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Review of the general characteristics of Khasi Mandarin (*Citrus reticulata* Blanco.) for evaluation of an elite germplasm

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Abstract

Northeast region is the primary centre of origin for most of the citrus species, and the Khasi mandarin is one of the most important among them in view of its production and consumer demand. Even then, the productivity of mandarin is way lower than the national average due to various reasons. For the generation of a quality orchard with higher profits, first of all the planting material needs to be of higher quality which can be availed by selecting elite plants for the generation purpose. For the selection of elite or better performing plants, the usual performance range of the particular plant has to be specifically known, so that a comparison can be made and the higher performing ones can be selected. In this study, the range of various plant morphological characters, along with its growth habit, fruit morphological and qualitative characters, as well as yield and yield attributing characters has been studied, and a range bracket for them has been obtained, like plant height and breadth are in between 8.20m-3.20m and 15.50cm-12.53cm respectively, the yield ranges from 1.47t/ha-35.63t/ha etc. Therefore, the obtained data of various parameters for judging a Khasi mandarin plant is expected to tremendously help ultimately in the revival of the Khasi mandarin orchards in the seven sister states of India.

Keywords: Khasi mandarin, characteristics, morphological, qualitative, elite, germplasm

Introduction

The North eastern region is a home to more than hundreds of horticultural species which gives apt evidence of its popularity as a center of huge genetic variability. The region has shined as a hotspot for some major fruits like mango, banana and citrus (Chaturvedi *et al.*, 2018) [3]. Citrus is a large group under the family Rutaceae, consisting of several species with various different characteristics, be it of fruit, the plant, the yield or the suitable geographical area. The region boasts of having atleast few members if not all of each of the major citrus groups, i.e. Mandarin, Sweet orange, Grapefruit and pummello, the acid group and also the wild members belonging to the group papeda. The mandarin group has several ecotypes existing in India, for instance, Kinnow mandarin in the Punjab-Haryana region, Darjeeling mandarin around the Darjeeling area, Coorg mandarin in the south, Nagpur mandarin in Maharashtra area etc. One such ecotype is that of Khasi mandarin, which occurs in the north eastern region and is known locally as Soh-sohnamtra in Khasi language and Humoptira or komola in Assamese. Khasi Mandarin is known for its distinct sweet and sour taste with its unique blend of sugar and acid. The medium sized fruits have vivid bright orange-yellow colour, with glossy smooth loose skin, medium to thick rind size and both rind and the segments are easily detachable. They are also known to have a good shelf life (Ngachan *et al.*, 2010; Hangsing *et al.*, 2016; Barbora *et al.*, 2019) [7, 4, 2].

Though the North eastern India is home to most of the citrus species, and mandarin is one of the most economically important citrus crop in this region, but the productivity of mandarin in the northeast at 5.86MT/ha is way lower than the national productivity of 11.08MT/ha (Barbora *et al.*, 2019) [2]. Therefore, to help the plant regain its lost glory due to different reasons, it is important to select the best performing or elite germplasm to be used as mother plants.

Elite germplasm simply refers to the ones which are better performing in most of the aspects than the others. The need of revival of the citrus orchards calls for selection of some elite citrus germplasm and their successful multiplication. Now, identifying the criteria to decide an elite plant among others is as much important as the very selection process, which can range from the plant morphological characters, reproductive characters and so on.

The characteristics or parameters for judging the elite nature of a plant may vary depending upon the species. Therefore, for bringing a new life to the declining Khasi mandarin orchards of the region, the very first step lies in the identification of the characteristics leading to selection of the elite germplasm, followed by the mass multiplication of their disease-free versions.

Growth habit, height and girth of the plant

Different citrus species may show different patterns of growth habit. Some are more spreading type, some are droopy, whereas some are very erect. A deviation from their usual growth habit may indicate a possible effect of biological or physical stress. Therefore, a preliminary judgement about the health of the plants can be made by visual screening of the plants, based on its growth habit.

