E-ISSN: 2582-9467
Popular Article
Kaushik et al. (2024)

Impact of Climate Change on Vegetables' Production

Parul Kaushik[1]*, Pooja Kaushik[2] and Karmnath Kumar[3]

[1,2]*PG Scholar, Department of Horticulture, SGT University, Gurugram, Haryana-122505, India.*
[3]*PG Scholar, Department of Agronomy, SGT University, Gurugram, Haryana-122505, India.*

Corresponding Author
Parul Kaushik
Email: parulsureshkaushik@gmail.com

OPEN ACCESS

Keywords

Impact, Climate, Vegetables' Production

How to cite this article:

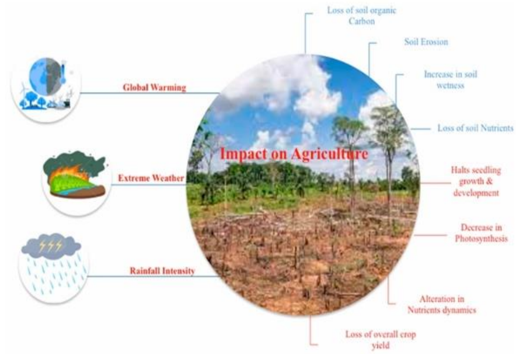
Kaushik, P., Kaushik, P. and Kumar, K., 2024. Impact of Climate Change on Vegetables' Production. *Vigyan Varta* 5(11): 38-45.

ABSTRACT

Globally, climate change has a major impact on vegetable production. Many vegetable crops have growth cycle disruptions due to rising temperatures, changing precipitation patterns, and an increase in the frequency of extreme weather events, including storms, floods, and droughts. Elevated temperatures can potentially diminish the output of heat-sensitive plants such as broccoli, spinach, and lettuce. Drought strains plants, lowering growth and quality, while too much water can lead to root infections. Changes in growing seasons and the availability of water resources force farmers to adjust by altering crop varieties or planting times. Vegetables are susceptible to fluctuations in temperature and water availability, which affects their nutritional content. Prolonged exposure to harsh circumstances can deplete nutrient content, lowering food quality. Overall, climate change's influence on vegetables is causing increased concern about global food security, farmer livelihoods, and consumer nutrition. Sustainable methods are critical for mitigating these difficulties.

