). All these variation in yield and yield attributing characters might be due to variation in genotypes and collection from different aged plants from different climatic conditions. Similar types of result were reported by Hangsing *et al.*[3], Yadav *et al.*[7], 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 5.82cm, fruit diameter ranges from 5.42 to 6.93cm and peel thickness ranges from 0.21 to 0.24cm which was comparable with the present finding. Das *et al.*[2], reported fruit length of 5.28cm, fruit diameter of 5.22cm on Khasi mandarin in Meghalaya which was also corroborate with the present finding. Medhi *et al.*[5], reported fruit weight (113.3 to 159.6g) of Khasi mandarin in Assam.

**Quality parameters:** The quality parameters of Khasi mandarin fruits were analyzed, recorded and presented in Table 2. There was significant difference among the genotypes. Highest juice content was recorded in CRS-4 (46.82 ml) which was at par with CRS-2, CRS-5 and CRS-8. The lowest juice content was recorded in CRS-7 (43.33 ml). Yadav *et al.*[7], found fruit juice ranging from (37.94 to 47.78%) comparable with the present findings. Medhi *et al.*[5], reported juice content (45.18 to 50.51%) in Assam comparable with the present findings. Regarding acidity content, CRS-4 recorded minimum (0.66%) which was at par with CRS-2 (0.67%) and maximum was recorded in CRS-8 (0.78%). CRS-4 recorded maximum TSS content (12.23 $^0$Brix) which was at par with CRS-2 (12.00 $^0$Brix) and the minimum was recorded in CRS-1 (10.53 $^0$Brix). Again, CRS-4 also recorded highest TSS: Acid (18.53) followed by CRS-2 (17.91) and the lowest TSS: Acid (14.11) was recorded in CRS-3. These results were similar with the finding of Yadav *et al.*[7], with TSS ranging from 9.30 to 10.65 $^0$Brix, acidity ranging from 0.69 to 1.06% and TSS: acid ratio ranging from 9.43 to 14.79. Similar result was also reported by Das *et al.*[2], with TSS (10.43 $^0$Brix) and acidity (0.840%). Medhi *et al.*[5], reported fruit acidity ranging from 0.42 to 0.48% and TSS ranging from 9.28 to 10.80 $^0$Brix of Khasi mandarin in Assam. The maximum ascorbic acid (45.17 mg/100 ml) was recorded highest in CRS-4 followed by CRS-2 (43.70 mg/100 ml) and the lowest ascorbic acid content was recorded in CRS-5 (39.07 mg/100 ml). Further, CRS-4 also recorded highest reducing and non-reducing sugar (2.71%) and (3.88%) and CRS-7 recorded lowest reducing sugar (2.18%) and non-reducing sugar (2.50%). Regarding total sugar content, CRS-4 recorded the highest (6.72%) which was followed by CRS-2 (6.54%). The lowest was recorded in CRS-7 (5.27%). However, CRS-4 also recorded highest shelf-life (21.33 days) which was followed by CRS-2 (19.33 days) and the lowest shelf-life was recorded in CRS-1 (15 days). A similar result was reported by Das *et al.*[2], with total sugar (6.10%) and non-reducing sugar (2.192%) while lower in ascorbic acid (21 mg/100ml) and reducing sugar (3.910%) respectively. Yadav *et al.*[7], also reported comparable ascorbic acid (28.40-35.50 mg/100ml) content with the present finding. Medhi *et al.*[5], found total sugar ranging from (6.29 to 6.76%) and ascorbic acid (43.82 to 50.44 mg/100ml) of Khasi mandarin fruits in Assam.

**Infestation level (%) of pest and diseases:** There was a significant difference between the eight Khasi mandarin genotypes (Table 3). CRS-5 recorded the maximum infestation of Trunk borer (6.83) and CRS-7 recorded the least infestation (3.07) as compared to the other clones. CRS-6 recorded the maximum infestation of Leaf miner (11.33) and CRS-7 was observed to be least infested (8.37). Lemon butterfly infestation was highest in CRS-6 (9.13) and lowest in CRS-7 (4.17). In case of Mealy bug, highest infestation was recorded in CRS-5 (6.87) and the lowest was recorded in CRS-7 (2.30). Regarding disease, twig blight infection was maximum in CRS-5 (6.43) and lowest was recorded in CRS-7(1.83). *Phytophthora* root rot disease was observed to be highest in CRS-5 (6.73) and the lowest in CRS-7 (2.10). Citrus Tristeza Virus was recorded highest in CRS-1 (5.33) and lowest was recorded in CRS-7 (1.33). Likewise, Citrus greening disease was observed to be highest in CRS-8 (5.40) and the lowest was recorded in CRS-7 (2.20).

