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Effects of Climate Change on Horticulture Sector Productivity: A Review

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ABSTRACT

This comprehensive analysis provides a thorough examination of the significant influence of climate change variability on the horticultural yield. The focus is specifically on recent trends and changing patterns within various major sectors of horticulture, namely Pomology, Olericulture, Floriculture, Post-Harvest, and Landscaping. The impact of rising temperatures altered precipitation patterns, and increased occurrences of extreme weather events is profoundly transforming the horticultural landscape. By delving into in-depth analyses of recent studies, this article sheds light on noteworthy changes in flowering and fruiting patterns in Pomology, as well as alterations in phenological stages in Olericulture. Furthermore, it highlights the innovative approaches in controlled-environment agriculture that have been adopted in Floriculture. The effects of climate change on post-harvest processes and the adoption of novel technologies are also explored within the context of post-harvest. Additionally, the integration of horticulture and landscape architecture is emphasized as a crucial strategy in adapting Landscaping practices to the variability brought about by climate change. The review is supported by various facts that illustrate global temperature anomalies, fruiting periods, phonological shifts, impacts on flower quality, adoption rates of post-harvest technologies, and the integration of horticulture and landscape architecture. The main objective of the review is to offer a brief understanding on the impact of climate change on horticultural productivity. Ultimately, the review highlights the urgent need to implement adaptive strategies and sustainable practices across diverse sectors of horticulture to ensure resilience in the face of ongoing climate change. This study suggests that vertical farming, climate resilient landscaping, Genomic Wide Association Studies, and Smart Breeding of crops as well as Controlled Environmental Agricultural methods might be suitable to encounter climate change.

Keywords: Climate Change, Horticulture, Productivity, Emerging Trends

INTRODUCTION

Global Climate Change, characterized by fluctuations in temperature, precipitation patterns, and an increase in extreme weather conditions, presents an unparalleled menace to global ecosystems. The ramifications of these transformations extend well beyond atmospheric modifications, profoundly affecting various sectors essential for human sustenance, such as the horticulture sector, which is particularly vulnerable to evolving climate conditions. According to the Intergovernmental Panel on Climate Change (IPCC), there is a consistent upward trend in global temperatures, primarily attributed to human activities such as the burning of fossil fuels and deforestation (IPCC, 2022). This temperature rise is causing disruptions in climate patterns, impacting precipitation regimes, and intensifying the frequency and severity of extreme weather events like hurricanes, droughts, and heat waves. These shifts in climate are fundamentally altering the agricultural landscapes, posing challenges to traditional practices and necessitating the adoption of adaptive strategies.

Over the past century, the Earth's average surface temperature has been steadily increasing, with recent decades witnessing unprecedented warming (IPCC, 2022). Climate change's agricultural advantages in certain areas and situations are overshadowed by its negative implications. Unexplored areas may host several fruit species. In regulated environments, extra CO_2 may improve photosynthesis and agricultural production (Annappa et al., 2023). On the other hand, climate change has several detrimental implications on agriculture, threatening food supply and security. Droughts, rising temperatures, and changing precipitation patterns may lower agricultural output which leads to reduced crop yields, modify ideal growing zones for specific

horticultural crops, necessitating agricultural methods and perhaps lowering crop quality and productivity (Annappa et al., 2023). Climate change has altered European horticulture zones. Warming temperatures have allowed crops to flourish in northern latitudes (Hänninen, 2015).

