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Innovations in Agriculture

There has been considerable increase in production of food grains from 72.3 million MT during 1965-66 to 329.7 million MT during 2022-23 in spite of net cropped area remaining about 141 million hectares. Production of other crops also witnessed spectacular increase during the period. This has become possible due to intensification of agriculture driven by Green Revolution in mid 1960s through adoption of fertilizer responsive high yielding varieties (HYVs) of wheat and rice and later on of other crops. Use of fertilizers to meet the demand of HYVs, better irrigation facilities, adoption of better farm practices by the farmers, backed by favourable policy environment transformed India from ship to mouth to the food surplus country within 5 decades. Improving or maintaining such a growth in future would be a challenging task as the intensive agriculture which primarily relied on increased use of inputs and exploitation of natural resources has started showing signs of fatigue. Limiting land and water resources; plateauing crop yields; emerging environmental concerns in the form of climate change; and shrinking biodiversity, etc. are posing serious threats to agricultural sustainability and food security.

Indian agriculture faces various natural and manmade challenges including small and fragmented land holdings; lack of proper marketing and storage infrastructure; low input use efficiencies and poor adoption of improved farm technology. Declining crop response, loss of biodiversity, and deterioration of soil health exacerbated by the impending climate change pose newer challenges in enhancing production on a sustainable basis. To stay relevant, farmers have to make smart choices to cope up with challenges of climate change, soil erosion and biodiversity loss; satisfy consumers' changing tastes and expectations; and rising demand for more food of higher quality. Farming profession has to transform itself from being a 'subsistence livelihood activity' to 'profitable business enterprise'.

It is beyond doubt that future growth in Indian agriculture will come from improvement in crop productivity as there is practically no scope of bringing more area under cultivation. Precision agriculture principles, which have gained impetus in India during the last 15 years or so, will have to progressively expand to replace currently practiced intensive agriculture. The adoption of mobile devices, access to high-speed internet, GPS, low cost and reliable satellite communications and advanced farm equipment including drones will help to move towards precision agriculture. E-extension services can provide decision-support services on mobile apps or other digital platforms. Using information from a variety of sources – weather data, GIS special mapping, soil sensor data, satellite/drone pictures, etc. e-extension platforms can provide real-time recommendations to the farmers. Many companies have developed agriculture apps that provide valuable guidance on best management practices like land preparation, crop sowing, crop planning, fertilizer application, seed treatment, pest and disease management, weed management, and irrigation scheduling. Industry has taken the lead to make available nano urea and nano DAP for use by the farmers. Such innovations, among others, are driving transformation in agriculture, offering solutions to feed the growing population sustainably while addressing the challenges posed by climate change, resource constraints, and socio-economic inequalities.

Application of digital technologies, besides streamlining farm production, can make agricultural markets more efficient. Mobile phones, online ICTs, e-commerce platforms, and digital payment systems can reduce transaction costs throughout the value chain. Governments have taken measures for digitization of land records which help in transferring benefits to farmers, and customizing agri-services such as inputs, technologies and marketing. The use of artificial intelligence and block chain is being promoted in farming. A wealth of digital information is available from Government Schemes/ Missions such as Crop Insurance, Soil Health Card, and Kisan Credit Card on the status of farmers and their crops. e-National Agriculture Market (e-NAM) Scheme, a pan India electronic trading of the Government, connects the Mandis for agro-commodities. Gramin Bhandaran Yojana provides funding for construction of scientific storage of grains. Government also floated a

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scheme incentivizing states to adopt alternative fertilizers. Kisan Drones programme, will drive digital transformation of Indian agriculture towards economizing labour-intensive farm operations such as spraying, monitoring and delivery.

Opening up critical datasets is the most important factor for unlocking the digital agriculture economy. The start-ups offer agri-tech innovations in partnership with industries and financial institutions, but lack scaling up due to the high cost of serving the small and marginal holding farmers. Government should engage itself in the private-public R&D partnerships to deliver digital and high-tech services to farmers, which would enable them to cut costs, find new markets, and gain competitiveness in the global markets. Infrastructure such as seamless internet connectivity, automatic weather stations, digital literacy among field workers, data sharing protocols in both public and private domains, etc. need to be given more momentum to encourage the adoption of digital technologies in agriculture

Protected cultivation is a promising area for higher productivity, better produce and improved market realization. It also protects crops from vagaries of weather due to climatic change. There are number of parameters to be considered for expansion of protected agriculture. Selection of site and choice of type of structure, are important and depends on agro-climatic condition, crop type, availability and affordability of resources. Drip irrigation is mandatory for poly-house crop cultivation along with fertigation technique. Drip technology enhances water and crop productivity and minimizes incidences of diseases, pests and weeds, arrests moisture fluctuations, optimizes the irrigation frequency. This technology becomes more relevant and useful for the small and marginal farmers to realize better returns even during off-season. Some of the state governments, giving subsidy to promote greenhouse technology, can be utilized by the farmers for more productive uses and realizing better net returns.

The growing requirement of high quality crops, environmental concerns and thrust on improved nutrient use efficiency have driven the growth of specialty/innovative fertilizer products. Such fertilizers lead to additional benefits to growers by way of improving nutrient availability to crops. Among such products, 100% water soluble fertilizers have been witnessing good growth. Application of 100% water soluble fertilizers with drip irrigation has great potential in agriculture, particularly for horticultural crops.

The Farmer Producer Organizations will be helpful to maximize farmers' income. Towards this, they provide services and activities which help cater to such needs and supply of quality production inputs like seeds, fertilizers, pesticides, etc. at affordable prices.

Farmers need to be incentivized to replace rice and wheat with crops such as millets, oilseeds, fruits and vegetables and adopt integrated farming along with dairy, poultry and fisheries. State-specific and season-specific crop replacements could lead to annual water-saving which could be diverted to critical and supplementary irrigation for millions of small and marginal farmers. This will also benefit the population to increase nutritional security with increased consumption of nutri-cereals and pulses. Sustainable agriculture practices through implementing agro-ecological approaches like conservation agriculture, crop rotation, and integrated nutrient & pest management are necessary to promote soil health, bio-diversity, and long-term productivity while minimizing environmental impacts.

Live to the impact of climate change on agriculture, Government initiated series of policy initiatives and programmes. ICAR's flagship NICRA project was started to undertake systematic long-term research on impacts and adaptation of Indian agriculture to climate change. Several *in-situ* and *ex-situ* water conservation technologies are being up-scaled through Integrated Watershed Management programme and Mahatma Gandhi National Rural Employment Guarantee Scheme in rainfed areas. Scientific and technological innovations are essential for maintaining food and nutritional security on sustainable basis.

The special issue of Indian Journal of Fertilisers has been brought out with due focus on various aspects of Innovations in Agriculture. This issue contains 9 papers focusing on the theme. We hope that the readers will find the contents of the issue relevant and useful. ■