Scale Neutrality of Frontier Technology in Agriculture: A Case Study of Bt Cotton Production in Nimar Valley Agro-climatic Zone of Madhya Pradesh

Sunil Nahatkar and Sachin Yadav*

The study aims to assess the scale neutrality of frontier technology in agriculture for which a case study for Bt cotton was undertaken in leading Bt cotton producing agro-climatic zone in Nimar valley of Central India. For the purpose of investigation 45 Bt-cotton producers, 15 from each size group i.e. small (up to 2 ha), medium (2 to 4 ha) and large (> 4 ha) were selected from Bhikangoan block of Khargoan district of Nimar valley of Madhya Pradesh. The selected Bt-cotton producers were interviewed through survey method for collection of required primary data related to the agricultural year 2008-09. The data were analysed using simple frequency distribution and averages. It was observed that the cropping pattern on the selected farms is dominated by cotton crop irrespective of different size groups. The total labour employment for production of Bt cotton was 85 days ha\(^{-1}\) and female labour employment was higher as compared to male labour employment. And more or less similar trend of gender specific labour employment was observed on different size of holdings because the harvesting operation (picking) of cotton is mainly performed by female labour and it is harvested at regular interval for 5-6 times due to indeterminate nature of Bt cotton varieties grown in India. Use of machine power was negligible on different size groups and none of the small farmers were using machine power owing to poor access to machine power even on hire basis thus revealing that Bt cotton production is labour intensive. Planting geometry and tools used for planting of Bt cotton marginally affects the seed rate of Bt cotton on different sizes of farms. The use of insecticide was more or less identical on different size groups. Although, the use of insecticide is at much higher level even after use of Bt cotton varieties and this was mainly due to indiscriminate use of insecticides irrespective of need as guided by field representative of different insecticide companies. The total explicit cost for cultivation of Bt cotton was ₹ 15949.28 ha\(^{-1}\) and this accounts for 75.62 per cent of the total cost of cultivation. The implicit cost accounts for 24.38 per cent of the total cost. The overall cost of cultivation of Bt-cotton was ₹ 21091.31 ha\(^{-1}\) and overall cost per hectare did not reveal much variation on different size of farms leads to conclude that this frontier technology is scale neutral with respect to cost incurred. Productivity of Bt cotton ranges between 14.93 q to 17.15 q ha\(^{-1}\) on sample farms and on an average it was 16.46 q ha\(^{-1}\) Although per hectare net income was higher on small

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farms as compared to medium and large farms but per quintal net income at overall cost was more or less identical irrespective of size of holdings. It is concluded that the frontier technology in agriculture like Bt cotton technology is scale neutral and has benefitted all the farmers irrespective of their size of holdings. And therefore, it is a wrong myth to say that frontier technology are not adopted by small and marginal farmers due to cost and access factors. On the contrary this type of technology was adopted by all the farmers irrespective of size groups due to high positive technological response in terms of productivity, cost saving and thus profitability. It is recommended that this type of frontier technology needs to be promoted in other crops after rigorous bio-safety and food safety assessment for overall socio-economic development of the country.

Adoption and Impact of Technology on Pearl Millet Production in India: Farm and Regional Level Ex-ante and Ex-post Impact Analysis

N. Nagaraj, Surajit Haldar and Cynthia Bantilan†

Pearl millet is predominantly grown in arid and semi-arid regions of India under rainfed conditions and continues to play a prominent role in the dryland ecologies. Since the last four decades, improved cultivars occupied more than 70 per cent of pearl millet area under rainfed conditions. The adoption of frontier technologies by the farmers had a significant impact on improving productivity of pearl millet in most marginalised harsh agro-climatic ecologies of India. The productivity of pearl millet increased appreciably from 2.9 qtls per ha to 10.7 qtls per ha an increase of five fold between 1960 to 2010 due to genetic improvement, crop management and growing markets. Due to high productivity, there has been saving of land which has been allotted to other crops. The ex-ante analysis indicated that with the adoption of improved cultivars along with management practices, the productivity and incremental returns doubled. The impact appraisal indicated that the productivity gain and the spread of benefits from hybrid cultivars is substantial as indicated by high net present worth and interest rate of returns of 35 to 45 per cent. Furthermore, from the view point of small and marginal farmers, the hybrids are valuable as these farmers are completely dryland dependent and the hybrid ensure them some level of assured yield even in drought season. In order to stimulate demand for pearl millet, value addition at micro and macro levels with technological support is crucial. There is policy bias towards procurement and support prices for pearl millet. In addition, it has been treated as an inferior cereal in spite of several advantages.

