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Climatic fluctuation and breeding efforts to mitigate: A review

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Abstract
Climate change is deviations from the average atmospheric state produced by both natural and anthropogenic. Deforestation and greenhouse gas such as CO_2, CH_4 and N_2O are the main factors of causing climatic fluctuation. Climatic fluctuation has direct and indirect effects on agricultural production and productivity as well as on social healthy. Phonological changes, phenotypic changes, morphological changes, effects on plant production and landscape changes are direct while effects on soil, fertility, water quality pest and disease incidence and drought problem are indirect effects of climate changes. Different action has to be taken to tackle the difficult situation of climatic fluctuation. Rapid breeding cycles, developing drought resistant varieties, soil carbon sequestration, and rehabilitating degraded land are the main action.

Keywords: Climate, temperature, resistant variety

1. Introduction

Climate change is deviations from the average atmospheric state produced by both natural and anthropogenic forces such as the orbit of the earth's revolution, volcanic activity, and crustal motions. Climate change affects the land and its agriculture by yearly rainfall, average temperature, heat waves, changes in weeds, pests, or microbes, worldwide changes in atmospheric CO_2 or ozone levels, and sea level oscillations. The prospect of changing global climate has piqued scientists' interest, as these changes severely influence global crop productivity and jeopardise global food security (Raza *et al.*, 2019) [18]. Droughts and floods, which always result in acute food shortages, are illustrative of the grave consequences of extreme weather conditions for crop productivity (Mba, Ghosh and Guimaraes, 2012) [13].

According to some projections, agriculture is the most threatened activity as a result of climate change (Raza *et al.*, 2019) [18]. It is climate-dependent and has distinct regional characteristics and is disturbed by agricultural environment altering climatic factors (Geneti, 2021) [8]. (Rosenzweig *et al.*, 2001) [26] reported as temperature and rainfall influence the spread, growth and survival of pathogens which indirectly affect the crop. Climate fluctuation also affects human health by heat waves, floods, and fires and indirectly owing to its effects on agriculture, food supply, and diets (Springmann *et al.*, 2016; Ceccarelli, 2019) [27, 4].

Human activities, shifts in climate patterns, greenhouse gas emissions from natural systems and composition are the main factor of climate change (Temesgen, 2021). According to (Shahzad, 2019) [20] study, CO_2, CH_4 and N_2O fluorinated greenhouse gas which lead to drastic changes in the temperature, rainfall patterns and ultimately cause undesirable effects on the land and water resources, droughts and floods.

Plant breeding is the art and science of genetically improving plants for the benefit of humankind. One of the effective ways for crop production to grow under new challenges from climate change is through improving genetic makeup of varieties by plant breeding. In the past, genetics was mainly used to enhance yield and product quality but also it can equally contribute to climate change mitigation and reducing the environmental impacts of farming (Abberton, no date). Therefore, to tackle successive climate fluctuation integration of plant breeding in climate change strategies is one of the best paths to sustainable food production and a suitable ecological environment. Therefore this review is designed with the objectives of assessing plant breeding efforts in controlling climatic variability and ways of mitigation through plant genetic improvement.

2. Literature Review

2.1 Impact of Climate Fluctuation

Climate change is one of the processes that have already overstepped the safe planetary boundaries, together with the rate of biodiversity loss and human interference. In recent time climate variability is a high hotspot issue all over the world since all the life of living things may affect if the climate fluctuation is not properly managed. According to Glaszmann J.C. *et.al.* (2013) climate change is projected to reduce yield growth rates in much of the world, especially in tropical regions. The Intergovernmental Panel on Climate Change (IPCC) reported that climate change might reduce yields per hectare of wheat, rice, and maize by up to 2 percent per decade starting 2030 compared with projected yields without climate change. Deressa and Hassan (2007) [6] showed that seasonal climate conditions (including rainfall and temperature) and agro-ecological settings had a significant impact on technical efficiency in Ethiopian agriculture.

Climate fluctuation in local climates, rather than global climate trends, has an impact on agriculture. Changes in climatic factors are a major stumbling block to guaranteeing food security for the world's rising population (Leisner CP, 2020) [11]. According to the Intergovernmental Panel on Climate Shift (IPCC), global temperatures may rise by 1.7 to 4.8°C during the twenty-first century, and precipitation patterns may change as well. Furthermore, the direct and indirect effects of climate change would alter nutrient availability and bioavailability in soils (IPCC, 2014) [9]. In addition climate change's impact on biotic and abiotic pressures has already lowered worldwide agricultural production by 1% to 5% over the last three decades (Newbery F.*et. al*., 2016) [16].