According to NRCC Nagpur, a full-grown bearing tree of Khasi mandarin shows erect tree growth habit (Singh *et al.*, 2016) [10]. Not just Khasi mandarin, mostly all the mandarins are erect in nature, if compared to other citrus trees, but Khasi mandarins are easily distinct because of their pronounced upright plant growth habit (Annon., 2014) [1].

Different species of citrus trees have different average plant heights. A deficiency or a disease can stop the development of the plant, and make it stunted. Therefore, if we know the average plant height of a particular species, we can screen out the low performing ones and based on our available range we can choose the elite ones. Similarly, with proper development of a healthy plant, the girth of the tree also increases. The plant girth can simply be measured using a measuring tape at the right height.

In case of Khasi mandarin in the Garo hills of Meghalaya, Hangsing *et al.*, 2016 [4] reported the tallest plant to be of 6.48m and the shortest plant was of 4.60m. While surveying the elite khasi mandarin plants in 2019, Barbora *et al.* 2019 [2] found the highest plant height to be 4.37m, closely followed by the one with 4.13m plant height, and the lowest was noticed to be 3.20m. In the very study, the highest plant girth was found to be of 13.47cm, closely followed by 13.20cm and the lowest girth was observed as 12.53cm. During the 2017 study conducted in three districts of Manipur namely Tamenglong, Noney and Bishnupur, the height of Khasi mandarin plants were found to be in the range of 7.03m to 8.20m, with the highest recorded in Tamenglong district. The stem girth of the Khasi mandarin plants was found to be in the range of 15.50 cm and 14.00 cm as the highest and lowest respectively (Kakoti *et al.*, 2019) [2].

Leaf and canopy characteristics

Leaves are very important for the selection of elite germplasm. First of all, they can be a major player in identifying different species of the citrus or any plant for that matter. The colour and condition of the leaves can also be a window for judging the health of the plant, as in case of any disease or disorder, it usually gets reflected in the leaves in some way or other.

NRCC Nagpur reported that the fully expanded leaves of spring flush of Khasi mandarin show a leaf length range of 7-8 cm and leaf width range of 3-4cm (Singh *et al.*, 2016) [10]. According to Barbora *et al.* (2019) [2], the highest leaf lamina length was observed as 8.27cm in case of CRS-4 germplasm, and in the same case the leaf lamina width was also found to be the maximum as 4.17cm.

The leaf dimensions are not the sole indicator of a plant's health. If the health of the plant declines, so does the overall growth and spread of the plant. As the branches will not develop properly, and the plant will possibly be smaller and thinner than usual. The east- west and north- south canopy spread as well as the canopy volume may show us a healthy growing tree, with greater area to bear fruits.

The study in case of some well performing genotypes revealed the highest canopy spread to be 4.67m and 5.10m in the N-S and E-W directions respectively. The lowest spread was found to be 3.40m and 3.57m in the respective directions. The canopy volume was also evaluated, which was found in the range of 38.67m³ to 49.67m³ (Barbora *et al.*, 2019) [2]. While studying about the performance of Khasi mandarin in the Garo hills in 2019, Hangsing *et al.* 2016 [4] noticed that, the range of the canopy spread in the N-S and E-W directions were 4.82m to 3.5m and 5.25m to 3.56m respectively. The highest tree volume was marked as 16.9m³, closely followed by 15.5m³, and the lowest was recorded as 8.3m³.

Age of the plant and performance

The age of the plant definitely has a major role to play in the performance of any species of plant. If the plant is too young, every parameter will be lower than the optimum and if the age of the plant is too old, the health and vigour of the plant will definitely decrease eventually, and again the performance of each parameter will not be up to the mark. So, while selecting a candidate plant of Khasi mandarin, the age of the plant is one important parameter to take a note of.

