

Unveiling the global vegetable crisis amidst accelerated climate change

Abhishek, Aditya*, Neeraj, C P Mehla and J N Bhatia

National Institute of Food Technology Entrepreneurship and Management, Kundli, Sonipat, Haryana 131 028

Vegetables play a crucial role in ensuring nutritional stability and are a vital element of a well-rounded diet. The presence of bioactives in vegetables underscore the importance of consuming a varied and colourful array of plant-based foods to support optimal health. Incorporating a wide range of vegetables into the diet provides an abundance of bioactive compounds that can collectively contribute to a healthier lifestyle and reduce risk of chronic diseases. The primary global challenge confronting humanity and the planet is acknowledged to be climate change, which significantly affects the cultivation of vegetables and agriculture as a whole. Vegetables are particularly susceptible to the impacts of climate change, posing a threat to food security. Since vegetables are a primary source of essential nutrients for human diet, the negative impacts on their production can threaten global food security and exacerbate malnutrition. It is imperative to concentrate on a comprehensive strategy that involves the creation of climate-resistant vegetable varieties, sustainable farming methods, the incorporation of biotechnological advancements and more in order to alleviate the adverse effects of climate change on vegetable production.

Keywords: Climate change, Food security, Global Warming, Nutrition, Vegetables

In the present global context, vegetables have become indispensable in guaranteeing sufficient nourishment and ensuring food stability. India has emerged as a significant player in vegetable production, with a staggering output of 204.83 million metric tonnes from an area spanning 11.35 million hectares in 2022–23. Based on the 2021 report by the Food and Agriculture Organization (FAO), India is recognized as the leading cultivator of okra and ginger, surpassing all other vegetables in production. Additionally, India secures second in producing onion, potato, cabbage, cauliflower, and brinjal. Moreover, India also stands as the world's second-largest producer of vegetables, contributing approximately 15% of global production. However, cultivating vegetables is highly susceptible to adverse environmental conditions, making them vulnerable to high

temperatures and limited soil moisture. These factors act as significant deterrents to achieving high yields and the impacts of climate change further compound the situation. Climate change is recognized as the foremost global challenge facing humanity and the earth, and has profound consequences on vegetable cultivation and agriculture as a whole. This, in turn may inevitably affect worldwide food security. The impacts of climate change, specifically in tropical regions where developing countries are situated, exhibit greater significance and endure lasting consequences. These countries face the brunt of the adverse impacts over an extended period, exacerbating the challenges encountered in their agricultural practices and food production systems.

India plays a significant role in vegetable production, but climate

change threatens this industry. Global warming, erratic rainfall and extreme weather events are affecting vegetable cultivation worldwide. These unprecedented changes create significant challenges for farmers. Although vegetable farming offers advantages over traditional cereal crops, such as higher yields, shorter growth cycles and more job opportunities, it also exposes crops to climate change risks like heat waves, droughts and floods. To ensure the future of vegetable production, it is crucial to prioritize research on the effects of climate change and find solutions to mitigate its impact on vegetable growth, yield, and quality.

Issues from climate change regarding sustainable vegetable crop production

Addressing these challenges requires a multi-faceted approach that includes developing climate-resilient crop varieties,

implementing sustainable farming practices, improving irrigation and water management systems and adopting integrated pest and disease management strategies. By focusing attention on understanding and mitigating the impacts of climate change on vegetable production, we can work towards ensuring food security and sustainable agricultural practices in the face of a changing climate.

