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Green Technologies for Sustainable Agriculture: Policy Options Towards Farmer Adoption

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ABSTRACT

Bio-fertilisers (BF) and bio-control agents (BCA) are the biotechnological interventions tried to improve crop production and protection for sustainable agricultural development. This paper based on a study, conducted in the state of Kerala, depending both on primary and secondary data, analyses the consumption pattern and farmer responses to the technology and cases thereof. A total of 840 farmers were surveyed using a structured, pretested questionnaire. Later on, the crop-wise use was estimated through a post stratification of the data. Logit analysis was done to study the adoption behaviour of the respondents. In Kerala, BF/BCA is produced by the public sector, private sector and NGO, and is distributed either directly to the farmers or indirectly through the retail shops. A sizeable part of production is sold to the Department of Agriculture itself as part of department schemes where the BF/BCA is given at subsidy. The analysis on the level of adoption of BF/BCA showed that the percentage of adoption is more in the case of BCA when compared to BF. The adoption of BF was found to be less than 1 per cent and for BCA it was around 11 per cent. The logistic regression analysis to study the adoption behaviour of the respondents (rice farmers) showed that educational level, farming experience, returns from farming and extension of technical support received by the farmers are the major factors that influenced the decision making with regard to the adoption of bioagents. Though subsidies facilitate the economic access to the technology, it did not ensure the sustained adoption and scientifically proper application. The analysis supports the statistically significant influence of technical support in the adoption of the technology, which underlines the importance of infrastructural and technological support mechanism in the wider adoption of the technology. Thus subsidies can be considered as a necessary but not a sufficient condition for the sustained technology adoption.

Keywords: Biofertiliser, Logit analysis, Technology adoption, Sustainable production.

JEL: L650, Q160, Q20, Q110

I

INTRODUCTION

The negative externalities associated with green revolution technologies are discussed and documented world over (Van Der Hoek *et al.,*1998; Wilson 2000). In spite of considerable primary success, indiscriminate use of mineral fertilisers have often led to deterioration in the overall soil health of the country leading to stagnation of foodgrain production (Abrol *et al.,* 2000; Wang *et al.,* 2003). There are states where fertiliser consumption increases without any conspicuous corresponding gain in production. With a view to sustain the soil health and thereby maintain the

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productivity levels of agricultural soils, more emphasis is now being paid on the integration of organic inputs with mineral sources of nutrition. Use of such organic materials not only increase the nutrient status of the agricultural soils but also help to improve the various physical, chemical and biological properties of soil leading to betterment of soil quality and also to increased fertiliser use efficiency (Dick and Gregorich, 2004). This awareness and concern has necessitated technological interventions for substitutes, to attain the objective of sustainable agricultural development. Thus, biotechnological interventions are tried in crop production to substitute/compliment for chemical based farming. Bio fertilisers (BF) are the technology to make use of the nutrients which are abundant in nature for agricultural production with the help of micro organisms. Similarly, the natural microbes are utilised for pest disease management in the place of chemicals (Bio Control Agents - BCA). For the technological advancements to yield social gains, the infrastructural and social settings need to be properly designed and developed. Correspondingly, there were many policy interventions to facilitate technological, infrastructural and social support development for promoting the field level adoption of these technologies. Input subsidies has been most widely accepted policy instrument in agriculture, since the green revolution era .This is also applied in popularising the green technologies and this paper tries to analyse the farmer responses to the technology (Bio Fertiliser (BF) and Bio Control Agents (BCA)) and see whether the subsidy support has resulted in sustained adoption of the same.

II

METHODOLOGY

The paper is based on a study, conducted in the state of Kerala, depending both on primary and secondary data. The consumption pattern and farmer responses were studied, gathering information from the respondents. From each of the 14 districts in Kerala one CD block was randomly selected for the study. From the selected block, two panchayats each were randomly identified. From the list of agricultural holdings (compiled from Krishi Bhavan, the base level unit of Department of Agriculture, Government of Kerala) 15 agricultural holdings adopting organic farming (OF) technology and 15 who does not follow OF, were randomly identified as respondents. It was hypothesised that bioinput use may be higher in OF than their counterparts. All organic farmers chosen were not certified farms, but were following organic methods of farming. Thus the total sample size was 840 farm holdings.

