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Food Security under the Era of Climate Change Threat

Dhiman Mukherjee

Department of Agronomy, Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya, Kalayani-741235

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ABSTRACT

Agriculture production is directly dependent on climate change and weather. Possible changes in temperature, precipitation and CO₂ concentration are expected to significantly impact crop growth and ultimately we lose our crop productivity and indirectly affect the sustainable food availability issue. The overall impact of climate change on worldwide food production is considered to be low to moderate with successful adaptation and adequate irrigation. Climate change has a serious impact on the availability of various resources on the earth especially water, which sustains life on this planet. The global food security situation and outlook remains delicately imbalanced amid surplus food production and the prevalence of hunger, due to the complex interplay of social, economic, and ecological factors that mediate food security outcomes at various human and institutional scales. Weather aberration poses complex challenges in terms of increased variability and risk for food producers and the energy and water sectors. Changes in the biosphere, biodiversity and natural resources are adversely affecting human health and quality of life. Throughout the 21st century, India is projected to experience warming above global level. India will also begin to experience more seasonal variation in temperature with more warming in the winters than summers. Longevity of heat waves across India has extended in recent years with warmer night temperatures and hotter days, and this trend is expected to continue. Strategic research priorities are outlined for a range of sectors that underpin global food security, including: agriculture, ecosystem services from agriculture, climate change, international trade, water management solutions, the water-energy-food security nexus, service delivery to smallholders and women farmers, and better governance models and regional priority setting. There is a need to look beyond agriculture and invest in affordable and suitable farm technologies if the problem of food insecurity is to be addressed in a sustainable manner.

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*Corresponding author. e-mail: author@university.edu

Introduction

Globally, agriculture is one of the most vulnerable sectors to climate change. This vulnerability is relatively higher in India in view of the large population depending on agriculture and poor coping capabilities of small and marginal farmers. Impacts of climate change pose a serious threat to food security. "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996). This definition gives rise to four dimensions of food security: availability of food, accessibility (economically and physically), utilization (the way it

is used and assimilated by the human body) and stability of these three dimensions.

According to the United Nations, in 2015, there are still 836 million people in the world living in extreme poverty (less than USD1.25/day) (UN, 2015). And according to the International Fund for Agricultural Development (IFAD), at least 70 percent of the very poor live in rural areas, most of them depending partly (or completely) on agriculture for their livelihoods. It is estimated that 500 million smallholder farms in the developing world are supporting almost 2 billion people, and in Asia and sub-Saharan Africa these small farms produce about 80 percent of the food consumed. Climate change threatens to reverse the progress made so far in the fight against hunger and malnutrition. As highlighted

by the assessment report of the Intergovernmental Panel on Climate change (IPCC), climate change augments and intensifies risks to food security for the most vulnerable countries and populations. Few of the major risks induced by climate change, as identified by IPCC have direct consequences for food security (IPCC, 2007). These are mainly to loss of rural livelihoods and income, loss of marine and coastal ecosystems, livelihoods loss of terrestrial and inland water ecosystems and food insecurity (breakdown of food systems). Rural farmers, whose livelihood depends on the use of natural resources, are likely to bear the brunt of adverse impacts. Most of the crop simulation model runs and experiments under elevated temperature and carbon dioxide indicate that by 2030, a 3-7% decline in the yield of principal cereal crops like rice and wheat is likely in India by adoption of current production technologies. Global warming impacts growth, reproduction and yields of food and horticulture crops, increases crop water requirement, causes more soil erosion, increases thermal stress on animals leading to decreased milk yields and change the distribution and breeding season of fisheries. Fast changing climatic conditions, shrinking land, water and other natural resources with rapid growing population around the globe has put many challenges before us (Mukherjee, 2014). Food is going to be second most challenging issue for mankind in time to come.

India will also begin to experience more seasonal variation in temperature with more warming in the winters than summers (Christensen *et al.*, 2007). Climate change is posing a great threat to agriculture and food security in India and its subcontinent. Water is the most critical agricultural input in India, as 55% of the total cultivated areas do not have irrigation facilities. Currently we are able to secure food supplies under these varying conditions. Under the threat of climate variability, our food grain production system becomes quite comfortable and easily accessible for local people. India's food grain production is estimated to rise 2 per cent in 2020-21 crop years to an all-time high of 303.34 million tonnes on better output of rice, wheat, pulse and coarse cereals amid good monsoon rains last year. In the 2019-20 crop year, the country's food grain output (comprising wheat, rice, pulses and coarse cereals) stood at a record 297.5 million tonnes (MT). Releasing the second advance estimates for 2020-21 crop year, the agriculture ministry said food grain production is projected at a record 303.34 MT. As per the data, rice production is pegged at record 120.32 MT as against 118.87 MT in the previous year. Wheat production is estimated to rise to a record 109.24 MT in 2020-21 from 107.86 MT in the previous year, while output of coarse cereals is likely to increase to 49.36 MT from 47.75 MT. Pulses output is seen at 24.42 MT, up from 23.03 MT in 2019-20 crop year. In the non-food grain category, the production of oilseeds is estimated at 37.31 MT in 2020-21 as against 33.22 MT in the previous year. Sugarcane production is pegged at 397.66 MT from 370.50 MT in the previous year, while cotton output is expected to be higher at 36.54 million bales (170 kg each) from 36.07. This production figure seem to be sufficient for current population, but we need to improve more and more with vertical farming and advance agronomic and crop improvement tools for future burgeoning population figure under the milieu of climate

