



Innovation in Science-led Indian Agriculture

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INTRODUCTION

Science technology and innovation are the pillars of nation present-day agriculture is fundamentally based on all these three platforms. The search for new plants for human use and traditional technologies and knowledge has played an important role in evolution of agriculture since its origin about 10,000 years ago. Several agricultural technologies and innovations have been developed and Used by the farmers themselves to make agriculture more convenient and productive. Therefore innovations and technological interventions are inevitable for consistent development of agriculture sector and for farmer's well-being.

Agriculture plays a major role in building the nation's economy as approximately 58% of the workforce still is dependent on this and it is an important component al the nation GDP and export. It is today realised that The nation's economy is driven by rural demand and higher output agriculture boosts the paying capacity and overall economy. Agriculture in India is a source of livelihood of almost two-thirds of the working population. Apart from nation building, agriculture provides us food and nutritional security which is the backbone of any sovereign nation.

The development index of countries has a direct link between technological innovations and national economic prosperity. Most developed nations of the world are the most advanced in technological innovations. The importance of innovation has been rightly elaborated by the former President of India Dr. A.P.J. Abdul Kalam. He said, "Innovation opens up new vistas of knowledge and new dimensions to our imagination to make everyday life more meaningful and richer in depth and content." It is therefore imperative to comprehend the need for innovation in every field of human life. Similarly, greater emphasis by our present prime Minister on agricultural innovation and use of technology to increase farmers and make agriculture more attractive for the young generation are step that would pay rich dividends in the near future.

The role of science and technology in managing soil quality, efficient water use, crop management. Sharing information with farmer's post-harvest technology and developing value chain is highly important. Several technological innovations in these areas by the premier organization, the Indian Council of Agricultural Research (ICAR), has resulted in manifold increase in production of almost all the agricultural commodities, be it cereals, pulses, oilseeds, vegetables fruits, milk, meat, poultry, fishery, etc.

Innovations in Agriculture

India primarily being a country based on agrarian economy, has seen significant contribution of innovations during the evolution of present day agriculture. Cleaning the fields from weeds, making small implements made up of stone and iron, developing water channels for irrigation, selection of healthy plants for seeds, harvesting and storing grains in earthen pots for safety and increased longevity were small but significant innovations during the evolution of agriculture by farming communities themselves. Therefore, the farmer is considered as the first scientist, innovator and custodian of agriculture.

In the real sense, the use of innovative technology was initiated in agriculture with the invention of the "plough" probably 6000 years ago and later irrigation devices led to the great relief of farmers from direct physical effort to dependence on other forms of energy, initially animal power, and presently fossil fuel and electricity. Recent innovations in solar energy are going to make path breaking changes in use of non-conventional or green energy in the agriculture sector. Use of solar pumps and establishment of agri-voltaic systems would be benefiting the farmers in many ways. Farmers' varieties, technologies and innovations have been documented by various organizations, but once in the public domain, these are extensively used by wider farming communities across the world. Progress in agriculture happened in the early phase of

Industrial Revolution which witnessed new agricultural practices like mechanization, crop rotations and selective breeding by the farmers themselves. The science-driven innovations of 19th and 20th centuries led to the mechanization of cultivation, i.e. the use of tractors and several other mechanical and electrical devices and implements giving Agriculture totally new dimensions.

When we see the global agriculture scenario, several innovations and inventions impacted modern agriculture. Some of these developments that brought enormous improvements and gains in agricultural production are invention of chemical fertilizers in 1918 combined with the Green Revolution using the science of plant breeding to develop dwarf wheat varieties in Mexico. These two innovations have changed the way of doing agriculture. Contribution of the famous agricultural scientist Dr. Norman Borlaug and the chief architect of the Indian "Green Revolution", Dr. M.S. Swaminathan, who were awarded the Nobel Peace Prize and World Food Prize, respectively, are unforgettable in this mission. Not only did these innovations give us food security but they also provided confidence in the scientific community which further led to the White (milk and dairy) and Blue (fish) revolutions in Indian agriculture. Development and dissemination of several new technologies and efforts of farmers led to multifold increase in the overall production of agriculture commodities. India has successfully attained increase in the production of food grains by 5.4-fold, oilseeds by 6.2 times, milk by 9.6-fold and fish by 14.4-fold since 1950-51.

Similarly, rice production by 3.6 times, wheat 4.3 times, maize 4.7 times, pearl millet 4.4 times, pulses 2.7 times, cotton 10.9 times, sugarcane 5.36 times, jute 2.4 times, eggs 47.6 times and meat (over 1998-99) 3.88 times since 1950-51 are the glaring examples of technology-led agricultural development in the country.

India has also emerged as the second largest producer of fruits and vegetables in the world and their production has touched a record 300 million tonnes during 2016-17, which is about three-times over the 1991-92 production. In recent years, remarkable increase in pulses production to 23 mt and increasing production trend in oilseed crops are because of technological advancements vis-a-vis farmers' adoption of new technologies.

Agricultural Technologies and Development

Scientific plant breeding started in 1920s taking lessons from Gregor Johann Mendel's 1866 paper that paved the way for new varieties in food crops. Since then, significant developments and innovations in science-led agriculture have led to cross-breeding, mutation breeding, molecular breeding, transgenics, speed breeding and now gene editing, all having immense potential in significantly enhancing the yield and quality of crops.

