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Climate Smart Agriculture – A Holistic Solution to Combat Climate Change

Frank Notes

Satish Chander

India faces a daunting task of meeting future food demand and providing nutrition security to 19% of the global population and providing feed and fodder to 11% of the world's livestock population on 2.3% of the land and only 4% of the world's fresh water resources. To feed 1.38 billion mouths, India produced 308.7 million tonnes (Mt) of foodgrains and 329.7 Mt of horticulture produce in 2020-21. Estimated requirements for 2050 are 405 Mt food grains, 39 Mt oilseeds, 645.8 Mt horticulture produce for 1.69 billion people. Abysmally low water and nutrient use efficiencies, declining nutrient response ratios and factor productivity, loss of biodiversity, deterioration of soil health pose newer challenges in meeting the production targets. Climate change or global warming adds more complications to meet the targets.

Climate change or global warming is the rise in atmospheric temperatures caused by the anthropogenic emissions of greenhouse gases viz., carbon dioxide, nitrous oxide and methane. As per 6th Assessment Report of the IPCC Working Group I released recently, the world will probably reach or exceed 1.5 °C of warming within just the next two decades. Report further warns that if no additional efforts are made to reduce the greenhouse gas (GHG) emissions and growth of these emissions synchronizes with increase in the global population and economic activities, then the global mean surface temperature will rise by 5.7 °C in 2100 compared to pre-industrial levels.

Climate change has multiple effects on different ecosystems. Apple belt moving to higher altitudes in Himachal Pradesh and accelerated shrinking of the Himalayan glaciers are the glaring examples of impact of climate change in India. Changes in climate variables such as precipitation, temperatures, windiness and solar radiation are responsible for increases in heat extremes, extended heat waves, and intense precipitation. While monsoon rainfall over the country may increase by 10-15%, the winter rainfall is expected to decrease by 5-25%, and seasonal variability would be further compounded. Western Rajasthan, southern Gujarat, Madhya Pradesh, Maharashtra, northern Karnataka, northern Andhra Pradesh, and southern Bihar are likely to be more vulnerable to the extreme events.

Climate change induced droughts and heavy precipitation have a potential to inflict the crop damage, leading to significant yield reductions in different parts of the country. For instance, cereal productivity is projected to decrease by 3-18% by 2040, and 10-40% by 2100 due to increased temperature, increasing water stress and reduction in number of rainy days. For every 1 °C rise in temperature, yields of wheat, soybean, mustard, groundnut and potato are expected to decline by 3-7%. Rice yields may decline by 6% for every 1 °C increase in temperature.

Water requirement of crops is also likely to go up with projected warming. Reports indicate that farming now consumes up to 30% more water due to "high evaporative demand and crop duration due to forced maturity" in states such as Andhra Pradesh, Punjab and Rajasthan. Although in some regions temperature and precipitation changes will offer some production benefits, in general a changing climate will result in overall lower agriculture yields. Besides rising temperatures directly impacting the crop yields, global warming will also witness steady rise in sea levels, increased cyclonic activity, and changes in ambient temperature and precipitation patterns in the Indian subcontinent. Sea level rise over the 21st century, predicted to be 30-120 cm, could cause large-scale inundation of freshwater wetlands along the coastline.

Resource-poor farmers of rainfed agriculture cultivating 52% of the country's net cultivated area and contributing about 40% of national food basket, and supporting more than 60% of livestock population are vulnerable to the vagaries of climate change/variability, yield gaps, low water productivity, and deteriorated soil health. Ironically, the mineral fertilizer application alone can neither sustain the crop productivity nor soil health in the rainfed ecologies critically low in soil organic carbon. Several location-specific climate resilient technologies *viz.* integrated nutrient management (INM) practices involving locally available organic sources; balanced nutrition including use of micronutrients; site-specific nutrient management practices, and foliar spray of potassium for drought mitigation have been developed at Central Research Institute for Dryland Agriculture.

