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Rapporteur's Report on 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 applications, IT uses, nanotechnology, etc. Keeping in view the need for enhancement of productivity in agriculture to meet the future food challenges, frontier technological approaches are essential to address the biotic and abiotic stresses thereby improving crop productivity and farmers' income.

By recognising the future economic potential of frontier technologies, the Indian Society of Agricultural Economics (ISAE) has chosen the topic as one of the themes to generate knowledge on the subject, and also facilitate discussions to choose suitable policy options.

The papers were invited under broad-headings of Biotechnology, GIS & Remote Sensing, Nanotechnology, etc. for discussion under this theme in the conference. In total, 31 papers were contributed under this theme, out of which 22 were recommended for discussion. The recommended papers covered issues ranging from biotechnology including Bt, hybrids/improved cultivars of crops, cross-bred livestock (12 in number); ICT in agriculture (5 in number); application of GIS & Remote Sensing (3 in number); and protected agriculture/polyhouse agriculture (2 in number). Five papers were selected as full length papers, while the remaining were in summary form.

BIOTECHNOLOGY

The review paper done by Deepak Shah addressed issues relating to development and adoption of Bt cotton, its price regulations, investments and benefits accrued to farmers and future prospects in India. The large scale adoption of Bt-cotton has dramatically changed the cotton scenario in the country. It was observed that during a short span of 5-6 years between 2001 and 2006, a large area to the extent of two-kinds was covered under Bt-Cotton. The farmers cultivating Bt- cotton derive multi-agronomic, economic and welfare benefits, this study summarised. The benefits emanating from Bt-cotton cultivation have increased substantially ever since government regulations in terms of price control of seed came into force in 2006

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stipulating that the 450 gm packet of Bt cotton seed price should not exceed Rs. 1600. It is to be noted that in the recent past, the total R& D investment in cotton crop improvement in India has been to the tune of Rs. 2500-3000 million by more than 37 firms involved. Although it is assumed that seed price controls might reduce the incentive to innovate by the company, it is reported that R&D investments have substantially increased. S.S. Kalamkar also reviewed the adoption and performance of Bt cotton in India. During past decade, the growth in cotton production and yield was estimated to be 14 and 11 per cent per year respectively. The paper also reveals the inconsistency in the yield of Bt-Cotton which played a role in fuelling the controversy over the use of Bt cotton and its benefits to a few Indian farmers.

K.R. Ashok *et al.* emperially examined the economic and environmental impact of Bt cotton in India through economic impact quotient (EIQ) and economic surplus model. The survey of 80 Bt cotton growers and 40 non-Bt cotton growers in each of the states of Maharashtra, Gujarat, Andhra Pradesh and Tamil Nadu was conducted during 2007-08. The decomposition of the impact of Bt-technology exhibited that the farmers benefitted from the adoption of Bt-technology through higher profitability, mainly due to reduced pest control costs and higher yields, although with significant variation. The 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. However, the study did not give any policy recommendations.

Vasant P. Gandhi and Varsha Khandker reviewed the progress of spread of Bt cotton in India and examined the economics of Bt cotton in Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu using survey data collected during 2004-05. It was observed that pesticide spraying could not be eliminated even after adoption of Bt-cotton in the selected states. Similarly, farmers find no difference in the seed rate, fertiliser and irrigation market preference between Bt and non-cotton. The comparison with non-BT cotton shows the advantage of BT cotton on pest incidence, pesticide cost, cotton quality, yield and profit.

Sunil Nahatkar and Sachin Yadav estimated the production cost and profitability for Bt and non-Bt cotton in Nimar Valley of Madhya Pradesh. The paper concluded that the Bt-technology in cotton helped in realising gains in yield and profit across all categories of farmers in the region. Similarly, M.N. waghmare and P.N. Shendage examined the productivity and profitability of BT cotton in Western Maharshtra. Comparing the different economic parameters and using Cobb Douglas production function they found that genetically modified technology was the major contributor to the total productivity and income difference between BT and non-BT cotton. Higher productivity and higher profitability and a lower pest problem have been quoted as the important factors behind preference for Bt cotton. R. Vijaya Kumari compared the cost of cultivation and net returns between different Bt-cotton and non-Bt cotton in Northern Telengana region of Andhra Pradesh during 2002 to 2005. It was

observed that some of the non-Bt hybrids performed exceptionally better than Bt-cotton.

