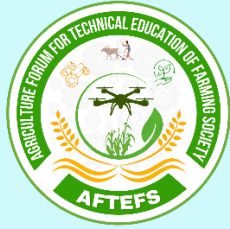


## AGRICULTURE FORUM FOR TECHNICAL EDUCATION OF FARMING SOCIETY

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### Beat Heat Stress in Mango: Yield Loss Mitigation Guide

#### Authors

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#### INTRODUCTION

Anthropogenic climate change has pushed *Mangifera indica* cultivation into a physiological crisis, as orchard temperatures often exceed the optimal range of 24–30°C and sometimes rise above 40°C. This rise in temperature has made heat a major abiotic stress factor; heat waves occurring during sensitive stages such as anthesis and fruit set have become about 25% more frequent over the past decade. In India, temperatures reaching 41–47°C during the 2024–2026 seasons caused serious disruptions, including premature flowering, poor fruit set, and clear reductions in fruit quality, such as lower sugar content and shorter shelf life.

#### Impact of high temperature (heat waves) on yield and quality of mango:

##### 1. Physiological and Biochemical Disruptions

Thermal stress increases vapor pressure deficit (VPD), which induces stomatal closure and shifts Rubisco activity toward photorespiration, thereby limiting dry matter accumulation. High temperatures destabilize Photosystem II (PSII) and trigger an oxidative burst of reactive oxygen species (ROS), leading to chlorophyll degradation and membrane leakage. Although heat shock proteins (HSPs) offer initial protection, prolonged heat exposure results in physiological disorders such as spongy tissue, jelly seed, and premature softening due to accelerated enzymatic activity.

##### 2. Phenological Disruptions

Thermal stress disrupts mango phenology by promoting vegetative reversion and shy flowering, which suppress floral induction. Elevated temperatures shorten the flowering period, narrow the pollination window, and desiccate stigma surfaces. This leads to reproductive asynchrony, with reduced pollen viability and inhibited pollen tube growth, preventing successful fertilization. After fertilization, heat-induced increases in abscisic acid

(ABA) and ethylene cause substantial fruit abscission. The remaining fruit often ripens prematurely, showing insufficient biomass accumulation and poor flavor development.

##### 3. Quality Disruptions and Internal Disorders

Excessive thermal exposure causes apical necrosis and chlorotic halos, while higher respiration and transpiration rates accelerate physiological loss in weight and tissue desiccation. Internally, heat induces maladaptive ripening, marked by elevated total soluble solids (TSS), rapid degradation of organic acids, and altered volatile organic compounds (VOCs). Cultivar-specific disorders include spongy tissue in Alphonso, driven by convective soil heat, and internal breakdown in Dashehari; extreme heat waves also promote lumpy or ricey tissue through enzymatic inactivation and pitting necrosis due to disrupted calcium (Ca<sup>2+</sup>) transport.



Sunscald



Spongy tissue

##### 4. Pest and Disease Resurgence

Shifting thermal regimes and erratic weather have elevated minor pests—such as thrips, hoppers, and mealybugs—to major threats, causing up to 90% yield losses in India during 2025–2026. High humidity and heat favor the development of anthracnose (*Colletotrichum gloeosporioides*) and powdery mildew (*Oidium mangiferae*), leading to systemic fruit degradation. A notable 2026 outbreak in Haveri district (Karnataka) caused blossom blight that destroyed about 90% of the crop, as erratic heat and humidity triggered rapid blossom blight.



Blossom blight



Mealy Bug

### Adaptation and Mitigation Strategies:

#### 1. Strategic Selection of cultivar and Rootstocks

Cultivars: Late-maturing cultivars like Kesar and Rataul avoid peak thermal windows, whereas sensitive varieties like Dashehari and Himsagar suffer severe tissue mummification.

Rootstock: Polyembryonic rootstocks (Olour, Kurukkan) maintain high stomatal conductance and induce Systemic Acquired Resistance (SAR), buffering scions against heat and pests.

Interstock: Double-grafting (e.g., Olour/Mallika/Olour) maximizes leaf sugar content and proline accumulation, which acts as an osmoprotectant against dehydration.

#### 2. Orchard Microclimate Modification

Canopy Management: Strategic pruning maintains an optimal canopy density of 76–80%, shielding scaffold branches from sunscald while enhancing ventilation. Modern architectures like espalier-trellis, optimize light interception and eliminate parasitic branches, outperforming traditional open-vase canopies.

Organic Mulching: Paddy straw or mango leaf mulch, optimize the rhizosphere environment by preventing greenhouse trapping associated with synthetic films. Organic materials stabilize soil temperatures and enhance moisture retention by approximately 28%.

Shade Netting: White, yellow, or pearl photo-selective nets establish a cooling microclimate, mitigating transpirational shock and preventing solar injury. Conversely, black netting is typically avoided due to excessive attenuation of Photosynthetically Active Radiation (PAR), which precipitates yield declines.

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Net Color	Impact on Mango (2025-2026 Findings)	Yield / Quality Outcome
White & Yellow	Provides the best microclimate for growth; enhances water use efficiency	Highest yield and fruits per plant.
Pearl / Red	Increases TSS and peel thickness; improves shelf-life	Higher fruit weight and reduced disorders.
Beige & Green	Improves photosynthetic rates	Good yields

#### 3. Physical Protection and Physiological Priming

**Bagging:** Brown and white paper bags act as thermal barriers that stabilize the fruit microenvironment. Bagging 35–45 days post-fruit set delays maturity, increases ascorbic acid content, and reduces pest-driven losses by up to 60%.

Bagging Material	Impact on Heat & Quality	Notable Results
Brown Paper (UV/Water Resistant)	Top Performer: Optimal UV filtration; reduces sunburn	Highest fruit weight (630g) and TSS (22.6 Brix)
White Paper	Reflective; excellent for temperature reduction	Increase in Ascorbic Acid (Vit C) and total phenolic content
Muslin Cloth / Sacks	High ventilation but lower UV protection.	Effective for pest exclusion but less efficient at preventing sunburn



UV resistant brown paper bag

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**Reflective Treatments:** Foliar application of 6% kaolin clay reflects UV and infrared radiation, lowering leaf temperatures and preserving photosynthetic pigments. Supplements like potassium silicate ( $K_2SiO_3$ ) and biostimulants stabilize antioxidant activity and growth hormones (IAA/GA) under severe stress.

#### 4. Precision Resource & Post-Harvest Management

Micronutrient Foliar Sprays: Zinc (Zn) and Boron (B) have been found to enhance the trees resilience to climate-induced stressors.

Irrigation Strategies: Optimized drip irrigation ensures consistent moisture delivery, facilitating continuous transpirational cooling of foliar and reproductive tissues. Strategic application of regulated deficit irrigation during non-critical phenological stages induces physiological hardening.

Monitoring Maturity: harvest at 75–80% physiological maturity.

Post-harvest hydro-cooling is critical to dissipate field heat, slowing metabolic acceleration and ethylene production triggered by high ambient temperatures.

#### CONCLUSION:

The physiological susceptibility of *Mangifera indica* L. to thermal stress threatens global pomological stability, as extreme temperatures during anthesis and fruit set induce gametic sterility and premature abscission. Mitigation requires precision climate-smart interventions: canopy cooling technologies—such as reflective kaolin films and micro-irrigation—offer immediate thermoregulation, while heat-stable genotypes provide a long-term genetic buffer. Ultimately, securing productivity depends on integrating plant physiology research with adaptive orchard architecture to enhance resilience against intensifying heat cycles.

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