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EDITORIAL

The Scorching Reality: Heat Waves and Crop Production

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Climate change stands as a significant and urgent concern in our present-day world, exerting an adverse impact on the delicate balance of Earth's ecosystems. While the planet has experienced natural fluctuations in climate throughout its history, the pace and scale of such changes have surged dramatically over the past century. This acceleration is primarily attributed to the consequences of human activities that have led to the release of unprecedented levels of greenhouse gases into the atmosphere. As a result, we are witnessing an alteration in the long-established climate patterns along with negative consequences that span from rising sea levels to escalated global temperatures leading to frequent and severe weather events at present.

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The escalation of global average temperatures (GATs) has created a pressing concern in the current scientific landscape. Over the last century, GATs have surged by 0.9°C, primarily attributable to the rise of greenhouse gas (GHG) emissions into the Earth's atmosphere. Projections forecast an even more dramatic increase, with estimates suggesting that the rise may reach 1.5°C by the year 2050, and potentially exceed this threshold given the ongoing rate of deforestation. Such alarming trends have been exhibited in the form of increasingly scorching hot days that not only intensify in frequency but also eclipse the historical record. According to the World Meteorological Organization, by the year 2022, the planet had already warmed by 1.15 ± 0.13°C compared to the pre-industrial era (1850-1900), setting the last eight years as the warmest ever recorded. July of 2023 further highlighted this concerning trajectory, as Earth consecutively broke or tied records for the hottest day ever documented, four days in succession. This unprecedented hike in GATs has resulted in increased occurrences of droughts, wildfires and notably heat waves worldwide.

According to Perkins and Alexander (2013), heat waves are defined and understood in varying ways across different research sectors. Particularly from a terrestrial perspective, a widely accepted definition of a heat wave warrants at least three consecutive days of hot weather during which the maximum temperature surpasses the 90th

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percentile for the specific location and time. This definition emphasizes the meteorological aspect of heat waves, disregarding their potential ecological implications (Perkins and Alexander, 2013). On the other hand, the WMO provides an alternative definition characterizing a heat wave as an incidence of intense hot weather that occurs for five or more consecutive days during which the daily maximum temperature surpasses the average maximum temperature by 5 °C (9 °F) or more. Both definitions underline the prolonged period of elevated temperatures that mark heat waves, but they diverge in terms of the exact criteria used to identify and quantify these extreme heat events.

Heat waves often arise when high-pressure systems become stagnant, causing winds on their rear side to consistently transport hot and humid air towards the northeastward (Marx et al., 2021). The polar jet stream plays a crucial role in shaping weather patterns across the middle latitude regions of North America, Europe, and Asia, making its behavior a critical factor in identifying and defining the frequency, intensity, and duration of heat waves in climate predictions. Hence, scientists have raised concerns about the potential impact of global warming on the weakening of the polar jet stream which could contribute to an elevated possibility of stationary weather patterns, ultimately leading to episodes of heavy rainfall or prolonged heat waves.

The adverse impacts of heat waves on crop production pose a multifaceted challenge to the agricultural sector. These detrimental effects can be particularly severe when heat waves occur frequently, intensify, or persist during sensitive stages of crop growth, development, and reproduction. Heat stress affects multiple stages of the life cycle of a crop, encompassing seed germination, vegetative growth, tiller production, dry matter allocation, maturation of reproductive organs, pollen tube growth, fertilization, grain filling, and grain quality (Hatfield et al., 2011; Kumar et al., 2023). Consequently, major grain crops like wheat, rice, and maize experience growth inhibition, reduced grain quality, and diminished yields. Further, extreme temperatures disrupt pollination, hinder fruit set, induce premature ripening, and reduce yields in fruit and vegetable crops. As a result, farmers, who are already burdened by the unpredictability of weather patterns, may face additional pressure as their crops become further weakened by excessive heat occurrences. Such issues have negative financial and social consequences for farming communities, jeopardizing livelihoods and worsening socio-economic disparities, eventually threatening global food security. As the world's population continues to grow, the inability to meet the increasing demand for food due to heat-induced crop failures and diminished yields may lead to potential threats such as hunger, malnutrition, and global social instability in the long run.

Furthermore, heat stress disrupts the essential roles of pollinators in crop production. Gérard et al. (2022) highlighted the notable impact of heatwaves on the global decline in bee populations and subsequent hindrance to crop pollination. Since approximately 35% of global crop production relies on bee pollination (Klein et al., 2007), the adverse effects of heat waves on the reduction in bee population may cause substantial reductions in crop yields posing a substantial threat to the sustainability of crop production and global food security.

Moreover, prolonged exposure of plants to elevated temperatures has profound implications for plants' natural defense mechanisms while making them vulnerable to insect pest infestations and disease outbreaks. This occurs when heat-induced stress disrupts complex physiological and biochemical processes within plants such as impairing plant’s capacity to produce essential defensive compounds and deactivating immune responses. Besides, insect pests such as aphids, whiteflies, and mites flourish in the conducive conditions created by heat waves with accelerated reproductive rates and intensified herbivorous activity resulting in rapid population growth and subsequently exacerbated crop damage (Deutsch et al., 2018). Furthermore, insect pests like the fall armyworm (Sing et al., 2022) and locusts that have emerged as significant agricultural threats generally thrive in high temperatures due to their poikilothermic nature (i.e.

increased levels of high temperature-dependent metabolism and feeding patterns). Similarly, plant pathogens find the hot weather conducive to their rapid growth and reproduction. Pathogens including fungi, bacteria, and viruses generally benefit from elevated temperatures making heat-stressed plants more vulnerable to disease incidences (Gautam et al., 2013). Therefore, high infection rates and increased symptom severity have been reported in crops like tomatoes, cucumbers, and leafy greens under high temperature levels concerning major diseases including powdery mildew, blight, and viral infections.

