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Problems and Prospects of Crops with Changing Temperature

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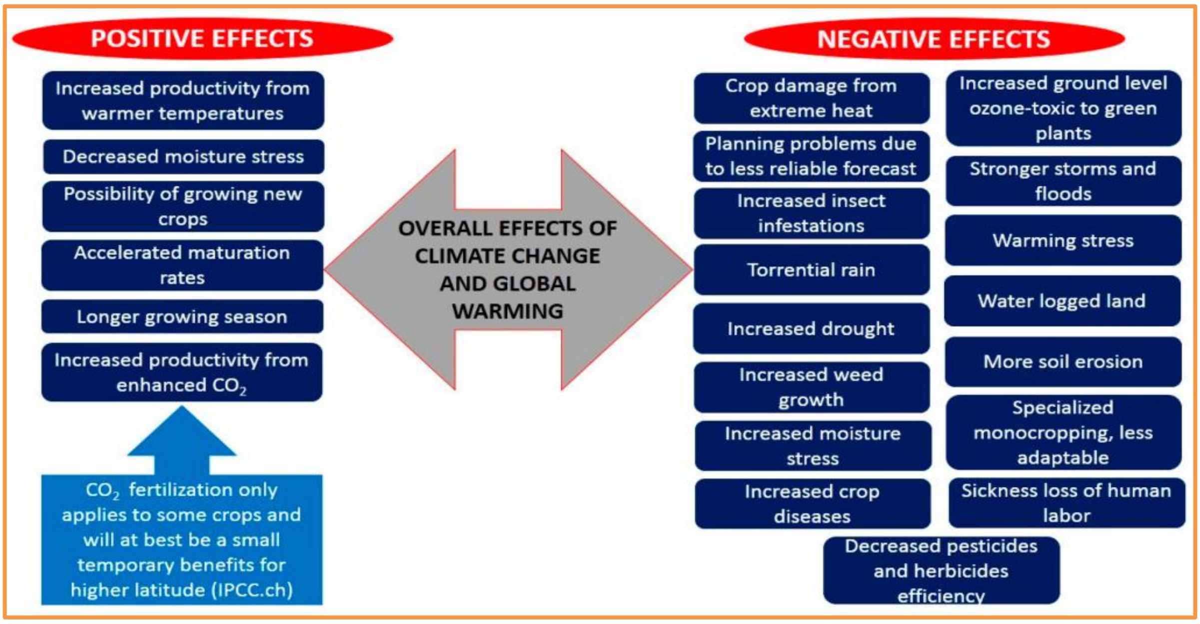
Agriculture, climate change, food security and poverty reduction are inextricably linked. As the world population grows to a projected 9 billion by 2050, agricultural production must also increase by an estimated 70 percent according to FAO, 2022. Climate volatility, more frequent extreme weather events and temperature changes increasingly threaten the viability of agriculture and forestry sectors and rural infrastructure throughout the world. The sector holds a large mitigation potential, mainly through reduced deforestation, soil management and increased productivity. Agriculture is therefore part of the problem and part of the solution to climate change.

Keywords: Agriculture, Climate change, Development, Growth and Physiology

Temperature is a critical environmental factor that significantly regulates the growth, development and yield performance of crop plants. Ongoing climatic changes, especially the gradual increase in global atmospheric temperature, are exerting substantial impacts on agricultural production systems worldwide. Elevated temperatures influence several physiological and metabolic activities including photosynthesis, respiration, transpiration, flowering and seed development, which ultimately affect crop productivity and produce quality (Zhao, 2017). Moreover, the occurrence of extreme climatic events such as heat waves, prolonged droughts and erratic rainfall patterns further aggravates crop stress and poses a serious threat to global food security (Wheeler and Von, 2013).

The response of crop plants to temperature variation differs according to species, genetic constitution, developmental stage and ecological adaptability. Increased temperature often hastens crop phenological processes, shortens the crop growth duration and reduces the grain filling period, thereby resulting in yield reduction (Ray *et al.*, 2015). Reproductive phases like flowering and pollination are particularly vulnerable to heat stress, leading to pollen sterility, poor fertilization and decreased harvest index. Additionally, higher temperatures may favor the proliferation of pests and diseases, disturb nutrient dynamics and increase crop water requirements, creating major constraints for sustainable agricultural production in diverse agro-climatic regions.

Although rising temperatures present numerous challenges, they also open new avenues for agricultural advancement and adaptation. Progress in plant breeding, biotechnology and climate-smart farming approaches has created opportunities for developing heat-resilient and stress-tolerant crop varieties. Adaptive management practices such as efficient irrigation methods, conservation agriculture, modification of sowing time and precision agriculture can reduce the harmful effects of temperature stress while improving resource-use efficiency. .



