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Adoption of Integrated Pest Management Practices in Paddy and Cotton : A Case Study in Haryana and Punjab

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Abstract

The study has examined the adoption of IPM practices on cotton in Punjab and on paddy in Haryana and has assessed the impact of key socio-economic and institutional factors on IPM adoption. The Poisson count regression models have been used to analyze technology adoption. The awareness generation about technology through formal crop-specific IPM training provided by the farmers' field schools has been found extremely effective in wider adoption of IPM in the study areas. Hence, investment in IPM education through these programmes will have long-term beneficial impact. Regarding effectiveness of extension services, the study has not shown (frequency of meeting extension personnel) any statistically significant impact on IPM adoption rates. Mixed evidence has been observed about the relationship between farm-size and adoption of IPM practices. In the case of paddy, a negative relationship has been observed, while the cotton has shown a positive relationship. The study has concluded that a higher gross value of crops does not appear to have a positive impact on IPM technology adoption in cotton.

Introduction

Indiscriminate and excessive applications of synthetic pesticides have not only damaged environment and agriculture but have also caused their entry into the food chain. Evidences of pesticide threats to human health and economic effects have been documented in several studies (Rola and Pingali, 1993; Antle and Pingali, 1994). Integrated pest management, which is essentially a knowledge-based technology, involves integration of different methods of disease and pest management. This technology has not only shown decreased applications of pesticides and low environmental risks but has also raised crop yields and net returns. However, despite these favourable results, its adoption has remained miniscule.

Farmers' adoption of integrated pest management (IPM) package depends on many factors, such as their technical skill and socio-economic conditions as well as psychological and cultural factors, etc.

Since farmers are the final decision-makers for adoption of any technology, it is important for the technology developers/providers to identify how farmers' react to the provided techniques and what about the adoption process of certain innovations. However, not much attention has been paid to assessing of farmers' perception and knowledge

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about pest and pest-control practices, quantifying levels of adoption of different IPM components and their determinants.

Against this backdrop, this paper has examined the impact of key socio-economic and institutional factors on adoption of integrated pest management practices in paddy and cotton which consume a sizeable share of total pesticide application in the country. Moreover, farmers' perception regarding pest control practices and impact of IPM practices will augment farm efficiency.

Database and Methodology

Sampling Framework

The study was conducted in the states of Punjab and Haryana, representing one of the most progressive regions in terms of agricultural productivity and input-usage and also characterized by highly commercialized agriculture. The study is based on the primary data, collected for the year 2003-04 from a sample of 95 cotton farmers from the Bhatinda and Ferozpur districts of Punjab and 83 farmers cultivating paddy in the Karnal and Kaithal districts of Haryana. Farmers were interviewed personally and primary data on socio-economic characteristics of sample farmers, cultivation practices with particular emphasis on plant protection and adoption of IPM practices in crop production, was collected.

Empirical Model

The study has used a Poisson count regression model to analyze technology adoption by using cross-sectional data obtained from primary survey. In this model, the dependent variable, i.e. IPM adoption, was assumed to be an integer-value gradient. Since, IPM technology is a bundle of practices and is essentially specific to particular crop and location, the efficiency of IPM would vary depending upon which components/practices farmers actually employ. Hence, each IPM practice was weighted according to its contribution to biologically intensive pest management. Weights ranged from 1 to 5. IPM adoption was measured by counting the number of practices adopted by farmer duly weighted by its importance as per the above-mentioned criteria. Under those circumstances, OLS was not the ideal choice statistically, as it performs best when the dependent variable is continuous and normally distributed. Hence, the parameters were estimated by maximum likelihood method.