Various aspects affected by climate change

Temperature: Temperature significantly impacts vegetable plant growth, affecting yield, flowering, fruit quality and development stages. High temperatures lead to negative effects like bud loss, abnormal flowers, reduced pollen and seed viability and limited carbohydrates. These heat-induced reproductive issues result in small, low-quality fruits and poor fruit sets, as observed in studies on cauliflower curd initiation. Temperatures exceeding 30°C in tomato cultivation cause a rise in the loss of flowers and fruits. In contrast, elevated temperatures following the release of pollen reduce the formation of fruits and the overall yield. Onion bulbs also suffer from reduced size when exposed to temperatures exceeding 40°C. In bean crops, high temperatures cause a delay in flowering due to the promotion of

a short-day photoperiod. Similarly, in okra, crop temperatures above 42°C lead to a drop in flowering and a subsequent loss in yield. On the other hand, low temperatures during extreme winter conditions can also significantly impact vegetable crop production. Crops such as potatoes, brinjals (eggplants) and tomatoes are particularly affected. Temperature plays a crucial role in determining the sexual characteristics of cucumber plants. Specifically, colder temperatures leads to a higher occurrence of female flowers, while warmer temperatures promote the production of male flowers. Carrots exhibit optimal root development, color, texture and size at temperatures ranging from 10–15°C. However, low temperatures of around 13.0°C in tomatoes lead to a drop in flowering. Slight variations in temperature and rainfall can substantially influence the quality of vegetables, thereby impacting both domestic and international trade related to these crops.

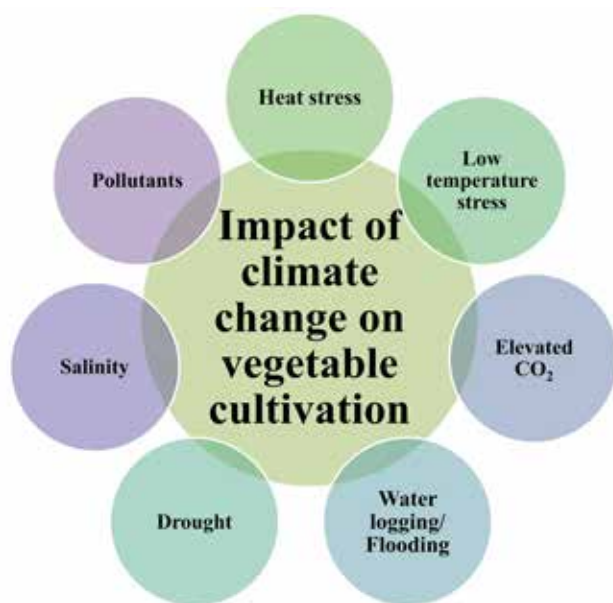
Alterations in temperature and humidity levels will also have an impact on pest populations. As a result, we can anticipate the invasion of new and aggressive insects, diseases, and weeds that pose threats to our crops. Temperature fluctuations significantly impact vegetable crops, affecting growth, yield and quality. To counter these effects, farmers and researchers must

account for temperature sensitivities, adjusting cultivation and mitigation strategies accordingly.

Flooding: Flooding jeopardizes vegetable crops as it deprives their roots of oxygen, impairing vital processes of the crops. Nutrient absorption is hindered, stunting growth or causing plant demise. Tomatoes for instance, face heightened ethylene production due to flooding-induced low oxygen. This stress elevates l-amino-cyclo-propene-l-carboxylic acid, a precursor to ethylene, compounding the threat by further impacting oxygen and nutrient availability.

Drought: Most vegetables are highly sensitive to drought, with over 90% water content, making them prone to water scarcity effects. Drought leads to significant yield reductions as plant cells undergo changes that lower water potential, damaging cell membranes and disrupting processes like photosynthesis. Drought's timing, intensity and duration affect vegetable production, especially during flowering and edible part development stages. Stress during these critical periods can cause substantial production losses. If climatic factors such as rainfall undergo significant changes in a particular region, surpassing the tolerance levels of the species inhabiting it, the natural distribution pattern of those species may be disrupted and altered.