Adapting to the challenges caused by heat waves in agriculture requires an innovative, multifaceted, and holistic approach. The combination of heat waves and water scarcity aggravates the hardships faced by farmers, particularly through intensified drought conditions that reduce water availability for irrigation and crop growth. Given that, innovative farming practices such as precision agricultural techniques would be an ideal option to harness the power of technology in resolving the above-mentioned environmental challenges. Precision agriculture enhances crop yields and minimizes adverse environmental impacts on crop growth and development through real-time monitoring and precise adjustments of irrigation, fertilizer application, and pest and disease control options. This sort of synergy between technology and agriculture safeguards the resilience of farming systems and consequently, promotes sustainable resource management to combat evolving climatic challenges.

Hydroponics and vertical farming techniques that are characterized by climate-controlled settings and efficient resource-use systems also provide a robust solution to the unpredictable consequences of heat waves on crop production. Such systems ensure consistent and year-round crop produce along with promising solutions within the agricultural landscape. Further crop production under controlled environmental settings has also become a resilient alternative to problematic conventional soil-based crop production systems. Integration of advanced and automated water management practices inside the above-mentioned crop production settings, such as drip irrigation, further enhances resource use efficiency by conserving water and nutrients through precise applications. Additionally, the cultivation of heat and drought resistant crop varieties plays a vital role in sustaining crop resilience against the combined threat exerted by heat waves and water scarcity scenarios. Therefore, to effectively navigate the changing agricultural landscape, investment in research and development is crucial to develop heat and drought tolerant and pests and diseases resistance crop varieties. Further, early warning systems and surveillance networks can offer timely information to empower farmers in proactively managing their crops against heat waves and pest and disease outbreaks.

Diversification of farming systems through agroforestry and integrated crop-livestock approaches can also enhance plants' resilience to extreme climates. Agroforestry combines the inclusion of trees with crops is one such beneficial solution. Agroforestry systems provide shade and regulate microclimate while reducing the impact of extreme temperatures on the crops. Integrated systems that combine crops and livestock also bring synergies into the system through advantageous ecosystem services such as animal waste inclusion in enriching the soil naturally with necessary nutrition, beneficial microbiota, and conserved moisture.

The alteration in crop production patterns due to the consequences of the occurrences of heat waves also generates logistic challenges in planning and accommodating infrastructure for different agricultural practices including the planting calendars, the timing of irrigation schedules, allocating labourers, and coordinating harvesting and post-harvest operations. These shifting necessities need to be addressed through a good collaboration among farmers, agricultural advisors, and policymakers to generate the required guidance, support, and resources for overcoming the challenges. Therefore, the responsibility to address this crisis extends beyond the agricultural community. Governments need to play a pivotal role in shaping policies that support farmers and invest in climate-resilient agricultural solutions. International collaborations are also crucial for sharing knowledge, resources, and best practices across borders, given the global nature of this environmental challenge. With all that, government support is paramount particularly when partnering with the policymakers. Specifically, solutions for water scarcity issues should be prioritized to incentivize efficient water use tactics, promote water-saving technologies, and facilitate investments in water infrastructure. Therefore, it is a must to strengthen the collaborations between governments, farmers, and water resource management authorities to ensure sustainable water allocations and equitable access to everyone.

The urgency to address the impact of heat waves on crop production cannot be underestimated. The consequences of inaction can be far-reaching, causing adverse impacts on farmers and also on global food security and the overall well-being of humankind. By acknowledging the severity of this issue and implementing proactive solutions, we will be able to safeguard food security, the livelihoods of farmers, and a sustainable future for generations to come. The time to act is now.

REFERENCES

Deutsch, C. A., Tewksbury, J. J., Tigchelaar, M., Battisti, D. S., Merrill, S. C., Huey, R. B., & Naylor, R. L. (2018). Increase in crop losses to insect pests in a warming climate. Science, 361(6405), 916-919.

Gautam, H. R., Bhardwaj, M. L., & Kumar, R. (2013). Climate change and its impact on plant diseases. Current science, 1685-1691.

Gérard, M., Amiri, A., Cariou, B., & Baird, E. (2022). Short‐term exposure to heatwave‐like temperatures affects learning and memory in bumblebees. Global Change Biology, 28(14), 4251-4259.

Hatfield, J. L., Boote, K. J., Kimball, B. A., Ziska, L. H., Izaurralde, R. C., Ort, D., ... & Wolfe, D. (2011). Climate impacts on agriculture: implications for crop production. Agronomy journal, 103(2), 351-370.

Klein, A. M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. Proceedings of the royal society B: biological sciences, 274(1608), 303-313.

Kumar, S., Bhushan, B., Wakchaure, G. C., Dutta, R., Jat, B. S., Meena, K. K., ... & Pathak, H. (2023). Unveiling the Impact of Heat Stress on Seed Biochemical Composition of Major Cereal Crops: Implications for Crop Resilience and Nutritional Value. Plant Stress, 100183.

Marx, W., Haunschild, R., & Bornmann, L. (2021). Heat waves: a hot topic in climate change research. Theoretical and applied climatology, 146(1-2), 781-800.

Perkins, S. E., & Alexander, L. V. (2013). On the measurement of heat waves. Journal of climate, 26(13), 4500-4517.

Singh, G. M., Xu, J., Schaefer, D., Day, R., Wang, Z., & Zhang, F. (2022). Maize diversity for fall armyworm resistance in a warming world. Crop Science, 62(1), 1-19.