Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 06, Issue: 02 (MAR-APR, 2026)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Climate Change Impacts on Seed Physiology and Storage Behaviour

Ashwini Ramchandra Mehare[1] and *Ruchika[2]
[1]M.Sc., Seed Science and Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri
[2]M.Sc., Seed Science and Technology, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, HP
*Corresponding Author's email: ruchikasingh6770r@gmail.com

Climate change is increasingly influencing agricultural productivity and crop sustainability across the globe. Rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events have significant impacts on seed development, physiology, and storage behaviour. Seeds represent the fundamental unit of crop production, and their physiological quality directly affects germination, seedling establishment, and crop yield. Environmental conditions during seed development and storage determine seed longevity and vigor. Climate-induced stresses such as heat, drought, and elevated atmospheric carbon dioxide can alter seed composition, viability, and storage stability. This article discusses the effects of climate change on seed physiology and storage behaviour, focusing on the physiological, biochemical, and environmental factors that influence seed quality and longevity. Understanding these impacts is essential for developing adaptive seed management strategies and ensuring future food security.

Introduction

Climate change is one of the most pressing challenges facing global agriculture today. Changes in temperature, rainfall distribution, and atmospheric carbon dioxide levels are affecting crop growth, productivity, and seed quality. Seeds play a crucial role in agriculture because they determine the success of crop establishment and yield potential. Seed physiology refers to the biological processes that regulate seed development, maturation, dormancy, germination, and storage. These processes are strongly influenced by environmental conditions. Climate change can disrupt these physiological processes, leading to poor seed development, reduced viability, and altered storage behaviour. Seed storage behaviour describes how seeds respond to drying and storage conditions. Seeds are generally classified into three categories based on their storage behaviour: orthodox, recalcitrant, and intermediate seeds. Climate change can affect the storage characteristics of seeds by altering their moisture content, biochemical composition, and tolerance to environmental stress. Understanding the impact of climate change on seed physiology and storage behaviour is critical for maintaining seed quality and ensuring sustainable agricultural production.

Climate Change and Seed Development

Environmental conditions during seed development have a significant influence on seed quality and physiological performance. Temperature, moisture availability, and nutrient supply determine the accumulation of storage reserves such as carbohydrates, proteins, and lipids in developing seeds. Rising temperatures associated with climate change can accelerate seed maturation, reducing the time available for proper accumulation of storage compounds. As a result, seeds produced under high-temperature conditions may exhibit lower weight, reduced nutrient reserves, and poor germination performance. Drought stress during seed

development can also negatively affect seed formation by limiting nutrient transport and metabolic activities within developing seeds. Seeds produced under drought conditions often show reduced size, lower vigor, and decreased storage potential.

Effects of Temperature on Seed Physiology

Temperature plays a crucial role in regulating seed physiological processes such as dormancy, germination, and metabolic activity. Climate change is causing a gradual increase in global temperatures, which can significantly influence seed physiology. High temperatures during seed development can lead to changes in membrane stability, enzyme activity, and hormonal balance. These changes may disrupt normal seed maturation processes and affect the ability of seeds to remain viable during storage. Elevated temperatures also increase respiration rates in stored seeds, accelerating metabolic reactions that lead to seed ageing and deterioration. As a result, seeds stored under warmer conditions often lose viability more rapidly than those stored under cooler conditions.

Influence of Moisture and Drought Stress

Changes in rainfall patterns and increasing drought frequency are major consequences of climate change. Water availability during seed development and storage strongly affects seed physiology and longevity. Drought stress can alter the biochemical composition of seeds by reducing the synthesis of storage proteins and carbohydrates. This reduction affects seed vigor and germination potential. In addition, drought conditions may increase the production of stress-related metabolites that influence seed dormancy and germination behavior. Moisture levels during seed storage are equally important. High humidity conditions can increase seed moisture content, leading to enhanced metabolic activity and accelerated seed deterioration. Under climate change scenarios, increased humidity fluctuations may make it more difficult to maintain optimal storage conditions for seeds.