According to Rymbai *et al.* (2022) [8], a six year old tree should be able to give an yield of 40 to 50 fruits per tree, even though the optimum age might be a few years later as found in some other researches. From the study carried out in the Garo hills of Meghalaya, taking the age of the plant as the basis for judging the performance of Khasi mandarin plants for various aspects, it was found that, plants in the age range of 21 to 30 years performed outstanding for almost all the yield attributing characters, like they showed the highest fruit weight and number of fruits were also found to be maximum. Whereas, the oldest trees of 40 or more years exhibited the poorest yield attributing characters. Similar results were noticed in case of few other characters like fruit length, fruit diameter, number of segments and peel thickness, where the highest value was marked by the age range of 21-30 years, as 66.42mm, 68.41mm, 10.40 and 2.81mm respectively. The next best performance was exhibited by the young group of 10-20 years, while also showing the highest number of seeds per fruit and peel weight as 16.20 and 43.15g respectively. From this it can be inferred that, the plants are at their prime age of performance in their twenties, and after the age of 30, the performance gradually declines and after crossing 40, they perform very poorly in the matter of yield (Hangsing *et al.*, 2016) [4].

Morphological characteristics of the fruit

The fruit morphological characters directly affect the yield. The bigger and heavier the fruit will be, the taller will be the graph of yield. Therefore, the evaluation of these characters are inevitable for the selection of elite germplasm of Khasi mandarin.

NRCC Nagpur has reported about few of the morphological characteristics of the Khasi mandarin fruit at its harvest maturity. Accordingly, the fruit weight was found to be in the

range of 110g to 140g and the fruit diameter in the range of 60mm to 70mm. The highest and lowest of fruit length at its harvest maturity was found to be 65mm and 55mm respectively. Both the shape of the fruit base and fruit apex were of truncate nature. Moreover, at the harvest maturity the fruit rind thickness or epicarp thickness was found to be of 2-3mm with dark orange colour. The boldness of the seed, measured as gram weight of 20 seeds was found to be more than 1.10g and the number of seeds per fruit was reported to be more than 5 (Singh *et al.*, 2016)^[10].

However, in the districts of Manipur state, the fruit length was recorded the highest in the Tamenglong district as 7.33cm and the lowest was found in the Bishnupur district as 5.23cm. The highest and lowest of the fruit breadth was recorded as 8.43 cm and 6.67cm cm respectively. The fruit weight of 243.55g in Tamenglong recorded as the highest and Bishnupur recorded the lowest fruit weight of 133.31g (Kakoti *et al.*, 2019)^[2]. Whereas Ladaniya (2008)^[6] reported that Khasi mandarin fruit, with its deep orange colour, weighs between 90 to 100 g.

In another study conducted in the North eastern region of India, the fruit length of Khasi mandarin was found in the range of 5.40cm to 7.13cm, while the range of fruit width was recorded as 6.57cm to 8.57cm (Barbora *et al.*, 2019)^[2]. Yet again, Khasi mandarin plants of Meghalaya recorded the range of the fruit length to be 49.25mm to 66.42mm, fruit diameter in the range of 55.25mm to 68.41mm, peel thickness range as 2.17mm to 2.81mm, peel weight range as 20.77g to 43.15g, number of segments in the range of 9 to 10.40 and the number of seeds were found in the range of 10.60 to 16.20. Moreover, the fruit weight was found in the range of 80.59g to 130.69g (Hangsing *et al.*, 2016)^[4].

Qualitative characteristics of the fruit

Not just the morphological aspects of the fruit, but the yield only is relevant if the quality of the fruit is also up to the mark. As, the quality of the fruit determines a lot of things ranging from appeal to the customers, grasping a sufficiently higher price in the market and hence making enough profit for the farmers. Therefore, it is one of the major parameters for judging the elite nature of a germplasm.

The NRCC Nagpur reported about few of the qualitative characteristics of the Khasi mandarin fruit at its harvest maturity, like the juiciness of the fruit was found to be more than 45%, and the TSS was reported more than 11 ° brix. The citric acid percentage or the titratable acidity at harvest maturity of the fruit was found to be in the range of 0.5 to 0.7%. (Singh *et al.*, 2016)^[10].