Poisson Count Regression Model

The Poisson maximum likelihood regression model predicts the score of IPM practices used by growers. The number of additional pest management practices used on a given crop indicates the farmers' reliance on multiple biological and cultural pest management, a key ingredient of IPM use (Vandemen *et al.*, 1994). According to Greene (1997), the Poisson regression is represented by the basic Equation (1):

$$\text{Prob}\ (Y_i = y_i) = [\ e^{-\lambda_i} l_i^{y_i}\ ]\ /\ y_i\ ! \qquad \ldots(1)$$

where, $y_{i\,=}\ 0,1,2,\ldots\ldots\ldots$

The parameter λ_i is assumed to be log-linearly related to regressors x_i. Therefore,

$$\ln\ (\lambda_i) = \beta'\ x_i$$

The log-likelihood function is given by Equation (2) :

$$\ln L = \Sigma_{\ i=1,2,\ldots,n}\ [\ -\ \lambda_i + y_i\ \beta'\ x_i - \ln y_i\ !] \qquad \ldots(2)$$

The expected number of IPM practices per farm is given by Equation (3):

$$E[y_i \mid x_i\ ] = \text{Var}[y_i \mid x_i\ ] = \lambda_i = \exp\ (\beta'\ x_i + \mu_i) \qquad \ldots(3)$$

where, β is a $1 \times k$ vector of parameters; x is a $k \times 1$ vector with the values of k independent variables in the ith observation and n is the number of observations.

Equation (3) can also be expressed as Equation (4) :

$$\begin{aligned} E(Y_i) &= \exp^{(\beta_1\ x1i)}\ \exp^{(\beta_2\ x2i)} \ldots.\ \exp^{(\beta_k\ xki)} \qquad \ldots(4) \\ &= \exp(\beta_j X_{jn})\ C_i \quad (i=1,\ldots\ldots.,n) \end{aligned}$$

where, j can take any value from 1 to k and identifies a specific explanatory variable and C_i is a constant representing the product of the remaining exponential terms in Equation (4).

For dichotomous explanatory variables, if $x_{ji}=0$, $E(Y_i)=C_i$,

and when $x_{ji} = 1$, $E(Y_i) = \exp(\beta_j)C_i$. $\qquad \ldots(5)$

Therefore, $100 \times (\exp^{\beta_j} - 1)$ calculates the percentage change on E(Y) when x_j goes from zero to one, for all observations (i). In general, for independent variables that take several integer values, the percentage change in the expected level of adoption when x_j goes from x_{j1} to x_{j2} can be calculated as: $100 \times (\exp^{(\beta_j x_{j2})} - \exp^{(\beta_j x_{j1})}) / (\exp^{(\beta_j x_{j1})})$.

Based on the conceptual framework, the empirical model was estimated using the farmer's characteristics that conditioned adoption behaviour, including age, education, knowledge regarding negative externalities of pesticide-use, perception regarding expected yield losses due to pest if pesticide was not used; institutional factors such as membership in farmers' club/self-help groups; farm- size and frequency of meetings with extension personals, etc. as regressors (Table 1). The study hypothesized that the level of education will have a positive effect and age a negative effect on adoption behaviour towards IPM technology. In addition, farmers' economic characteristics (farm-size and gross value of crop) and institutional variables, IPM training, frequency of meeting with extension personnel, years of experience in practicing IPM) will also have positive effects on IPM adoption. Farmers' perception about yield loss due to pests if no pesticide was used, was hypothesized to have a negative influence on IPM adoption.

Results and Discussion

Farmers' Knowledge and Awareness regarding Pest and Pest Control Decisions

Farmers' Perception on Pest Incidence

Farmers' knowledge of pest management was examined based on their perceptions regarding changes in the extent of pest problems over time and pest control decisions. In the study area, most of the farmers perceived that frequency of infestation of insects and diseases had increased over the past 10 years in the case of paddy. However, in cotton, the majority opined that insect problem had increased remarkably, but there was no change in disease infestation over the past 10 years (Table 2).