Seed quality parameters like as reproduction, blossom, pollen viability, pollination and seed fill, set, size, dormancy, and yield can all be affected by climate change. Changes in crop/weed interactions, loss of pollinator biodiversity, and genetic diversity caused by climate change can all have an impact on seed quality. Several research have found that greater CO_2 levels in the air improve plant biomass and seed production, whereas another study found that higher CO_2 concentrations reduce nitrogen levels in seed. Since Agriculture is extremely vulnerable to climate change, it impedes the yield directly disturbing the agro-ecological environment and indirectly by discouraging growth and products. According to prediction of (Tubiello FN and Fischer G., 2007.) [28], compared to 1990 undernourished people could be increased by 150% in the Middle East and North Africa and by 300% in sub-Saharan Africa by the year 2080.

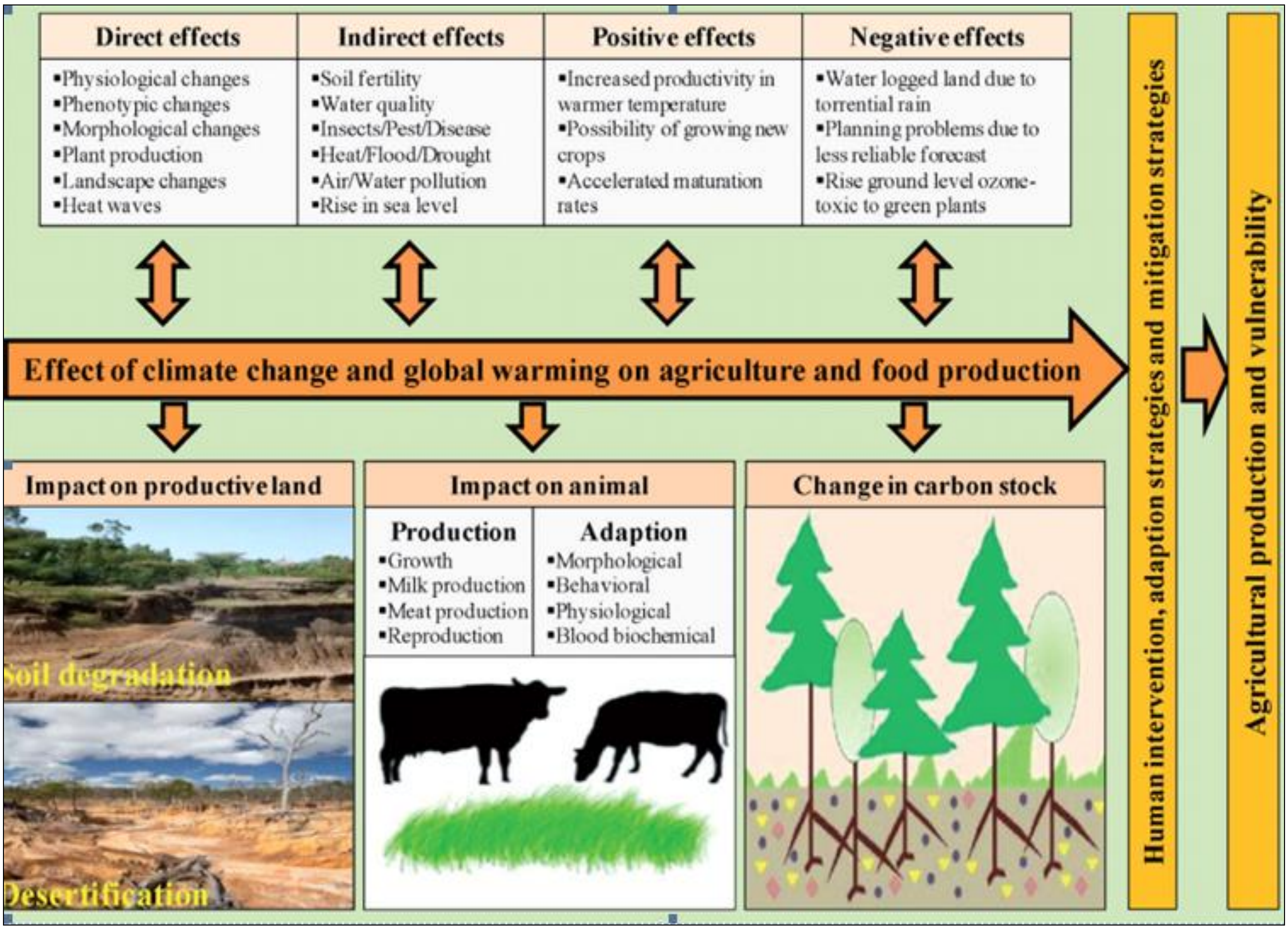
Research findings reveal that weather variability and climate change have significant impacts on global and regional food production systems and particularly have serious impacts on agriculture in Africa (UN-OHRLLS, 2009) [23]. Climatic variation affect specifically world developing country than developed country since their production entirely depends natural precipitation. Ayinde *et al*. (2010) [3] analyzed climate change and agricultural production in Nigeria using Granger causality approach which reported that changes in rainfall positively affected agricultural production in Nigeria. Kumar and Sharma, (2013) [10] studies on impact of climate revealed that, climate variations had a negative impact for most of the food grain crops and non-food grain crops in quantity produced per unit of land and in terms of value of production. In addition they reported an econometric estimation of the state-wise food security index which revealed that food security had been adversely affected due to climatic fluctuations. Mulwa (2015) studies the influence of climatic factors and agro-ecological zone factors on farm level efficiency in Kenya. The study reported that temperature, rainfall, standardized precipitation evapotranspiration index, altitude and adaptation strategies all influenced farming efficiency in the country negatively and positively and at different magnitudes.