Large-scale perennial commercial crops have blooming and fruiting problems. Shivanna et al. (2020) report alterations in these important stages, which impact pollination and harvest timing. Such changes affect fruit availability and quality, which are essential for nutrition and economic activity. The phenological phases of important vegetable crops are changing due to climate change (Raza et al., 2021). Modifications in planting and harvesting time interrupt agricultural patterns and need modifications to cultivation operations to sustain production. Flower output depends on the weather. According to De, (2018), variable weather might impair floral quality and availability. Post-harvest horticultural crop storage, shipping, and preservation is difficult. Yadav et al. (2023) emphasize post-harvest technology, cold chain management, and storage facility advances to combat climate change. These solutions are essential to horticulture supply chain resilience in a changing environment. The shifting climate affects every element of landscaping, from plant selection to design. Raza et al. (2019) emphasizes the need of merging horticulture and landscape design to build climate-resilient landscapes. This introduction provides a basis for examining current trends and scientific issues on climate change and horticulture production. Recent climate change research and new solutions are our emphasis. This study synthesizes and critically evaluates existing information to help academics, policymakers, and practitioners maintain the horticulture industry in a constantly changing environment.

EFFECTS OF CLIMATE CHANGE ON HORTICULTURAL CROPS

1. Effects of Climate Change on Fruit Crops

Fruit farming is crucial to global agriculture and food security. Fruit tree phenology is one of the most visible effects of climate change on horticultural crops. Flowering, fruit setting, maturity, and harvesting depend on temperature. Climate change harms fruit crops, leading to various physiological disorders as reported by several researchers. These include unfruitfulness in Aonla caused by high temperatures (Bhargava et al., 2011), fruit cracking in pomegranates due to fluctuations in day and night temperatures (El-Rhman, 2010), granulation in citrus fruits caused by excessive water moisture (Zong et al., 1979), and flower and fruit drop in mangoes and grapes due to lacking pollination and high temperatures (Jawanda et al., 1974, Pandey, 1998). As climate change warms, fruit trees may accelerate phenological phases, affecting the reproductive cycle (Prevéy et al., 2020). Panchaat et al. (2022) stressed the importance of studying the phenology, physiology, growth, and yield of fruit crops concerning the increased CO_2 and water deficit. These changes may impair pollination and fruiting. Flowering and pollination seasons may be mismatched by temperature, precipitation, and pollinator availability. Thus, this mismatch may affect fruit set and quality. For instance, high temperatures might influence bee behavior and longevity, reducing their pollination efficiency. This pollination disturbance may have a major effect on insect-pollinated tree fruit harvests like apples and cherries (Beauvieux et al., 2018). Temperature rises may accelerate blooming and fruiting, disrupting fruit farmers' harvest schedules. Higher temperatures increase fruit maturity, affecting flavor, texture, and nutrition (Davies, 2013). Temperature increases may reduce Apple fruit firmness and increase sugar content, affecting taste (Dalhaus et al., 2020). Warmer temperatures may help bugs grow, which can harm fruit plants. Disease distribution may also fluctuate with precipitation patterns, reducing fruit production and quality. It is challenging to use post-orchard mitigation strategies, to counteract the declines in fruit production caused by climate change, new approaches are required (Ritik et al., 2021).

2. Effects of Climate Change on Vegetable Crops

Climate change is causing problems for vegetable production. According to Nizamutdinov et al. (2022), crop growth is stressed, phenological phases change and planting and harvesting timetables change. Germination, blooming, and fruiting of vegetable crops are directly affected by temperature and precipitation patterns. Kaniewski et al. (2023) found that these alterations disturb coordinated growth cycles, which are necessary for vegetable output. Rising temperatures may accelerate phenological phases, causing blooming and fruiting mismatches (Colmenares, 2020). Climate change-induced temperature rises cause heat stress in vegetable crops, affecting growth and development. Extreme temperatures during blooming and fruit setting are especially harmful to vegetables. High temperatures may reduce production, fruit quality, and pest and disease susceptibility. A recent study suggests growing heat-tolerant vegetable cultivars to meet these issues (Raza et al., 2021). Due to their ability to resist greater temperatures, these types may produce more consistently in a

rising environment. Changes in precipitation make vegetable production harder. Intermittent rainfall patterns, protracted droughts, and strong rainfall events alter soil moisture and vegetable crop water availability (Fierros & López, 2021).

