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Organic Nursery Management in Khasi Mandarin (*Citrus reticulata* Blanco)

Heiplanmi Rymbai*, Hammylliende Talang and Bapyndaplang Dohling

Horticulture Section, ICAR Research Complex for NEH region, Umiam, Meghalaya – 793 103

**Corresponding author: rymbaihort@gmail.com*

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ABSTRACT

Khasi mandarin is an ecotype of the mandarin group grown mainly in northeastern India. It is one of the most important commercial crops of the region due to its premium quality. Reports have indicated that organic mandarin fruits have higher quality attributes, including biochemical, volatile and antioxidant compounds. The "organic" labelled products of *Khasi* mandarin fruits have to be organically certified at all production stages by a certification agency. The strict adoption of organic guidelines in nursery management is a critical step toward achieving an organically certified product. Therefore, the most ideal conditions for organic nursery management are the selection of a nursery site free from insect pests and diseases, the use of sterilized substrates and tools, a certified progeny block, and practices of organic management of insect pests and diseases. The adoption of appropriate technology in the management of organic citrus nurseries may facilitate the production of certified quality planting materials and also enhance the quality attributes and pricing of crops.

Keywords: Khasi mandarin, Organic nursery management, organic cultivation, certified planting materials

1. INTRODUCTION

Khasi mandarin (*Citrus reticulata* Blanco) is an important fruit crop of northeastern India due to its premium quality for its unique aesthetic, organoleptic and nutritional characteristic (Deshmukh et al., 2016; Rymbai et al., 2022a). The fruits of mandarin are easy to peel and are increasingly popular in the fresh fruit market as well as in processing and value addition (Rymbai et al., 2024b). Mandarin fruits are a huge, distinct, and diverse category of citrus fruits that contain some of the best and most well-known citrus fruits and are usually referred to as "loose-skin oranges." The fruits of Khasi mandarin and its products labeled "organic" are those that have been certified organic throughout the production process. An independent organization, usually known as a certification agency, which is recognized by an authority, validates the compliance of growers with these standards (e.g., the national authority in the producing or importing country). The good horticultural organic practices promote crop rotation, biodiversity, etc., and the ban of synthetic pesticides and

fertilisers (Reganold and Wachter, 2016). The organic production system of any crops requires stringent measures at all stages of production. Nursery management following strict procedures of organic guidelines is the critical step toward achieving an organically certified labeled product. Therefore, the most ideal conditions for organic nursery management are to choose a nursery location free from insect pests and diseases, sterilized rooting substrates and tools, a certified mother block, etc. In view of these, a write-up was attempted to highlight the adoption of appropriate technology in the organic management of citrus nurseries for the production of certified quality planting materials and enhancing quality attributes and attractive prices of fruits.

2. Site selection

The availability of virgin nursery sites is critical to organic production systems. It lowers the risk of soil-borne diseases such as *Phytophthora* and *Pythium*, in addition to pests such as nematodes, to which citrus seedlings are very susceptible.

3. Management of rootstock block

An area designated for the explicit purpose of growing only the desired rootstock variety is known as a rootstock block. The block provides fruits for the extraction of seeds to raise seedlings. The block must be well maintained. All the production aspects should be ideally based on organically propagated planting materials/varieties. When certified organic seed and plant materials are not available, the conventional seed and plant materials that have not been chemically treated are allowed to be used, and they must be propagated under certified organic systems. It is also prohibited to use any genetically engineered seeds (GMO crops) or transgenic plants in organic farming.

The majority of the citrus orchards in India are of grafted plants; however, in the northeastern hill region of India, were of seedling origin. The selection of rootstock is based on its adaptability to local conditions and resistance to soil-borne diseases. The most widely used rootstock for Khasi mandarin is Rough Lemon (*Citrus jambheri* Lush). The other rootstocks are Rangpur lime (*Citrus limonia*), Kharna Khatta (*Citrus karna*), Volkameriana, etc (Talang et al., 2024). The use of Rough lemon should be avoided in locations where blight and nematodes are prevalent.