Deressa and Hassan (2007) [6] analyzed the economic impact of climate change on crop production in Ethiopia. They showed that seasonal climate conditions (including rainfall and temperature) and agro-ecological settings had a significant impact on technical efficiency in Ethiopian agriculture. In addition, the negative impacts of future climate change entailed serious damage to the production of teff and wheat, but relatively maize yield will increase in 2050 according to the report by Zerihun (2012) [25]. Mintewab *et al.* (2014) [14] assessed the impact of weather and climate change measures on agricultural productivity and result showed that contrary to expectations for rain-fed agriculture rainfall generally had a lesser important role to play than temperature. Liangzhi *et al.* (2005) [12] studied climate impact on Chinese wheat yields and they found that a 1% increase in the temperature in the wheat growing season reduced wheat yields by about 30%. From this study, it is possible to say that wheat prefers a highland area where the temperature is low and the trait for this climate should be selected by adaptation breeding in several locations.

2.2 Climatic Change and Plant Breeding

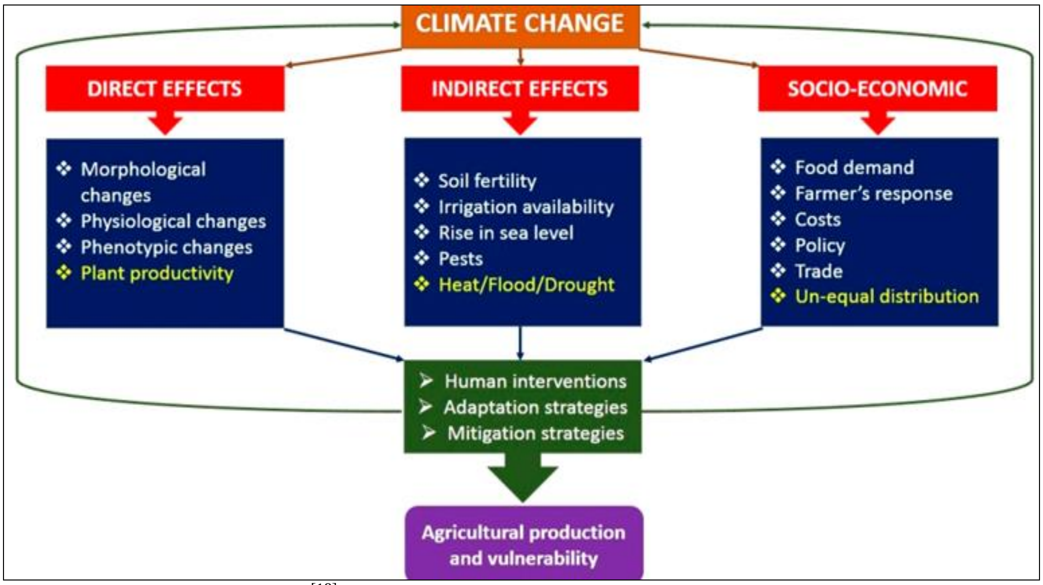
In the coming decades, population expansion will raise the requirement for food production, but changing climate and pest and pathogen threats may have an influence on main food crop outputs. Crop breeding, both traditional and GM-assisted, might be able to help to handle these issues if it's backed up by enough information about the future environment.