INTRODUCTION

Climate change refers to the average change in climatic factors including temperature, rainfall, relative humidity, and gas composition throughout time in a certain geographical area (Raza *et al.*, 2019). Climate vulnerability factors (exposure, sensitivity, and adaptive capacity) also affect the vegetable production and agricultural livelihoods of farmers in differing agroecological systems (Sanfo *et al*., 2022). It has been a significant global concern in recent decades. Extreme weather events, changing precipitation patterns, and rising temperatures challenge traditional farming operations. This highlights the need for a shift towards sustainable vegetable cultivation practices. Sustainable vegetable production, which prioritizes eco-friendliness, resource efficiency, and resilience, can help mitigate the impact of climate change. Sustainable vegetable production, based on ecological principles, prioritizes environmental health, economic viability, and social well-being. This method prioritizes organic and natural inputs, minimizes synthetic chemicals, and uses conservation strategies to conserve soil fertility. However, since vegetables are typically vulnerable to climate extremes, high temperatures and low soil moisture are the main reasons for low yields since they have a significant impact on physiological and biochemical processes. Adjusting farming practices to changing weather patterns is a crucial component of sustainable vegetable production. Farmers must develop robust vegetable types that can flourish in a variety of conditions due to variations in temperature and precipitation patterns. Hydroponics and controlled environment agriculture are two more precision farming methods that minimize the ecological impact of vegetable farming while maximizing resource use (Babu *et al*., 2024). Climate change has led to more frequent droughts, floods, high and low temperatures, salinity, and changes in atmospheric CO2 and ozone levels, affecting vegetable crop yield and quality (Bulgari *et al*., 2019; Raza, 2022). Plant growth and agricultural productivity are greatly impacted by climate change, particularly the growing season, growth rate, and growth distribution. The growth season for plants can be extended by climate change, and the areas that can be planted with crops can increase (Zhang, 2023). Additionally, the temperature, microbial activity, nutrient cycling, and quality of the soil will also be affected by climate change, which will have an impact on plant development. (Jansson *et al*., 2020) Even though climate change is a gradual process that takes a long time and involves only modest variations in temperature and precipitation, it nonetheless has an impact on several soil processes, especially those that are connected to soil fertility. It is anticipated that changes in soil moisture conditions and subsequent rises in soil temperature and CO2 levels will be the primary ways in which climate change will affect soils (Qui *et al*., 2023). Vegetable crops, including tomatoes, potatoes, onions, and cabbage, contribute to the local economy and food security. Understanding their vulnerability to climate change is vital for developing measures to protect and adapt against future environmental difficulties (Scheelbeek *et al*., 2020). The agricultural sector has seen a rise in the frequency of extreme events that cause flood and drought disasters due to variations in global rainfall, average temperature, and carbon dioxide levels. These variations pose a serious threat to global crops and cereal productivity (Hussain *et al.*, 2019; Duchenne-Moutien *et al*., 2021). Crop growth and maturity are directly impacted by variations in temperature and precipitation, which exposes the crops to a range of biotic and abiotic challenges (Chaudhary and Sidhu *et al.*, 2022). Modern agriculture requires techniques that address soil health, crop yields, and climate change-related environmental challenges. There are various ways to improve soil fertility and plant growth, including standard soil additions and new solutions. Innovative farming practices can improve soil fertility and agricultural production while also mitigating the effects of climate change on agriculture and the environment (BIBI and Rahman., 2024).



(Fig.1): The effects of climate-related adverse conditions on agriculture, soil, and crops.

Effect of temperature

The temperature of the earth has been rising steadily since the turn of the century. The temperature has increased by 1.1 °C between 1850 and 1900. Global temperatures are predicted to rise by more than 1.5°C on average throughout the next 20 years (IPCC 2022). Temperatures above 35 °C in carrots cause a reduction in cell-enhanced relative cell damage and membrane stability (Nijabat *et al.*, 2020). Furthermore, spinach and lettuce start flowering when exposed to high temperatures for extended periods, which lowers the quality of the veggies. When a plant experiences extreme heat stress, its enzymatic processes are interfered with, which causes an oxidative burst and a compromised metabolism that eventually results in senescence (Raza, 2022). Cold stress disrupts the integrity of intracellular organelles, causing loss of compartmentalization. It reduces and impairs photosynthesis, protein assembly, and metabolic activities (Atayee and Noori *et al.*, 2020). It alters the ultrastructure of chloroplasts, affecting light-harvesting chlorophyll antenna complexes and thylakoid structures. This reduces photosynthesis and osmotic adjustments in potato plants (Wu and Yang *et al.*, 2019) Minimum appropriate temperature (°C) for veggies and signs of cold stress injury.

Vegetables	Lowest safe temperature (°C)	Cold stress injury symptoms
Potato	7.0	sweetening, Mahogany browning,
Okra	7.0	Water-soaked areas, pitting, decay, Discoloration
Cucumber	7.0	Pitting, water-soaked lesions, decay
Eggplant	7.0	Surface scald, Alternaria rot, seed blackening
Asparagus	7.0	Dull, grey-green, limp tips
Pumpkin	10.0	Decay, especially Alternaria rot

from Laxman RH, 2024

Effect of water stress

Vegetable crops require consistent irrigation, but lack of precipitation, increased evapotranspiration from global warming, and depleted groundwater have led to water scarcity, negatively impacting crop productivity and quality (Seleiman *et al.*, 2021). Water stress can significantly impact vegetable output and quality due to their high-water content (90%). Drought stress occurs when soil moisture levels are low or precipitation is below normal for an extended period (Chaudhary *et al.*, 2022). Waterlogging occurs when soil moisture levels exceed optimal requirements. Water-logging fills soil pores, resulting in hypoxia (low oxygen concentrations) or anoxia (total lack of oxygen) (Fukao *et al.*, 2019).