A structured questionnaire was developed and pretested through a pilot study to finalise it. The data from the respondents were gathered through personal interview method using the questionnaire. Focus group discussions were also done to elicit more information on attitude. The use pattern, costs, returns and farmers responses were gathered through this process. Later on, the crop wise use was estimated through a post-stratification of the data.

The adoption of the technology and its probability is generally decided by a host of factors, both social and economic. Logit and Probit model are generally used to predict the effect of change in the independent variable on the probability of belonging to a group when the dependent variables are dichotomous (Suresh *et al.*, 2007; Pandit *et al.*, 2007). This approach makes use of the heterogeneity in population that is relevant for the behavioural response in favour of ecofriendly technologies. Hence, to generate dependent variables, the respondents were divided into two groups, those who have applied any of the bioagent and those who do not. Logit model was used in this analysis, using SPSS package. So,

$Pi = \frac{1}{1+e^{-zi}}$ where Pi is the probability that the farmers follow ecofriendly methods

$1-Pi = 1-\frac{1}{1+e^{-zi}}$ is the probability that the farmers do not follow ecofriendly methods

Taking logarithm on both sides,

$$Ln\left(\frac{Pi}{1-Pi}\right) = Zi = a + \sum_{i=1}^{n} \beta_i X_i + e_i$$

where Xi is the vector of independent variables and β_{is} are the coefficients to be estimated.

Here the variables are,
Y = non-adopter/adopter (0, 1)
X1= age in completed years
X2=education level of the farmer
X3=area under farming (ha)
X4=subsidised supply of BF or Not (1, 0)
X5=returns from the farming (Rs./ha)
X6=exposure to information on BF.

The analysis was done by the using package SPSS 17.0, separately for rice farming and for the whole sample.

III

RESULTS

BF market in India is projected to be to the tune of \$10.2 billion by 2017. Currently the installed capacity of BF production is reported as 86078 tonnes (2009-10), of which nearly one quarter is utilised. The capacity utilisation has shown wide temporal variation, ranging from 23.28 per cent (2009-10) to 56.35 per cent (2003-

04). The production is reported as 20040.35 tonnes in 2009-10. The states of Tamil Nadu (18.62 per cent) and Karnataka (18.44 per cent) together constitute nearly one-third of the production. Kerala, the third major producer has a share of less than 10 per cent.

Government of Kerala has adopted the organic farming policy in the year 2010, with the objective of converting the agriculture in the state to fully organic in the next ten years. As such, there has been increasing public policy support to promote the production and use of BF and BCA, which include, financial assistance and subsidies to private and public sector initiatives in setting up biofertiliser production unit (one time grant) and promoting production by public sector firms. Parallelly, the demand side interventions were initiated by extensive mechanism (private/public) to increase the awareness and adoption. Moreover farm demonstrations and other extension tools are employed to promote the spread of the technology. There are targeted schemes to supply these inputs with full or partial subsidy mechanism.

Biofertiliser (BF)/Bio Control Agents (BCA) producing units in Kerala are managed under three categories: public sector, private sector and NGOs. The major ones in the public sector include the Department of Agriculture, Kerala Agricultural University, Fertilisers and Chemicals Travancore Ltd. and Commodity Boards. One unit is run by Local Self Government. The major private sector units (11 nos.) have formed an association. Apart from this there are distributors of BF and BCA from the neighbouring states, which are usually marketed as beneficial micro organisms. Thus the market for bioagents in agriculture includes BF, BCA and large number of commercial formulations (Efficient Microorganisms-EM) whose technical standards are not fully understood.