Plant breeders have to work to solve the immense problems posed by climate change by developing new seed varieties and assisting producers in improving genetics from stress-tolerant germplasm. To overcome the difficulties of climate change, plant breeders must collaborate more closely with climate scientists and crop modelers. Investigation of fruitful areas to identify key target breeding traits and develop improved success criteria, identification of those conditions in which multiple stress factors are important in breeding programs, use of climate information to inform trial site selection, identification of the range of environments and locations under which crop trials should be performed, identification of appropriate trial duration, and derivation of improved success criteria (Faloon *et al.*, 2015) [7]. It will be critical to incorporate stress-adaptive characteristics into crops that already have a solid agronomic package to ensure yield stability. Drought resistance, heat tolerance, and water use efficiency are currently the subjects of greatest interest in breeding efforts around the world. The development of superior varieties with climate change resilient crops is important for increasing productivity parallel to increasing human population. With the rapid increment in world population, agricultural productivity should be increased to overcome food security problems. Therefore, conventional crop plant improvement should be integrated with marker assisted breeding procedures to address the serious challenges of the world through enhancing crop genetic improvements (Varshney RK. *et al*., 2018) [24].



***Source*:** Smart Breeding for Climate Resilient Agriculture. DOI: http://dx.doi.org/10.5772/intechopen.94847

Fig 1: Adverse effect of climate change on agriculture and food technology.



Source: Raza, A. *et al.* (2019) [18]

Fig 2: Direct, indirect and socio-economic effects of climate change on agricultural production.

2.3 Cause of Climatic Fluctuation

Climate refers to a long-term change in the atmospheric condition of a given place or region, whereas climate change refers to a progressive shift in the climate system caused by both natural and man-made factors. Environmental and management factors interact strongly with the plant genotype, so that higher-order Genotype*Environment*Management interactions must be considered in both breeding and agronomy (Cooper *et al*. 2020) [5]. Changes in each component of the climate system, such as the atmosphere, hydrosphere, biosphere, cryosphere, and lithosphere, or sophisticated interactions among those components, create climate change. The causes of climate change can be split into two categories: natural and man-made. Changes in solar activity, volcanic eruptions, seawater temperature, ice cap distribution, westerly waves, and atmospheric waves are all-natural factors. Artificial causes, on the other hand, include carbon dioxide emissions from industry and agricultural production activities, deforestation, acid rain, and Freon gas destruction of the ozone layer, with global warming as the representative (Presidential Advisory Council on Education, Science, and Technology: PACEST, 2007).

The greenhouse effect generated by carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydro fluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride results in an average increase in Earth's temperature (SF6). Global warming, defined as an increase in the Earth's temperature over time owing to the greenhouse effect, began during the Industrial Revolution, coinciding with a significant increase in fossil fuel usage.

2.4 Special concerns of plant Breeders in Developing Country

Plant breeders' ultimate goal in underdeveloped countries, particularly African ones, is food security independence, while other breeding challenges such as climatic variation serve as a binary target. Breeding goals such as yield increment, disease resistance improvement, lodging resistance, yield and yield associated features, and other quality traits are primarily researchable traits in under developing countries. However, some abiotic factors that have a great impact on agricultural productivity are not a priority for research. But for the future, climatic factors research must be conducted in conjunction with other researchable traits in order to reduce climatic impact and sustain productivity.

2.5 Mitigating Climatic Fluctuation

To mitigate the impact of climatic fluctuation incorporating stress-adaptive traits into crops that already have a strong agronomic package will be vital to provide yield stability. According to (Angela Lovell, 2014) [2] study current drought, heat tolerance and water-use efficiency are subjects receiving the most focus in breeding programs around the world. Different ways of mitigating climate factors are rapid breeding cycle, afforestation, improving resistant variety to drought, soil carbon sequestration, and rehabilitating degraded lands are core.

The substantial significance that crops genetic modification is playing in raising agricultural productivity. Genetic materials have been used to improve crop yield and product quality, as well as to slow global warming and lessen the environmental effects of agricultural productivity. Climate wise agriculture assists in reducing and eliminating greenhouse gas emissions wherever and whenever practicable. Avoiding deforestation due to agriculture and boosting the capacity to absorb CO_2 from the atmosphere are two types of mitigation techniques (Senapati N *et al*., 2019) [19].

3. Conclusion and recommendation

In general climatic factors are affecting the day-to-day social and economic movement of this world. If this situation continues without any interference the bio life on the planet is at great risk. To mitigate this crucial problem, plant breeders have great responsibility by releasing resistant varieties to drought and efficient user plants for society. In developing countries plant breeders concerns only about yield and yield attribute traits for food security purposes only. In these conditions the impact of climate in general is forgotten or as the binary plan which must not be. On the other hand developed countries that are with huge numbers of industries must have taken great care of the recent world climatic situation. Ozone-depleting gas released from this industry and disturb normal climatic conditions. The afforestation and resistance variety to the fluctuation must be the main issues for the world community to tackle the current climatic condition.

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