Pest Control Decisions

Farmers' access to pest management information in a variety of ways. Hence, development of any outreach programme can benefit by finding the most commonly used method by the farmers. It was found that farmers accessed the information on pesticide-use through multiple sources. For paddy-growing farmers, the main information source was extension personnel of the State Department of Agriculture and State Agricultural University (71 %), followed by the

Table 1. Description of independent variables used in Poisson Regression Analysis

Variables	Definition	Units
Dependent variables		
IPM adoption score	Weighted number of IPM practices adopted by farmer	Number
Independent variables		
Age	Farmer's age	Years
Education	Farmer's education level	Illiterate =0, Primary=1, Middle=2, Higher=3
Farm-size	Farmer's operational holding	Hectare
SHG	Farmer belong to Self-Help Group/Farmer's club	Yes =1, No =0
Train-IPM	Formal training of IPM practice	Yes =1, No =0
F_EXT	Farmer frequently consulted extension personnel	Yes =1, No =0
YRisk	Farmer's perception on yield loss due to pest if no pesticide was used	%
FKNScore	Farmer's knowledge score about pesticide externalities to environment	Scores
Exp_IPM	Farmers' experience with IPM in concerned crop	Years
GRETURN	Gross return from concerned crop	Rupees

Table 2. Farmers' perceptions about frequency of pests infestation in cotton and paddy over past 10 years

(Per cent)

Particulars	Paddy	Cotton
Insects		
No changes	28.11	12.50
Declining	5.40	15.00
Increasing	65.14	72.50
Do not know	1.35	0
Disease		
No changes	9.46	76.25
Declining	8.11	13.75
Increasing	81.08	5.00
Do not know	1.35	5.00

private pesticide dealers (49 %) and fellow farmers and media (38 %). The cotton farmers of Punjab were mainly influenced by the private pesticide dealers (88 %), followed by fellow farmers and media sources (64 %) and State Department of Agriculture and State Agricultural University (60 %).

The most important criterion followed by the farmers to initiate insecticide application was their own determination of pest-infestation levels in both the crops (Table 3). In the case of cotton, about 50 per cent farmers consulted extension personnel before going for insecticide application. This criterion was considered to be closest to the economic threshold level. A sizeable number of farmers depended on local sources of information comprising fellow farmers and media sources. In paddy, one-third of the farmers regarded insecticide application as a standard practice.

Adoption of IPM Practices

It has been observed that among IPM trained farmers, various cultural practices have widespread adoption as against very low adoption of biological practices (Table 4). In cultural practices, more than two-thirds paddy and cotton farmers were found practising deep summer ploughing, trimming of bunds, destruction of crop residues, etc. Among the mechanical practices, pheromone traps were being used by only four per cent of farmers in paddy, mainly because of farmers' poor knowledge about its use and non-availability of pest-specific lures. However, a sizeable number of farmers used these traps in cotton. Use of biological control methods for pest control was observed at very low level in both the crops.

Farmers also complained about difficulty in using light traps in paddy due to their short-life as well as non-availability of bulbs. *Trichogramma* was the major bio-agent used in paddy IPM, but its adoption was found abysmally low in paddy and non-existent in cotton. The major problems reported in its adoption were its slow action against the target pest, lack of easy availability, short shelf-life and low survival of these bio-agents on farmers' field. Similarly, use of neem-based pesticide was also found very low (14 %), mainly because of its slow action and lack of availability at local pesticide dealers. Only 28 per cent farmers reported using pesticides on the basis of economic threshold levels of pest infestation in paddy-growing areas as against 10 per cent in cotton.

Determinants of IPM Adoption at Farm Level

Poisson regression results on the determinants of adoption of weighted aggregate IPM practices in paddy and cotton have been summarized in Table 5. The empirical model was estimated having dependent variable as weighted number of IPM practices adopted by each farmer. The explanatory variables included farmer's characteristics that condition adoption behaviour such as his age, education,

Table 3. Farmers' decision criteria for pesticide application

(in per cent)

Decision criteria	Paddy	Cotton
Farmers' own determination of pest-infestation level	82	98
Standard practice or history of insect problems	34	15
Consultation with extension personnel for infestation thresholds	24	50
Local information (other farmers, Radio, TV, etc.)	21	91

Table 4. Adoption of integrated pest management practices

(% farmers)

Particulars	Paddy	Cotton
Cultural practices		
Deep summer ploughing, trimming of bunds,destruction of crop residues and timely planting	70	72
Use of resistant / tolerant varieties	56	58
Avoiding excess nitrogen application	34	64
Mechanical practices		
Use of sex pheromone traps	4	29
Use of light traps	11	0
Biological control		
Release of *Trichogramma*	5	0
Use of neem products / neem-based pesticides	14	10
Release of Trichoderma	0	5
Chemical control		
Use of pesticides based on ETL	28	10