Innovations in molecular tools for transgenic through genetic manipulations, and more recently use of CRISPER-cas9 for editing specific genes is guiding the development of designer plants suitable for different agro-ecological regions. The Indian National Agricultural Research System has developed 635 high yielding climate resilient crop varieties/hybrids of field crops in the last two-three years and released for cultivation in different agro-ecologies of the country. This also includes 17 bio fortified varieties in rice, wheat, maize, pearl millet, Indian mustard, lentil, cauliflower, sweet potato and pomegranate that are rich either in iron or zinc or protein or vitamins or anthocyanin to address the issues of malnutrition. While HD 2967, a flagship wheat variety, has occupied more than 30% of wheat growing area in the country, basmati rice variety, Pusa Basmati 1121, developed by Indian Agricultural Research Institute, New Delhi has become the landmark in the foreign market earning more than Rs. 15,000 Crores, annually. In the animal sector, four new breeds of pig and three

new productive varieties of poultry, nine vaccines for livestock and poultry and 32 diagnostic kits were developed.

The farm technologies developed by agricultural sciences are demonstrated to farmers through Krishi Vigyan Kendras (KVKs), ICAR research institutes and state extension departments. With a view to provide resilient and profitable models to small holder farmers, ICAR has developed 45 Integrated Farming Systems (IFS) models and 42 Organic Farming Technologies covering 15 agro-climatic regions of the country.

Information Technology - A Game Changer

Information technology has been directly linked to the nation's development. Its potential is viewed in many places as a way to stimulate economic development, social connections, and civic engagement. A study by the Boston Consulting Group on "The Rising Connected Consumer in Rural India" reveals that the share of rural India in smart phone mobile users would jump to 48% by 2020. The Digital India initiative of the Prime Minister is playing an important role in the promotion of digital literacy and digital infrastructure in rural India.

To support the transmission and extension of farm based services, technologies, and to make farming more socially, economically and environmentally sustainable, the use of Information and Communication Technology (ICT) is pivotal. The development of various mobile apps and other tools to facilitate and benefit farmers instantly and quickly from government schemes, agriculture-based information and technologies are the important steps towards "Digital Agriculture". Today our farmers are taking advantage of this technology through various mobile applications and Web Portals.

Krishi Vigyan Kendras, the major agriculture extension network in India, has strengthened its "Knowledge Network" using this technology. "Kisan Call Centers" and Mobile apps like Livestock Disease Forewarning-Mobile App (LDF-mobile app)

and Kisan Suvidha are comprehensive and multilingual mobile apps launched by PM Shri Narendra Modi in 2016 that provide information on current weather, next five days forecast, market prices, etc. IFFCO Kisan Agriculture app launched in 2015 by IFFCO is also an important app providing diverse useful information to farmers; PUSA KRISHI-Technology Mobile App launched in 2016 aims at information and technologies developed by the Indian Agriculture Research Institute (IARI). Similarly, other important apps facilitating the farmers in services and technology dissemination are RML Farmer-Krishi Mitra, Agri App, Kheti-badi, Krishi Gyan, Crop Insurance, Farm-o-pedia, Pashu Poshan, application for Poultry and Agri-Market.

Besides, several mobile apps for providing specific information to farmers include Mobile app "riceXpert, E-Kapas Network and Technology Documentation, PulsExpert for pests and diseases, e-Pest Surveillance and Advisory, System for Horticulture Crops, Online Pest Monitoring and Advisory Services, Pest Forewarning application and KRISHI-Digital data portal.

All these mobile applications developed for farmers are helping them in technology application and enhancing income through higher production. There are several other information technological tools developed by the State Agriculture Universities and State Agriculture Departments in regional languages to help the farming communities. In addition, agri-startups are providing agri-businesses technology and expertise to create smarter and safer food supply for consumers around the world. These startups are also helping farmers in adopting global agricultural practices and improving farm productivity. This calls for a professional and business-oriented public-private partnership.

Futuristic Agriculture

As part of technology fore-sighting, innovations like use of drones in agriculture,

precise gene editing in plants, epi-genetics, wireless sensor networks, precision technologies machines, smart wind and solar power, AI (Artificial Intelligence) based application of robotics, mega-scale desalination technology etc. would definitely change the future of agriculture in the world. Some of these technological innovations are already in use in developed nations and our present leadership in India is keen to bring and/ or develop such technological land marks for our farming communities.

Nonetheless, India needs to explore deeper into the history behind all pioneering inventions. Here funding agricultural research and development in India as compared to other countries becomes important. Overall, the US allocates close to 2.7% of its GDP for research and development, while India allocates only 0.85%. Even when we compare within BRICS countries where India is a member, India's expenditure on Research and Development has been the least. This clearly points towards the urgent need for increasing our funding for basic and fundamental research to achieve the desired and futuristic goals of sustainability. This would help us in realizing the "Ever Green Revolution" in India, while also achieving the short-term target of "Doubling Farmers' Income by 2022".

Given these circumstances, Indian agriculture faces many challenges. On one side we need to ensure food and nutritional security for more than 1.25 billion people of this country on a sustainable basis. On the other side, we have to effectively manage the enormous pressure on our natural resources, large scale urbanization, land fragmentation, changing food habits and distraction of youth from agriculture. However, the Government of India is enabling policy frameworks to ensure that India remains self-sufficient and sustainable in the farm sector while also raising the happiness index of the farmers. Fusion of agriculture, digital and engineering technologies with modern biotechnological

tools are welcome efforts to revolutionize Indian agriculture in the coming years.

As the human population in India would touch 1.6 billion by 2050, ensuring food and nutritional security for such a large population would be the greatest challenge of the millennium. In this regard, innovation-driven technological development would be the only way out to transform Indian farms to

Smart Farms and the Indian Farmers to Smart Farmers. The importance of agriculture to the country is best summed up by this statement: "If agriculture survives, India survives", therefore, we need to regularly innovate, invest and invoke our agrarian economy, the backbone of social development in the country.