4. Raising of seedling rootstocks

***Primary nursery*:** The primary nurseries are raised either in seedbeds or in containerized nurseries. A seedbed of 1-1.5 m width or 10-15 cm height of convenient length can be prepared for sowing of seeds. It can also be sown in plastic trays (size: 60 x 40 x 12 cm) with a hole at the bottom of the tray to drain excess water. The tray is filled with solar-sterilized media and kept 1.5 feet above the ground on a cemented floor in a net house or greenhouse to check the contamination. The mucilaginous covering the seed must be removed after extraction by washing and rubbing in water or rubbing in wood ash, and the seed is then dried under shade. Following this, the seed treatments can be done with Beejamrit and then with *Trichoderma viride* and *Pseudomonas fluorescens* (@5–10 g per kg of seed). When there is a high prevalence of seed-borne disease, the seeds can be treated with clove and cinnamon oil or any other seed treatment solution. Seeds should be sown in the nursery immediately after extraction (within 1 week) at a depth of 1.5–2.0 cm at a 10 x 5 cm distance (in the seedbed) and 2.5–3.0 cm in the rows (in the tray). After sowing, light irrigation is

given with a watering can or with automatic sprinklers or misting irrigation systems. Before sowing, the media mixture is solar sterilized for at least two days in full sun by covering it with a polythene sheet or steam sterilization. Substrate drenching with suspensions of *T. viride* and *P. fluorescens* (at 10 g each in 1 liter of water) in cases of heavy soil infestations. About 1-2 days after media treatment, it can be used in plastic trays and polybags. In extreme cases, the mixture can also be steam sterilized (Deshmukh et al., 2007; Rymbai et al., 2024a).

***Secondary nursery*:** Seedlings are transplanted in secondary beds or polythene bags (size – 8 x 4'', 2-4 holes at the bottom and containing soil, river sand, and FYM, 1:1:1 v/v) or root trainers (soil + river sand + coco peat + compost, 1:1:1:2 v/v) at 4-6 leaf stages. The media mixture must be solar sterilized. Avoid planting too small or too tall seedlings when transplanting to ensure uniform nucellar seedlings. Taproot seedlings with hook-necked, bent, or distorted taproots should also be avoided. Prior to transplanting, seedling treatment must be carried out by dipping the roots in Beejamrit and then in a suspension containing *T. viride* (10 g in 1.0 liter of water) + *P. fluorescens* (10 g in 1.0 liter of water). Allow the seedlings suspended in this solution to soak for 15–20 minutes before transplanting. Seedlings raised inside the polyhouse have straight growth with a single stem, healthy, least infested with insect pests, and are ready for planting / grafting /budding in a year. While the seedlings raised in open conditions take more than 1½ years to profusely grow. During July-August the seedlings are ready for softwood grafting and February-March of next year for budding (Rymbai et al., 2024a).

5. Management of progeny block

It is a block of superior or elite trees with all the desirable characteristics maintained solely as a source of scion sticks or budwood. The elite mother plants are selected on the basis of disease resistance, drought tolerance, high quality, and yield performance for maintaining in the mother block. The progeny plants also should have a well-known pedigree, virus-free and certified. In case of the need for the procurement of planting materials, they should be procured from reputable nurseries to ensure that they are free of diseases (particularly viruses) and pests and that the authenticity of rootstock and scion cultivars is guaranteed. The progeny block is maintained under organic standard operation and regularly monitored (Rymbai et al., 2024a).

6. Multiplication block

***Budding technique*:** Budding of Khasi mandarin should preferably be done in a season when the bark of the rootstock seedlings slips, i.e., in February-March, using the "inverted T" or shield budding method. An inverted T-shaped cut is made with a budding knife in the bark at 15-20 cm above ground level. The two flaps of bark are loosened with the help of the bare blade of a budding knife. A shield-shaped patch of bark measuring 2.5 cm in length is removed, containing a bud from the scion of the selected mother plant. The bud is inserted into the 'inverted T' cut on the stock. The budded portion is wrapped with 100-200-gauge polythene strip, leaving the bud open. It is preferred to bud at a height of 15-20 cm above ground level to protect the buddings from foot rot infestation. Buds should be collected from progeny blocks, which are healthy, and disease-free trees of the desired cultivar. Buds are commonly selected from the next-to-last growth flush (the wood behind the current flush) and from the current growth flush after it has matured and hardened. Bud wood

should be well developed but still dormant, round (not angular as in young wood), relatively straight, and have well-formed buds in the leaf axils. The scion (bud stick) material for bud wood should be selected on the mother plant before one week of budding operation, and leaves should be cut off, leaving a stub of the petiole, which helps in swelling buds. Trimmed bud sticks should be labelled and used immediately or placed in plastic bags in a cool place to avoid exposure to desiccation. T-budding is the most common method of vegetative propagation of Khasi mandarin using rough lemon as rootstock on a commercial scale in the region (Rymbai et al., 2022a).