S.P. Bhardwaj attempted to develop an economic model for pricing of genetic agribiotech products development. Different approaches like modelling supply enhancing agribiotech products, efficiency gains in agriculture due to innovation, IPR pricing, etc. were mentioned. However, the application of these methods was not discussed.

The impact of adoption of hybrid pearl millets across different states was studied by N. Nagaraj *et al.* The authors explained that the benefits from hybrid HHB-67 released by CCS Haryana Agricultural University (HAU) in 1995-96 started flowing from 2006 to 2011. It was widely adopted by the farmers in Haryana and Rajasthan states. The study explained that due to public-private partnerships in the areas of developing varieties, production and delivery of improved seed, coupled with outreach activities enabled to increase seed replacement rate phenomenally. The productivity of pearl millet increased manifold benefiting the farmers. The hybrid helped in improving the productivity up to 10.79 q/ha. This was also supported by high Internal rate of return (IRR) of 35 to 45 per cent. However, major concern shown was the policy bias in terms of procurement and support prices which constrained the growth of pearl millet in a big way.

A. Amarender Reddy *et al.* and others have looked into the impact of technological intervention in chickpea production in south India. The paper observed that during last two decades, the area under chickpea in northern states have declined very fast due to expansion in irrigation facilities, however, it was compensated by corresponding increase in area in southern states like Andhra Pradesh, Karnataka, Maharashtra and Gujarat. Many institutional, technological factors like chickpea introduction in black cotton soil, adoption of short duration and high-yielding variety (HYV) like KAK-2 and JG-11, large scale mechanisation are some of the factors for expansion of chickpea area into south Indian states.

FRONTIER TECHNOLOGY IN DAIRYING

The study by K.D. Sharma *et al.* has examined the impact of progeny improvement and balanced nutrition of dairy animals in milk production in Himachal Pradesh. The study compared dairy keepers of 30 beneficiaries (trained) and 30 non-beneficiaries in 20 villages around Palampur of Himachal Pradesh during 2010-11. The results showed that due to various cattle improvement/development programmes launched in the state, there has been a steady increase in the number and proportion of crossbred cows while indigenous cows and buffaloes decreased. It was estimated that the beneficiary dairy keepers could earn about Rs. 58 per animal/day additional income due to training and Rs. 87 animal/day additional income due to improved breeds. However, there were some emerging issues and constraints such as declining land holding, rising labour wages, weed infestation in pasteur lands, etc. are thwarting the desired results.

The success story of Gowardhan, a synergistic efforts of transformation of unorganised dairy into organised dairy in Pune, Maharashtra state, has been highlighted in the paper by Sangeeta Shroff and Jayanti Kajale. The study has examined how Gowardhan dairy started in 1993 as a small unit, procuring milk from farmers and selling in pouches to nearby urban centres now procures from 1.25 lakh farmers and handles 1.2 million litres of milk every day. The farm is spread over 35 acres and also has a herd of 3000 cows of Holstein Friesian breed. Milking process is fully mechanised with rotary parlour, where as the cow enters, the computerised chip fitted to the cow is connected to the computer and all data related to the cow is made available instantly, enabling identification and monitoring of health easy. Besides vaccination and balanced nutrition supplements, the cows are kept in total controlled environment to harvest maximum yield from each cow. The average yield of cow was reported to be 23 litres per day, with maximum of 53 litres per day. Use of IT and scientific farm practices made Gowardhan not just an ordinary cow shed but the success story of a white revolution.