The distribution channels for products from public sector is direct. For instance, the purchase register of public sector units shows most of the individual buyers as farmers in the same or neighbouring districts. Here, the beneficiary has to come in person and purchase. Most often, the farmers associations (Padasekhara Samities) or groups depute one of the members to take up the task. A sizeable part of production is sold to the Department of Agriculture itself as part of department schemes where the BF/BCA is given at subsidy. In such cases, the Agricultural Officers make arrangements to collect them from the production unit. The assured quality standards attached to the products from public sector, official procedural convenience (when sold to public sector) and price advantage ensure a steady market, (without deliberate marketing efforts) for these units. The existing marketing channel for bioagents produced by the private sector and FACT is the same as that of chemical fertilisers. The retail outlets which were handling chemical fertilisers/ pesticides/other agrochemicals widen their brand/product base through incorporating these agents.

The public sector efforts to facilitate the use of bioagents through extension techniques and subsidy support ideally may result in wide scale adoption of the technology. The farm level data gathered on the use pattern gives reflections on this aspect.

Farm Level Responses to the Technology

The farm level adoption of any technology is influenced by several factors and there are several theories which discuss this process. According to Roger's Innovation Diffusion Model, adoption of an innovation depends on five elements, viz., relative advantage of the innovation over the earlier practice, compatibility of the innovation with the existing needs, values and experiences of the social system, complexity, trialability and observability (Rogers, 1995). Response Hierarchy Models of Communication explains different stages of adoption process and discuss how an individual pass through these stages and end up in sustained adoption .We tried to understand the farmer's adoption behaviour through studying their action in the previous season of the crop, based on the farm level data gathered. The level of adoption of these technologies in major crops of Kerala is presented in Tables 1 and 2.

TABLE.1. ADOPTION LEVEL OF BIO FERTLISERS BY SAMPLE FARMERS

(per cent)

Sl no. (1)	Type of biofertiliser (2)	Organic adoption (3)	Non organic adoption (4)	Average adoption (5)
Rice		n=239	-	-
1.	Phosphobactor	1.67	-	1.67
2.	*Azospirillum*	3.77	-	3.77
3.	Biopotash	0.42	-	0.42
4.	BM (commercial formulations)	6.28		6.28
Banana		n = 92	n = 62	-
1.	*Azospirillum*	1.1	1.61	1.3
2.	BM	2.2	-	
Cardamom		n = 12	n = 18	
1.	*Azospirillum*	8.3	-	8.3
2.	Biopotash	8.3	-	8.3
3.	BM	33	-	33
Vegetables		n = 16	n = 3	
1.	BM	18	-	18

The BF application was found to be concentrated on crops like rice, banana, cardamom and vegetables. Compiling the data in the major rice producing districts in Kerala, it could be seen that the diffusion of the BF technology as not up to the expected level. The average level of adoption of BF is only 13 per cent in rice, if the nondescript commercial BMs are also included. The social pressures, government regulations, market signals and awareness have created an environment for alternative technologies for pest/disease management. Hence, the adoption of BCA is more, as compared to that of BF. These technologies which are to be adopted as a preventive strategy is seen followed by 28 per cent of the rice farmers covering 25 per cent of the area cultivated. Tricho cards (*Trichogramma*) are widely used by the farmers for the control rice stem borer and leaf roller.

TABLE 2. ADOPTION LEVEL OF BIO-CONTROL AGENTS BY SAMPLE FARMERS

(*per cent*)

