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Citrus Decline In Nagpur Mandarin (*Citrus reticulata* Blanco) orchard in South-Eastern Rajasthan

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Mandarins are commercially cultivated in distinct regions across India, including Nagpur Mandarin in Central India, Khasi Mandarin in the Northeast, and Coorg Mandarin in the Southern states. The largest cultivation areas are found in Madhya Pradesh, followed by Maharashtra and Punjab. Among citrus fruits, mandarins account for 42% of the total cultivated area and 43% of the total citrus production. In India, the total mandarin production stands at 6.27 million tons, grown over 0.46 million hectares, yielding a productivity rate of 13.6 tons per hectare (Anon., 2022).

The "Nagpur Mandarin" is considered one of the finest and most popular varieties both in India and globally, renowned for its high-quality fruit. This variety is highly polyembryonic, characterized by medium-sized, upright trees with an evergreen growth habit and relatively few thorns. The leaves are medium-sized, lanceolate in shape, with a prominent midrib and long, narrowly winged petioles. The flowers are small to medium in size, and the fruit is typically globose or sub-globose, with a pale orange-yellow peel that easily separates from the segments. The seeds are small, pointed, and contain green cotyledons, numbering between 10 and 15. Each fruit typically contains 10 to 12 segments. The fruit offers a mild flavour, excellent quality and is notably juicy, with a total soluble solids (TSS) content of 10–12° Brix and an acidity level of 0.5 to 0.9 per cent. Mandarin juice is not only refreshing but also nutritious, appreciated for its ascorbic acid content, sweet-tart taste and vibrant colour.

In Rajasthan, mandarin is the dominant fruit crop in terms of both cultivated area and production. The crop covers an area of 0.24 lakh hectares, yielding

a total production of 0.44 million tonnes (Anon., 2022). Within the state, Jhalawar district leads in mandarin cultivation, particularly of Nagpur mandarin, with cultivation spread over 0.23 lakh hectares and a production of 4.30 lakh tonnes (Anon., 2022). In Jhalawar, growers typically adopt both the Ambe and Mrig bahar cropping patterns, although the Mrig bahar is predominantly favoured. This preference is due to the adverse effects of the high temperatures between April and June, which cause significant fruitlet drop and economic losses for growers. The flowering period for Ambe bahar in Jhalawar lasts from the last week of February to the end of March, with fruit setting completed by the end of March or early April. In contrast, the Mrig bahar flowering season begins in June and continues through the first week of July, with fruit setting completed by the end of July or early August.

Water scarcity significantly impacts mandarin cultivation, with groundwater resources steadily depleting each year. Jhalawar, which receives an annual rainfall of 1200 mm, is also classified as a "dark zone" where water availability is critically low. Water is a crucial component in plants, constituting nearly 90 per cent of their biomass. It comprises 60 to 90 per cent of the root mass, 35 to 95 per cent of the leaves, and 70 to 90 per cent of the water content in fleshy fruits. Consequently, water plays a central role in cytoplasmic functions across all plant tissues. It is also vital for the plant's hydraulic processes and serves as a medium for transporting nutrients from the soil to the plant tissues. During photosynthesis, water is an essential component in the synthesis of food. Additionally, water regulates temperature in plants, acting as a key determinant in their growth, development, and overall survival.

Globally, water scarcity is a pervasive issue affecting all plant-growing regions, with horticulture in Rajasthan and other parts of India being particularly vulnerable. During peak summer, water availability for crop production becomes critically scarce. Over-extraction of groundwater from aquifers, without adequate replenishment, has led to progressively deeper wells. This exacerbates the water shortage, especially in the summer months, leaving no water for both horticulture and agriculture (Mellado *et al*. 2005; Hasan *et al*. 2007).

Citrus decline represents a significant threat in this region, with many orchards experiencing the detrimental effects of this disease. Initially, affected trees exhibit robust growth and perform well during the early years of orchard establishment. However, over time, they begin to deteriorate in health, producing minimal fruit and becoming economically unviable (Koli, 2010). Rather than dying abruptly, the trees undergo a gradual decline, slowly losing vitality. These trees, once a potential source of profit, turn into a considerable liability for growers. The quantity and quality of fruit also suffer markedly, with fruit size shrinking and its overall quality deteriorating. The fruit develops a rough, leathery rind, lacks shine and contains significantly less juice. The feeder root system may become depleted, with roots turning black. In some cases, affected trees persist in a weakened state, slowly declining over time, a condition known as slow decline. However, there are instances where trees die

rapidly within a few days, referred to as quick decline. The disease may affect only a few trees within an orchard or impact the entire orchard within a given locality. The severity of the problem intensifies as the trees age, with trees older than 15 to 20 years becoming increasingly uneconomical. No orchard in the area has been found entirely free from citrus decline (Singh and Bhatnagar, 2017).

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