

Protecting Plants from Extreme Weather: Tips and Strategies

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INTRODUCTION

Plants are inherently exposed to environmental fluctuations and have evolved diverse mechanisms to cope with stress. However, the current pace and intensity of extreme weather events associated with climate change often exceed the adaptive capacity of many plant species and cropping systems. Extreme weather refers to meteorological events that are rare or unusually intense for a particular region, including prolonged droughts, heat waves, cold spells, floods, storms, and erratic rainfall patterns. Such events can occur suddenly or persist over extended periods, causing both immediate and long-term damage to plants.

In agricultural systems, extreme weather leads to crop failure, reduced yield, poor-quality produce, and increased vulnerability to pests and diseases. In natural ecosystems, it disrupts plant community composition, regeneration, and ecosystem services. Urban plants and ornamental landscapes are also increasingly affected, influencing aesthetics, microclimate regulation, and human well-being. As climate models predict further increases in temperature extremes and rainfall variability, the need for effective strategies to protect plants has become urgent.

Plant protection from extreme weather is not limited to emergency responses. It involves proactive planning, informed crop and species selection, improved management practices, and the integration of technological innovations. This article explores the types of extreme weather stresses, their impacts on plant systems, and practical strategies that can be implemented at different scales, from home gardens to large-scale agriculture.

Types of Extreme Weather Affecting Plants

Heat Waves

Heat waves are periods of abnormally high temperatures lasting several days or weeks. High temperatures disrupt enzymatic activity, increase transpiration rates, and reduce photosynthetic efficiency. Heat stress can cause leaf scorching, flower drop, pollen sterility, and accelerated senescence, leading to significant yield losses.

Drought

Drought results from prolonged periods of insufficient rainfall and is one of the most damaging stresses for plants. Water scarcity limits cell expansion, nutrient transport, and metabolic processes. Severe drought can lead to wilting, reduced biomass accumulation, root damage, and plant death.

Flooding and Waterlogging

Excessive rainfall, floods, and poor drainage cause waterlogging, which reduces oxygen availability in the root zone. Anaerobic conditions impair root respiration and nutrient uptake, often resulting in root rot, chlorosis, and reduced growth.

Cold Stress and Frost

Cold stress includes chilling injury at low but non-freezing temperatures and freezing injury caused by frost. These conditions damage cell membranes, disrupt metabolic processes, and may kill sensitive tissues. Frost is particularly harmful during flowering and early growth stages.

Storms, Cyclones, and Hailstorms

High winds, heavy rains, and hail cause physical damage such as lodging, defoliation, stem breakage, and fruit injury. Storms can also lead to salt spray damage in coastal areas and increase disease incidence due to prolonged leaf wetness.

Unseasonal Rainfall and Temperature Fluctuations

Erratic weather patterns, including unexpected rainfall or sudden temperature shifts, disrupt normal phenological stages. These changes can interfere with flowering, fruit set, and maturity, resulting in yield instability.

Physiological and Morphological Responses of Plants to Extreme Weather

Plants respond to extreme weather through a combination of physiological, biochemical, and

morphological adjustments. Under heat and drought stress, plants often close stomata to reduce water loss, although this also limits carbon dioxide uptake and photosynthesis. Accumulation of Osmo protectants such as proline and sugars helps maintain cell turgor. Antioxidant enzymes are activated to counteract oxidative stress caused by extreme temperatures. Morphologically, plants may develop deeper or more extensive root systems under drought conditions, thicker cuticles to reduce transpiration, and altered leaf orientation to minimise heat absorption. Flood-tolerant plants form aerenchyma tissues that facilitate oxygen transport to roots. While these adaptations provide some resilience, they are often insufficient under severe or prolonged stress, highlighting the need for external protective strategies.

Strategies to Protect Plants from Extreme Weather

Soil and Water Management

Healthy soil is the foundation of plant resilience. Soil organic matter improves water holding capacity, drainage, and nutrient availability. Practices such as compost application, green manuring, and reduced tillage enhance soil structure and microbial activity.

Efficient irrigation methods, including drip and sprinkler systems help maintain optimal soil moisture during drought while conserving water. Rainwater harvesting and on farm water storage structures provide supplementary irrigation during dry periods. Proper drainage systems are essential in flood-prone areas to prevent waterlogging and root damage.

Mulching

Mulching involves covering the soil surface with organic or inorganic materials. Organic mulches such as straw, leaves, and crop residues moderate soil temperature, reduce evaporation, suppress weeds, and improve soil fertility. Plastic mulches are effective in controlling moisture loss and soil temperature in horticultural crops. Mulching is particularly useful in mitigating both heat and drought stress.

Microclimate Modification

Altering the immediate environment around plants can significantly reduce weather stress. Shade nets and shelters reduce solar radiation and temperature during heat waves. Windbreaks

such as hedgerows and shelterbelts protect crops from strong winds and reduce evapotranspiration. In cold-prone areas, row covers and low tunnels help retain heat and protect plants from frost.

Crop and Variety Selection

Choosing crops and varieties adapted to local climatic conditions is one of the most effective strategies for weather resilience. Drought-tolerant, heat-tolerant, flood-tolerant, and cold-tolerant varieties are increasingly available through plant breeding programs. Traditional and indigenous varieties often possess valuable stress tolerance traits and can be integrated into modern farming systems.

Adjusting planting dates to avoid critical growth stages coinciding with extreme weather events also reduces risk. Diversification through intercropping and crop rotation helps spread risk and improve system stability.