Effect of salinity stress

Salt stress can be a serious issue for sustainable agriculture practices since it poses a significant risk to the agriculture industry in arid and semi-arid regions of the world (Hopmans *et al.*, 2021 Khondoker *et al.*, 2023). Climate change, including temperature changes and water loss, raises salt levels, affecting agricultural growth and productivity (Arnell *et al.*, 2021; Zandalinas *et al.*, 2023). Salt stress is a complicated phenomenon that causes physical, physiological, and ionic abnormalities in plants (Seleiman *et al.*, 2022). Furthermore, over 10% of the total land area is salt-stressed, making it difficult for crops to develop and thrive (Behera *et al.*, 2022). According to (Giordano *et al.*, 2021), salinity disrupts the exchange of water and nutrients between roots and soil, thus impacting photosynthesis. Drought and low rainfall cause salts to accumulate in soils due to capillary rise and salt migration from the groundwater table to the surface (Corwin, 2021).

Effect of CO2

Elevated CO2 increased eggplant and tomato yield by 24% and 31%, respectively. Disorders in leaf and branch growth occurred, resulting in a decrease in active leaf surface area. Two onion cultivars had faster rates of photosynthesis and leaf area expansion during the pre-bulbing stage, increasing bulb production by 28.9-51.0 percent. However, the time of bulb maturity was also extended because of the increased CO2 concentration. Elevated CO2 (550 ppm) influenced growth and development in tomato variety. Arka Ashish, resulting in a 24.4% increase in production. Plant height, the number of secondary branches, and leaf area were the growth parameters that increased at higher levels compared to ambient values during the fruiting stage. As CO2 levels increased, there was also the formation of dry matter in the fruits, leaves, and stems. At higher CO2, photosynthesis increased, but stomatal conductance and transpiration decreased. Fruit production increased compared to the chamber control because there were more fruits per plant under higher CO2 (Babu *et al*., 2024).

Effect of ozone

Increased O3 levels in the troposphere reduce plant growth and vegetable productivity in India's fertile agricultural regions (Mukherjee *et al*., 2020). Impact of O3's on plant can cause reactive damage and accelerate leaf senescence, leading to reduced crop yield (Yadav *et al.*, 2019; Sicard et al. 2020). (Suganthy and Udayasoorian 2020) found that exposing potatoes (*Solanum tuberosum* L.) to greater levels of surface oxygen during tuber initiation at a high altitude of Western Ghat reduces yield from 4.56 to 25.5%. Excessive O3 levels in soybeans reduce seed protein, which is associated with a negative response to nitrogen fixation (Broberg *et al.*, 2020).

Effect of climatic change on biotic factors

As temperatures rise, pests like moths and butterflies will relocate to new places. As temperatures rise, pests such as the American leaf miner (*Liriomyza*) may expand northward. Non-indigenous pests may establish themselves in protected crops due to increased importation of plant material. Pests will gradually grow in field crops as climate changes. *Bactrocera zonata*, a fruit fly, is primarily found in northern India. Until the late 1990s, this fruit fly was overwintered in northern India. In recent years, adults have been caught during winter in Uttar Pradesh, likely because of rising soil temperatures caused by climate change. Climate change is expected to increase sucking pests in vegetables, including thrips, mites, and leafhoppers. The number of leafhoppers in okra will grow. The diamondback can increase up to 28-35 OC but decreases as temperatures rise (Nitta *et al*., 2024)

Vigyan Varta an International E-Magazine for Science Enthusiasts
Vol. 5, Issue 11
E-ISSN: 2582-9467
Popular Article
Kaushik et al. (2024)

Climate barriers are no longer effective, accelerating the movement of vectors, pests, and disease toward the north. This leads to more severe outbreaks of plant-disease vectors such as aphids, whiteflies, and thrips, extending disease transmission throughout the growth season and introducing new species. As more vectors survive from one vegetative phase to the next, disease spread faster. Citrus greening is transmitted by the *psyllid Dysphoria citri* (Nitta *et al.*, 2024).

