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Review Article

Impact of Climate Change on Agriculture and Food Security: A Review

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ABSTRACT

Climate change has emerged as a major man-made global environmental problem, characterized by an increase in the earth's air temperature as a result of large-scale emissions of greenhouse gases. Agriculture and climate change are intrinsically linked in different ways, since biotic and abiotic stresses are primarily caused by climate change, all these factors have a detrimental effect on a region's agriculture. Agriculture is affected by climate change in various ways, e.g., heat stress at the reproductive stage, shortening of growing season length, pests or microbes, modification in weeds, and increase in CO_2 *level. The challenge of changing global climate has driven the scientists' interest, As a result of these changes, global crop production is suffering and global food security is in danger. The current study sheds light on the impacts of climate change on agriculture, as well as the consequences for food security.*

Keywords: *Climate Change, Agriculture, Food Security.*

INTRODUCTION

Climate change is one of the most important issues facing the world today, and it has significantly reshaped or is in the process of reshaping the planet's ecosystems. Anthropogenic activities, mostly greenhouse gas (GHG) emissions in the atmosphere, have increased global temperature by 0.9°C since the nineteenth century (Solomon et al., 2007). According to the Intergovernmental Panel on Climate Change, temperature changes over the next 30–50 years are expected to be in the 2–3°C range (Tripathi et al., 2016).

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Climate and weather systems are becoming warmer, will lead to a significant shift in atmospheric CO_2 concentrations (280 to 395ppm) (Stocker, 2014), and the intensity of weather events around the world, such as temperature rises, drought, uneven rainfall patterns, heat waves, and flood (Ahmed et al., 2018). Climate change has a range of effects, but the agricultural sector, which is responsible for the majority of the world's food production and economy, is now clearly visible (Ahmed et al., 2019).

Agriculture production will be impacted by severe extreme weather events, which will have a direct impact on water demand, crop growth, as well as water availability, soil fertility, irrigation, pest and disease prevalence. It's also worth remembering that the global population is projected to exceed 9.7 billion people by 2050, putting even more pressure on agricultural lands to meet rising food demands already impacted by climate change. According to data published by the Food and Agriculture Organization (FAO) in 2016, if current GHG emissions and climate change trends persist, major cereal crop yields will decline by the year 2100 (20–45 % in maize yields, 20–30 % in rice, and 5–50 % in wheat). The current study will look at how climate change is affecting the agriculture sector, including how it affects the crop, horticulture production, insect pests, pathogens, agricultural soil, and food security.

Climate change impact on crop production

The rate of growth and development around the plant is influenced by global warming (Campbell et al., 2016). Climate change has the potential to alter precipitation, runoff, and soil water, as well as shorten crop maturation times and restrict crop production in many areas. Barlow et al. (2015) found that excessive heat decreased grain number and lengthened grain filling time, while frost induced sterility and abortion of developed grains in a recent study of the effects of temperature extremes on wheat. Climate change would have a huge impact on the production of major food crops like rice, as crop development and production are primarily influenced by water, temperature, and sunlight (Naylor et al., 2007). There has been a decrease in micro-and macronutrients in wheat when CO_2 levels are high (DaMatta et al., 2010). Water stress as a result of the decrease in humidity, intense light, and strong winds, can cause average granule size to decrease in wheat, affecting the crop's overall yield (Hurkman & Wood, 2011). If the temperature of the atmosphere rises, the temperature of the leaf surface rises as well, impacting primary production (Poudel & Kotani, 2013). Heat stress causes starch quality to deteriorate in maize, granule size to shrink, branch chains to shorten, and yield to drop (Wang & Frei, 2011). Wheat's Ca, Mg, S, and N content has been found to decrease as CO_2 levels rise, whereas P and K content has changed (Högy & Fangmeier, 2008).

Rice foliage glucose content increases as CO_2 concentration in the atmosphere rises, making the foliage more vulnerable to insect attack (Shimono et al., 2010). According to some simulation models, increased CO_2 level improves rice yield due to its fertilization effect, while the higher temperature can hinder the production of rice (Krishnan et al., 2007). Climate change's effect on oilseed, coarse grain and other minor crops like sorghum, sesame, and pearl millet has been found in China up to 2030, with a huge loss in coarse grain and other crops. India and Pakistan, on the other hand, experienced higher losses in oilseed crops.