Sl. No. (1)	Type of bio control agents (2)	Organic adoption (3)	Non organic adoption (4)	Average adoption (5)
Rice		N= 239	-	
1.	*Trichogramma*	28	-	28
Banana		n = 92	n = 62	
1.	Pseudomonas	9.78	9.68	9.74
2.	Trichoderma	-	3.22	1.3
3.	Beauveria	-	1.6	.65
Pepper		n = 85	n = 25	
1.	Pseudomonas	23.53	--	18.18
2.	Trichoderma	9.41	-	7.27
Vegetables		n = 16	n = 3	
1.	Pseudomonas	6.25	-	5.26
Cardamom		n = 12	n = 18	
1.	Trichoderma	8.33	-	3.3
Coconut		n = 144	n = 70	
1.	Pseudomonas	4.12	-	2.8
2.	Trichoderma	0.7	-	0.47
Ginger		n = 23	n = 24	
1.	Pseudomonas	69.57	-	34
Nutmeg		n = 22	n = 6	
1.	Pseudomonas	36.36	-	28.57
2.	Trichoderma	27.27	-	21.43
Turmeric		n = 7	n = 2	
1.	Pseudomonas	57.14	-	44.44
2.	Trichoderma	42.86	-	33.33

The BF application in banana farming was done by only around one per cent farmers. The commercial formulations of BM were mainly applied by them. The adoption of BCA was considerably better and there was no significant difference between the two groups (organic and non-organic), with respect to the number of farmers adopting the practice. The average level of adoption was 11.7 per cent. Pseudomonas application was more popular.

None of the sample pepper farmers were applying BF. The average level of adoption of BCA was 23.53 per cent (mainly pseudomonas). The adoption level for BF among the organic cardamom farms ranged from 8.33 per cent to 33 per cent. Azospirillum, biopotash and BM were applied to cardamom. The use of BCA was limited to only trichoderma.

Generally, the BF application was found to be done in organically managed farms. It may be pointed out that, the information presented on a crop wise basis is based on post-stratified data. The homestead or small holding farming situation in Kerala usually follows a mixed cropping pattern (except rice). As such, the number of farmers who adopted the technology is only less than one percent though crop-wise it may be slightly higher. In the case of BCA, the average adoption level was estimated as 11 per cent on a farm level basis. Pseudomonas, due to its fungicidal and plant growth promoting factor is mostly preferred and was seen applied in almost all the crops. The adoption was considerably high among organic farmers, except in the case of commercial banana farming.

The BF/BCAs were first used by many farmers as part of subsidised supply by the State Department of Agriculture. The private sector producers were entrusted to ensure the supply in the locality through the agri-input retail shops. Some farmers, who can be categorised as innovators, have gained their knowledge and awareness regarding the technology (mass media/trainings) and have taken efforts to try the technology on their own. They were equally aware of the poor quality standards of the products available in the open market and always made it sure to get quality BF, preferably from public sector units. For instance, the preventive methods of pest control using *Trichogramma* were very popular among the rice farmers and they have even standardised indigenous cost effective methods of placing the cards in the field. The repeat adoption of the technology in the subsequent crop seasons were almost cent per cent in such cases. The farmers of Thrissur and Palakkad sourced the cards from the Department Laboratory and hence the quality was also assured.

The Department of Agriculture has an ongoing system of ensuring quality of all inputs used in agriculture. For BF/BCA the producers have to submit samples of the produce for granting license for the units to start commercial production or for sale. Upon getting these samples these are sent for quality analysis in the notified laboratories (notified under FCO1985). Since Kerala do not have the facility the samples are sent to the lab under the Regional Centre of Organic Farming (RCOF), Bangalore. Only after satisfactory report the firms are permitted to operate.

Simultaneously, the department draws samples from the market regularly and sends it for analysis. Every year the Deputy Director (Quality Control) (there are four numbers in the state) is given a target number of samples to be drawn and sent for analysis. Currently, these samples are also being sent to RCOF. Most often the results are received only after a long period, and by that time the whole lot must have been sold off. The existing system for quality control is to be strengthened through better infrastructural facilities.

Owing to the improper quality monitoring arrangements, there is a large number of reports on the poor quality of the BF that is supplied in the market. This naturally has limited the scope for further continued adoption as well the adoption among fellow farmers due to poor demonstration effect.

There are instances where the technology transfer was limited to input supply, and there was inadequate information transfer. Some farmers perceived the BF as organic manure and the scientific aspects of application method also were not properly understood by the farmers. There were cases where the BF was applied along with chemical fertilisers.