3. Effects of Climate Change on Landscape and Ornamentals Plants

Climate change is threatening the floriculture industry. Temperatures and climatic trends are disrupting floral bloom timing and length. Rising temperatures may extend blooming seasons for certain ornamental species (Johnson et al., 2022). These changes may affect flower availability during certain seasons, causing floriculture market supply-demand mismatches. Heat stress may affect floral quality, color, and scent. Changes in global climate have affected considerably open field and protected cultivations of ornamental plants (Gruda et al., 2019). According to Pástor et al. (2022), water availability and blooming plant health may also be affected by precipitation patterns. Climate change-related storms and high rains endanger the floriculture business and may harm flowers, causing petals to fall off, stems to break, and market value to drop. Corner (2011) identified the floriculture industry main challenges as soil erosion from temperature extremes and less rainfalls, plant growth and production, insect and disease abundance and severity, crop adaptability, ideal cultivation locations, and crop selection. Landscape design, plant choices, and outdoor area look are all affected by climate change. Temperature and precipitation patterns may make certain plants less resilient or invasive, making them unsuitable for landscaping. According to Chisholm et al. (2016), landscape designs should consider local climate and encourage biodiversity to adapt to changing climates. According to Beard et al. (2016), severe weather events like heatwaves and storms may damage landscape features. Extreme weather events are becoming more frequent, which might damage landscaping projects' aesthetic and practical features. Cameron et al. (2021) recommend using climate-resilient plant species and sustainable landscaping strategies like rainwater collecting and soil conservation to preserve outdoor designs. This adaptability is necessary for landscaped areas to flourish with climate change.

4. Effects of Climate Change on Post-harvest handling

Climate change has a major influence on post-harvest operations and landscaping, affecting the resilience and quality of horticultural products. Climate change affects storage, transportation, and product preservation after harvest. Climate warming accelerates fruit ripening, reducing shelf life and quality (Battisti & Naylor, 2009). The growing frequency of severe weather events like storms and heavy rainfall makes transportation problematic and may damage or destroy perishable horticultural goods (FAO, 2023). Climate change may favor post-harvest diseases, demanding modified storage and management measures (Challinor et al., 2014).

EMERGING TRENDS AND ADVANCEMENTS IN HORTICULTURE

The above studies demonstrate new and creative climate change solutions for the horticulture sector. These works provide new horticulture-specific approaches, technology, and insights into climate change adaptation. Sustainable adaptation is needed to mitigate climate change's impacts on horticulture sectore. Effective water management, resilient agricultural types, and better infrastructure are needed. To coordinate worldwide efforts to reduce greenhouse gas emissions, which cause climate change, international agreements like the Paris Agreement are essential. To maintain a safe and sustainable food supply, these concerns must be addressed as the world population expands. Each research addresses climate change in horticulture differently:

The latest study conducted by Zulfiqar et al (2022) reported that a carbon-rich material named BioChar, is commonly used to enrich the physical and chemical properties of the soil, offering resistance against biotic and abiotic stress for the horticultural crops like pumpkin, potato, tomato, Faba beans, cow peas and lettuce. Zhang et al (2023) described that breeding new climate-resilient cultivars could increase the horticultural yield. Smart breeding techniques based on micro-omics and Genome Wide Association Analysis (GWAS), and integrated genomic environment prediction (iGEP) aid horticulturists in coping with climate change to execute efficient selection and breeding of high-quality multi-resistant cultivars. Wang and Zhang (2010) recommend fully exploring Precision agriculture and novel technologies like artificial intelligence and robotics to increase resource efficiency and horticulture yield. Revolutionary adaption method that challenges conventional climate-smart practices in pomology by Hellin et al. (2023). Sarker et al. (2019) provide essential climate change assessment and adaptation methods. These new technologies use spatial modeling to help landscaping stakeholders make educated choices and create green areas that are both attractive and climate-resilient. Aich et al. (2022) recommend combining conventional breeding methods with genomic technologies to enhance heat