Application of Information Technology for Sugarcane Extension and Development in Uttar Pradesh

A.K. Sharma and Brahm Prakash*

Considering that the information technology has a great scope in modernising extension, the Indian Institute of Sugarcane Research (IISR), Lucknow entered into a memorandum of understanding (MoU) with the Reuters India Pvt. Ltd., a Thomson Reuters Company (world’s leading source of intelligent information with 192 bureau across the world) during 2009 for one year for providing improved package of practices on various facets of sugarcane cultivation in the form of monthly advisories and disseminating the appropriate information to the growers of Uttar Pradesh by using an ICT based mode, preferably mobile based SMSs. The paper attempts to study the constraints in the application of IT and the impact of this intervention in sugarcane extension in Uttar Pradesh. The IISR, Lucknow supplied information on cane cultivation in the form of monthly advisories to Reuters and Reuters provided it to its individual subscriber cane farmers with customised, localised and personalised cane crop related information, weather forecasts, local crop prices and agricultural news in the form of SMS messages sent to their mobile phones in local language. Apart from this Reuters also used other media like internet, voice, portals, print and electronic media. This service was provided through mobile networks by charging subscription from the member farmers in the form of pre-paid scratch cards in quarterly, half yearly and yearly service packs, sold through agricultural inputs-shops, co-operative banks and other rural sales network. The impact of this IT intervention was clearly visible on the yield of sugarcane of the subscribing farmers due to easy access to customerised content mobility benefits, improved convenience and saving on travel. The package of practices and information about new technologies were quickly and efficiently disseminated across Uttar Pradesh state in a cost-effective manner to large number of subscriber-cane farmers. The constraints associated with this intervention is that this service is available to the member subscribers who were generally large and medium farmers. Most of the small and marginal farmers remained deprived of this intervention during the first year of its implementation. The response of these farmers to subscribe the paid services was just 10 per cent. Some difficulties were also experienced in generating monthly crop advisories at the research institute as per specific requirement of the private sector. The new approach was not very encouraging to the research institute in the initial stage due to lack of clarity on terms and conditions as well as researchers’ ease to work with conventional approach and methods. The study indicates that agricultural research institutions are not yet tuned to work with a private partner in a PPP mode and there is an urgent

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need to focus on institutionalising such type of partnerships so that customer-oriented services may be provided to the farmers.

**Role of Information Technology in Agricultural Sector of India**

**S.S. Chahal, A.A. Devi and P. Kataria†**

The e-market can save time and money and improve accuracy by eliminating middlemen who offer little added value. In this backdrop the present study was undertaken to assess the performance of e-market, and to estimate the benefits of e-market. It was found that e-commerce carried through e-choupal, MCX, NCDEX, etc. have been the most successful initiative to wire India and to involve the farmers in learning to conduct business online. E-commerce has been successful in making the farmers feel the sense of ownership and motivate them to generate additional revenue by eliminating middlemen. It was noticed that the participating farmers have been able to enhance their income and eliminate the delay in getting the payment once the product is sold, thereby reducing the debt burden of the farmers. The success of e-commerce has given new lessons to the corporates in India and abroad. The gains from the novel initiative are manifold to ITC, the farmers and other companies. The business through e-commerce has helped the farmers to improve their productivity and get better prices, whereas the agencies has benefited by better sourcing of raw materials. The success of e-commerce has heralded a new era in the Indian agro-sector. The work needs to be carried forward and replicated in the other untapped areas. Creating business channels that can create a win-win situation both business and farming community has enormous economies of scope. Once a channel is created it could be used for many products and services as shown in this case study. The main reasons for the success of the platform have been the involvement of local farmers and maintenance of the rural IT network by the corporate entity.