**Table 1: Plant height (m), stem girth (cm), leaf lamina length (cm), leaf lamina width (cm), N-S plant spread (m), E-W plant spread (m) and canopy volume ($m^3$), fruit length (cm), fruit width (cm), fruits/plant, fruit yield/plant (kg), fruit yield (t/ha), fruit weight (g) and time taken for maturity (days) of Khasi mandarin genotypes**

| Genotypes | Plant height | Stem girth | Leaf lamina length | Leaf lamina width | N-S plant spread | E-W plant spread | Canopy volume | Fruit length | Fruit width | Fruits /plant | Fruit yield /plant | Fruit yield | Fruit weight | Time taken for maturity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CRS-1 | 3.20 | 12.63 | 7.63 | 3.80 | 4.07 | 4.57 | 43.33 | 5.97 | 6.67 | 723.33 | 138.00 | 32.27 | 155.00 | 244.67 |
| CRS-2 | 4.13 | 13.20 | 8.13 | 4.13 | 4.53 | 4.83 | 48.00 | 7.00 | 8.03 | 753.67 | 140.33 | 33.43 | 161.67 | 231.00 |
| CRS-3 | 3.40 | 12.80 | 8.07 | 3.63 | 3.93 | 4.20 | 45.00 | 5.50 | 6.63 | 714.00 | 134.33 | 32.00 | 152.00 | 241.00 |
| CRS4 | 4.37 | 13.47 | 8.27 | 4.17 | 4.67 | 5.10 | 49.67 | 7.13 | 8.57 | 782.67 | 146.33 | 35.63 | 172.67 | 238.67 |
| CRS-5 | 3.73 | 12.67 | 7.53 | 3.93 | 3.40 | 3.57 | 38.67 | 6.93 | 7.87 | 656.00 | 109.34 | 26.97 | 138.33 | 239.67 |
| CRS-6 | 3.33 | 12.53 | 7.60 | 3.40 | 3.63 | 4.07 | 39.00 | 6.23 | 7.27 | 683.00 | 129.67 | 29.33 | 123.00 | 247.00 |
| CRS-7 | 3.40 | 13.03 | 8.07 | 3.13 | 3.80 | 4.17 | 44.33 | 6.47 | 7.57 | 673.00 | 123.68 | 28.67 | 132.00 | 249.00 |
| CRS-8 | 3.27 | 12.60 | 7.59 | 3.83 | 3.57 | 4.10 | 39.33 | 5.40 | 6.57 | 692.67 | 131.67 | 30.67 | 138.33 | 246.00 |
| SEd (±) | 0.11 | 0.11 | 0.27 | 0.09 | 0.14 | 0.08 | 0.88 | 0.15 | 0.23 | 2.55 | 1.47 | 1.68 | 1.70 | 1.64 |
| CD at 5% | 0.26 | 0.27 | 0.63 | 0.20 | 0.34 | 0.19 | 2.08 | 0.35 | 0.55 | 6.05 | 3.48 | 3.98 | 4.04 | 3.89 |

**Table 2: Juice (ml), acidity (%), TSS ($^0$Brix), ascorbic acid (mg/100 ml), TSS: Acid, reducing sugar (%), non-reducing sugar (%), total sugar (%) and shelf-life (days) of Khasi mandarin genotypes**