Nutrient Management

Balanced nutrition enhances plant vigour and stress tolerance. Adequate potassium improves water use efficiency and resistance to heat and drought. Calcium strengthens cell walls and improves tolerance to temperature extremes. Foliar application of micronutrients and anti-stress compounds can provide temporary relief during extreme conditions.

Structural Protection

Physical structures provide direct protection against extreme weather. Greenhouses, polyhouses, and net houses create controlled environments that shield plants from excessive heat, cold, wind, and rainfall. Temporary structures such as hail nets and frost protection covers are cost-effective solutions for high value crops.

Integrated Pest and Disease Management

Extreme weather often increases pest and disease pressure by weakening plant defences and creating favourable conditions for pathogens. Integrated pest and disease management practices, including monitoring, resistant varieties, biological control, and judicious pesticide use help maintain plant health under stress conditions.

Use of Weather Forecasting and Technology

Access to reliable weather forecasts enables farmers and gardeners to take timely preventive measures. Early warning systems help plan irrigation, harvesting, and protective actions such as deploying covers or adjusting irrigation schedules. Precision agriculture tools, remote sensing, and decision support systems enhance adaptive capacity and resource efficiency.

Long Term Adaptation and Climate-Resilient Planning

Protecting plants from extreme weather requires long term strategies beyond immediate responses. Climate resilient agriculture emphasizes system level adaptation, including landscape management, agroforestry, conservation agriculture, and sustainable water use. Agroforestry systems buffer temperature extremes, improve soil health, and enhance biodiversity. Conservation agriculture practices such as minimal tillage and residue retention increase resilience to both drought and floods. Research and development play a crucial role in breeding climate-resilient crops and developing innovative technologies. Farmer training, extension services, and policy support are essential for widespread adoption of protective strategies. Urban planning that incorporates green infrastructure also contributes to plant resilience and climate mitigation.

Role of Home Gardens and Urban Green Spaces

Home gardens and urban green spaces play an increasingly important role in plant protection under extreme weather conditions, particularly in rapidly urbanising regions. Urban plants are frequently exposed to higher temperatures due to the urban heat island effect, irregular water availability, and limited soil volume. Despite these constraints, well-managed green spaces can significantly enhance plant resilience and contribute to environmental sustainability.

The selection of climate adapted plant species is crucial in home gardens and urban landscapes. Native and drought-tolerant species require less water and maintenance while showing greater tolerance to temperature

extremes. Improving soil quality through compost addition enhances water holding capacity and nutrient availability, reducing stress during drought and heat waves. Mulching around garden plants further moderates soil temperature and conserves moisture.

Rainwater harvesting systems integrated with rooftops and paved surfaces provide supplementary irrigation during dry periods.

Shade structures, vertical gardens, and strategic plant placement reduce exposure to intense sunlight and wind. Urban trees and green roofs help lower ambient temperatures, protect understory vegetation, and improve overall microclimatic conditions. Community-driven green initiatives strengthen resilience while improving food security and quality of life.

Table 1. Major Extreme Weather Events and Their Impacts on Plants

Extreme weather event	Major impacts on plants
Heat waves	Reduced photosynthesis, leaf scorching, pollen sterility, and yield loss
Drought	Wilting, reduced growth, nutrient deficiency, plant mortality
Flooding	Root hypoxia, chlorosis, root rot, stunted growth
Frost	Cell membrane damage, tissue death, flower and fruit loss
Storms and hail	Lodging, defoliation, stem breakage, and physical injury

Table 2. Strategies for Protecting Plants from Extreme Weather

Strategy	Weather stress addressed	Key benefits
Mulching	Heat and drought	Moisture conservation and soil temperature regulation
Shade nets	Heat stress	Reduced radiation and canopy temperature
Drainage management	Flooding	Improved root aeration and plant survival
Stress-tolerant varieties	Multiple stresses	Stable yield under adverse conditions
Structural covers	Frost and hail	Physical protection of sensitive tissues

Future Perspectives

Future plant protection strategies must address the increasing frequency, intensity, and unpredictability of extreme weather events. Incorporating climate projections into agricultural and horticultural planning will allow better anticipation of risks and timely implementation of protective measures. Advances in artificial intelligence, remote sensing, and machine learning are expected to improve weather forecasting accuracy and early warning systems.

Plant breeding will continue to play a central role, with greater emphasis on multi-stress tolerance rather than resistance to single environmental factors. Genomic tools, high-throughput phenotyping, and gene editing technologies offer new opportunities for developing climate-resilient crops. Digital agriculture platforms and mobile-based advisory services can further enhance adaptive capacity, especially among smallholder farmers.

Participatory research involving farmers, scientists, and policymakers will be essential to ensure that innovations are practical and locally

relevant. Sustainable financing, supportive policies, and international collaboration will strengthen long term resilience in climate-vulnerable regions.

CONCLUSION

Extreme weather events pose a serious and growing threat to plant health, productivity, and ecosystem stability. Although plants possess natural adaptive mechanisms, these are often insufficient under severe and rapidly changing climatic conditions. Protecting plants from extreme weather, therefore, requires an integrated, proactive, and science-based approach. Effective strategies include improving soil and water management, modifying microclimates, selecting resilient crops and varieties, adopting structural protection, and using modern weather forecasting and digital tools. Long-term climate-resilient planning supported by research, policy, and capacity building is essential for sustainable plant protection. By integrating traditional knowledge with scientific innovation and system-based management, it is possible to enhance plant

resilience and safeguard agricultural, urban, and natural ecosystems against the challenges posed by extreme weather.

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