**Protected Cultivation of Vegetables in Uttarakhand: An Economic Analysis**

**Deepika Joshi, S.P.R. Chaurasia and H.P. Singh*†**

The objectives of the paper are (i) to estimate the cost of production of various crop enterprises grown and crop rotations followed under polyhouse cultivated, (ii) to workout the financial feasibility of vegetable cultivation under polyhouse and (iii) to seek farmers’ opinion about the polyhouse scheme and its prospects for future

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expansion. For the purpose primary data have been collected through survey method for the agricultural year 2007-08 from Lohaghat block of Champawat district, Uttarakhand. The study revealed that in Champawat district, the production of vegetables in polyhouse was found to be beneficial to producers as well as to consumers by way of offseason vegetable production. Capsicum was found to be the most profitable crop generating a net income of Rs. 171414 per acre. Among all the crop rotations followed by the farmers, capsicum- cabbage- tomato appeared to be most profitable crop rotation generating a net income of Rs. 371496 per acre. The establishment cost of polyhouse was found to be economically feasible and the benefit-cost ratio was greater than one under the situation of granting subsidy or without subsidy. The payback period was found to be around 2.5 years. The per acre returns from vegetables cultivated under polyhouse was substantially higher as compared to per acre returns obtained from open field cultivation. The farmers were satisfied with the financial scheme of polyhouse executed by government in the study area. However, certain additional provisions like drip irrigation system, making availability of water tank and sprinklers have to be made in the scheme for secured irrigation. Presently, the vegetables produced under polyhouse are locally disposed off. However, if the area under polyhouse cultivation is increased, there will be need of developing transportation facilities and good market for making the crop remunerative.

Economics of Hi-Tech Protected Cultivation in Himachal Pradesh- An Exploratory Study of Pandit Deen Dayal Kisan Bagwan Samridhi Yojna (PDDKBSY)

Priyanka Sharma and Virender Kumar†

The paper attempts to examine the progress and benefits of protected cultivation and is based on the data collected from 60 polyhouse growers comprising 27 small and 33 large farmers selected randomly from two blocks of Mandi district in the year 2010-11. The majority of polyhouse owners were farmers belonging to marginal category. The average area under protected cultivation was 228 m$^2$ on small category and 673 m$^2$ on large category of polyhouse owners. The capital investment per unit varied from Rs. 2.80 lakh for small category and Rs. 7.60 lakh for large category. The area under capsicum accounted for maximum area under protected cultivation followed by tomato and cucumber. On an average, the productivity of cucumber was the highest followed by tomato and capsicum. The productivity was found higher on small category which may be due to better management practices adopted on small units. Variable cost for 100 m$^2$ of area was more in case of tomato for both small and

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large categories of farmers. However, the gross and net returns per 100 m² area were maximum for capsicum under both small and large categories. The study also revealed that protected cultivation has started making good contribution to gross farm income in the study area. The major problems encountered by the farmers in protected cultivation were lack of technological know-how and training, lack of guidance from agricultural experts, lack of skilled labour and problems in control of diseases. Therefore, training should be imparted and efforts should be made to train the farmers before construction of polyhouse units and only capable and interested beneficiaries should be selected while sanctioning the new schemes. Proper expert advice must be made readily available to the farmers especially about crop selection and disease/pest management for which a special cell should be created in agriculture department of each block to solve the emerging problems of polyhouse owners.

Role of Improved Breeds and Management Practices in Enhancing Dairy Animal Productivity in Himachal Pradesh

K.D. Sharma, S.K. Chauhan and Alok Sharma*

The study which forms part of NAIP Project, “Visioning Policy Analysis and Gender (V-PAGe)” undertaken in CSKHPKV, Palampur (Himachal Pradesh) tries to examine the role of R&D endeavours in dairy development in Himachal Pradesh. The study is based upon the data collected from 30 beneficiary (trained) and 30 non-beneficiary dairy keepers selected randomly from 20 villages around Research Stations of CSKHPKV, Palampur during the year 2010-11. The study indicates that due to various cattle improvement/development programmes launched in the state, there has been a steady increase in number and proportion of crossbred cows while indigenous cows and buffaloes decreased. The population and production of milk of crossbred cows increased at the impressive growth rate of more than 9.5 per cent per annum. The trained beneficiary dairy keepers who had kept good progeny of crossbred cows (pure bred or more than 75 per cent Holstein/Jersey cross) obtained higher productivity as compared to non-beneficiary farmers. The beneficiary dairy keepers had got better knowledge regarding feeding, health care and management practices than the non-beneficiary dairy keepers. Due to high productivity, the cost of milk production on beneficiary farms was Rs.13.19 per litre as compared to Rs.18.38/liter on non-beneficiary farms implying thereby cost saving of more than Rs.5 per litre. The significant factors affecting the dairy animal productivity were improved breed, training acquired and quantity of cattle feed used. It was estimated that the beneficiary dairy keepers could earn Rs 58.39 per animal/day additional

