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Climate smart agriculture and food security

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Received: June 2022 Accepted: July 2022

Abstract

As agriculture is very climate sensitive, having indirect as well as direct detrimental effects on production techniques. Climate change, a rise in the frequency and power of climate shocks (drought, floods, and severe temperatures), and altering rainfall distribution and timing are all key variables affecting sustainable agricultural production. The greatest issue for today's plant scientists is meeting rising food demands as the world's population grows. Climate change is bringing new challenges to agricultural development, production, and efficiency. Scholars are now launching more ambitious genomic expeditions to solve food security challenges in the face of expanding population and climate change opponents after successfully using gene editing to alter basic traits. Climate change is integrated during designing and execution of sustainable agriculture, also influences how priorities are set. Knowing effective approaches to encourage the adoption to many environmentally friendly options is a critical goal for increasing productivity and reducing yield unpredictability.

Keywords: Climate, smart agriculture, food security, yield, global warming

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Introduction

Global warming, especially harsh weather and other linked occurrences, poses difficulties to developing-country agriculture and global food security (Mehrabi *et al*., 2022). Crop production is extremely vulnerable to climatic alteration. Extreme weather events, interannual climatic variability, shocks at certain developmental periods, and long-term trends in rainfall and average temperature all have an effect on this. Approximately 2.40 billion people are predicted to be added to the world's developing-country population by 2050. In developing countries, agriculture is an important source of employment, but now, more than 20% of the community experiences food shortages (Christiaensen *et al*., 2021). Almost 75 percent of the world's poor people live in rural regions, and agriculture is their primary source of income. Improving agriculture productivity in the small-scale production sector is critical for alleviating poverty and achieving food security, as a fundamental component and driver of economic transformation and development, particularly in the context of urbanization and non-farm sector advancements. It is anticipated that by 2050, the agriculture industry must increase by 60% to fulfill the increasing demand caused by a constantly rising numbers of individuals, and this could be only accomplished by boosting crop production concerning changing climate (FAO, 2014). As a result, farming in emerging countries have to go through substantial change in order to accommodate the expanding population as well as the interrelated concerns of food insecurity and climate change. Rising adoption of a "climate-smart agriculture" (CSA) technique is one recommended method for achieving long-term agricultural production (FAO, 2010).

CSA is comprised of three major pillars: boosting agricultural output and incomes in a sustainable manner; adapting to and creating resilience to climate change; and decreasing and/or eliminating greenhouse gas emissions in comparison to traditional techniques (FAO, 2013). The agricultural technology and practices that comprise a CSA approach closely parallel those of sustainable agriculture and sustainable intensification. As a result, the purpose of this study is to provide an overview of the function of climate wise agriculture and its practices in ensuring long-term crop production.

Principles of climate smart agriculture

Climate Smart Agriculture (CSA) is a method of developing technological, strategic, to accomplish sustainable agricultural growth for food security in the climate change environment as well as investment conditions. Because of the magnitude of the effects of climate change in agricultural systems, it is critical to ensure that these consequences are fully integrated into initiatives, investments, and planning for agriculture on a national scale. Under the emerging realities of climate change, CSA is reshaping and shifting toward more sustainable agriculture practices to ensure food security. It is an FAO concept that is a method to establishing the technical, policy, and to accomplish sustainable agricultural growth for food security in the face of climate change, there are certain investment requirements (FAO, 2013).It is based on three key pillars:

1. Boosting agricultural output and incomes in a sustainable way;
2. Adapting to and creating resilience to climate change; and
3. Reducing and/or eliminating greenhouse gas emissions whenever possible.

Temperature changes as a result of climate change

Temperature variations can take several forms, such as changes in the general typical temp, alteration in day and night temp, or adjustments in the timing, length, and severity of severe freezing or scorching environment. Plants are often more sensitive to high temperatures during reproductive, grain filling, and ripening phases. Plants' responses to rising temperatures are species-specific, aided by photosynthesis process for the buildup of plant biomass, which controls plant development, and controlled by all daytime morphological and physiological changes in plants. The effect of stress is determined by each species' susceptibility to temperature fluctuations during its embryonic period. To adjust to these consequences, a various type of response system is required. Increased temperature throughout plant growth season resulted in a high respiration rate, implying a low quantity of energy remaining for plant maintenance and development. Even a 1°C increase in the median temperature might result in a 5-10% decrease in critical food crops (Zhao *et al*., 2017).