According to Ladaniya (2008)^[6], Khasi mandarin fruit has seeds and is juicy in nature having acidity in the range of 0.6 to 0.8% and TSS of 13-14 °Brix. An interesting observation related to the fruit colour was made, where it was noticed that in the lower elevations the fruits appear yellowish green, whereas in higher altitudes, that is around 1000m to 1500m of elevation, a full deep orange colour develops.

The study conducted in the districts of Manipur revealed that the juice content of Khasi mandarin fruits was in the range of 46.53% to 41.40%, and the acidity content showed its highest and lowest as 0.62% and 0.69% respectively. Highest TSS was obtained both in the Tamenglong and Noney district as 12.33 Brix, whereas the lowest of 10.00 Brix was obtained in the Bishnupur district of Manipur. The range of ascorbic acid content was found to be 38.34mg/100ml to 50.49mg/100ml

(Kakoti *et al.*, 2019)^[2]. In another study conducted on Khasi mandarin in the North eastern region, the highest juice content was found to be in the range of 43.33ml to 46.82ml, whereas the acidity content ranged from 0.66% to 0.78%. In addition, the TSS was found in between 10.53°Brix and 12.23°Brix. The range of ascorbic acid content was found to be 39.07mg/100ml to 45.17mg/100ml, whereas the total sugar content ranged from 5.27% to 6.72%. Moreover, the shelf life of the fruits were found to be in the range of 15 days to 21.33 days (Barbora *et al.*, 2019)^[2].

According to Hangsing *et al.* (2016)^[4], in the Garo hills of Meghalaya, the highest TSS was found to be 10.98°Brix, and the lowest was 10.36°Brix. The pH of the fruit juice ranged from 3.74 to 4.2. The acidity of the fruit was found to be in the range of 0.73 to 0.81, whereas the total sugar content ranged from 7.27% to 8.99%. Moreover, the ascorbic acid ranged from 28.10mg/100ml to 31.46mg/100ml of juice.

Fruit yield per plant and time taken for maturity

Fruit yield is one of the most important parameters to be judged for the selection of an elite germplasm, as the reproductive health is one of the major indication of a healthy tree, and this is the ultimate goal of planting an orchard in the first place.

In the Manipur study, the maximum number of fruits per plant was recorded in Tamenglong as 126.00, and also the highest fruit yield/ plant (28.33kg) and fruit yield (11.32t/ha) was found in the same district. The lowest fruits per plant, fruit yield/ plant and fruit yield were noted in Bishnupur district of Manipur (Kakoti *et al.* 2019)^[2]. According to Barbora *et al.* (2019)^[2], the highest number of Khasi mandarin fruits per plant were recorded as 782.67 and the lowest as 656. The highest fruit yield per plant and fruit yield were noted as 146.33kg and 35.63t/ha respectively. The fruit weight ranged from 123g to 172.67g. Yet another study in the hills of Meghalaya recorded the Number of Khasi mandarin fruits in the range of 66.67 to 124, whereas the productivity of the fruit was found to be in between 1.47t/ha to 4.70t/ha (Hangsing *et al.*, 2016)^[4].

The time period from the formation of fruit to the point of its harvesting for the market can simply be termed as its time taken for maturity. This might differ from cultivar to cultivar and also based on the climatic and soil conditions of the region. According to Barbora *et al.* (2019)^[2], the Khasi mandarin plants took a minimum day of 231 to a maximum of 249 days to reach marketable maturity.