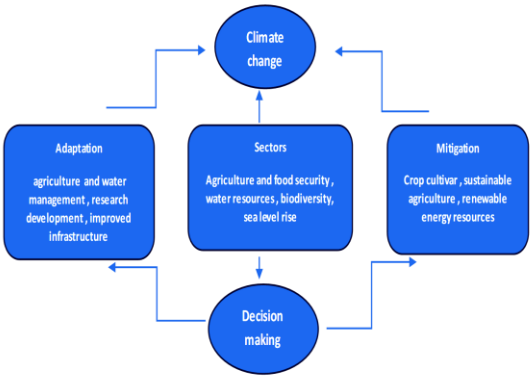
List of vegetable cultivars that can withstand abiotic stresses

Crop	Abiotic stress	Variety
Potato	Heat	Kufri Surya
Tomato	Heat	Thar Anant, Pusa Sadabahar
Onion	Excessive soil moisture	Arka Kalyan
Radish	High temperature	Pusa Chetki
Cucumber	High temperature	Pusa Barkha
Chili	Drought	G4, Arka Lohit and LCA334
Okra	Salinity	Pusa Sawani
Egg plant	Salinity	Pragati and Pusa Bindu
Cowpea	Water limiting condition	Arka Garima, Arka Suman

Adopted from RH Laxman 2024

Management Strategies under a Changing Climate Scenario

To counteract the negative effects of climate change on agricultural sustainability, several adaptation and mitigation techniques have been developed. Weather-smart activities (stress-tolerant varieties, ICT-based agrometeorological services), carbon-smart activities (zero tillage, legumes, crop residue management), and knowledge-smart activities (agricultural extensions to enhance capacity-building) are among these technologies. Water-smart practices (laser land leveling, rainwater harvesting, micro-irrigation, crop diversification, raised-bed planting, and direct-seeded rice) are among them. By limiting the negative consequences, these technologies improve crop adaptation to the changing climate. They also considerably lessen the effects of climate change on crops. Large-scale economic losses are expected in climate change, but some initiatives can help to offset those losses. Yet these actions need to be planned (Malhi *et al.*, 2024). (Rawat *et al.*, 2024) depict a list of recent studies on the sectoral consequences of climate change with global adaptation and mitigation strategies.



CONCLUSION

In conclusion, extreme weather events such as heat waves, cold snaps, droughts, flooding, salt stress, and variations in atmospheric CO_2 or ozone levels have become more frequent in climate change. Vegetable crops' productivity and quality are decreased when they are subjected to certain kinds of abiotic stressors. Abiotic stressors have several important physiological and biochemical impacts, including membrane damage, oxidative burst, decreased chlorophyll concentration, and slowed photosynthesis. Thus, both adaptation and mitigation techniques are required to maintain the yield of vegetable crops in changing climatic circumstances. Adopting climate-smart production techniques, climate-resilient cultivars, PGPR use, appropriate cultural practices, varied cropping systems, and mulching are necessary. Given that implementing crop management strategies is expensive, an economical mix of adaptation

REFERENCES

Arnell NW, Lowe JA, Challinor AJ, Osborn TJ. Global and regional impacts of climate change at different levels of global temperature increase. Clim Chang. 2019; 155:377–91.

Atayee AR, Noori MS (2020) Alleviation of cold stress in vegetable crops. Journal of Scientific Agriculture 4: 38-44.