Soft wood / wedge grafting: Grafting is a specialized type of plant propagation where part of one plant (the scion) is inserted into another (the rootstock or stock) in such a way that they unite and grow as a single plant. Budding success on Khasi mandarin under Meghalaya conditions is very low; therefore, soft wood grafting developed by the ICAR Research Complex for NEH Region, Umiam, may be used as an alternative method for raising the quality planting material of Khasi mandarin. Softwood grafting should be done in July-August on a 6–7 months old rootstock. Proper selection and preparation of scion stick are very important for higher success. A scion shoots of 3-4 months old shoot of the previous seasons is ideal for this technique. The scion shoots of 2-4 mm thickness with 3-4 healthy buds of 8-10 cm (short internodal length) long and round shape are used for grafting. Selected scion shoots are defoliated on the mother plant about 7-10 days prior to detaching. At the same time, the leaves of the selected scion should be cut off, leaving a stub of the petiole, which helps in forcing the dormant buds to swell. After selection of the scion, the rootstock (seedling) is headed back to a 7.5–10 cm long stem above the polythene bag, and leaves of the rootstock should also be removed, leaving 2–3 leaves on the lower side of the rootstock before grafting. Then, the beheaded rootstock is split about 1.5-2 cm deep through the center of the stem with a grafting knife. A wedge-shaped cut, slanting from both sides (1.5-2 cm long), is made on the lower side of the scion shoot. The scion sticks are then inserted into the split of the stock and pressed properly so that cambium tissues of the rootstock and scion stick should come in contact with each other. The union is then tied with the help of a 100-200 gauge polythene strip, 1.5 cm wide and 20-25 cm length. Immediately after grafting, the graft is covered by a 4 x 15 cm long white polythene cap. The scion starts sprouting after 20–25 days, which is visible from outside. The cap is removed after 35 days in the evening hours, or grafts should be kept inside the polyhouse to ensure more grafting success, early sprouting, and better growth as compared to open and inside the net house conditions (Rymbai et al., 2022b).

7. Care and management

Light and frequent irrigation is provided to budded and grafted plants with automatic sprinklers or misters to maintain sufficient moisture. Care should be taken to avoid water stagnation in the bags. Weeding and light hoeing are applied to prevent weed infestation and to make the soil porous. The side shoots of seedlings or suckers that arise below the bud/grafted union should be removed periodically to maintain a single straight stem (Rymbai et al., 2024a).

In addition to the regularly recommended nutrient mixture, foliar applications of vermiwash (5%), Panchagavya (3%), and farm-made protein hydrolysate (4-5 ml/L of water) are all ideal constituents to improve the growth of planting materials. Furthermore, adequate use of organic manures may be followed by drenching with fermented dung-urine slurry (such as Jivamrit). Bio-

fertilizers, particularly mycorrhiza and PGPRs (Plant Growth-Promoting Rhizobacteria) can be applied when required. Depending on the situation, either one, a combination of two, or all of these can be used.

The quality planting materials can be multiplied at a government farm or by other organizations such as certified private nurseries that are involved in the propagation and distribution of planting material. Regularly monitor the nursery unit at least twice a year for the incidence of any serious insect pests and diseases such as citrus tristeza virus and citrus greening disease through reliable diagnostic tools (Ganesh *et al.,* 2018). To maintain cultivar purity, weak, and off-type seedlings are rouged out.

9. Insect pests

A significant number of insect pests are known to be associated with nursery that caused serious impacts to the plant's growth. The incidence and intensity of these pests vary from region to region and elevations. The most common insect pests observed in the nursery of Khasi mandarin are leaf miners and scale.

Leaf miner (*Phyllocnistis citrella*): Larvae feed in the epidermis of leaves, making zig-zag galleries, which are colored silver because of entrapped air. The leaves become distorted, crumpled, and gradually dry up. A serious attack may cause defoliation. This insect mostly attacks newly emerged leaves during the flushing season.

Citrus Scales (*Aonidiella aurantii* & *A. orientalis*): All parts except the roots are infested by scales. Due to the attack, the leaves turn yellow, become bristly, and fall off. Fruits become mottled and shriveled, and shoots and twigs wither.

10. Diseases

The most common diseases found in citrus nurseries are damping off, powdery mildew, and sooty mold.