ICT IN AGRICULTURE

The study by M.S. Jairath and Hema Yadav examined the impact of mobile phones on market decision of farmers and identified the information needs and its access by the farmers in arid Western region of Rajasthan state. The region has strong presence of IFFCO Kisan Sanchar Ltd (IKSL) alongwith its partnership with KVK for providing extension and advisory services to farmers. The survey was conducted in four districts with 245 respondents in the year 2011. Short message service (SMS) is being provided on timely tips and crop advisory, pest management, best practices, market prices as well as market arrivals. The study observed that majority of the farmers received information regarding newly introduced SMS of IKSL services through the distributors. The farmers growing coarse grains and oilseeds regarded weather information as the most vital information along the crop management. Availability of better information on managing the crops and diseases made them more capable of management of fertiliser dosage, and disease management. The study suggests these barriers need to be surmounted by better customer care and a proactive approach in reaching the client to provide solution to technological glitches.

Women's access to ICT was studied by Rajni Jain *et al.* to explore the status of access to ICTs and identify the use pattern among farm women in selected villages of Haryana. One-third of women of medium size farms and 4 out of 5 women of large farms had access to these ICTs which shows a positive relationship between ICTs access by farm women and farm size. To examine the impact of ICT use on empowerment, a variable decision score was generated to represent the average participation of women farmers 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.

A.K. Sharma and Brahm Prakash examined the role of ICT based tools and techniques in dissemination of information at Indian Institute of Sugarcane (IISR), Lucknow. The institute entered into a MoU with the Reuters India Pvt. Ltd. to provide information in respect of sugarcane cultivation in Uttar Pradesh. IISR supplied information on cane cultivation to Reuters and Reuters provided it to its individual subscriber cane farmers with customised, localised and personalised cane crop related information. Reuters provided this service through mobile networks by charging subscription from the member farmers in the form of prepaid scratched cards. The impact of the IT intervention was clearly visible on the yield of sugarcane 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.

The paper by S.S. Chahal *et al.* has discussed e-commerce carried through e-choupal, MCX, NCDEX, etc., which involved the farmers in learning to conduct business online. E-commerce make the farmers feel the sense of ownership, enhances their income and eliminate the delay of getting payments, reduces the farmers' debt burden. The success of e-commerce has given a new lesson to the corporates in India and abroad. The success of e-commerce creates business channels that can create win-win situation for both business and farming community as it has enormous economics of scope. The main reason for the success of e-commerce is involvement of local farmers and maintenance of rural IT network by corporate entity. Thus, the paper highlights the importance gained by information technology in the agricultural sector.

Samir Samantara and Nirupam Mehrotra explained the efficacy of Kisan Credit Card (KCC) Scheme which was introduced in the year 1998-99 with a view to improving credit delivery system of crop loans. To increase the efficiency of the scheme, Mobile-enabled KCC (m-KCC) was launched as pilot project in Villupuram district of Tamil Nadu. The cost-benefit indicated that per m-KCC benefits were more than four times of the cost as the farmer, input dealer and local bank are linked by a common secure mobile enabled technology, making it safe to transact with it. The study also indicated that the benefit of the farmer is the highest (69 per cent) followed by bank (25 per cent) and input dealer (6 per cent). The project appears to be viable.

GIS AND REMOTE SENSING IN AGRICULTURE

The study conducted by Amit Kumar *et al.* on application of GIS in dairy industry in improving the supply chain in the industry explained that there are many critical success factors such as understanding the baseline operation, implementation of the tool in an effective manner etc. For growing private dairy firm like Creamline

dairy in Andhra Pradesh, the implementation of IT tools like GIS will be a strategic decision for quick and effective decision-making in optimising procurement expenditure, identifying new procurement areas and also for diversifying the business in terms of providing input services, rural marketing of milk and milk products etc. Information system with real time data can prove to be a boon to the dairy enterprises. Milk procurement in different BMCUs of Creamline dairy follows a specific seasonality pattern. Maintaining the balanced supply of raw milk to processing plant will be a challenge to private dairy. GIS as IT tool discussed in the present study could prove to be beneficial for practical and effective decision making.