Conclusion

Therefore, after referring to various recorded studies, it can be concluded that, the range of Khasi mandarin plant height is 8.20m to 3.20m and the plant girth ranges from 15.50cm to 12.53cm. The range of the North south canopy spread is 4.82m-3.40m whereas the East-west canopy spread range is 5.25m-3.56m, whereas the canopy volume ranges between 38.67m³ and 8.3m³. It has been found that Khasi mandarin plants are at the peak of their performance in the age of 21 to 30 years and above the age of 40, the performance falls drastically. The range of fruit weight was 243.55g to 80.59g, fruit diameter was found in between 70mm to 55.25mm, the fruit length range was 7.33cm to 4.92cm, fruit breadth 8.57cm to 6.57cm, peel thickness of 2-3mm, peel weight of 20.77g-43.15g, 9-10.40 no. of segments and 5 to 16.20 no. of seeds were found in case of Khasi Mandarin and the leaf length and

breadth ranged in between 7-8.27cm and 3-4.17cm respectively.

While evaluating the qualitative parameters, the juice content was found in between 41.40% to 46.53%, the acid content 0.5%-0.81%, TSS in the range 10-14 °Brix. The ascorbic acid content of the fruits ranged from 28.10mg/100ml to 50.49mg/100ml, pH from 3.74 to 4.2 while the total sugar content ranged from 7.27% to 8.99%. While dealing with the yield and yield attributing characters, the range of no. of fruits per plant, fruit yield per plant and fruit yield were found to be 66.67-782.67, 28.33kg-146.33kg and 1.47t/ha-35.63t/ha respectively. It was observed that, the plants took about 231-249 days for reaching maturity.

From these data, a general overview of the Khasi mandarin plant can be obtained, and the same can be used for evaluating whether a plant of Khasi mandarin is elite or not based on the performance of that particular plant and comparing it with the available data range, so that further multiplication of elite trees can be carried out, finally resulting in a better performance of the fruit in the region.

References

1. Anonymous. Khasi Mandarin-GI application No. 465. Geographical Indications Journal No.63. Government Of India; c2014. p. 24-34.
2. Barbora AC, Saikia J, Kakoti RK, Deka S, Hazarika B, Gogoi A, *et al.* 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. *Int J Pure App Biosci.* 2019;7(1):469-474.
3. Chaturvedi A, Pandey NK, Indu, Tripathy PP, Mishra RC, Tripathy AN, *et al.* Rejuvenation of citrus in Arunachal Pradesh. *Int. J Pure App Biosci.* 2018;6(4):688-695.
4. Hangsing H, Mathew B, Kalita DC. Performance of Khasi Mandarin in Garo Hills of Meghalaya. *Int J Sci Environ Technol.* 2016;5(5):3213-3223.
5. Kakoti RK, Saikia J, Deka S, Gogoi A, Barbora AC. Present Status of Khasi Mandarin in Manipur State of North East India. *Int. J Curr Microbiol App Sci.* 2019;8(6):2157-2165.
6. Ladaniya MS. Commercial fresh citrus cultivars and producing countries. *Citrus Fruit.* Academic Press. 2008;1(5):13-65.
7. Ngachan SV, Roy SS, Sharma PK, Patel RK, Prakash N. Citrus Scenario in North Eastern India: Issues and Strategies. In: *Citrus Biodiversity: National Seminar on Citrus Biodiversity for Livelihood and Nutritional Security*, Nagpur, India, 4-5th October. Shivankar VJ, Singh IP, editors; c2010. p. 28-37.
8. Rymbai H, Talang HD, Rymbai D, Mawleiñ J, Devi MB, Assumi SR, *et al.* Good orchard management practices in Khasi Mandarin (*Citrus reticulata* Blanco). *Agri Journal World.* 2022;2(7):1-7.
9. Amit Kumar Singh 1, 2, Ng. Tombisana Meetei1,2, Brijesh Kumar Singh1 and Nirmal Mandal1
10. Singh AK, Meetei NT, Singh BK, Mandal N. Khasi mandarin: its importance problems and prospects of cultivation in north-eastern Himalayan region. *Int. J Agric. Environ Biotechnol.* 2016;9(4):573-592.
11. Ebid WM, Mabrouk AM. Physicochemical and microbiological properties of functional Labneh fortified

with mandarin peel powder during refrigeration storage. *Int. J. Food Sci. Nutr.* 2022;7:46-53.