Creating new ways to minimize greenhouse gas emissions

Agriculture, along with land use changes, is becoming a major contributor to greenhouse gas emissions, accounting for over a quarter of total anthropogenic GHG emissions. Agriculture contributes to GHG emissions mostly through the agricultural and animal sectors, and it is also a major contributor to deforestation and peat land degradation. Non-CO_2 emissions from agriculture are likely to rise if the industry continues to develop at its current rate. However, there are a number of approaches to limit these gases' emissions from the agriculture industry. One of the most significant agricultural mitigation techniques for decreasing emission intensity (CO_2 eq/unit product) is sustainable development. Another important technique to minimize emissions is through agriculture's high carbon sequestration rate. The capacity of plants and soils to collect CO_2 from the atmosphere and store it in their biomass is known as carbon sequestration. Carbon sequestration may be accomplished through increasing tree cover in livestock and agriculture systems (agroforestry), as well as minimizing soil disturbance (reduced tillage). Even yet, this reduction in emissions may not be permanent, as stored CO_2 can be released if trees are chopped down or soil is plowed. Despite the obstacles, high carbon sequestration has a large mitigation potential, especially when the agricultural techniques that provide the sequestration simultaneously play a vital role in food security adaptation (Zhao *et al*., 2017).

Adaptation to climate change and reducing vulnerability

The Intergovernmental Panel on Climate Change (IPCC) recently released its 5th assessment report, which highlighted that the effects of climate change have been noticed in many parts of the world. The findings revealed that extreme climate change consequences were more common than favorable ones, and that impoverished nations were more vulnerable to the negative effects of climate change on agriculture in the future (IPCC, 2014). When average and seasonal maximum temperatures continue to rise in the medium to long term, this results in a high average of rainfall, but these consequences are not fairly distributed, since rainy regions and seasons get more rainfall than dry parts and seasons (Clarke *et al*., 2022). Reduce risk exposure by establishing an input supply system, diversifying incomes or production, and utilizing extension services for timely and efficient input use, as well as the use of stress resistant or tolerant varieties, livestock breeds, and forestry species and fishes, to name a few examples.

A climate-smart food system and supply chain

Climate change has been demonstrated to have a strong and constant worldwide tendency, which may have ramifications for food supply. Climate change may undermine the stability of complete food systems due to short-term supply variations. At the regional level, the potential impact is less clear, but climatic instability and transition are likely to exacerbate food insecurity in places already prone to hunger and malnutrition. According to the data, considerable investment in adaptation and mitigation strategies is required to develop a "climate-smart food system" that is more robust to the effects of climate change on food security (Christiaensen *et al*., 2021).

Climate change's impact on agriculture production

Climate change has impacted the whole agricultural production system, posing a threat to global food security. However, the most severe effects of these shifts have been documented in developing nations. Over the next decade, it is expected that billions of people, primarily in developing nations, would face water and food scarcity, as well as a severe danger to life and health owing to climate change. Developing nations are more vulnerable to changing climatic conditions because they lack the social, financial, and technical resources necessary to address climate change (UNFCCC, 2007). Climate change is expected to produce a significant decline in maize output in southern Africa. It may also cause a 10% decline in major crops in South Asia, including rice, and a 20% fall in millet and maize output (Grote *et al*., 2021). Productivity may rise with a 1-3°C increase in the mean local temperature of some moderate- to high-latitude locales, depending on the crop. In contrast, crop output declined with even the slightest variation in relative temperature range in lower latitude locations (IPPC, 2007).

Climate-smart agricultural production technologies of the future

Plant agronomic conditions, soil nutrients, diseases, and pests are expected to suffer as a result of climate change, that involves extreme heat and drought. As a result, climate-resilient cultivars with a broad spectrum of biotic and abiotic stress tolerance and long-term persistence are required. Precision genome editing (Tripathi *et al*., 2019) is a revolutionary genetic engineering technology for crop development. Several approaches, including as zinc finger nucleases (ZFNs), TAL effector proteins (TALENs), RNA directed nucleases (RGENs), and CRISPR (clustered regularly interspaced short palindromic repeats)/Cas9 (CRISPR associated protein 9) have been developed for targeted genome editing in plants. Both methods rely on the production of double stranded breaks at certain loci as well as the activation of the DNA repair mechanism (Weinthal and Gürel, 2016).

