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Subject II

Applications of Frontier Technologies for Agricultural Development

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The pace and structure of future agriculture would be driven by the knowledge intensive technological approaches such as biotechnology, geo-system and IT applications, nanotechnology, etc. The role of frontier technologies in agriculture has to be evaluated in the context of increasing demand for food in particular for quality foods, declining quality of land and water resources and challenges posed by the impacts of emerging climate change as well as globalisation-induced impacts. There is also a paradigm shift in the generation and dissemination of agricultural technologies compared to the late 1960s and 1970s when the research outputs from the public sector institutions have fuelled the productivity growth in agriculture. In recent years there is an increasing trend towards commercialisation of private funded agricultural research output aided by the emerging intellectual property regime. All these developments have raised several socio-economic issues which necessitate scientific research to generate knowledge and facilitate informed decision-making in the larger interests of future agriculture.

The papers contributed under this theme fall under the broad categories; biotechnology, geographic information system (GIS) & remote sensing, ICT in agriculture and protected agriculture. This session broadly addressed the following issues: impact of Bt cotton on costs and profitability of cotton cultivation and adoption of Bt cotton in different States was the important issue discussed by number of papers. Another important area of research was on Government intervention in Bt seed pricing and its impact on profitability of farmers and also on the incentive to innovate by the seed companies and investments in R&D for the development of frontier technologies. The other issues discussed with reference to Bt cotton include distributional impacts, environmental consequences, scale neutrality of technology and gender issues with reference to Bt technology. The impact of technological and institutional changes on the adoption rate of specific crops like pearl millet and chickpea was another important area of study.

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Salient Findings/Discussions

During past decade, the growth in cotton production and yield was estimated to be 14 and 11 per cent per year respectively. The results indicate that the farmers benefitted from adopting Bt-technology through higher profitability, mainly due to reduced pest control costs, although with significant variation. The comparison with non-BT cotton showed advantage of Bt cotton on pest incidence, pesticide cost, cotton quality, yield and profit. Bt-technology in cotton helped in realising gains primarily on account of reduction in pesticide costs across all categories of farmers and proved to be scale neutral. But some studies reported that pesticide spraying could not be eliminated even after adoption of Bt-cotton in the selected states. Similarly, the farmers find no difference in terms of seed rate, fertiliser application and irrigation between Bt and non-cotton and some of the non-Bt hybrids performed exceptionally better than Bt-cotton. The decomposition of the source of the higher yield in Bt cotton has estimated that 17 per cent increase due to technology and 15 per cent due to higher input use. However serious concerns were expressed over methodology being adopted for these impact studies. Government regulations in terms of price control of seed price came into force in 2006 limiting the 450 gm packet of Bt cotton seed price to not exceed Rs. 850. Economic surplus estimated showed that with supply elasticity, producer surplus declined while consumer surplus increased considerably. Furthermore, the environmental impact quotient was significantly lower for Bt cotton on account of reduced pesticide consumption, which is however a short term observation with one year data. Although it assumed that seed price controls might reduce the incentive to innovate by the company, it is reported that R&D investments have substantially increased and the profits to the private companies also increased due to economies of scale in view of rapid expansion of cotton area under Bt hybrids over the period.

The adoption on hybrid pearl millets across different states concluded that public-private partnerships in the areas of developing hybrids, production and delivery of improved seed, and outreach activities increased the seed replacement rate phenomenally. The hybrids helped in improving the productivity of the pearl millets up to 10.79 q/ha. Another study on the impact of technological intervention in chickpea production in South India reported institutional and technological factors and adoption of short duration and HYV coupled with large scale mechanisation enabled expansion of chickpea area into south Indian states.

The results of progeny improvement and balanced nutrition of dairy programme in Himachal Pradesh showed that there has been a steady increase in number and proportion of crossbred cows while indigenous cows and buffaloes decreased. The emerging constraints for dairy are declining land holding, rising labour wages, weed infestation in pasture.

