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Effect of rootstocks on growth, yield, quality, and leaf mineral composition of Nagpur mandarin (*Citrus reticulata* Blanco.), grown in red lateritic soil of West Bengal, India

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ABSTRACT

The present study reports the influence of seven different rootstocks (namely, Karna khatta, Rangpur lime, Lemon, Gandharaj, Kumquat, Rough lemon, and Acid lime), on the growth, yield, quality, fruit physicochemical and leaf mineral concentrations of Nagpur mandarin (budded onto), assessed over two successive years (at 4th and 5th year of tree age). The results revealed that the maximum canopy volume (81.26 m^3) of Nagpur mandarin was recorded when the concerned scion was budded on Karna khatta. The maximum number of fruits per plant (238.33) and yield (37.52 kg $tree^{-1}$) were recorded when Rough lemon was used as rootstock. Fruits with lowest acidity were produced when Nagpur mandarin was budded on Karna khatta rootstock. However, the fruits exhibiting maximum values for other quality parameters like total soluble sugar, total sugar, and ascorbic acid were obtained in Kumquat rootstock. The highest leaf N and K contents of Nagpur mandarin were recorded in Karna khatta rootstock, whereas, both the Kumquat and Acid Lime rootstock revealed superiority in leaf P acquisition over the others. Unweighted pair group method with arithmetic mean (UPGMA) clustering analysis revealed that Lemon, Gandharaj and Rough lemon rootstocks, displaying a close association with each other, exhibited an overall comparable horticultural performance and yield. From other cluster analysis, the Kumquat rootstock was recognized for its uniqueness and superior biochemical quality attributes, and was found to be separated from other rootstock clusters. Hence, the results of this study hold the potential to meet the consumers' demand, by selecting the suitable region- and agro-climate-specific rootstalk, that was unavailable so far.

1. Introduction

Nagpur mandarin (*Citrus reticulata* Blanco.) is the most esteemed member of the citrus group and cultivated throughout India with a major proportion grown in Maharashtra, Rajasthan, Karnataka, Madhya Pradesh, Nagaland, West Bengal, Assam, Meghalaya, and Tripura. Mandarin fruits are well-known to be enriched with high amounts of ascorbic acid, calcium, and potassium, apart from other essential oils that are used in the cosmetics industry and for other pharmaceutical purposes (Koli et al., 2014). In India, citrus industry ranks third amongst the fruit-based industries, succeeding mango and banana. In 'citriculture', the rootstock is considered as the prime factor, since the success or failure of a plantation is predominantly regulated by it, in comparison to any other cultivation factor. It is a tried and tested fact that availability of appropriate rootstock is the key to profitable citrus production with extended productive life of the trees. Accordingly, orchardists use rootstocks as an eco-friendly cultivation practice to improve the overall performances of orchard trees (Dubey and Sharma et al., 2016), since long decades. As high as a six-fold improvement in yield of citrus was observed with standardized scion-rootstock combinations (Wutscher and Bowman, 1999). Rootstocks also have potential to mitigate detrimental impacts of several biotic and abiotic factors (i.e. disease, pest, soil, and climate etc.), by regulating the uptake and movement of water and nutrients amongst the plant organs (Sharma et al., 2016). The rootstocks, along with various nutrients influence the growth, yield, and quality of citrus fruits that in turn is affected by the nutrient availability or their absorbing capacity, depending on rootstock species (Josan and Thatai, 2008). To make fruit cultivation profitable, it is important to study the growth parameters of a scion influenced by a particular rootstock. Multiple facets of scion including

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shape, size, and fruit production etc. also comprehensively rely on rootstocks (Singh et al., 2012). A number of new rootstocks, such as Cleopatra, Trifoliate, and Sour orange are being increasingly used for Nagpur mandarin, along with Rough lemon and Rangpur lime. Having both advantages and disadvantages, no single rootstock can be considered ideal for: all the citrus species, all the varieties within a species, and, all types of agro-climatic regions. Five districts of the state of West Bengal, India, enriched with red lateritic soil are considered as prospective regions for Nagpur mandarin cultivation. However, the availability of suitable rootstalk to meet the region-specific and agro-climatic requirement, as well as consumers' demand is still lacking. Considering these facts, the present study was conducted to evaluate the influence of rootstocks on plant growth, fruit yield and quality, as well as leaf mineral composition of Nagpur mandarin, and to select the appropriate rootstock(s) for successful cultivation in the red lateritic soil of West Bengal, India.

2. Material and methods

2.1. Experimental site

A field experiment was conducted at Regional Research Station (Red and Laterite Zone), Jhargram, West Bengal (22°45′ N, 87°01′ E and 9.75 m above mean sea level) (Fig. 1), situated in the red-lateritic agro-climatic zone, in order to assess the performance of different rootstocks on plant growth, yield, quality and leaf mineral composition of Nagpur mandarin. The soil of the experimental field was sandy-loam in nature (containing 43.9% sand, 49.8% silt, and 6.3% clay), having pH of 5.5, available N 320 kg ha^{-1}, P 31 kg ha^{-1} and K 110 kg ha^{-1}. Annual precipitation of the area was 1100 mm with a maximum temperature of 42 °C in the month of May and minimum of 11 °C in the month of January.