Genome editing

To fulfill the needs of a growing global population and the impact of climate change on agriculture, crops with better yields and greater tolerance to abiotic stress are required. On the other hand, traditional crop enhancement by genetic recombination or random mutagenesis is a time-consuming procedure that cannot keep up with expanding agricultural demand. Genome editing tools such as clustered regularly interspaced short palindromic repeat (CRISPR)/CRISPR-associated protein (CRISPR/Cas) enable the selective change of practically any crop genome sequence to produce new variety and accelerate breeding efforts. In crop improvement, we anticipate a gradual movement away from traditional breeding and toward targeted genome editing cycles. Crop enhancement by genetic modification is not constrained by existing variety or the requirement to select alleles across multiple generations of breeding. Current crop genome editing applications are limited by a lack of complete reference genomes, a lack of understanding of prospective alteration targets, and the legal position of modified crops (Scheben *et al*., 2017).

Gene silencing

Gene silencing is a technique for inhibiting the functional expression of certain genes by overexpressing RNA sequences (RNAi). Despite the fact that it has been around for a long time, it is increasingly being utilized to turn off certain genes. Disabling pathogen assault mechanisms or stress response components in future food protection applications might be particularly valuable in light of global warming. Gene editing is a method for creating precise, targeted alterations in genomes on a one- or few-nucleotide scale. CRISPR, CAS9 nuclease, and transcriptional activator-like effectors' nucleases are two examples of these small-scale genomic modifications (TALEN). There have been comparisons made between CRISPR-based genome editing and a "search and replace" feature (Ledford, 2015).

Conservation agriculture

Conservation agriculture (CA) is a farming method that uses as few procedures as possible to use agricultural leftovers, mulches, or cover crops are used to maintain permanent soil cover, and crop rotation is used to minimize soil disturbance for planting (FAO, 2010). CA is defined by Cárceles *et al*. (2022) as a farming technique that promotes natural ecological processes in order to boost agricultural yields and sustainability by avoiding soil disturbance, preserving permanent soil cover, and diversifying crop rotations. Management of soil fertility and organic matter, as well as improvements in nutrient input efficiency, enable more to be produced with proportionally less fertilizers (FAO, 2010). This technique aims to avoid soil erosion, preserve soil structure, boost organic matter content, and improve water infiltration and retention, all of which have the potential to raise long-term yields and reduce yield variability even in the face of climate change (Ferreira *et al*., 2022). conservation Agriculture also helps with climate change adaptation by minimizing crop susceptibility. The preceding crop's protective soil cover shelters the soil surface from heat, wind, and rain, keeps the soil cooler, and lowers moisture losses through evaporation (FAO, 2010). In dry circumstances, it decreases crop water requirements, improves soil water usage, and allows for deeper roots of crops in highly wet situations. CA promotes rainwater infiltration, which increases water efficiency and protects crops from drought, minimizing soil erosion and the risk of downstream floods. Mulch also protects the soil from temperature fluctuations and helps to keep pests and diseases at bay (FAO, 2014).

Conclusion

The world's population is anticipated to rise 9 billion by 2050, necessitating a doubling of present food supply to fulfill demand. Regardless of how this growth is expected to be accomplished, there is a key challenge with regard to changing climate. Interventions are so necessary to feed the world's rapidly rising population, particularly in underdeveloped countries. As a result, the need for to approaches for reduction and adaptation is even more pressing to satisfy food demands in the face of a changing climate. In this context, the climate smart agriculture (CSA) method provides a realistic and sustainable alternative for achieving optimal crop output of high quality while having no negative environmental impact. CSA is defined as "agricultural that sustainably increases production, improves resilience, and reduces/removes GHGs whenever possible." Crop production is crucial for reducing and adapting to climate change because it provides options for adaptation and mitigation. Sustainable crop production ideas and methods of climate change adaptation and mitigation are both consistent. Climate-smart agriculture uses naturally self-control mechanisms to change agriculture from a fragile system to one that is highly effective, robust, and sustainable. Technology advancements like gene editing, gene silencing, and DNA sequencing have altered agricultural growth strategies in terms of yield. Using genomics technologies, information on how plants respond to stress may be disclosed, and this knowledge can be turned into climate resilient crops. Molecular markers connected to significant agronomic properties may be found through genomics, assisting in the improvement of crop types in terms of production quality, ability to handle stress, and resilience to illness. These several approaches will contribute to a more secure food supply throughout the world. Approaches are a necessary solution to implement. As a result, CSA ideas and practices are critical for providing triple wines of increased productivity and revenue, long-term production of agricultural products, adaptation to climate change and mitigation.

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