

Influence of Climate Change on Mango Cultivation

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Introduction

Mango (*Mangifera indica*), often known as the "King of Fruits," is one of the most prized tropical fruits in the world, renowned for its unique flavor, aroma, and nutritional benefits. It thrives in hot, humid, and tropical climates, particularly in countries such as India, Thailand, and the Philippines. However, climate change, characterized by shifting temperatures, erratic rainfall, and extreme weather events, has a profound impact on mango cultivation. These climatic changes affect mango growth, yield, quality, and even the areas where it can be cultivated, raising concerns about its future. It is one of the most popular fruit crops of Kerala. Mango's flowering and fruit set are highly dependent on climatic conditions prevailing in that area. Recently climate change studies have become increasingly important for understanding the flowering of mango under different climatic conditions. Varietal responses to the environment within and between mango cultivars account for their relative performance at different locations. Thus, phenological patterns are strongly under environmental control in mango. Most of the introduced varieties and hybrids are not performing well under changed climatic situations and they are also highly susceptible to pests and diseases. A lot of traditional and high yielding varieties are found in our homesteads. Many traditional mango cultivars are seemed to resist the change in climatic situations.

1. Impact on Flowering and Fruiting

Mango trees are particularly sensitive to temperature changes during the flowering and fruiting stages. The flowering phase in mangoes is triggered by a period of cool weather. However, due to global warming, the prolonged warm temperatures disrupt the flowering process, leading to irregular or delayed flowering. High temperatures can reduce the rate of fruit set, while fluctuations can hinder pollination, thereby impacting yields. Furthermore, untimely rain during flowering can damage flowers and increase the susceptibility of blossoms to fungal infections, reducing overall fruit quality.

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flowering of mango under different climatic conditions. The seasonal cyclic changes of growth in shoot, root, flower, fruit and their development depend on cultivars and climatic conditions. Unpredictable rains during pre-flowering and flowering periods may cause poor fruit set and low pollinator activities. In the changing climatic scenario, a major portion of the harvest may be wiped out by heavy rains during later fruit development stage in mango. Changes in rainfall patterns can adversely affect the quality and appearance of ripe mango fruits. Unseasonal rains encourage pests, which also lowers fruit yield.

2. Effect on Growth and Development

Climate change alters mango tree growth patterns and influences the physiological processes involved in fruit development. Higher temperatures increase the rate of evaporation, putting mango trees under water stress, particularly in regions with limited irrigation facilities. This stress negatively impacts the quality and size of the fruit. Moreover, extreme weather events, such as cyclones and storms, can damage mango orchards and uproot trees, causing substantial financial loss to farmers.

3. Influence on Mango Yield

Mango yield is intricately linked to environmental conditions, and climate change disrupts each phase of mango production, from flowering to fruit development.

- Temperature Sensitivity and Flowering:** Mango trees require a period of cool temperatures to trigger flowering. Rising temperatures, especially during winter, can lead to irregular or reduced flowering, directly affecting the number of fruits a tree can produce. High temperatures above 35°C during the fruit-setting period can damage developing flowers, significantly reducing the fruit set. This reduction in initial fruit set decreases overall yield.
- Erratic Rainfall and Water Stress:** Mango trees thrive in warm, humid conditions but rely on consistent, predictable rain for ideal fruit development. Climate change, however, has led to erratic rainfall patterns, including heavy rains

followed by extended dry periods. Prolonged dry periods put trees under water stress, limiting their growth and reducing flowering and fruit set. Conversely, excessive rainfall leads to waterlogged soil, root damage, and nutrient leaching, all of which can hamper fruit development and reduce yields.

- c. **Extreme Weather Events:** Cyclones, storms, and heatwaves can devastate mango orchards. Cyclones and storms can uproot trees, damage flowering branches, and defoliate trees, reducing the tree's ability to produce fruit in subsequent seasons. Excessive wind can also cause physical injuries to fruits, reducing both yield and quality.
- d. **Pest Proliferation:** Warmer temperatures and increased humidity are favorable for pests like fruit flies, mealybugs, and thrips, which can damage mango flowers, leaves, and developing fruits. Pests like the mango hopper, which thrives in humid and warm conditions, can significantly reduce yields by feeding on flowers and fruit-bearing branches, disrupting the tree's capacity to bear fruit. Furthermore, climate conditions that support a higher pest population often require more chemical intervention, raising costs and environmental impacts for farmers.

4. Influence on Mango Quality

The quality of mangoes encompasses their size, color, flavor, sweetness, nutritional content, and shelf life—all of which are impacted by climate change.