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income due to training and Rs. 87.34 animal/day additional income due to improved breeds. The elasticity of production revealed that training enhanced the animal productivity by 17.57 per cent, cattle feed to the extent of 29.39 per cent and improved breed (above 75 per cent of cross bred cows) enhanced yield to the extent 18.69 per cent. However, there were some emerging issues and constraints thwarting the desired progress in dairy sector in the state. Among these declining interest in dairying, shrinking of arable and pasture lands, weed infestation on pasture land and fodder scarcity due to diversification towards vegetable farming were the major concerns that need immediate attention to harness the full potential of dairy enterprise in the state.

**IT Impacts Assessments in Agricultural Credit Sector**

**Measurement of Impacts and Benefits**

Samir Samantara and Nirupam Mehrotra†

Kisan Credit Card Scheme (KCC) was introduced in the year 1998-99 with a view to improving the credit delivery system of crop loans. Over the last 13 years, all the intended benefits have not accrued to the farmers, as many of the aspects of the KCC have not been implemented. As of now, even if KCC were to be introduced as a plastic credit card/ smart card, the likelihood of its being accepted by input shops appears very low, though it was originally envisaged in KCC that farmers would withdraw loan amount as per their requirement in smaller chunks, which will result in reduced interest burden, studies have revealed that in most of the KCCs there was only one lump disbursement thereby precluding the possibility of benefit of reduced interest expenditure/amount for the KCC borrower(farmer). Branchless banking is the paradigm shift of banking in the new era. A pilot project on ‘Mobile Enabled KCC’ was launched by NABARD on 2nd October 2011 in Villupuram district of Tamil Nadu for the farmers having KCC accounts with Pallavan Grama Bank (PGB) a regional rural bank sponsored by Indian Bank. With a view to assess and gain insights into the various facets of the project including the cost and benefits a quick study of the m-KCC project was undertaken. The study aimed at assessing the impact/benefit to all the major stakeholders, especially farmers. The share of benefits accrued due to reduction in transaction cost indicates that the benefit to the farmer is the highest followed by bank and input dealer. Reduction in transaction cost to the system as a whole as a percentage to the amount-transacted amount is 1.65 per cent. The study has also revealed that per m-KCC benefits are more than four times the costs per m-KCC indicating very high level of viability of the project. The project may be introduced for a much larger area if not for all KCCs. Scaling up will call for more efforts on capacity building on m-KCC use of technology to farmers, project holder,

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bank staff and merchant/vendors. Apart from merchant/vendor acting as a BC, providing cash withdrawal and cash deposit (including cash deposit for repayment also) facility roping in “other BC’s” (BCs of Financial Inclusion who are not input dealers) would greatly boost the scalability of the project as well as BC’s business viability. Thus scaling up will also have positive impact on sustainability of BCs and thereby on financial inclusion efforts of banks. Eventually the connectivity costs will be factored in the price of inputs and need not be funded.

**Frontier Technologies in Agriculture Biotechnology: The Promise and Performance of Bt Cotton in India**

Vasant P. Gandhi and Varsha Khandker*

The study examines the performance and economics of Bt cotton in India. Secondary data analysis indicates a major turnaround in cotton since the introduction of Bt cotton. There has been rapid adoption of Bt cotton and rapid growth in cotton production making India the second largest cotton producer in the world. The study further uses primary data covering major cotton growing states of Gujarat, Maharashtra, Andhra Pradesh and Tamil Nadu, with a sample of 694 farmers, to examine the performance of cotton and Bt cotton. Adoption of the technology is found to be scale neutral. The responses indicate that Bt cotton offers good resistance to bollworms on farmers’ fields. The yields of Bt cotton are found to be higher by 31 per cent on an average, and the yield increase is statistically significant in all the states. The value of output per hectare is higher in all the states and the cost of production is also higher given higher expenditure on many inputs including seed cost and less reduction in pesticide cost. However, in the net, the profit is found to be higher in all the states to an extent of about 80-90 per cent on an average. The responses of the farmers indicate that farmers observe advantage in Bt cotton over non-Bt cotton in terms of pest incidence, pesticide cost, cotton quality, yield and profit. The adverse effects on other crops or the environment have not been reported by any farmer and almost all farmers indicate that they plan to continue with Bt cotton in the future. The experience analysed indicates substantial promise of biotechnology in offering frontier solutions. To increase the benefits from Bt technology there is need to offer more hybrids, keep seed cost low, control sale of spurious seeds, and provide field extension and demonstrations on the correct techniques and farming practices to be followed.