Salinity: Salinity is a significant problem affecting crop productivity in India and worldwide. The increasing salinity in the soil threatens vegetable production, especially in irrigated farmland, which is crucial in supplying 40% of the world's food. The excessive presence of salts in the soil negatively impacts the growth and yield of various vegetables at different stages of their development. Onions are highly susceptible to saline soils, while crops like cucumbers, eggplants, peppers and tomatoes show moderate sensitivity. Under extreme temperature conditions, when evapotranspiration is high, there is a substantial loss of water, leaving behind salt deposits around



Factors affecting vegetable crops due to change in climate

the roots of plants. These salt deposits interfere with the plant's ability to absorb water, leading to adverse effects. The plants experience a loss of turgor pressure, reduced growth, wilting, curling of leaves, shedding of leaves, decreased photosynthesis, changes in respiration, compromised protective outer layer (cuticle), tissue necrosis and in severe cases, even death. The detrimental effects of salt stress on plants result in visible symptoms and physiological changes that ultimately lead to reduced crop productivity. This issue is not confined to India alone but affects vegetable production globally, posing a challenge to food security.

Emission of greenhouse gases: Various gases, such as carbon dioxide, methane, sulfur dioxide and nitrous oxide, are among the primary contributors to global warming, negatively impacting the quality and productivity of vegetable crops. The release of greenhouse gases from sources like industry, agriculture and deforestation plays a significant role in the recent changes in the Earth's climate. Rising temperatures caused by global warming have

detrimental effects on agriculture and vegetable crops in particular. The concentration of carbon dioxide in the atmosphere has experienced a substantial increase, rising from 280 parts per million (ppm) during pre-industrial times to 458 ppm in 2023. Similarly, other greenhouse gases like methane and nitrous oxide have significantly increased global atmospheric concentrations. The continuous escalation of greenhouse gas emissions has resulted in a 0.74°C increase in global temperatures over the past century, and these emissions are projected to continue rising in the future. Consequently, the higher global temperatures will necessitate a greater demand for vegetable crop varieties that are adaptable to higher temperatures.

Way forward and adaptations to climate change

Development of resilient crop varieties and hybrids: Efforts are being made to create plant varieties that can withstand adverse climate conditions. These varieties are designed to tolerate extreme temperatures, drought, floods and other climate-related stresses.

Adoption of climate-resilient technologies: Various technological advancements are being implemented to mitigate the impact of climate change on agriculture. This includes changing the timing of sowing to align with favourable climate conditions, using protected cultivation techniques to shield crops from harsh weather, employing drip irrigation systems for efficient water use, implementing soil and moisture conservation practices, managing fertilizers through fertigation and utilizing weather-based agricultural advisory services. These measures aim to enhance productivity while minimizing the impact of climate variability.

Biotechnological approaches for stress tolerance: Biotechnology plays a crucial role in developing crops with enhanced tolerance to multiple stresses. Through genetic engineering and other biotechnological methods, scientists are working on creating plants that can better withstand adverse environmental conditions, such as heat, drought, salinity and pests.

Crop simulation models: The development of crop simulation models enables the analysis of



Tomato: Arka Meghali
Drought stress, Heat stress



Tomato: Arka Vikas
Drought stress, Heat stress



Onion: Arka Kalyan
Drought stress



Onion: Agrifound Dark Red
Drought stress



Chilli: Kashi Anmol
Drought stress, Delayed monsoon



Brinjal: Kashi Sandesh
Drought stress, Delayed monsoon, Heat stress



Carrot: Ooty-1
Cold stress



Bottle gourd: Kashi Ganga
Drought stress, Delayed monsoon

Climate resilient vegetable crop varieties and hybrids

Source: ICAR-Indian Institute of Horticultural Research, Bangalore; Tamil Nadu Agricultural University, Coimbatore

regional impacts, adaptations, and vulnerability to climate change. These models provide valuable insights into how different crops will respond to changing climatic conditions, helping farmers and policymakers make informed decisions regarding crop selection and management practices.

Capacity building and education: The capacity of farmers, researchers and other stakeholders is essential for effective adaptation to climate change. By providing training, education, and resources, individuals can acquire the knowledge and skills needed to implement sustainable agricultural practices and respond to climate challenges.