Crop Susceptibility to Climate Change

Crop susceptibility to climate change refers to the sensitivity of crop plants to variations in climatic factors such as temperature, rainfall, atmospheric carbon dioxide concentration and extreme weather events. Climate change significantly affects crop growth, development and productivity by altering physiological, biochemical and reproductive processes. The main effected parameters due to climate change are

1) **Abiotic effects:** Crop development and yield impacted by

a. **Temperature changes:** Temperature strongly affects crop growth and yield. High temperatures shorten crop duration, reduce grain filling and negatively affect flowering and pollination, leading to lower yields. Heat stress also disturbs photosynthesis and other metabolic activities, reducing crop productivity and quality.

b. **Precipitation changes:** Changes in rainfall patterns such as droughts, irregular rainfall and floods greatly influence crop production. Low rainfall reduces soil moisture and nutrient uptake, while excess rainfall causes waterlogging and disease incidence. These variations affect crop growth, establishment and final yield.

2) **Biotic effects:** impacts agricultural productivity:

a. **Pest pressures:** Climate change can increase the incidence and spread of insect pests, diseases and weeds. Higher temperatures and humidity favor rapid pest multiplication and survival. Increased pest pressure causes severe damage to crops and reduces yield and quality.

b. **Availability of pollination services:** Climate change affects the activity and population of pollinators such as bees and butterflies. Temperature and rainfall variations may disrupt flowering and pollinator interactions. Reduced pollination decreases fruit set, seed formation and overall crop productivity (Lobell and Gourdji, 2012).

3) **Climate Change effects on Production:** Climate change exerts wide-ranging effects on agricultural production that extend beyond individual agro-ecosystems. Agriculture is a highly complex and climate-dependent system influenced by factors such as temperature, precipitation, solar radiation and atmospheric gas composition. Variations in these climatic parameters directly affect crop growth, productivity and resource-use efficiency.

4) **Climate Change effects on Soil Resources:** Soils play a vital role in providing essential ecosystem services that support agricultural sustainability and environmental health. They facilitate nutrient cycling and supply nutrients necessary for food and fiber production. Soils also help in flood mitigation by enhancing water infiltration, filtration and storage

capacity (Pathak *et al*., 2012). In addition, they provide structural support for plant growth and act as major reservoirs for carbon sequestration by storing atmospheric CO_2 and other greenhouse gases in surface and organic layers.

5) **Changing Production and Effects on Erosion:** Changes in temperature and precipitation are altering cropping patterns, sowing dates, harvesting time, tillage practices and overall crop management. Most studies indicate that climate change may increase soil erosion and reduce soil fertility. However, improved conservation and management practices may help reduce erosion risks and improve ecosystem resilience under changing climatic conditions (Lesk *et al*., 2016).

In and win…

Climate change is a significant factor that affects crop agriculture, and it poses both challenges and opportunities for crop growth and development. Here are **some of the problems and prospects of crops with changing temperature:**

➢ **Problems:**

1. **Heat stress:** Rising temperatures can lead to heat stress in crops, affecting their physiological processes and reducing yields. Heat stress can cause damage to plant tissues, lower photosynthesis rates, and reduce the availability of water to plants.
2. **Water scarcity:** Climate change can alter precipitation patterns, leading to increased drought conditions in some regions. Reduced water availability can negatively impact crop growth and development, making it challenging for plants to complete their life cycles.
3. **Increased pest and disease pressure:** Changes in temperature can influence the distribution and prevalence of pests and diseases, leading to new challenges for crop management. Some pests and diseases may expand their ranges to previously unaffected areas, causing crop damage and yield losses.
4. **Altered growing seasons:** Shifts in temperature patterns can disrupt the timing of planting and harvesting, leading to mismatches between crop growth stages and optimal environmental conditions. This can affect crop quality and yield.
5. **Reduced crop diversity**: Certain crops may become less suitable for specific regions due to changing temperature and weather conditions. This can lead to a loss of crop diversity and increase the vulnerability of agricultural systems to environmental shocks.

• **Prospects:**

1. **Adaptation and breeding:** Crop breeding programs can be directed towards developing varieties that are more tolerant of heat stress and other climate-related challenges. Heat-tolerant and drought-resistant varieties can help farmers cope with changing temperature conditions.
2. **Precision agriculture:** Advances in technology and data analytics can enable farmers to make more informed decisions about planting, irrigation, and crop management. Precision agriculture techniques can optimize resource use and improve crop resilience.
3. **Expansion of suitable growing areas:** While some regions may become less suitable for traditional crops, changing temperature patterns may open up new areas where certain crops can be grown successfully. This can diversify agricultural production and improve food security (Porter *et al*., 2014).
4. **Crop rotation and diversification:** Farmers can adopt crop rotation and diversification strategies to mitigate the impacts of changing temperature on crops. Diversifying crops can spread risks and reduce the dependence on a single crop.
5. **Improved water management:** Developing efficient water management practices, such as rainwater harvesting, drip irrigation, and water-saving technologies, can help address water scarcity issues and ensure sustainable crop production.