change issue. Our rural mass and tribal people have very limited resources and they sometime complete depend on forest microhabitat. To order to ensure food and nutritional security for growing population, a new strategy needs to be initiated for growing of crops in changing climatic condition. The country has a large pool of underutilized or underexploited fruit or cereals crops which have enormous potential for contributing to food security, nutrition, health, ecosystem sustainability under the changing climatic conditions, since they require little input, as they have inherent capabilities to withstand biotic and abiotic stress. Apart from the impacts on agronomic conditions of crop productions, climate change also affects the economy, food systems and wellbeing of the consumers (Abbade, 2017). Crop-nutritional quality become very challenging, as we noticed that, zinc and iron deficiency is a serious global health problem in humans depending on cereal-diet and is largely prevalent in low-income countries like Sub-Saharan Africa, and South and South-east Asia. We report inefficiency of modern-bred cultivars of rice and wheat to sequester those essential nutrients in grains as the reason for such deficiency and prevalence (Debnath *et al.*, 2021). Keeping in mind the crop yield and nutritional quality become very daunting task to our food security issue and this can overcome with the proper and time bound research in cognizance with the environment.

Threat and challenges

In recent years, climate change has become a debatable issue worldwide. South Asia will be one of the most adversely affected regions in terms of impacts of climate change on agricultural yield, economic activity and trading policies. Addressing climate change is central for global future food security and poverty alleviation. The approach would need to implement strategies linked with developmental plans to enhance its adaptive capacity in terms of climate resilience and mitigation. Over time, there has been a visible shift in the global climate change initiative towards adaptation. Adaptation can complement mitigation as a cost-effective strategy to reduce climate change risks. The impact of climate change is projected to have different effects across societies and countries. Mitigation and adaptation actions can, if appropriately designed, advance sustainable development and equity both within and across countries and between generations. One approach to balancing the attention on adaptation and mitigation strategies is to compare the costs and benefits of both the strategies. The most imminent change is the increase in the atmospheric temperatures due to increase levels of GHGs (Green House Gases) i.e. carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and chlorofluorocarbons (CFCs) etc into the atmosphere. The global mean annual temperatures at the end of the 20th century were almost 0.7 degree centigrade above than those recorded at the end of the 19th century and likely to increase further by 1.8- 6.4°C by 2100 AD. The quantity of rainfall and its distribution will be affected to a great extent resulting in more flooding. The changes in soil properties such as loss of organic matter, leaching of soil nutrients, salinization and erosion are a likely outcome of climate change in many cases. Water crisis can be a serious problem with the anticipated global warming and

climate change. With increasing exploitation of natural resources and environmental pollution, the atmospheric temperature is expected to rise by 3-5 °C in next 75-100 years (www.ipcc.ch/sr15/chapter/chapter-1). If it happens most of the rivers originating from the Himalayas may dry up and cause severe shortage of water for irrigation, suppressing agriculture production by 40-50%.

There has been considerable concern in recent years about climatic changes caused by human activities and their effects on agriculture. Surface climate is always changing, but at the beginning of industrial revolution these changes have been more noticeable due to interference of human beings activity. Studies of climate change impacts on agriculture initially focused on increasing temperature. Many researchers, including reported that changes in temperature, radiation and precipitation need to be studied in order to evaluate the impact of climate change. Temperature changes can affect crop productivity. Higher temperatures may increase plant carboxylation and stimulate higher photosynthesis, respiration, and transpiration rates. Meanwhile, flowering may also be partially triggered by higher temperatures, while low temperatures may reduce energy use and increased sugar storage. Changes in temperature can also affect air vapor pressure deficits, thus impacting the water use in agricultural landscapes. This coupling affects transpiration and can cause significant shifts in temperature and water loss (Mukherjee, 2017). In chickpea and other pulse crop this increase in temperature due to climate change affects to a greater extent flower numbers, pod production, pollen viability, and pistilfunction are reduced and flower and pod abortion increased under terminal heat stress which ultimately leads to hamper its productivity on large scale. There is probability of 10-40% loss in crop production in India with the expected temperature increase by 2080-2100. Rice yields in northern India during last three decades are showing a decreasing trend (Aggarwal *et al.*, 2000). Further, the IPCC (2007) report also projected that cereal yields in seasonally dry and tropical regions like India are likely to decrease for even small local temperature increases. Wheat production will be reduced by 4-5 million tonnes with the rise of every 1°C temperature throughout the growing period that coincides in India with 2020-30. However, grain yield of rice declined by 10% for each 1°C increase in growing season. A 1°C increase in temperature may reduce rapeseed mustard yield by 3-7%. Thus a productivity of 2050-2562 kg/ha for rapeseed mustard would have to be achieved by 2030 under the changing scenario of climate, decreasing and degrading land and water resources, costly inputs, government priority of food crops and other policy imperatives from the present level of nearly 1200 kg/ha.