Prioritizing vegetable resistance: Given the specific vulnerability of vegetables to climate change, efforts are focused on developing resistant varieties. The negative impacts of changing environmental conditions on vegetable crops can be minimized by breeding or engineering vegetables with increased tolerance

to climate stresses.

Global collaboration and integration of efforts: Addressing the challenges of climate change requires a collective and collaborative approach. Instead of individual institutions working in isolation, a holistic strategy that integrates global efforts is necessary. Countries and organizations can pool their efforts to develop effective solutions for adapting to climate change and ensuring food security by sharing knowledge, resources, and expertise.

SUMMARY

Vegetables are a cornerstone of a healthy human diet, offering a multitude of essential nutrients and bioactive compounds that contribute to overall well-being and disease prevention. Their nutrient density, combined with their diverse array of bioactive compounds, makes vegetables an indispensable part of a balanced and nutritious diet, promoting optimal health and well-being throughout life. The bioactive

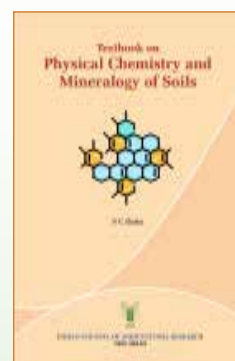
compounds in vegetables, such as antioxidants, polyphenols, and carotenoids, help protect cells from damage, reduce inflammation and lower the risk of chronic diseases like heart disease, diabetes and certain cancers. The production of vegetable crops faces considerable difficulties due to climate change. The increasing temperatures, alterations in precipitation patterns, and occurrence of extreme weather events can negatively affect the overall growth, development, and productivity of vegetable crops. It is crucial to promptly address and prioritize the effects of climate change on vegetables. Efforts should focus on developing climate-resilient varieties, adopting sustainable agricultural practices and promoting global collaboration to overcome the challenges and ensure the stability and productivity of vegetable crop production in a changing climate.

*Corresponding author's e-mail:
adityabhatia29@gmail.com

Textbook on Physical Chemistry and Mineralogy of Soils

Physical chemistry of soil and soil mineralogy are the two pillars which form the basic foundation of soil science. Once the students become familiar with these basic concepts, they can easily understand the other properties of the soil, say physical and biological properties, pedology and soil fertility. To become an expert of soil fertility, comprehensive knowledge of all the soil properties is essential which in turn is supported by the knowledge of physical chemistry of soils and soil mineralogy.

The present Textbook on 'Physical Chemistry and Mineralogy of Soils' has been written very cogently by the author who has been a teacher with an experience of nearly four decades of teaching in a premier Institute that is ICAR-Indian Agricultural Research Institute. The book includes all the topics prescribed by ICAR for the Postgraduate students of Soil Science. The introductory chapter describes basic definitions of soil science. Chapters like 'Bonding in solid structures', 'Elements of crystallography', 'Chemical thermodynamics' and 'Electrochemistry of soils and clays' are basic in nature and have been dealt very lucidly for easy understanding of students. Two chapters on characterisation of soil minerals are practical oriented. Other chapters focus on the structures of soil minerals, weathering and formation of minerals in soil environment, adsorption and ion exchange on soil colloids, double layer theory of soil colloids—its evolution and application, chemisorption and precipitation reactions in soil, soil organic colloids and their properties and chemistry of submerged soil. This book will be very much useful for the Postgraduate students of Soil Science.



TECHNICAL SPECIFICATIONS

No. of pages : i-xii + 348 • Price : ₹ 650 • ISBN No. : 978-81-7164-228-1

For obtaining copies, please contact:

Business Unit

Directorate of Knowledge Management in Agriculture
Krishi Anusandhan Bhavan-I, Pusa, New Delhi 110 012
Tel : 011-25843657, Fax 91-11-25841282; e-mail : bmicar@gmail.com