Climate change impact on horticultural Crop Production

Horticultural crops have importance economically, aesthetically, and environmentally (Adeyela et al., 2016), it directly depends upon the temperature, soil moisture, sunlight, and soil fertility. Climate change imposing a great impact on horticultural crops directly and indirectly. Extreme environmental changes affecting the morphological, physiological, biochemical, and developmental stages of the plants. Plants became stressed because the temperature is increasing, which speeds up the potential evaporation, alters photosynthesis rate, the phenology, shorten the days to flowering and fruiting, crop duration, hasten ripening, senescence, and fruit maturity (Malhotra, 2017). Temperature variations cause the ripening of fruits to be delayed and the sweetness of melons to be reduced. Hot, humid weather promotes vegetative growth and reduces female flower development in cucurbitaceous vegetables such as bottle gourd, ash gourd, and pumpkin, resulting in low yield (Ayyogari et al., 2014). Water-stress condition affects the plants in terms of narrow-leaf orientation, lesser germination, delayed maturity, small and delayed flowering, the decline in chlorophyll content, reduced rate of transpiration, less uptake of nutrients, and severe reduction in yield (Bhardwaj, 2012). In tomato plants, drought causes flower abscission (RM et al., 2009).

Soil salinity can affect seed germination through osmotic effects; wilting, growth reduction, loss of turgor, epinasty, growth reduction, decreased photosynthesis, loss of cellular integrity, respiratory changes, tissue necrosis, and death of the plant (Mukhopadhyay et al., 2020). Salinity decreases leaf area, net assimilation rate, dry matter production, and leaf area in chili (López et al., 2011). Flooding damages crops in general because it reduces oxygen in the root zone, inhibiting aerobic processes. Flooded conditions in tomato plants accumulate endogenous ethylene, resulting in a rapid epinastic leaf response (Drew, 2009). CO_2 concentrations have elevated, and they can alter plant tissues in terms of growth and physiological behavior directly influenced the yields (Pathak et al., 2012). In coconut, areca nut, and cocoa, increased CO_2 led to higher biomass production and total dry matter content (Singh, 2010).

Climate change impact on soil properties

Soil serves as a rooting medium for plants, any negative climatic effect has an impact on the biological and physicochemical properties of soil, change in climate, and agricultural zones are all affecting agricultural production and yield (Mihailović et al., 2016). Temperature rises are likely to impact soil quality by reducing water holding capacity and soil moisture, which are two important properties that affect nutrient accessibility to crops. The climate affects the dominant plant species, their fertility, litter deposit, and decomposition rate which in turn has an indirect impact on soil reaction (Pankova & Konyushkova, 2013). A temperature rise is likely to encourage the proliferation of pests that are harmful to livestock and crop production (Sharma & Prabhakar, 2014). Plant growth is driven by increased CO_2 levels in the atmosphere, which increases carbon allocation below ground, allowing the microbial community to speed up nitrogen fixation, mycorrhizal interactions, mineral weathering, and soil aggregation (Karmakar et al., 2016).

Excessive precipitation can lead to a substantial nutrient loss in the soil. Agricultural soils with poor drainage that experience regular or extreme precipitation can become waterlogged and hypoxic (Otero et al., 2011). A decrease in the supply of water for irrigation due to climate change will result from the shrinking of water bodies. When large water bodies recede, whole economies are likely to suffer (Tripathi et al., 2016). Surface sealing can limit leaching due to unpredictable rains. As a result, subsoil drying increases, raising the salt content of the soil solution even more. Salinization increases with a rise in upstream recharging rainfall in those areas where recharge processes are the reason for salinity (Elliott et al., 2014).

Climate change impact on insect pests

Insect pests are major agricultural constraints, and their effects are likely to become more significant as the world's population grows (Godfray et al., 2010) The challenges that phytophagous insect pests face now and in the future would almost certainly be exacerbated by expected global warming (Fischedick et al., 2014), which can encourage pest population growth, enhance the geographic spread of many pest species, and increase outbreak frequency, become a reason for the food security threat and economic losses (Thackeray et al., 2016). Due to climate change, the distribution of insect pests is affected more at high temperatures as compared to lower (Sharma, 2016). There are at least four different types of responses to climate change, population and tropic interaction, life history trait, and changes in geographic range (Pecl et al., 2017). All of these factors have an impact on the number of economic harm pests do. Climate change could result in higher densities of the population of *Maruca vitrata* (Fab.) and *Helicoverpa armigera* (Hub.), as well as a transition to temperate regions, wreaking havoc on pulses and related crops (Sharma, 2010).

The density of the Coffee Borrow Beetle (CBB) increases as the temperature rises, it can grow in temperatures ranging from 15 to 32°C and develops more quickly in the 27-30°C range (Läderach et al., 2010). Increased levels of CO_2 in the atmosphere directly impact plant nutrition and insect growth and development (Xu et al., 2019). It has been confirmed in a report that *Spodoptera litura* is a serious pest when the CO_2 level increased (Kranthi et al., 2009). However, as many studies have indicated, plants grown at higher temperatures or with more CO_2 are less nutritious and have a longer larval cycle and a higher mortality rate than insects that feed on them. Furthermore, increases in CO_2 and temperature have an effect on volatile organic compound emissions produced by herbivores (Arneth et al., 2010).