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Biotechnology – A Potential Frontier Technology for Agricultural Development in India

R. Vijaya Kumari†

Among different emerging frontier technologies for agricultural development, biotechnology (biotech crops) seems to be one of the fastest adopted crop technology in the history of modern agriculture with a 94-fold increase in hectarage from 1.7 million hectares in 1996 to 160 million hectares in 2011. A historical decade of cultivation of Bt cotton has transformed the cotton production in India. An increase from 50,000 hectares of Bt cotton in 2002 to 10.6 million hectares in 2011, represents an unprecedented 212-fold increase in 10 years. This has enhanced the Indian farm income from Bt cotton by US$9.4 billion in the period 2002 to 2010 and US$2.5 billion in 2010 alone by increasing yield substantially, decreasing insecticide applications by 50 per cent, and through welfare benefits, contributed to the alleviation of poverty of 7 million small resource-poor farmers and their families. Though there were several controversial opinions on the performance of Bt cotton in India, the long run benefits of its cultivation in the country were well forecasted by some researchers during early years of Bt cotton introduction in to the country. The present prosperity in the acreage of Bt cotton in India is a good evidence indicating that nothing can stop a creditable technology from adoption by the farming community. The results of four years research study on ‘Economic analysis of Bt cotton cultivation in Northern Telangana Zone’ conducted in four major cotton growing districts i.e., Adilabad, Karimnagar, Warangal and Khammam of Andhra Pradesh from 2002-03 to 2005-06 also clearly revealed the positive impact of Bt technology particularly against Helicoverpa up to 90-100 DAS and pink bollworm to certain extent there by realising higher yields and bringing a major positive change in the socio-economic conditions of the farming community. In addition, it is felt that the incorporation of Bt gene into the most suitable varieties/hybrids specific to the growing locations and supply of the same seed in required quantities at reasonable prices would be more remunerative to the farming community. This success of Bt cotton in India can encourage the country to replicate the same in other agricultural produce, including vegetables and foodgrains for sustaining the country’s future food and nutritional security, as the genetically modified (GM) crops have the capacity to double agricultural growth rate to 4 per cent per annum from the present rate which is around 2 per cent.

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Methodological Study of Genetic Pricing Mechanism for Agbiotech Products

S.P. Bhardwaj*

Biotechnology is an applied science based on molecular biology and seeks to understand the biological processes, such as drought tolerance or other stress tolerance in plants, on the genetic level. The knowledge acquired can then be used to develop traits into crops. Modern biotechnology opens up vast global social and economic opportunities. The use of genetic resources in modern biotechnology applications has increased their economic, scientific and commercial value for a wide range of stakeholders. Genetic resources can be modified by human intervention and take on characteristics that do not exist in nature. When these modifications result in a new biotechnological invention that is capable of industrial application, the invention may qualify for patent protection. The Indian biotech industry has been growing at a fast pace since the last three decades both in terms of expansion of business conducted by contract service providers, research and innovation. In order to model the genetic pricing of an agbiotech product we take the help of Intellectual Property Rights of the products and accordingly the price is determined based on its fee/royalty etc. In the field of agbiotechnology two types of products are available (a) the product based on laboratory research and (b) the scientific knowledge to produce these products. The component of scientific knowledge to produce agbiotech products has been covered under IPR arrangements. Thus two types of agbiotech products are available in the market. The prevailing scenario of agbiotechnology has been attempted to capture in the form of an economic model. The effect of genetic pricing in the form of IPR has also been illustrated with the help of demand and supply curves.