Table 5. Determinants of adoption of integrated pest management technology in paddy and cotton

Variables	Paddy			Cotton		
	Coefficients	S.E.	z- value	Coefficients	S.E.	z- value
Intercept	3.004***	0.181	0.000	1.998***	0.259	0.000
Age	-0.002	0.002	0.418	-0.002	0.003	0.390
Education	-0.009	0.005	0.867	0.025	0.035	0.468
Farm-size	-0.006*	0.004	0.100	0.009*	0.005	0.109
Membership of SHG	0.505***	0.060	0.000	-0.025	0.066	0.708
Experience with IPM, years	-0.014	0.026	0.597	0.017	0.075	0.823
Frequency of meeting extension personnel	0.099	0.077	0.197	-0.041	0.098	0.677
Farmers’ perception about yield loss	0.001	0.001	0.308	0.006	0.004	0.870
Farmers’ knowledge score	-0.006	0.008	0.413	0.035**	0.016	0.025
IPM training	0.112**	0.049	0.024	0.568***	0.207	0.006
Gross value of crop	0.687	0.153	0.653	-0.591**	0.271	0.029
Chi square	76.54	-	-	72.57	-	-

Note: ***, ** and * denote 1 per cent, 5 per cent and 10 per cent levels of significance, respectively.

knowledge regarding negative externalities of pesticide-use; perception regarding expected yield losses due to pests if pesticide was not used; institutional factors such as membership in farmers’ club/self-help groups; IPM training, farm-size and frequency of meetings with extension personnel, etc. The Poisson regression model turned out significant, with chi-square values significant at 1 per cent level.

The results showed that formal training of farmers on IPM technology was positive and significant in both the crops. Using Equation (5), it was estimated that the adoption level of farmers who received formal IPM training was higher than those who did not undergo training by 12 per cent in paddy and 76 per cent in cotton farmers. In addition, the results clearly showed that those paddy farmers who participated in self-help groups and owned small landholdings were more likely to adopt IPM practices. Contrary to the common notion that small farmers are poor adopters of new technology, results of this study showed negative scale effect in the use of paddy IPM technology. This may be due to the fact that owing to the labour- intensive nature of some of the IPM practices, large farmers faced difficulty in carrying out the required operations. In the case of cotton, formal IPM training, knowledge level of farmers regarding adverse impact of pesticides on environment, farm-size and gross value of crop turned out to be significant in explaining high IPM adoption score. The coefficient of gross value of the crop tuned out to be negative, indicating risk adverse nature of farmers. They did not have much faith in alternative pest control technology in combating the pest menace.

The paddy farmers having membership of farmers' club/SHG were predicted to have 66 per cent higher adoption rates than those who were not members of any such organization. In the case of cotton, this variable did not turn up significant. Age and formal education did not show significant effect on IPM adoption in any of the selected crops.

Conclusions

The study has shown that technology awareness through formal crop-specific IPM training provided by farmers' field schools is extremely important for wider adoption of IPM in the study area. Hence, investment in IPM education through these programmes will have long-term beneficial impact. Participation in community organization/farmers' activities has also been found positively related to technology adoption, as they provide a better platform for farmer-to-farmer extension delivery approaches. The effectiveness of extension services is an important and frequently debated issue in developing countries like India, but study has not shown (frequency of meeting extension personnel) statistically significant impact on adoption rates. Farmers' knowledge regarding pesticide-related environmental problems has depicted a significant positive impact on adoption of eco-friendly pest control technologies like IPM in the case of cash crops like cotton, which use relatively higher level of pesticides. The study has found mixed evidence about the relation- ship between farm-size and adoption of IPM practices. In the case of paddy, a negative relationship has been observed, while cotton has shown a positive relationship. To achieve success in IPM, it is required to have a level of analytical skill and certain basic trainings in management of crop and ecological principles. These programmes are likely to develop farmers' capacity on decision-making and finding appropriate solutions.

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