Climate change impact on plant pathogens

The interaction of a virulent pathogen, environment and susceptible host plant causes plant disease. Since the climate has a tremendous impact on plants, pathogens, and their antagonists, whether directly or indirectly. Climate change may implicate the development of new pathogens and variations in the degree of losses caused by disease (Anderson et al., 2004). Global warming has an effect on plant disease occurrence and severity, as well as the evolution of pathogens and plants (Eastburn et al., 2011). Moisture and temperature may influence disease progression by influencing the host's susceptibility to infection and increasing symptom expression levels. Many pathogens are likely to spread to new regions as temperatures rise, where they can find new potential hosts. According to the projections of Evans et al. (2008) based on UKCIP02 for 2020 and 2050, shows how, over the next 20 years, temperature could increase the intensity and spread of plant disease geographically. Temperature and CO_2 concentrations are also increasing the threat perception of late blight (*Phytophthora infestans*), a potato disease, and two essential rice diseases, sheath blight (*Rhizoctonia solani*) and blast (*Pyricularia oryzae*) (Gautam et al., 2013). Under ECO_2, plant-pathogen (*Erysiphe cichoracearum*) aggressiveness increases, as there are changes in leaf epidermal characteristics of *Arabidopsis thaliana* L. (Lake & Wade, 2009).

In comparison to non-infected responses, ECO_2 increases stomatal density, trichome numbers, and guard cell length on leaves developing post-infection. Increased CO_2 increases the resistance of Moneymaker plants but decreases the resistance of plants inoculated with the nematode resistance gene Mi-1.2, according to (Guo et al., 2016).

Impact on Food Security

When everybody has constant physical and economic access to enough healthy and nutritious food to satisfy their nutritional needs, they are said to be food secure. Climate change, land depletion, and water scarcity, according to the United Nations Environment Programme, could result in the loss of up to 25% of the global food supply by 2050 (Pant, 2012). According to (Song & Wang, 2017), maize is unable to mature before the first frost as a result of global warming, reducing maize production by 6.55 × 103 million kg across the world—for example, by 32% reduction in the yield in Heilongjiang. For each degree Celsius rise in temperature, the average estimate for wheat yield loss is 6.0 ± 2.9% (Zhao et al., 2017). Though increased CO_2 is expected to benefit crop production at lower temperatures, it is also expected to reduce nutritional quality (high confidence) (Mbow et al., 2017).

Nearly 1 billion people in the developing world are unable to fulfill their nutritional requirements. In times of crisis, another 5-10 % faces "acute" food insecurity. Malnutrition affects 820 million peoples living in developing countries, according to the UN-FAO (Ahmad et al., 2018). Climate change would have an effect on food security by affecting all aspects of the local, national, and global food systems. Climate change variables have an effect on biophysical factors including animal and plant development, biodiversity, nutrient cycling, and water cycles, as well as how these are handled. Global climate change has reduced the amount of suitable and arable land available for agricultural production. Depleted water supplies, less fertile soils, insufficient precipitation, and increased pest and disease damage to livestock and crops result in a significant drop in animal productivity and crop yield, putting a strain on the labor force of the country (Dawson et al., 2016). Climate change may have a direct impact on the composition and use of micronutrients in many ways. It can have an effect on micronutrient composition by changing agricultural yields, influencing ways to grow crops with different nutritional values (Bharucha & Pretty, 2010). Climate change can lead to increased variability in agricultural production, which can lead to food instability (Tripathi et al., 2016).

CONCLUSION

Climate change is certainly showing its effects around the world, and the important determinant of agricultural productivity is "climate," which has a direct influence on global food production. Food security is affected by changes in precipitation patterns, as well as a rise in the frequency and severity of extreme events such as heat waves and drought. It is projected that there will be an increase of 2–3°C temperature at the end of this century. There will be an increase in the number of hot days, warm nights, and extreme rainfall that occurs in monsoon in Asia. Crops can start to fail as temperatures rise and rainfall becomes more variable, particularly in low and variable precipitation patterns. By the end of the century, this warming condition will result in a significant reduction in crop grain yields. Wheat yields in Pakistan are projected to drop by 50%, maize yields in China by 46%, cotton yields in the United States by 17%, and sugarcane yields in India will drop by 30%. The duration of several crops, as well as their yield, is likely to be decreased as the mean seasonal temperature rises. Climate change, on the other hand, has few negative consequences for economic activities such as agriculture, which ensures the availability and accessibility of food to peoples. Countries must follow climate change mitigation protocols and treaties to combat global food shortages and mitigate the negative effects of climate change. In light of the above, formulating and developing strategies that facilitate food availability through various agriculturally smart responses, improved and versatile livelihood sources is a crucial way to tackle food insecurity. Climate change can be mitigated by the development of heat-tolerant cultivars, changes in current production, and crop protection technologies. Countries are encouraged to adopt sustainable sustainability best practices, such as energy technologies with low carbon emissions and methods that are energy efficient. To ensure that communication about climate change and food security is meaningful, capacity building and understanding of the interrelationships of intricate physical, chemical, and biological systems should be enhanced. This enables people to make well-informed and responsible decisions about food security and the climate in the long run.

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