Impact of Elevated Carbon Dioxide

Rising atmospheric carbon dioxide concentrations can influence plant physiology and seed development. Elevated carbon dioxide often enhances photosynthesis and plant growth, which may increase seed yield in some crops. However, changes in carbon dioxide levels can also alter the chemical composition of seeds. Studies have shown that elevated carbon dioxide may reduce protein concentration while increasing carbohydrate content in certain crop seeds. Such changes in seed composition may influence germination behaviour, seed vigor, and nutritional quality.

Climate Change and Seed Storage Behaviour

Seed storage behaviour depends on the ability of seeds to tolerate drying and maintain viability under storage conditions. Climate change may influence this behaviour by altering seed structure, moisture content, and metabolic activity. Seeds produced under high temperature and drought stress often have reduced storage longevity because of structural damage to cellular membranes and reduced antioxidant capacity. Such seeds may deteriorate more rapidly during storage. Furthermore, fluctuating environmental conditions caused by climate change can affect seed storage facilities, especially in regions lacking controlled storage infrastructure. Increased temperature and humidity variability may accelerate seed deterioration during storage.

Physiological and Biochemical Changes in Seeds Under Climate Stress

Oxidative Stress: Environmental stresses associated with climate change can increase the production of reactive oxygen species within seed tissues. These molecules cause oxidative damage to cellular membranes, proteins, and nucleic acids, leading to reduced seed viability.

Membrane Damage: Heat and drought stress can disrupt membrane stability in developing seeds. Membrane deterioration increases permeability and results in leakage of cellular solutes during germination, which reduces seed vigor.

Changes in Hormonal Balance: Climate stress may alter the levels of plant hormones such as abscisic acid and gibberellins, which regulate seed dormancy and germination. These hormonal changes can influence seed germination behaviour and storage performance.

Strategies to Mitigate Climate Change Effects on Seed Storage

Improved Seed Storage Infrastructure

Developing temperature- and humidity-controlled storage facilities can help maintain seed viability under changing climatic conditions.

Development of Climate-Resilient Crop Varieties

Plant breeding programs should focus on developing crop varieties that produce seeds with improved stress tolerance and longer storage life.

Advanced Seed Treatment Technologies

Seed treatments such as priming, protective coatings, and antioxidant treatments can enhance seed tolerance to environmental stresses and improve storage stability.

Seed Banks and Conservation Programs

Establishing seed banks and genetic conservation programs is essential for preserving plant genetic resources and ensuring seed availability under changing climate conditions.

Future Perspectives

Future research should focus on understanding the molecular and genetic mechanisms that regulate seed responses to climate stress. Advances in genomics, proteomics, and metabolomics may provide new insights into the factors controlling seed longevity and stress tolerance. Integration of climate modeling with seed storage research can help predict future challenges and develop adaptive strategies for seed management. Improved storage technologies and climate-resilient seed systems will be critical for ensuring global food security.

Conclusion

Climate change has significant implications for seed physiology and storage behaviour. Rising temperatures, changing rainfall patterns, and elevated carbon dioxide levels can affect seed development, biochemical composition, and longevity. These changes may reduce seed quality and accelerate deterioration during storage. Understanding the physiological and biochemical responses of seeds to climate stress is essential for developing effective seed management strategies. By improving storage technologies, breeding climate-resilient crop varieties, and implementing adaptive agricultural practices, it is possible to mitigate the negative effects of climate change on seed systems and maintain sustainable crop production.

References

1. Walters, C., Wheeler, L. M., & Grotenhuis, J. M. (2005). Longevity of seeds stored in genebanks: Species characteristics. *Seed Science Research*.
2. Bewley, J. D., Bradford, K. J., Hilhorst, H. W., & Nonogaki, H. (2013). *Seeds: Physiology of Development, Germination and Dormancy*. Springer.
3. Walters, C. (2015). Orthodoxy, recalcitrance and in-between: Describing variation in seed storage characteristics using threshold responses to water loss. *Planta*.
4. Ellis, R. H., & Roberts, E. H. (1980). Improved equations for predicting seed longevity. *Annals of Botany*.