Babu, R. R., Baishya, L. K., Reddy, A., Pongener, A., HR, R., & Naik N, O. (2024). Climate Change Effects on Sustainable Vegetable Production in India: A Review. International Journal of Environment and Climate Change, 14(3), 804-814.

Behera TK, Krishna R, Ansari WA, Aamir M, Kumar P, Kashyap SP, Kol C. Approaches involved in the vegetable crops salt stress tolerance improvement: Present status and way ahead. Front Plant Sci. 2022; 12:787292.

Bibi, F., & Rahman, A. (2023). An overview of climate change impacts on agriculture and their mitigation strategies. Agriculture, 13(8), 1508.

Broberg MC, Daun S, Pleijel H (2020) Ozone-induced loss of seed protein accumulation is larger in soybean than in wheat and rice. J Agron 10(3): 357.

Bulgari R, Franzoni G, Ferrante A (2019) Biostimulants application in horticultural crops under abiotic stress conditions. J Agron 9(6): 306.

Chaudhry, S.; Sidhu, G.P.S. Climate change regulated abiotic stress mechanisms in plants: A comprehensive review. Plant Cell Rep. 2022, 41, 1–31.

Chaudhary, S., Devi P, Hanumantha Rao B, Jha UC, Sharma KD, Prasad PV, Kumar S, Siddique KH, Nayyar H (2022) Physiological and molecular approaches for developing thermotolerance in vegetable crops: a growth, yield, and sustenance perspective. Front Plant Sci 13: 1892.

Corwin, D.L. Climate Change Impacts on Soil Salinity in Agricultural Areas. Eur. J. Soil Sci. 2021, 72, 842–862.

Duchenne-Moutien, R.A.; Neetoo, H. Climate Change and Emerging Food Safety Issues: A Review. J. Food Prot. 2021, 84, 1884–1897.

Fukao T, Barrera-Figueroa BE, Juntawong P, Peña-Castro JM (2019) Submergence and waterlogging stress in plants: a review highlighting research opportunities and understudied aspects. Front Plant Sci 10: 340.

Giordano M, Petropoulos SA, Rouphael Y. Response and defense mechanisms of vegetable crops against drought, heat and salinity stress. Agriculture. 2021;11(5):463.

Hopmans JW, Qureshi AS, Kisekka I, Munns R, Grattan SR, Rengasamy P, Taleisnik E. Critical knowledge gaps and research priorities in global soil salinity. Advan agro. 2021;169:1–191.

Hussain, M.; Butt, A.R.; Uzma, F.; Ahmed, R.; Irshad, S.; Rehman, A.; Yousaf, B. A comprehensive review of climate change impacts, adaptation, and mitigation of environmental and natural calamities in Pakistan. Environ. Monit. Assess. 2019, 192, 48.

IPCC, (2022) Summary for Policymakers [H.-O. Pörtner, D.C. Roberts, E.S. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem (eds.)]. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3–33, doi:10.1017/9781009325844.001.

Jansson, J.K.; Hofmockel, K.S. Soil microbiomes, and climate change. Nat. Rev. Microbiol. 2020, 18, 35–46.

Khondoker M, Mandal S, Gurav R, Hwang S. Freshwater shortage, salinity increase, and global food production: a need for sustainable Irrigation Water Desalination—A. Scoping Rev Earth. 2023;4(2):223–40.

Laxman, R. H., Kumar, R., Ramesh, K. V., Saini, D. R., Sreekanth, D., Verma, R. K., & Behera, T. K. (2024). Impact of Climate Change on Vegetable Production and Management Strategies. Vegetable Science, 51, 11-21.

Malhi, G. S., Kaur, M., & Kaushik, P. (2021). Impact of climate change on agriculture and its mitigation strategies: A review. Sustainability, 13(3), 1318.

Mukherjee A, Yadav DS, Agrawal SB, Agrawal M (2021) Ozone a persistent challenge to food security in India: current status and policy implications. Curr Opin Environ Sci Health 19: 100220.