tolerance, insect and pest resistance, and climate adaptation. Strategies that help vegetable crops survive climate change and promote sustainability adapt by using agroecological techniques including cover cropping, crop rotation, and organic farming to improve soil health and resilience (Srinivasaroa, 2021). Orchardists may dynamically adjust to changing climates by optimizing water and fertilizer usage using sensor technology and data analytics (Saradha et al., 2016). Micro propagation has been used commercially to produce attractive plants, and vertical and digital farming and artificial intelligence have altered the floriculture sector (Wani et al., 2023). Sustainable techniques including INM, IPM, crop rotation, water efficiency, and energy-efficient are recommended (Jin et al., 2023). Growing horticulture products in a controlled environment to protect them from weather and temperature changes to maintain floral quality and reduce adverse weather effects (Chandel et al., 2022). To reduce the effect of severe weather patterns, Kisvarga et al (2023) recommend greenhouses and shelters.

Recent post-harvest management advances include smart technologies. Real-time temperature, humidity, and ethylene tracking require sensor-based monitoring systems and data analytics. Optimizing the cold chain is part of the post-harvest adaptation. Advanced refrigeration and transportation technology and effective cold storage facilities may avoid fast degradation of temperature-sensitive horticulture products (Khatiwada et al., 2022).

Indigenous and adaptive plant species are being used in landscaping. A recent study emphasizes creating green areas using local climate-adapted plants (De Jesus et al., 2022). This method lowers watering and upkeep and improves climate tolerance. Green infrastructure is becoming more popular in urban landscaping. The use of green roofs, permeable pavements, and rain gardens, help manage water runoff, regulate temperatures, and contribute to the overall resilience of urban landscapes. Van Deldan et al (2021) demonstrated that vertical farming practices can produce climate-resilient with no fertilizers and pesticides. Vertical farming practices could meet daily consumer demands for nutritious fresh products such as fruits and vegetables and herbs. Various global initiatives and platforms promote collaboration and sharing of knowledge to facilitate the adaptation of horticulture to climate change. The Consultative Group on International Agricultural Research (CGIAR) is devoted to enhancing agricultural methods, particularly in horticulture (CGIAR, 2022). The Global Horticulture Initiative (GlobalHort) promote collaboration among horticultural stakeholders and disseminate information about horticulture research and practices (GlobalHort, 2021).

CONCLUSION

As global temperatures continue to rise, precipitation patterns shift and extreme weather events become more frequent, the horticulture industry is facing unprecedented challenges. However, these challenges also offer opportunities for innovation and the adoption of resilient practices. The cultivation of climate-resilient cultivars, the implementation of precision orchard management, integration of advanced technologies and the optimization of cold chains in post-harvest processes, and the integration of climate-smart designs in landscaping exemplify proactive measures to mitigate adverse effects on crop yields, product quality, post-harvest losses handling, and the aesthetic appeal of outdoor spaces. Given the complex relationship between climate change and horticulture productivity, it is imperative to respond dynamically and collaboratively. Various stakeholders within the horticulture industry, including researchers, horticulturists, policymakers, and industry leaders, must work together to navigate this complex landscape. This collaboration involves the exchange of knowledge, the implementation of adaptive strategies, and the continuous refinement of practices based on scientific considerations, all of which are crucial in strengthening the resilience of the horticulture sector. Recent studies and adaptive approaches in the field of horticulture underscore the significance of integrating innovative technologies, breeding programs, and sustainable practices to address the challenges posed by climate change. Moreover, implementing international agreements like Paris Agreement, under the UNFCCC (United Nations Framework Convention on Climate Change) which is a worldwide climate change mitigation initiative. It helps nations to reduce greenhouse gas emissions and limit global warming to 2°C above pre-industrial levels.

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