

Thriving Under Temperature Stress: Innovative Approaches for Sustainable Fruit Production

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SUMMARY

Temperature stress, including both high and low temperature conditions, is a major environmental factor that adversely affects the growth, development, productivity and quality of fruit crops. Exposure to temperature extremes can cause disturbances in photosynthesis, water relations, flowering, fruit set, metabolic activities and cellular functions, ultimately resulting in yield reduction and quality deterioration. Different fruit crops exhibit specific symptoms under heat, chilling and freezing stress, making temperature management increasingly important under changing climatic conditions. The adverse effects of temperature stress can be minimized through integrated approaches such as appropriate irrigation and mulching, cooling measures, balanced nutrient supply, application of anti-transpirants and phyto-hormones and suitable post-harvest treatments, which collectively help improve plant tolerance and maintain crop productivity.

INTRODUCTION

A large variety of fruits are grown in India, of which mango, banana, citrus, grape, pineapple and apple are the major ones. World's population is increasing at an alarming rate and is expected to reach about nine to ten billion by the end of year 2050. The growing population will result in considerable additional demand for food and it will also contribute towards changing climate, which is an alarming issue to the world's food safety. Temperature stresses (high and low temperature) are the major environmental factors affecting plant growth, development and also induce morphological, physiological and biochemical changes in plants. Fluctuation in temperature affects the fruits during postharvest storage like development of a wooly or dry texture in the pulp, browning of carpelar membranes and lower resistance to mechanical injury and fungal and microbial attack (Sharma and Manjeet, 2020). According to a report of the Intergovernmental Panel on Climatic Change (IPCC) the global mean temperature has been risen around 0.9 °C. This change in global temperature may alter the geographical distribution and growing season of horticultural crops (Lamaoui *et al.*, 2018).

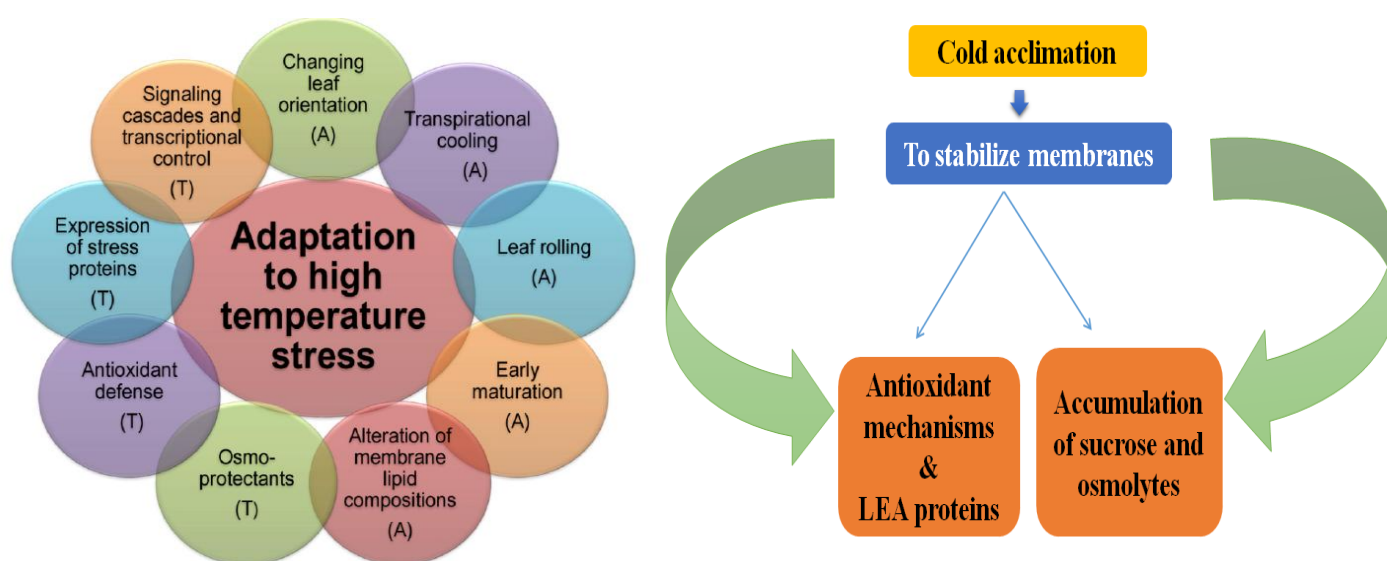


Fig.1. Adaption mechanisms to high and low temperature

Temperature stress

Temperature stress can be classified high temperature stress (plants unable to survive more than its optimum temperature and the plants are more affected when it reaches a high temperature above 40 °C), chilling stress (plants unable to survive at a temperature of 0 - 20 °C) and freezing temperature (plants unable to survive at a temperature of below 0 °C). In response to these temperature stresses various approaches are being used, which

can mitigate the effect of stress and lead to the adjustment of the cellular processes and plant tolerance (Hazarika, 2013). In response to these stress signals that cross talk with each other, plants naturally have developed diverse mechanisms for combating and tolerating them.