Food and Agriculture Organization of (FAO) the United Nations defined Climate Smart Agriculture as 'an integrated approach for developing technical,

The latest technologies on climate smart agriculture should be taken to farmers to combat climate change.

policy and investment conditions to achieve sustainable agricultural development for food security under climate change'. Its aim is to improve the food security, help communities to adapt to climate change, and contribute to climate change mitigation by adopting appropriate practices, developing policies and mobilizing needed finances. To address the issue, Indian Council of Agricultural Research (ICAR) launched the network project National Innovations in Climate Resilient Agriculture (NICRA) in February, 2011 with headquarters at the CRIDA, Hyderabad to develop the water smart, weather smart, nutrient smart, energy smart, carbon smart, and also knowledge smart agriculture.

Country's National Agricultural Research System (NARS) with NICRA as focal network has collated and developed region-specific climate smart adaptive and mitigation technologies. In the crop sector, identification and development of high yielding and nutritionally-rich crops/crop varieties capable of withstanding biotic and abiotic stresses constituted the key intervention. To make the public aware of the twin challenge of climate change and malnutrition, Honorable Prime Minister released 35 varieties of different agricultural and horticultural crops on 28th September, 2021.

Producing more crop per drop of water through micro-irrigation including drip-fertigation has a potential of effecting a saving of 50-60% on water, 20-40% on fertilizer N, and reducing the environmental footprint. Progressive shift to the aerobic rice cultivation and adopting system of rice intensification (SRI) technology are critical in reducing methane (CH_4) and nitrous oxide (N_2O) emissions, and decreasing nitrate leakage to the ground water.

Use of nutrient efficient varieties, soil health card-guided soil test-based fertilizer application, enhanced efficient N fertilizers, real time N application, site specific nutrient management, integrated nutrient management provide climate smart solutions for enhancing the N use efficiency, increasing farmers' income, improving soil health and environmental sustainability. Simple technological interventions like mandatory *neem* oil coating of urea and nano urea (liquid) for top dressing of N hold the key to sustainable N development. With focus on doubling farmers' income, integrated farming systems (IFS) approach as a sustainable solution to reduce the market input cost and also provide higher yields and assured income has been researched by the ICAR-IIFSR, Modipuram.

Information and communication technologies (ICTs) for short-term weather forecast and advisories at block level; use of mobile agro met advisory system (mAAS), rural mobile phone based (Rnet) social networking, awareness programmes; installation of rain gauge at village level and rainfall visualizer at local level could greatly help in addressing climatic extremes and develop contingency plans. Digital agriculture making use of big data, internet of things, robotics, sensors, and artificial intelligence holds the hope of sustaining future climate-stressed farm production systems, value chains and food systems.

Live to the impact of climate variability and climate change on agriculture, Government of India initiated series of policy initiatives and programmes. Ministry of Agriculture and Farmers Welfare started the ICAR's flagship NICRA project to undertake systematic long-term research on the impacts and adaptation of Indian agriculture to climate change. Several *in-situ* and *ex-situ* water conservation technologies are being upscaled through the Integrated Watershed Management Programme (IWMP) and Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) in rainfed areas. Major programmes such as National Food Security Mission (NFSM), Mission for Integrated Development of Horticulture (MIDH), National Mission on Sustainable Agriculture (NMSA), National Mission on Oilseed and Oil Palm (NMOOP), Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), Rashtriya Krishi Vikas Yojana (RKVY) and Paramparagat Krishi Vikas Yojana (PKVY) emphasize on implementation of climate-resilient technologies in farmers' fields.

Basket of region/location specific technologies have been standardized and upscaled for making Indian agriculture climate smart. Final success, however, depends on how climate smart are the farmers engaged in it. In addition to giving the latest updates on the emerging climate smart agro-technologies, these farmers have to be made ITC-literate. This is possible with the involvement of all the stakeholders, including private and public institutions.

This special issue of Indian Journal of Fertilisers is being brought out to commemorate the 5th International Agronomy Congress on Àgri-Innovations to Combat Food and Nutrition Challenges' to be organized at Hyderabad during November 23-27, 2021. It consists of 8 papers covering various aspects of theme of the Congress. We hope that all those concerned with Indian agriculture including scientists, policymakers, input suppliers, extension personnel and farmers will find the content of the special issue relevant and useful.■