Heat Tolerant Crops: Measure to Combat Climate Change in Agriculture

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OPEN ACCESS

Keywords

Climate Change, Heat Tolerance, Temperature, Resistance, Global Warming

How to cite this article:

Sarangi, G. K. and Rout, S. 2025. Heat Tolerant Crops: Measure to Combat Climate Change in Agriculture. *Vigyan Varta* 6 (5): 22-25.

ABSTRACT

Climate change nowadays has been a major issue to battle with in crop production. This has led to consider the factors such as inadequate monsoon and scarce rainfall, increased temperature and high humidity or conditions like drought. Hence, it has been essential to develop or bring into cultivation for heat stress tolerant crops in agriculture. This review comprises the facts and figures of commercially cultivated heat tolerant type crops that requires to be more emphasized for the future prospects.

INTRODUCTION

Global warming is predicted to have a general negative effect on plant growth due to the damaging effect of high temperatures on plant development. Heat stress is often defined as the rise in temperature beyond a threshold level for a period of time sufficient to cause irreversible damage to plant growth and development. In general, a transient elevation in temperature, usually 10-15°C above ambient, is considered heat shock or heat stress. However, heat stress is a complex function of intensity (temperature in degrees), duration, and rate of increase in temperature. The extent to which it occurs in specific climatic zones depends on the probability and period of high temperatures occurring during the day and/or the night. Heat tolerance is generally defined as the ability of the plant to grow and produce economic yield under high temperatures. However, not all plant species or genotypes within species have

similar capabilities in coping with the heat stress. (Wahid *et al.*,2007).

History of Heat Tolerant Crops

The development of heat-tolerant crops is a relatively recent focus, driven by climate change and the need for food security in increasingly hot regions, with research combining traditional breeding with genetic editing to create varieties that thrive in high temperatures.

Generally, the low lands of India along with middle-east region of Asia and specifically African territories are facing 15-20% drop in crop productivity due to 2-5°C rise in temperature affected by climate change. Occasional or prolonged high temperatures cause different morpho-anatomical, physiological and biochemical changes in plants. Since, it has brought the sight to genetically modify the crops for heat resistance and bring them under cultivation to mitigate the production losses.

Examples of Some Heat Tolerant Crops

Field Crops:

1. **Millet -** Millet is an ancient grain that is consumed across Africa and Asia. "It is very much climate resilient because it can grow in adverse conditions of high temperatures, from thirty to sixty degrees centigrade.

2. **Chickpeas** - Chickpeas are beloved around the world for their mild flavour and texture, as well as their nutritional attributes – and they also grow well in hot and dry conditions. They naturally rejuvenate the soil by fixing their own nitrogen and are water-use efficient.

3. **Seaweed -** Seaweed is a rapidly growing industry that is built on a highly sustainable and nutritious food. There are more than 12,000 varieties of seaweed that have their own nutritional profiles, but are each full of valuable compounds. And it's beneficial for the environment.

4. **Maize -** After a decade of rigorous effort, CIMMYT, along with public-sector maize research institutes and private-sector seed companies in South Asia, have successfully developed and released 20 high-yielding heat-tolerant (HT) maize hybrids across Bangladesh, Bhutan, India, Nepal, and Pakistan.

5. **Wheat -** The ICAR-IIWBR Karnal has initiated a specific research project entitled "Breeding high yielding wheat genotypes for stress conditions of warmer regions of India" on heat tolerant varieties. Besides, ICAR-IIWBR Karnal is also collaborating with International Maize and Wheat Improvement Centre (CIMMYT), Mexico on development of climate resilient wheat varieties.

Vegetable Crops:

1. **Malabar Spinach -** Malabar spinach is unrelated to true spinach but can be used similarly and has a similar flavour. It is named after a region in India where this subtropical vining plant is used in curries and stir-fries. This plant grows very differently than classic spinach.

2. **Okra** - Okra originated in Africa (in Ethiopia) and was made to resist the heat. It is so heat resistant that it has become a staple in the Southern United States, specifically Southern cuisine.

3. **Sweet Potato** - Sweet potatoes were originally considered native to Central and South America, but evidence has emerged that they were first cultivated in Polynesia and brought to the Americas. They are one of the best heat-resistant vegetables,

tolerating temperatures of 30 degrees and above.

4. **Chilli** – Chilli needs warm weather to grow and produce. In areas with shorter growing seasons, you will need to start pepper seeds indoors 2 months before the last frost day and transplant them out only once nighttime temps are consistently above 20 degrees. Cooler weather can stunt chilli plants.

5. **Tomatoes** - This quintessential summer crop is one of the most popular vegetables among backyard gardeners. There is nothing quite like a homegrown tomato. They taste best when picked during midday when the highest amount of sugar is concentrated in the fruits.

6. **Brinjal** – Brinjal love the heat the most. Like tomatoes, brinjals do best in daytime temperatures between 25-30 degrees, but they can also tolerate weather in the low up to 10-15 degrees.

7. **Cucumber** - With their high-water content, cucumbers need consistent moisture to produce crisp, delicious fruits. However, in the right conditions, they are still heat-resistant vegetables.

8. **Amaranth** - Another spinach substitute with a similar flavour is 'Edible Red Leaf' amaranth. Amaranth loves the heat and is drought-tolerant once established.

9. **Ridge gourd** - Ridge gourds are a fun addition to any garden. Aside from being left to mature and harvested for use as a shower sponge, they can also be harvested young and eaten like summer squash. They have a long growing season that requires a period of warm weather.

Benefits of Heat Tolerance

- Increased yield stability under stressful conditions.
- Reduced risk of crop failure.
- Improved food security.
- Reduced reliance on irrigation
- Potential for expansion of cultivation areas
- Improved reproductive performance
- Sustained biomass production
- Improved water and nutrient use efficiency

CONCLUSION

Plants exhibit a variety of responses to high temperatures, which are depicted by symptomatic and quantitative changes in growth and morphology. The ability of the plant to cope with or adjust to the heat stress varies across and within species as well as at different developmental stages. Although high temperatures affect plant growth at all developmental stages, later phenological stages, in particular anthesis and grain filling, are generally more susceptible. Pollen viability, patterns of assimilate partitioning, and growth and development of seed/grain are highly adversely affected. Other notable heat stress effects include structural changes in tissues and cell organelles, disorganization of cell membranes, disturbance of leaf water relations, and impedance of photosynthesis via effects on photochemical and biochemical reactions and photosynthetic membranes. Although physiological mechanisms of heat tolerance are relatively well understood, further studies are essential to determine physiological basis of assimilate partitioning from source to sink, plant phenotypic flexibility which leads to heat tolerance, and factors that modulate plant heat-stress response (Wahid *et al.*,2007).

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