Use of ICT in agricultural development was another important area of research. A study on the impact of Short message service (SMS) through mobile phones on crop

advisory and market information showed that access to information made the farmers more capable in managing fertiliser dosage and disease management. The study suggests these barriers need to be surmounted by a proactive approach in solving technological glitches. Another study on the impact of ICT use on empowerment generated a variable decision to represent average participation of women farmer in decision making. ICTs has been helping farm women in selling farm produce at current market rate and also in adopting improved technologies for cultivation of vegetables which have a significant impact on productivity. Public-private partnership model in ICT application in sugarcane cultivation showed visible impact on the yield of the subscribing farmers. The study also highlighted that agricultural research institutions are not yet tuned to work with a private partner. There is an urgent need to focus on institutionalising such types of partnership. Another study reported that E-commerce make the farmers feel the sense of ownership, enhances their income and eliminate the delay of getting payments and reduces the farmers' debt burden.

Few researchers who studied the economics of hi-tech protected horticulture showed that Tomato-capsicum-cucumber- French bean were the major crops grown in these polyhouses, out of which capsicum gave maximum net return for the farmers. The major problems encountered by the farmers were lack of technical know-how and training, lack of guidance from experts, high wages for skilled labour, etc. The future prospects of expanding area under polyhouse depended on grant of higher subsidy for creating secured irrigation facilities and assuring market facilities.

A study on application of GIS in dairy industry in improving the supply chain in the industry explained GIS will be a strategic decision making tool for quick and effective decision-making in optimising procurement expenditure, identifying new procurement areas and diversifying the business. Another study discussed the application of remote sensing and GIS in Lac Resource Mapping. This technological tool offers the most economic means of assessing, planning, managing and monitoring lac hosts.

Another important area is the application of GIS and remote sensing in soil fertility mapping and developed equation to obtain optimum dose of fertiliser application for a targeted yield of crops. The developed equation can be utilised to prescribe balance fertiliser dosage which will improve soil health as well as reduce the cost of crop production.

RECOMMENDATIONS

- Science has considerable potential to generate alternative technologies for enhancing food and agricultural production. Research agenda should include all technologies, traditional or modern that has visible impact in terms of yield improvement, cost savings and quality without damaging environment and human health. There is need to adapt new methods and procedures to

estimate more scientifically the impact of technologies on yield, risk and on environment.

- Most of the impact studies on Bt cotton were carried by using crude methods of impact estimation without considering counterfactual effects and not making comparisons. For instance, almost all impact studies on Bt cotton estimated the benefits on account of Bt cotton by comparing one variety of Bt cotton hybrid with other variety of non-Bt cotton hybrid. Therefore, the yield gains or pest resistance could be attributed to genetic potential of hybrid itself rather than Bt gene. The comparison should have been between same cotton hybrids - one with Bt and another without Bt under similar biophysical and crop management conditions. Unless such high quality and scientific impacts studies are carried out on any frontier technologies like Bt cotton, the benefits estimated by crude methods using one year data cannot be considered to yield any policy implications/policy advocacy.

- There is need for broad based economic impact studies on modern technologies encompassing economic, social, and environmental and health impacts. The studies should address issues like, counterfactual effect, scale bias, distributional impacts on producers, consumers and innovators.

- Studies are required on the role of government policies on pricing of embedded technologies like Bt cotton seed on attracting research investments and incentivising innovators. How far the existing regulatory policy and institutional mechanism is adequate to protect the interests of the farmers and other stakeholders? More studies are required in this direction.

- Another area which requires in-depth analysis is the economics of Bt cotton seed production including assessment of economic rationale in fixation of the cost of trait value/royalty.

- Studies on how the information communication technologies play an important role in enabling the farmers' access to information, impact on transaction costs associated with acquisition of information and on farm income.

- Appropriate institutional mechanisms to forge partnership between public-private public and private sectors in developing, sharing and dissemination of information needs to be developed. The contents should be in vernacular language and should be free from technical jargons. Effectiveness and impact of alternative innovative ICT models need to be studied.

- There is also need to explore use of GIS and remote sensing crop planning and assessment of crop loss due to pests and diseases and extreme climatic events. GIS use in precision farming is another important socio-economic research avenue.

- Increasing demand for vegetables creates new opportunities to farmers to grow off season vegetables under protected environments. Studies indicate that protected agriculture is highly remunerative but to realise wider impacts of this technology farmers need to be linked to markets through cost effective institutional innovations.

- Economic gain of nanotechnology in agricultural production and food industry is another area of research we need to look into.

- Studies are required to analyse the role of technology in mitigation and adaptation to climate change.