| Genotypes | Juice content | Acidity content | TSS | TSS:Acid | Ascorbic acid | Reducing sugar | Non-reducing sugar | Total sugar | Shelf-life |
|---|---|---|---|---|---|---|---|---|---|
| CRS-1 | 44.67 | 0.74 | 10.53 | 14.22 | 41.70 | 2.50 | 2.87 | 5.44 | 15.00 |
| CRS-2 | 45.67 | 0.67 | 12.00 | 17.91 | 43.70 | 2.68 | 3.86 | 6.54 | 19.33 |
| CRS-3 | 44.67 | 0.76 | 10.73 | 14.11 | 42.00 | 2.50 | 2.83 | 6.44 | 17.00 |
| CRS-4 | 46.82 | 0.66 | 12.23 | 18.53 | 45.17 | 2.71 | 3.88 | 6.72 | 21.33 |
| CRS-5 | 45.00 | 0.68 | 11.87 | 15.61 | 39.47 | 2.57 | 2.97 | 5.67 | 15.67 |
| CRS-6 | 45.67 | 0.77 | 11.27 | 14.63 | 42.59 | 2.19 | 2.97 | 5.31 | 18.67 |
| CRS-7 | 43.33 | 0.76 | 11.37 | 16.72 | 40.70 | 2.18 | 2.50 | 5.27 | 18.00 |
| CRS-8 | 45.67 | 0.78 | 11.77 | 15.08 | 39.07 | 2.43 | 2.79 | 5.42 | 16.33 |
| SEd (±) | 1.61 | 0.01 | 0.16 | 0.15 | 0.77 | 0.05 | 0.02 | 1.49 | 0.42 |
| CD at 5% | 3.81 | 0.02 | 0.39 | 0.34 | 1.83 | 0.12 | 0.05 | 3.54 | 1.00 |

**Table 3: Average infestation (%) of Trunk borer, Leaf miner, Lemon butterfly, Citrus looper, Mealy bug, Twig blight, *Phytophthora* root rot, Citrus Tristeza Virus and Citrus greening of Khasi mandarin genotypes**

| Genotypes | Trunk borer | Leaf miner | Lemon butterfly | Citrus looper | Mealy bug | Twig blight | *Phytophthora* root rot | Citrus Tristeza Virus | Citrus greening |
|---|---|---|---|---|---|---|---|---|---|
| CRS-1 | 5.70 | 9.97 | 7.73 | 4.77 | 5.10 | 4.37 | 4.90 | 5.33 | 4.23 |
| CRS-2 | 4.80 | 9.10 | 4.50 | 4.43 | 4.60 | 4.37 | 5.07 | 4.37 | 4.17 |
| CRS-3 | 6.07 | 9.20 | 6.60 | 5.83 | 6.17 | 5.47 | 5.60 | 5.20 | 5.20 |
| CRS-4 | 3.93 | 8.77 | 4.87 | 3.60 | 3.80 | 3.33 | 3.37 | 3.70 | 3.23 |
| CRS-5 | 6.83 | 11.30 | 8.67 | 6.63 | 6.87 | 6.43 | 6.73 | 5.23 | 5.37 |
| CRS-6 | 5.20 | 11.33 | 9.13 | 4.67 | 5.00 | 4.63 | 4.67 | 3.57 | 4.23 |
| CRS-7 | 3.07 | 8.37 | 4.17 | 3.13 | 2.30 | 1.83 | 2.10 | 1.33 | 2.20 |
| CRS-8 | 6.10 | 9.83 | 8.20 | 6.00 | 6.23 | 5.77 | 5.60 | 4.57 | 5.40 |
| SEd (±) | 0.29 | 0.32 | 0.17 | 0.20 | 0.21 | 0.15 | 0.21 | 0.20 | 0.14 |
| CD at 5% | 0.69 | 0.75 | 0.39 | 0.48 | 0.50 | 0.36 | 0.49 | 0.48 | 0.34 |

## CONCLUSION

The result of the experiment indicated that CRS-4 recorded the highest for most of the growth, yield and quality parameters followed by CRS-2. Therefore, it was concluded that among the eight selected elite Khasi mandarin genotypes, CRS-4 was considered as best genotypes and we recommend this genotypes followed by CRS-2 among the farmers for commercial cultivation of Khasi mandarin under climatic conditions of North- Eastern region. Though, there was lack of hybrid or superior genotypes, these two genotypes CRS-4 and CRS-2 can recover the need of the

farmers for getting highest production as it signifies best superior genotypes from this investigation. However, if we consider on biotic stress tolerance, CRS-7 was observed to be more tolerant as compared to the other genotypes and this genotypes can perform well where infestation of pest and diseases are more.

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