2.2. Experimental design and crop management

The present study was conducted in a completely randomized block design with seven rootstocks (Karna khatta, Rangpur lime, Lemon, Gandharaj, Kumquat, Rough lemon, and Acid lime) in four replications. Details of rootstocks used in this study are illustrated in Table 1. For authentication, the rootstocks were identified and validated by Prof. Satya Narayan Ghosh, Department of Fruits and Orchard Management, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India. The seeds of the rootstocks were sown (during October 2010) under open bed nursery conditions. At the time, when these seed-germinated plants attained 12 months age, they were shield budded (during October 2011) using approximately four-month-old, round, and plump scion buds of Nagpur mandarin. The budded plants were transplanted in the main field at a distance of 4 × 4 m in both the ways (during August 2012). Three plants of each combination were replicated four times in a randomized block design. The plants were fertilized with NPK at a dose of 100:25:50 g plant^{-1} in the 1st year and from 4th year onwards, the doses were fixed at 400 g N, 100 g P_2O_5 and 200 g K_2O (following Radha and Mathew, 2007), along with 30 kg FYM per plant. Fertilizers were applied in two splits i.e. in the months of June and September. Weeds were controlled by mechanical (hand weeding twice at 30 days interval during pre- and post-flowering stages), followed by chemical (Glyphosate at 0.5 kg ha^{-1}) management practices. Two prophylactic sprays (at 15 days interval during fruit set) were applied against leaf miner insect, bacterial canker, and scab diseases. Other cultural operations were carried out uniformly.

2.3. Measurements and observations

Observations on vegetative growth such as plant height, basal girth, and canopy volume of the trees were recorded during the month of February, at the 4th and 5th year of tree age. Trunk cross-sectional area (TCSA) was measured using the following formula, suggested by Sharma et al. (2016):

$$TCSA = \pi (d|2)^2$$

Where d = average of cross measurement of the trunk in N–S and E–W directions. Canopy volume was calculated using tree height and spread, with the help of the following formula (Westwood, 1978):

$$Canopy\ volume = {}^{4}/_{3} \times \pi \times a^2 \times b$$

Where, 'a' is the [canopy spread (E–W) + canopy spread (N–S)]/2 and 'b' is ½ tree height.

Individual fruit weight was determined by measuring the average weight of 20 matured fruits picked from tagged branches. The fruit yield was calculated by multiplying the fruit weight to a number of fruits plant^{-1} and then the resultant value was converted in kg ha^{-1}. Random samples of 10 fruits in each combination were picked from all sides of the trees and the samples were composited for determining their physicochemical characters as per standard methods. Fruit biochemical qualities like total soluble solids (°Brix), total acidity (%), vitamin C (mg 100 g^{-1}), and total sugar (%) were determined as per the guidelines of Association of Official of Analytical Chemists (AOAC, 2000).

2.4. Leaf mineral composition analysis

Leaf samples from each treatment (30 leaves from each plant) were

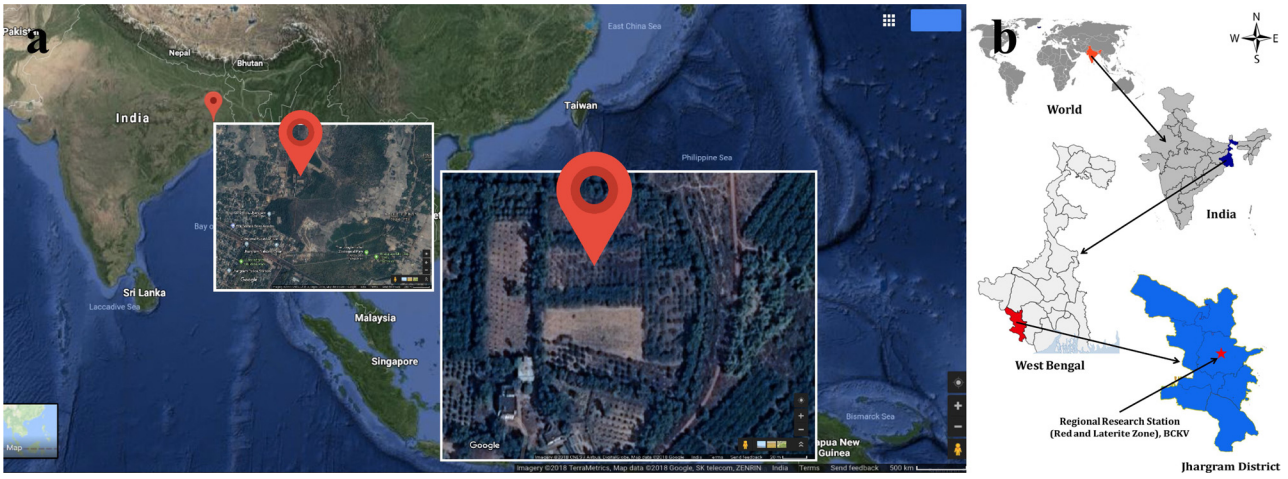

Fig. 1. Location map of the experimental site (22 ° 43′ N, 88 ° 30′ E and 9.75 m above mean sea level). a. Satellite view, b. Schematic view (not in scale).