***Damping off**:* Among the soil-borne pathogens, *Phytophthora* spp. is the major problem reported all over the citrus-growing regions. Heavy and poorly drained soil, excessive irrigation, the use of susceptible rootstock, and prolonged water stagnation near the trunk predispose the plant to soil-borne diseases. The first indication of the disease is the exudation of gum from the bark of the trunk. The bark cracks open and, in the later stage, dries up and falls off, exposing the wood to secondary infection by other organisms.

***Powdery mildew**: Erysiphe quercicola* is a common pathogen of powdery mildew in Khasi mandarin (Baiswar et al., 2015). A white cottony or powdery growth appears on all parts of the affected plant. The young leaves crinkle, turn yellow, and have distorted margins. Prominent blisters, cupping, and curling of the leaves take place. In severe conditions, the cottony growth becomes black, leading to premature leaf and fruit fall. Infected flowers start shedding, and affected fruits also turn black and drop off. Infected twigs exhibit dieback symptoms. Due to the death of growing shoots, many lateral shoots develop, causing a bushy appearance.

***Sooty mold**:* Black, moldy growth develops on honeydew secreted by insects like aphids, scales, and mealybugs. No parasitism is observed in citrus, but the presence of black matting of mycelium

may affect photosynthetic activity. The affected young fruit does not develop because of the black coating.

***Greening disease**:* The disease is caused by phloem-colonizing bacterium. It spread through the use of disease buds and the insect vector, citrus psylla. A characteristic symptom of the disease is the growth of small, leathery leaves with interveinal chlorosis and the distribution of green islands on a yellow area. Leaves drop prematurely.

Management strategies of insect pests and diseases

Pest and disease management in a citrus nursery under an organic production system can be achieved with the effective adoption of preventive measures to avoid heavy infections. The integrated management approaches combine cultural, mechanical and biological strategies in the first place for effective management. While the use of botanical and organically acceptable chemicals is only as a last resort. Regular monitoring and strategies for disease control include excluding or removing the source of infection, avoiding congenial conditions for disease promotion, and preventing entrance (Rymbai, 2024).

The most important strategy for organic pest management in citrus fruits is the choice of suitable varieties for the scions and rootstocks that are adapted to the local agro-ecological conditions, increasing plant resistance to pests and diseases. Regular monitoring of the orchard allows early identification of infections and timely intervention before major damage occurs. Adopt suitable cultural methods (such as spacing) to avoid overcrowding.

Apply and spray botanical pesticides such as neem oil, NSKE 4%, and biological insecticides (entomopathogenic fungi) such as *Beauveria bassiana* and *Lecanicillium lecani* @ 5 g or 5 ml/liter to manage insect pests. Releasing an egg parasitoid like *Trichogramma chilonis* @ 2.5 CC/ha can be used to control citrus butterfly and various lepidopteran pests. Spraying entomogenous bacteria like *Bacillus thuringiensis* @ 1-2 g/liter will help to control a variety of insect pests like Lepidoptera (caterpillars), Coleoptera (beetles), and Diptera (flies and mosquitoes). Spray the Nimbecidine or Neemazal @ 5-6 ml/L of water weekly during the flush period to manage citrus scales and other pest infestations. Natural pesticides such as pyrethrum, derris, neem, soaps, mineral and plant oils, and mass trapping techniques like light traps, yellow sticky traps for whiteflies, aphids, etc., and blue sticky traps for thrips and leaf miners are used in organic citrus production (Rymbai, 2024). Larvae must be handpicked and killed. Removal and destruction of infected plant parts reduce pest and disease pressure in the nursery.

Routine sprays with protective organic fungicides such as copper-based fungicides (Bordeaux mixture and lime) can protect nursery and field plants from disease control. Spraying with a Bordeaux powder (1% Bordeaux mixture) was found to be effective to manage diseases. Damping-off can be minimized by providing good drainage, such as raised beds, efficient irrigation systems, etc. Drenching around the root zone or polybag of grafted plants with Jeevamrit 20% (mixed with water) and at least once with suspensions of *T. viride* (or *T. herzianum*) and *P. fluorescens* (@ 10 g each in 1 liter of water) to control damping-off disease. A plant extract of *Eupatorium cannabinum* is also known to completely inhibit the growth of the fungus (Plantix, 2023). Depending on the situation, either one, a combination of two, or all of these can be used.

CONCLUSION

The organic management of nurseries in Khasi Mandarin is an important aspect of organic production systems. The strict adoption of organic standards facilitates the organic certification and may enhance the quality of the products as well as their appeal and prices. However, there is scope for future research regarding the development of more effective management and strategies for controlling pests and diseases and other related organic production systems and value chains.

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