Scope of Remote Sensing and Geographic Information System in Lac Resource Mapping

Govind Pal†, Md. Monobrullah‡ and R.K. Singh‡

Lac cultivation is an important source of income for the livelihood of forest and sub-forest dwellers in the country. Besides, it has high potential for generating employment for both men and women. India is the largest producer and exporter of lac in the world and Jharkhand is the leading lac producing and exporting state of the country. The objectives of the study are (i) to examine the resource mapping of lac host palas, ber and kusmi in Jharkhand at the block/district level using high resolution satellite imagery with field validation, (ii) preparation of distribution pattern of major

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lac host trees and (iii) to estimate the exploitation level of lac host and farmers engaged in lac cultivation. Inventory of lac host resources should be there to plan lac production system and to develop appropriate location-specific plans. The conventional method of surveying and estimating the lac hosts is time consuming and also involves high cost. However, the development in space technology, particularly the repetitive satellite remote sensing across various spatial and temporal scales, offers the most economic means of assessing, planning, managing and monitoring the forestry resources, including lac hosts. Remote sensing and GIS offers an efficient and reliable means of collecting the information required, in order to estimate the acreage as well as classify the hosts based on species. The present study will be helpful in knowing the precise number and distribution of different host species in the state, identification of the broodlac (seed) centres/clusters/production catchments, developing production strategies of rangeeni and kusmi lac cultivation on different host species and help in formulating suitable plans for raising new host plantation at suitable places.

Economic Benefit by Optimisation of Resource Use in Agriculture Using Geographic Information System (GIS) and Remote Sensing (RS) Technology

K.N. Singh and Prachi Misra Sahu*

In the present situation, the cost of production is increasing due to increase in the input cost such as fertiliser, irrigation, insecticide, pesticide, etc. Therefore, the government is giving lot of importance to precision farming i.e., optimum utilisation of resources. Geographic Information System (GIS) and Remote Sensing (RS) technology can play a very important role in the optimisation of resource use and resultantly in reduction in the cost of cultivation. In this paper, it has been demonstrated that using GIS and RS technology, how nutrients can be applied judiciously. Recently, attempts were made at Indian Institute of Soil Science (IISS), Bhopal to prepare soil fertility maps using RS and GIS techniques. Further, it has been shown that if fertilisers are applied in a scientific manner, then there was monetary benefit to the farmers. This has been demonstrated with the help of a case study in a selected district. Hoshangabad district was selected for fertility mapping as it has the highest consumption of fertilisers among the districts of Madhya Pradesh. It was felt that similar approach can be applied to a state/country where one can estimate the available nutrients using GIS and RS technology and the area can be demarcated under deficit nutrients. In this way, one can concentrate more on these areas. Research has been conducted under coordinating unit (Soil Test Crop Response Correlation) at IISS, Bhopal where they have developed equations conducting several experiments in different parts of the country to obtain the optimum dose of fertilisation (including manures also) for a targeted yield. These

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developed equations can be utilised in the whole country to prescribe balance fertilisation which will improve soil health also.

**Impact of Genetically Modified Crops on Productivity and Profitability - An Economic Analysis of Bt Cotton Cultivation**

M.N. Waghmare and P.N. Shendage†

The paper attempts to assess the impact of genetically modified crops on productivity and profitability in cotton growing area of Western Maharashtra. Specifically, it aims to examine the impact of Bt cotton cultivation on cost of pesticides, cost of production and profitability and estimate the resource use efficiency of Bt cotton as well as non-Bt cotton production. The study is based mainly on primary data collected from a sample of 60 farmers comprising five Bt cotton households and five non-Bt cotton farm households from six villages for the year 2008-09 and analysed using Cobb Douglas production function. On an average, per farm area under Bt cotton was 2.27 ha, accounting for 69 per cent of the total land holding. With a yield of 24.50 qtl/ha, Bt cotton has registered 32 per cent higher yield and 219 per cent higher net return over non Bt cotton, with net additional benefit being Rs. 20,418 /ha. The non-Bt cotton farmers use chemical fertiliser, pesticides and bullock labour excessively which result in lower net returns. Genetically modified technology has been found to be the major contributor to the difference in total productivity and income between Bt and non-Bt cotton households. Non-availability of quality seeds and in required quantity was the major constraint in adoption of technology in cotton cultivation. Higher productivity and higher profitability and lower pest problem have been indicated as the important factors behind preference for Bt cotton. However, high cost of seeds and incidence of pests and diseases other than bollworm have been observed as the major bottlenecks in the cultivation of Bt cotton. The study has concluded that Bt cotton cultivation is technically more efficient than non Bt cotton. To foster adoption, availability of quality and quantity of Bt cotton seed to farmers needs greater attention of the Government agencies.