Plant responses to high and low temperature stress

- Inhibition of seed germination
- Reduction of plant growth and development
- Alteration in photosynthesis, phenology, dry matter partitioning
- Water loss
- Yield and quality reduction
- Oxidative stress, ROS accumulation, Membrane leakage, Lowering of metabolic reactions and Protein denaturation

Table 1. Impact of high temperature stress on fruit crops

Crop	Effects
Mango	Fruit cracking, sun burn and Spongy tissue.
Banana	Hard lumps in fruits
Guava	Fruit fly increase.
Litchi	Fruit cracking and sunburn.
Papaya	Stigma and stamen sterility
Citrus	Sunburn, rind puffing and reduction in fruit size.
Grapes	Delays buds sprouting, reduced fruit set and berry discoloration
Custard Apple	Lead to no fruit setting
Sweet cherry	Abnormal pistil development
Macadamia nut	Produce multiple, spindly branches and chlorotic leaves

Table 2. Effect of low temperature stress in fruit crops

Crop	Effects
Citrus	Delay in initiation of flowering.
Mangosteen	Slows down the overall growth.
Grapes	No fruit set
Loquat	Purple spot incidence
Banana	Impedance of inflorescence and malformation of bunches.
Ber	Fruits are shrivelled, brown and turn black
Pomegranate	Hardening of fruits
Mango	Tend to produce male flowers
Almond	Pollination & fertilization is highly reduced
Aonla	Oozing of water from fruits
Citrus	Drying up of fruits and twigs

Innovative Approaches to Alleviate Temperature Stress

Cultural practices such as irrigation, mulching, cooling measures and planting at the appropriate time.

Helps in maintaining regular levels of the water level, photosynthetic system utilization, antioxidant enzyme activity and reducing damage from ROS compounds. Thereby enhancing crop yield.



Fig.2. Cultural practices followed in fruit crops to combat temperature stress

Nutrient Supply- N, K, Ca and trace elements (Se, Si)

Helps in alleviating the oxidative damage (ROS) by maintaining stress-responsive proteins and a foliar application or sub-irrigation nutrition supply mitigates temperature stress by maintaining photosynthesis and stress-response proteins (Turner *et al.*, 2007).



Fig.3. Nutrient application in fruit crops to combat temperature stress

Application of anti-transpirants and Phyto-hormones

Foliar application of anti-transpirants and Phyto-hormones, effectively control the high temperature stress, by increasing the sunlight reflection, decreasing leaf temperature and ABA concentration and increases IAA concentration so that, water use efficiency will more and tolerance to summer stress will more (Dinis *et al.*, 2018)