Agriculture vulnerable to temperature increases and rainfall changes

Agriculture is highly vulnerable to increases in temperature and changes in rainfall patterns caused by climate change. Variations in temperature affect crop growth, flowering, grain filling and overall productivity, while irregular rainfall influences soil moisture availability, irrigation demand and crop establishment. Frequent droughts, floods and extreme weather events further increase the risk of crop failure and yield reduction.

- A 2^0C rise in temperature decreases Indian wheat yield (Asseng *et al*., 2019)

- Up to 6% in sub tropical areas
- 17-18% in tropical areas

- For rice a 2^0C rise projected to reduce yields by 10-16% and a 4°C rise led to a 21-30% reduction (Jagadish *et al,* 2011).
- Sensitivity to monsoon

- 19% rainfall deficit in 2002 reduced Indian GDP by 3%

Strategies to Overcome Effect of Temperature Fluctuations on Agriculture

To overcome the effects of temperature fluctuations on agriculture and ensure stable crop production, farmers and agricultural practitioners can adopt various strategies (Raza *et al.*, 2019). Here are some effective strategies to mitigate the impact of temperature variations:

1. **Crop selection:** Choose crop varieties that are well-adapted to the local climate and temperature conditions. Opt for heat-tolerant or cold-tolerant cultivars based on the prevailing temperature range in the region.
2. **Crop rotation and diversification:** Practice crop rotation and diversification to spread the risk associated with temperature fluctuations. Growing a mix of different crops can help mitigate losses if one crop is negatively affected by extreme temperatures.
3. **Irrigation management:** Implement efficient irrigation systems to provide a steady water supply to crops during periods of high temperature. Drip irrigation and other water-saving techniques can help conserve water and reduce the impact of drought stress caused by heatwaves.
4. **Mulching:** Apply organic mulches (e.g., straw, leaves, or compost) around the base of plants to conserve soil moisture and regulate soil temperature. Mulching can buffer the plants from extreme temperature variations and reduce water evaporation from the soil surface.
5. **Shade structures and windbreaks:** Install shade structures or windbreaks to protect crops from excessive heat or cold. Windbreaks can help reduce the impact of chilling winds, while shade structures can provide relief from intense sunlight and high temperatures.
6. **Greenhouses and tunnels:** Utilize greenhouses or high tunnels to create a controlled environment for crops. These structures offer protection from extreme temperatures and allow for year-round cultivation of temperature-sensitive crops.
7. **Adjust planting times**: Time the planting of crops to avoid periods of extreme temperatures. Planting earlier or later in the season, depending on the crop's temperature requirements, can help reduce the risk of exposure to adverse conditions.
8. **Use of shade cloths and row covers:** Employ shade cloths or row covers during hot periods to shield crops from excessive heat and direct sunlight. These materials can help regulate temperature and protect plants from temperature stress.
9. **Fertilization and soil management:** Properly manage soil fertility and nutrition to support crop health and resilience to temperature fluctuations. Balanced nutrient levels can enhance a plant's ability to withstand stress (Bita and Gerats, 2013).
10. **Climate-smart agricultural practices**: Implement climate-smart agricultural practices that are adapted to the local climate and consider long-term climate projections. These practices may include conservation agriculture, integrated pest management, and precision agriculture techniques.
11. **Monitoring and forecasting:** Stay informed about weather patterns and forecasts to anticipate temperature fluctuations. Early warning systems can help farmers take proactive measures to protect their crops when extreme temperatures are expected.
12. **Research and innovation:** Support research and development efforts aimed at breeding heat-tolerant and cold-tolerant crop varieties. Innovations in agricultural technology and practices can contribute to more resilient and climate-resilient farming systems.

Conclusion

Climate change has emerged as a major challenge affecting crop growth, development and agricultural productivity worldwide. Rising temperatures and irregular rainfall patterns adversely influence physiological and reproductive processes in crop plants. Extreme weather events such as droughts, floods and heat waves further increase crop vulnerability and reduce yield stability. Changes in climate also intensify soil erosion, pest incidence, nutrient imbalance and water scarcity, thereby threatening sustainable agriculture. Different crops respond differently to climatic stresses depending on their genetic makeup and ecological adaptation. Agriculture, being highly dependent on natural resources, is therefore extremely sensitive to climatic variability.

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