**Biotechnology in Agriculture: Review of Adoption and Performance of Bt Cotton in India**

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An attempt has been made in this paper to review the adoption and performance of Bt cotton in India. Biotechnology and genetically modified crops have been the

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subject of controversial debate, especially with respect to developing countries. Like in other countries, introduction of Bt (*bacillus thuringiensis*) cotton in India led to an intense scientific debate and public controversy surrounding yield advantage, multinational control of seeds, human health, environmental risk and ethics. The commercial release of first GM crop, Bt Cotton in 2002 has led to the beginning of a ‘Gene Revolution’ in India. Today, almost 98 per cent of cotton area is planted under Bt cotton in India, with farmers adopting it in a rapid manner. Studies that looked into the impact of the Bt cotton on different parameters are not uniform and many voices have been raised for and against Bt cotton. Most of the studies have shown that Bt cotton cultivation has increased yield and thereby increased profit by reducing the expenditure on plant protection. However, the studies conducted by NGOs contradicted these conclusions and supported the Bt failure in terms of lower yields, higher debt and sometimes serious externalities. However, most of the studies noted that biotechnology helped in reducing the yield gap between the actual and the potential by resisting the dreaded American Bollworm. Smallholder cultivators benefited from its adoption and it proves that proper application of technology in product development can have positive impact on equity. The gains of Bt cotton cannot be generalised to all the farmers, all states, and all years. This inconsistency in the results surely played a role in fueling the controversy over the use of the Bt cotton and its benefits for Indian farmers. The issues of bio-safety and environmental impact continue to be critical and are to be monitored in the medium term.

**Technology and Transformation of Dairy Sector – Success Story of Gowardhan**

**Sangeeta Shroff and Jayanti Kajale†**

An attempt is made in this paper to explain how application of frontier technologies in dairy sector can promote development in the agricultural as well as allied sectors. A success story of Gowardhan dairy (the brand name for Parag Milk Foods Pvt. Ltd.), located in Manchar village, about 60 kms from Pune in the state of Maharashtra has been highlighted in this paper. The company started its operations in a small way in 1993, but presently procures milk from 1.25 lakh farmers in the unorganised sector and operates with 1.2 million litres of milk per day. After discussing the status in milk production and consumption in India and constraints in yield, the study uses qualitative data to explain how Gowardhan began its operations in a small way but increased its scale of operations over time and also introduced backward linkage by starting its own dairy farms. Gowardhan is an example where synergy between the organised and unorganised sector is created as it procures milk from the unorganised sector and provides the resource poor farmers from whom it procures milk with extension services. The company is now aiming to improve the

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genetic potential of cows and distribute them to its partner farmers. This will greatly help to increase milk production. Hence the activities of Gowardhan are in tune with that envisioned in the National Dairy Plan. Use of Information Technology and scientific farm practices have transformed Gowardhan from an ordinary cow shed to the success story of a white revolution. It explains how a farm-firm like Gowardhan can serve as catalyst for growth in the dairy sector involving the unorganised sector.

**Impact of Technological Interventions in Chickpea Production in South India**

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Historically India is the largest producer, consumer and importer of pulses. However during the year 2010-11 its projected deficit has been the lowest since last five years. Many policy and technological interventions helped to increase pulses production from 14.7 million tonnes (mt) in 2007-08 to 18.09 mt in 2010-11. With this background, the paper tries to examine the reasons for success of pulses production in recent years at all India level with special reference to chickpea. It also examines the reasons behind the successful introduction of new crop chickpea in Andhra Pradesh. The paper discusses the strategies followed to increase pulses production in the last five years and the way forward to sustain the increased production. The study used both primary and secondary data from 1990 to 2011. It highlighted the importance of successful government programmes like National Food Security Mission in increasing pulses production. Many institutional, technological factors contributed for this success, including mainly the introduction of chickpea into black cotton soils, availability of plenty of rabi fallow lands, adoption of short duration and high-yielding varieties like KAK-2 and JG-11, well developed land lease market facilitated large scale mechanisation which reduced labour use to cope with labour shortage in local economy are some of the contributing factors for the expansion of chickpea area into south Indian states. Due to adoption of high-yielding varieties (HYVs) of chickpea, cost of production reduced significantly, which enhanced the competitiveness compared to the competing crops. Yield and price stability of chickpea is much higher compared to competing crops. And the wider availability of highly subsidised cold storage warehouses helped the farmers to store chickpea during low prices to overcome monthly price fluctuations to reap profits from higher prices during later periods.

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