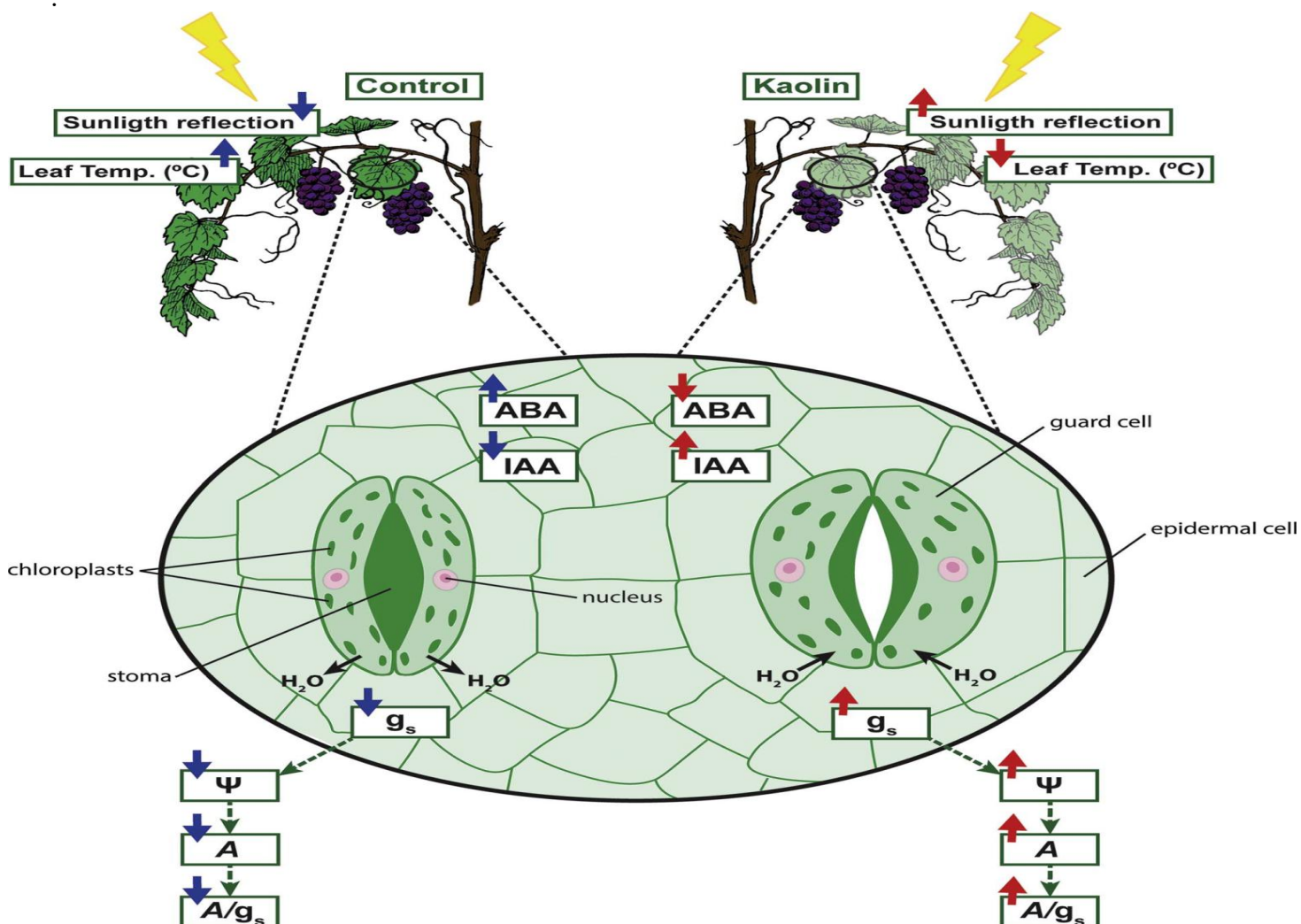


Fig.4. Physiology in grape crop on Kaolin application to combat temperature stress

Post-harvest treatments

Temperature pre-conditioning which consists of exposing the fruits to one or more periods of high temperature, (Hot water treatment, vapour heat treatment, cold storage) during their storage increases fruit resistance to low temperature. Controlling the storage atmosphere by decreasing O₂ and increasing CO₂ concentration also decreases the chilling and freezing injury (Wang *et al.*, 2018)

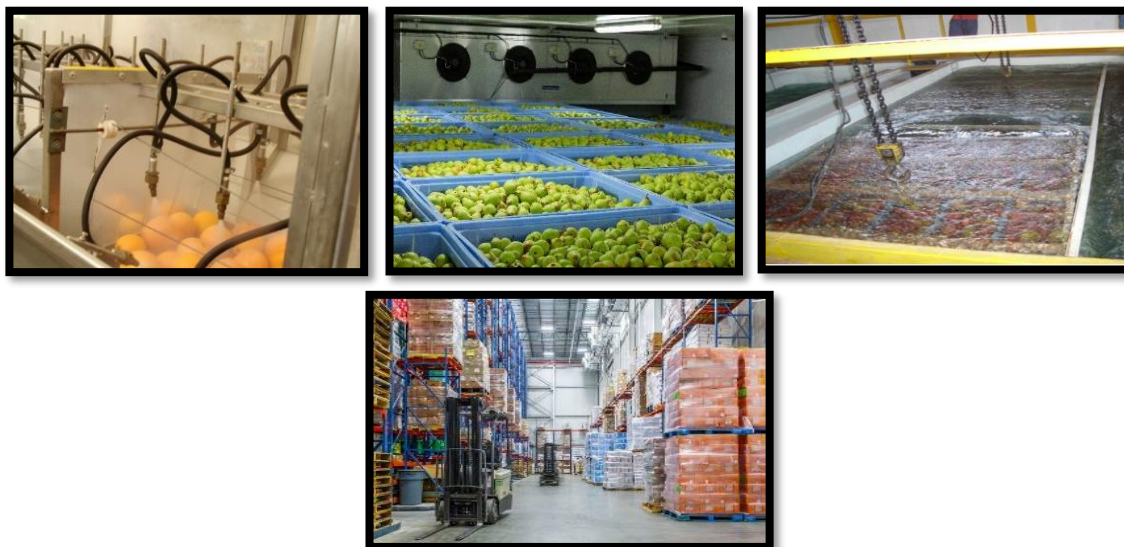


Fig.5. Pre-harvest conditioning of fruit crops prior to storage

CONCLUSION

Each fruit crop requires an optimum temperature range for normal growth, development and successful production; therefore, the increasing occurrence of temperature extremes under changing climatic conditions poses a serious challenge to sustainable fruit cultivation. Effective alleviation of temperature stress through suitable cultural practices, nutrient management, chemical interventions and post-harvest treatments can reduce stress-induced damage and enhance plant tolerance, fruit yield and quality. Hence, adopting appropriate and integrated temperature stress-management strategies based on the specific requirements of different fruit crops is essential for maintaining stable production and meeting the growing demand for fruits in the future.

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