Nijabat A, Bolton A, Mahmood-Ur-Rehman M, Shah AI, Hussain R, Naveed NH, Ali A, Simon P (2020) Cell membrane stability and relative cell injury in response to heat stress during early and late seedling stages of diverse carrot (Daucus carota L) germplasm. Hort Science. 55: 1446–1452.

Nitta, A., Natarajan, V., Reddy, A. J., & Rakesh, T. (2024). Impact of Climate Change on Pest Biology, Behaviour and Their Distributions. International Journal of Environment and Climate Change, 14(4), 46-56.

Qiu, J., Shen, Z., & Xie, H. (2023). Drought impacts on hydrology and water quality under climate change. Science of The Total Environment, 858, 159854.

Rawat, A., Kumar, D., & Khati, B. S. (2024). A review on climate change impacts, models, and its consequences on different sectors: a systematic approach. Journal of Water and Climate Change, 15(1), 104-126.

Raza A, Razzaq A, Mehmood SS, Zou X, Zhang X, Lv Y, Xu J (2019) Impact of climate change on crops adaptation and strategies to tackle its outcome: A review. Plants 8(2): 34.

E-ISSN: 2582-9467
Popular Article
Kaushik et al. (2024)

Raza A (2022) Metabolomics: a systems biology approach for enhancing heat stress tolerance in plants. Plant Cell Rep 41:741–763.

Sanfo, S., Slack, S., Saley, I. A., Daku, E. K., Worou, N. O., Savadogo, A., ... & Ogunjobi, K. O. (2022). Effects of customized climate services on land and labor productivity in Burkina Faso and Ghana. Climate Services, 25, 100280.

Scheelbeek, P.F.D.; Moss, C.; Kastner, T.; Alae-Carew, C.; Jarmul, S.; Green, R.; Taylor, A.; Haines, A.; Dangour, A.D. United Kingdom's Fruit and Vegetable Supply Is Increasingly Dependent on Imports from Climate-Vulnerable Producing Countries. Nat. Food 2020, 1, 705–712.

Suleiman MF, Al-Suhaibani N, Ali N, Akmal M, Alotaibi M, Refay Y, Dindaroglu T, Abdul-Wajid HH, Battaglia ML (2021) Drought stress impacts on plants and different approaches to alleviate its adverse effects. Plants 10(2): 259.

Suleiman MF, Aslam MT, Alhammad BA, Hassan MU, Maqbool R, Chattha MU, Battaglia M. Salinity stress in wheat: effects, mechanisms and management strategies. Phyton 2022;91(4).

Sicard P, De Marco A, Carrari E, Dalstein-Richier L, Hoshika Y, Badea O, Peter D, Fares S, Conte A, Popa I, Paoletti E (2020) Epidemiological derivation of flux-based critical levels for visible ozone injury in European forests. J For Res 31:1509 1519.

Suganthy VS, Udayasoorian C (2020) Ambient and elevated ozone (O3) impacts on potato genotypes (Solanum Tuberosum. L) over a high-altitude Western Ghats location in Southern India. Plant Arch 20(2):1367-1373.

Wu YS, Yang CY (2019) Ethylene-mediated signaling confers thermotolerance and regulates transcript levels of heat shock factors in rice seedlings under heat stress. Bot Stud 60(1):1-2

Yadav DS, Rai R, Mishra AK, Chaudhary N, Mukherjee A, Agrawal SB, Agrawal M (2019) ROS production and its detoxification in early and late sown cultivars of wheat under future O3 concentration. Sci Total Environ 659: 200-210.

Zandalinas SI, Fritschi FB, Mittler R. Global warming, climate change, and environmental pollution: recipe for a multifactorial stress combination disaster. Trend Plant Sci. 2021;26(6):588–99

Zhang, H. Impacts of climate change on ecosystem and agricultural production. Agric. Disaster Res. 2023, 13, 201–203.