- a. **Temperature and Fruit Quality:** Mangoes develop optimal sweetness, color, and aroma within a specific temperature range. Higher temperatures can lead to faster ripening but may also result in smaller fruits with lower sugar content. This rapid maturation can reduce the time available for the fruit to accumulate sugars, affecting the taste and nutritional quality. Mangoes grown under elevated temperatures may also have a paler color and reduced aroma, factors that impact marketability.
- b. **Increased Incidence of Physiological Disorders:** High temperatures, water stress, and sudden changes in humidity can lead to physiological disorders like "spongy tissue" and "jelly seed," where parts of the mango flesh become discolored and unpleasant in texture. These disorders can

reduce consumer appeal and lead to higher levels of waste. Heat and sunlight exposure can also lead to sunburn on the fruit's skin, reducing its visual quality and, consequently, its market value.

- c. **Rainfall and Fruit Diseases:** Excessive rainfall and humidity favor fungal diseases like anthracnose, powdery mildew, and black spot, which affect the fruit's appearance, texture, and shelf life. Anthracnose, for instance, leads to black lesions on the mango skin and flesh, making the fruit less appealing and more likely to rot. Increased humidity levels also promote the growth of fungi during storage and transportation, reducing the shelf life of mangoes and leading to higher post-harvest losses.
- d. **Impact on Nutritional Content:** Changes in climate may impact the nutrient profile of mangoes, especially vitamin C and antioxidant levels, which are sensitive to temperature and sunlight exposure. Warmer temperatures can sometimes boost certain nutrients but may also accelerate the degradation of heat-sensitive compounds, potentially resulting in mangoes with lower nutritional quality.
- e. **Shelf Life and Market Value:** Higher temperatures and altered humidity levels impact the storage and shelf life of mangoes. Fruits that mature quickly due to higher temperatures are often softer and may bruise more easily, making them prone to spoilage during handling and transport. This reduces the market value, as mangoes with shorter shelf life cannot be transported over long distances, affecting their export potential. Additionally, high-quality mangoes command a higher market price, so any reduction in quality due to climate factors directly impacts the profitability for mango producers.

5. Changes in Pest and Disease Patterns

Climate change creates favorable conditions for the proliferation of pests and diseases that affect mango crops. Warmer temperatures and increased humidity promote the growth of pests like mealybugs, thrips, and fruit flies. Rising temperatures also favor certain fungal pathogens, increasing incidences of diseases like powdery mildew and anthracnose, which can severely damage mango fruits and lower the yield. Consequently, farmers need to spend more

on pesticides and fungicides, raising production costs and affecting the profitability of mango cultivation.

6. Impact on Harvest Timing and Quality

Climate-induced changes in temperature and rainfall patterns can shift the timing of mango harvest. Warmer temperatures accelerate fruit maturity, resulting in an earlier harvest season. However, early ripening may compromise the fruit's size, flavor, and nutritional quality, as these characteristics are highly sensitive to changes in environmental conditions. Excessive rainfall can also lead to waterlogging and soil erosion, which can deteriorate fruit quality, lower shelf life, and reduce market value.

7. Shifts in Mango Cultivation Regions

As temperatures rise, traditional mango-growing regions may become less suitable for cultivation, while new areas that were once too cold may become more viable. For example, regions at higher altitudes or further north may emerge as potential mango-growing zones, disrupting traditional cultivation patterns and leading to changes in mango production areas. This shift can also affect local economies and cultural practices tied to mango cultivation in historic mango-producing regions.

8. Adaptation Strategies

To counter the effects of climate change, farmers and researchers are exploring various

adaptation strategies. The development of drought-resistant and heat-tolerant mango varieties can help mitigate the effects of rising temperatures and water scarcity. Additionally, the adoption of improved irrigation practices, such as drip irrigation, can help conserve water resources in water-stressed regions. Integrated pest management (IPM) strategies and organic farming practices can also reduce the dependency on chemical pesticides and minimize environmental damage. Government support and training programs focusing on sustainable practices can aid mango growers in adapting to climate challenges.

Conclusion

Climate change poses a significant threat to mango cultivation, impacting various aspects of its growth, yield, and quality. The effects of climate change on mango cultivation emphasize the need for proactive measures to ensure the sustainability of mango production. Through scientific research, adoption of resilient agricultural practices, and supportive policies, mango cultivation can be adapted to withstand changing climatic conditions. As the global climate continues to evolve, the resilience of mango cultivation will be a testament to the adaptability of agriculture and the dedication of farmers and scientists to preserving this valuable fruit for future generations.