Govind Pal *et al.* has described the issues and challenges of application of remote sensing and GIS in lac resource mapping. India is the largest producer and exporter of lac in the world and Jharkhand is leading lac producing and exporting state of the country. It offers the most economic means of assessing, planning, managing and monitoring and forestry resources, including lac hosts. Remote sensing and GIS offers an efficient and reliable means of collecting the information required in order to estimate average as well as classify the hosts based on species.

The paper by K.N. Singh and Prachi Mishra Sahu examined the economic benefits of resource use in agriculture using GIS and remote sensing. The soil nutrient fertility map was prepared for Hoshangabad district in Madhya Pradesh. By digitisation of toposheets according to soil fertility and geo-referenced maps can be inter-linked with soil test values. The research was conducted under coordinating unit (soil test crop response correlation) at IISS, Bhopal developed equation to obtain optimum dose of fertilisation for a targeted yield of crops. The developed equation can be utilised to prescribe balance fertilisation which will improve soil health as well as reduce the cost of crop production as well.

PROTECTED AGRICULTURE

Priyanka Sharma *et al.* studied the economics of hi-tech protected horticulture in Himachal Pradesh. The information collected from 60 ployhouses growers in the year 2010-11. The average area under protected cultivation was 228 m^2 for small and 673 m^2 for large polyhouses. These required an investment of Rs. 2.80 lakhs to Rs. 7.60 lakhs per unit, for which they get about 60 per cent subsidy from state government. 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 labours, etc.

The paper by Deepika Joshi *et al.* explains about protected cultivation of vegetables. In India, availability of vegetables is about 130 g per capita much less than the recommendation of 300g per capita. Off season availability of vegetables could be met through arranging its production in polyhouse. The study conducted in Champawat district of Uttarakhand for the year 2007-08 was found to be generating

profit of Rs. 171414 per acre in the case of capsicum to Rs. 371496 per acre in case of capsicum-cabbage-tomato rotation during offseason. The authors have also estimated BCR, NPW and IRR, all of which showed it a profitable options for the farmers. However, it was mentioned that the future prospects of expanding area under polyhouse depended on grant of higher subsidy for creating secured irrigation facilities and assuring market facilities.

ISSUES FOR DISCUSSION AND FURTHER RESEARCH

The papers on biotechnology issues have primarily focused on the economic benefits of Bt cotton adoption, and macro-level trends over the past 6 to 10 years. The authors estimated the economic benefits of Bt cotton as private financial profits without looking at long run sustainability issues. Keeping in view the various contemporary discourses on long run sustainability of GM crops, it would be useful to discuss a few issues related to biotech-products especially GM crops.

1. At the outset, it was agreed that the future agriculture would be a science-driven. Thus, what is the role of public sector in development and transfer of biotech products especially of GM crops-as currently available GM crops are from only private sector?
2. Is there a monopoly in Bt cotton technology?
3. Are there any environmental, health and social implications of Bt cotton?
4. Is there any economic rationale behind collection of trait value on Bt cotton?
5. What is the economics of Bt cotton seed production?
6. In view of the fact that the Gene Revolution of 21st Century is largely in the domain of private sector-particularly MNCs while the Green Revolution of the 1960s and 1970s was in the public domain, is there a need to have a proactive regulatory mechanism at the state level to monitor, and regulate quality of technology, pricing of technology (trait value oyalty) and as a whole to ensure fair trade in gene market?
7. Is the existing regulatory policy adequate to protect the interests of GM crop adopters?
8. Is price control of Bt cotton seed in some states affecting R&D investments?
9. What is the economics of private sector investments in GM crop development?
10. Is Bt cotton responsible to aggravate problems of cotton farmers in any state?
11. Farmers perception of the long-run sustainability of Bt cotton benefits?
12. Where the potential opportunities for application of ICT in agriculture, and their economic gains?
13. What are the impending factors to large scale use of ICT in agriculture?
14. Farmer awareness of GIS use in precision farming.
15. Economic benefits-both individual and societal benefits of GIS applications.
16. Expected economic gains of nanotechnolg in food industry.