In general the level of adoption of these ecofriendly technologies was far less than the desired levels. Studies in general have reported poor to low levels of adoption of the BF /BCA technology. Our findings are in conformity with the earlier reports, from across the nation and globally. Kabi and Poi (1998) highlighted the important constraints in using bio-fertilisers as ignorance of both the users and the supervising staff at grassroot level, non-availability of package of practices of inoculating bio-fertilisers and lack of improved transportation of rhizobium strain. Verma and Bhattacharya (1990) in their study indicated the factors responsible for the unsatisfactory use of bio-fertilisers as non-availability of quality inoculants, low shelf life of culture, improper soil condition and lack of education and training among farmers about the use of bio-fertilisers. The studies reported from across the globe and from various parts of India have highlighted the status of adoption of BF as rather poor in various crops (Bhattacharya and Dwivedi, 1992; Kute and Patel, 1993; Motsara, 1993; Singh and Satpathy, 1994; Marwaha,1995; Bhattacharya and Paliwal 1998; Borkar *et al.,*2000; Chothe and Borkar 2000; Bodake *et al*, 2009; Jayasankar and Thyagarajan, 2010; Binkadakatti *et al*, 2010; Nath and Mohapatra, 2011). The reasons reported were mostly the same in all these studies ranging from poor quality standards, low awareness, inadequate marketing and improper extension support. Going by these reports it can be seen that, even after a decade, the adoption level and reasons for the poor adoption remains the same.

Rao and Tagat (1985) suggested that since majority of the rural consumers exhibit low income and low capacity to invest, they have to initially be ‘induced’ through marketing exposures by private and voluntary organisations and government, not merely towards purchase and consumption of goods and services but also towards social processes. But this process of induced change puts the rural consumers more in the role of ‘beneficiaries’ of patronage rather than autonomous ‘buyers’. Going by this theory, it could be seen that in practice, such beneficiaries do not act as repeat adopters unless they are very much convinced of the technology and the supply conditions favour the purchase. In that perspective, the efforts and intervention by the public sector in the initial years of green revolution to spread the chemical fertiliser technology was on a much larger scale. The spread of the BF/BCA technology can be ensured only if such massive efforts are put in. Coupled with that, the infrastructural and supply chain arrangements should also be strengthened.

Can Technology Support Favour Adoption?

The decision to try a new technology is influenced by many factors. To understand the influence of various social and economic factors on the adoption behaviour, the statistical analysis employing Logistic regression was attempted and are presented in Table 3. The regression analysis (logit model) fitted to the data to analyse the adoption behaviour gives interesting findings. Education level (as measured by years of schooling), farming experience, returns from rice farming and extend of technical support received by the farmers were the major factors that influenced the decision making with regard to adoption of bioagents technology. The education indirectly helps in taking considerable scientific decision making and may act as a driver for scientific farming. There is higher chance of exposure to mass media and scientific information. Thus the high literacy level in Kerala favours the adoption. In the sample group the average level of schooling was 11 years. The experience in farming, which ought to have made the farmer aware of the negative externalities associated with chemical farming, was hypothesised to have a positive effect on the adoption behaviour. The experience in farming makes the person aware of the pros and cons of different methods of farming and technologies. The observations and discussion with fellow farmers and other sources of farming information are also presented. Our analysis suggest that the farmers who were more experienced in farming tend to go for eco friendly farming practices and limits chemicals application, due to sustainability concerns.

TABLE 3. ESTIMATED LOGISTIC REGRESSION COEFFICIENTS OF FACTORS INFLUENCING ADOPTION OF BIOAGENT APPLICATION (RICE FARMING)

Variable (1)	Co-efficient (β) (2)	Z statistic (3)
Age (years)	-0.1209	-0.68
Education (years of schooling)	1.1209*	1.65
Experience in eco-friendly rice cultivation(years)	1.0497***	6.59
Returns from rice cultivation (in '000 Rs.)	-0.2745**	-3.34
Training received by farmer (Dummy; Yes=1 No=0)	0.5111	1.09
Mass-media exposure (Dummy; Yes=1 No=0)	0.3422	0.82
Technical support received by farmer (Dummy; Yes=1 No=0)	1.0845**	1.94
Intercept	-2.1990**	-1.66
No. of observations	265	
Log likelihood	-26.01	
Pseudo R^2	0.8018	

Note: ***,** and * denotes level of significance at 1,5 and 10 per cent respectively.