Diseases and pest infestation

In future, plant protection will assume even more significance given the daunting task before us to feed the growing population under the era of shifting climate pattern, as it directly influence pest life cycle in crop calendar (Mukherjee, 2019). Every year, about USD 8.5 billion worth of crops are lost in India because of disease and insects pests and another 2.5 billion worth of food grains in storages. In the scenario of climate change, experts

believe that these losses could rise as high as four folds. Global warming and climate change would lead to emergence of more aggressive pests and diseases which can cause epidemics resulting in heavy losses (Mesterhazy *et al.*, 2020). The range of many insects will change or expand and new combinations of diseases and pests may emerge. The well-known interaction between host × pathogen × environment for plant disease epidemic development and weather based disease management strategies have been routinely exploited by plant pathologists. However, the impact of inter annual climatic variation resulting in the abundance of pathogen populations and realistic assessment of climatic change impacts on host-pathogen interactions are still scarce and there are only handful of studies. Further emerging of new disease with climate alteration in grain crop such as wheat blast, become challenging for growers and hamper food chain availability (Mukherjee *et al.*, 2019). Temperature increase associated with climatic changes could result in following changes in plant diseases:

- ✓ Extension of geographical range of pathogens
- ✓ Changes in population growth rates of pathogens
- ✓ Changes in relative abundance and effectiveness of bio control agents
- ✓ Changes in pathogen × host × environment interactions
- ✓ Loss of resistance in cultivars containing temperature-sensitive genes
- ✓ Emergence of new diseases/and pathogen forms
- ✓ Increased risk of invasion by migrant diseases
- ✓ Reduced efficacy of integrated disease management practices

These changes will have major implications for food and nutritional security, particularly in the developing countries of the dry-tropics, where the need to increase and sustain food production is most urgent. The current knowledge on the main potential effects of climate change on plant patho systems has been recently summarized by Pautasso *et al.* (2012). Their overview suggests that maintaining plant health across diversified environments is a key requirement for climate change mitigation as well as the conservation of biodiversity and provisions of ecosystem services under global change.

Changing in weed flora pattern under different cropping system become very challenging to the food growers, and threat to our food security issue. It has been estimated that the potential losses due to weeds in different field crops would be around 180 million tonnes valued Rs 1,05,000 crores annually. In addition to the direct effect on crop yield, weeds result in considerable reduction in the efficiency of inputs used and food quality. Increasing atmospheric CO₂ and temperature have the potential to directly affect weed physiology and crop-weed interactions vis-à-vis their response to weed control methods. Many of the world's

major weeds are C4 plants and major crops are C3 plants (Mandal and Mukherjee, 2018). The differential effects of CO₂ on C3 and C4 plants may have implications on crop-weed interactions. Weed species have a greater genetic diversity than most crops and therefore, under the changing scenario of resources (eg., light, moisture, nutrients, CO₂), weeds will have the greater capacity for growth and reproductive response than most crops. Differential response to seed emergence with temperature could also influence species establishment and subsequent weed-crop competition. Increasing temperature might allow some sleeper weeds to become invasive (Mukherjee, 2020; Science Daily, 2009). Studies suggest that proper weed management techniques if adopted can result in an additional production of 103 million tonnes of food grains, 15 million tonnes of pulses, 10 million tonnes of oilseeds, and 52 million tonnes of commercial crops per annum, which in few cases are even equivalent to the existing annual production (Rao and Chauhan, 2015). There is tremendous scope to increase agricultural productivity by adopting improved weed management technologies that have been developed in the country.

Conclusion

The greatest challenge before us is to enhance the production of required amount of food items viz., cereals, pulses, oilseeds, vegetable, underutilized fruit etc to keep pace with population growth through employing suitable crop cultivars, biotechnological approaches, conserving natural resources and protecting crops from weeds, insects pests and diseases eco-friendly with climate change. Research is a continuous process that has to be pursued vigorously and incessantly in the critical areas viz., evolution of new genotype, land development and reclamation, soil and moisture conservation, soil health care, seeds and planting material, enhancing fertilizer and water use efficiencies, conservation agriculture, eco-friendly plant protection measures etc. Due to complexity of crop environment interaction under different climate situation, a multidisciplinary approach to the problem is required in which plant breeders, agronomists, crop physiologists and agrometeorologists need to interact for finding long term solutions in sustaining crop production.

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