In practice, returns from farming act as a strong factor in the adoption of technological innovations. The perception of yield loss upon adoption of ecologically safe technologies is proved to have a significant negative influence on adoption decision (Divya, 2007). The higher perceived loss estimates, the lower the probability of conversion to safe technologies. Devi (2007) further identifies some of the personal and institutional variables influencing the perception regarding the yield loss. The average farmers' perception of crop yield loss due to pest attack was nearly twice as much as actual yield loss, without any pest. The results suggest that it is important to highlight the economic benefits of bioagents use in extension programmes designed to promote BF/BCA.

Technical support (trainings and visits) by Department of Agriculture is found to have a significant (5 per cent) positive effect on the adoption behaviour. The contact with the formal extension system in both ways (visit of Agricultural Officer to the farm and farmer to Krishi Bhavan) was found to have considerable influence on the chances of adoption. Public extension support to the farmers are two-fold, farmer's visit to the Agricultural Office and agricultural officials visit to the farms. Focusing on the aspect of chemical pest control methods, which is reported as the major threat to the environment, the question on the agent of consultation was posed to the respondents. Supporting the earlier observation on contact with the Agricultural Office (both ways), it was seen that nearly 50 per cent of the farms still depend on the fertiliser/pesticide dealers for getting the information regarding identification and choice of chemical. Consulting the agricultural officials is the practice among 22.5 per cent to 30 per cent of the farmers. Approximately the same number of farmers takes their own decision or discuss with friends. This highlights the need for refocusing the system of information dissemination in favour of sale point. But the sale of BCA through these networks is constrained by many factors. Their level of awareness regarding the technology is very low. The infrastructure for safe and scientific storage is scanty and the trade interests for sales promotion are low. Compared to chemical alternatives manufactured by large firms, the incentives and margin for sale of BF/BCA may be less attractive. This necessitates the decentralized production programmes for BF/BCA and more proactive role of public extension system.

The analysis highlights the favourable environment in Kerala for the spread of the technology. The higher literacy level is a strong positive aspect. The farmer group in the state belongs to the older age group (average more than 50 years) and the life expectancy is also high. The higher personal income of consuming population coupled with better literacy creates a favourable market for organic food products. Thus the premium price can act as a driver for better income realisation from farming. This in turn has a strong positive influence on the adoption level as revealed by the analysis. The role of technical support and guidance from formal extension system is underlined in the dissemination and diffusion of the technology. The public sector system may be geared to face this task by organising trainings, farm level demonstrations, advisory services and mass media advertisements.

IV

CONCLUSION

Chemical based farming has helped us to achieve commendable strides in agricultural production, at the cost of environmental quality. The social and economic factors presently favour the ecofriendly farming technologies and safe ecosystem, as environmental quality is highly income elastic.BF/BCA are ecologically safe technological options and the policy is trying to support the development and spread of these technologies. Though subsidies facilitate the economic access to the technology, it did not ensure the sustained adoption and scientifically proper application. The analysis supports the statistically significant influence of technical support in the adoption of the technology, which underlines the importance of infrastructural and technological support mechanism in the wide scale adoption of the technology. Thus subsidies can be considered as a necessary condition, but not a sufficient condition for the sustained technology adoption. However, it can be concluded that the supply side and demand side management of the technology is facing serious problems which need urgent focus.

The role of technical support and guidance from formal extension system is underlined in the dissemination and diffusion of the technology. The public sector system may be geared to face this task by organising trainings, farm demonstrations, advisory services and mass media advertisements.

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