Agricultural Economics Research Review
Vol. 20 January-June 2007 pp 77-86

Economic Evaluation of Pest Management Technologies for Sustainable Cotton Production in Punjab*

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Abstract

This study has been undertaken to make cotton production in the state of Punjab globally competitive by reducing the cost of production at farmer's level through adoption of new pest management technologies, namely Integrated Pest Management (IPM) and Insecticides Resistant Management (IRM). A sample of ten experimental and ten control plots has been taken for each technology in four villages of the cotton belt of Punjab. The study has revealed that the adopters of IPM and IRM technology could get significantly higher yield as compared to that by non-adopters. These technologies have been found cost-effective due to higher production and could reduce the per quintal production cost by Rs 253 and Rs 175, respectively. These technologies have been found to generate more income and employment as the adopters could earn Rs 6840/ha and Rs 5901/ha more income as compared to that by the non-adopters. The gain in human employment due to adoption of these technologies has been of 11 humandays/ha and 12 humandays/ha, respectively. The IPM and IRM technologies have reduced the pesticides consumption by 67 per cent and 54 per cent, respectively. The cost-benefit analysis has shown these technologies to be economically viable. The study has suggested that these technologies should be propagated among the farmers in the cotton belt of Punjab. These technologies will reduce the chemicals-consumption and enhance the productivity of cotton on sustainable basis with lower cost of production, which in turn would protect the environmental health and economic condition of the debt-ridden cotton growers on a long-term basis.

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* The data for this paper have been taken from the research project "Evaluation of Cotton Production Technologies for Yield, Fibre Quality and Economic Viability", funded by ICAR, New Delhi.

The authors thank the anonymous referee for his valuable suggestions.

Introduction

Cotton popularly known as 'white gold' is the main *kharif* crop of south-western Punjab. During 2004-05, Punjab produced about 17 lakh bales of cotton from about 5 lakh hectares of area. The average yield of cotton worked out to be 552 kg/ha, which is about two-thirds of the potential average yield of the important cotton varieties grown in the state. The major factor responsible for low productivity and quality deterioration of cotton in the state as well as in the country is the severe attack of insects/pests on this crop, from sowing to harvesting. These insects/pests, which include bollworm (BW) complex and sucking pests, cause about 50-60 per cent loss in seed cotton (Dhawan *et al*., 2004). To check this loss in cotton, farmers use huge amount of pesticides on this crop. About 54 per cent of the total pesticides are used only on cotton, leading to higher cost of its production and deterioration in its quality (GoI, 1997). The yield of the cotton crop witnessed a significant decline year-after-year during 1990s. The intertwining of increased cost of production with low yields has resulted in sharp declines in the net earning of the otherwise well-off cotton growers in the state. This phenomenon has pushed these farmers into debt-trap forcing some of them to commit suicides (Singh and Toor, 2005).

For sustainable cotton production in the state, efforts have been made by the Punjab Agricultural University (PAU), Ludhiana, to develop insect/pest management technologies. Under the Technology Mission on Cotton (TMC), set up by the Government of India in 2001, efforts were made to bring the pesticide-use down to 20 per cent (Mayee, 2003) by developing new technologies for cotton production, the most important being Integrated Pest Management (IPM) and Insecticide Resistance Management (IRM). The former (IPM) is a decision-support system for the selection and use of pest-control tactics, singly or harmoniously coordinated into a management strategy based on cost-benefit analysis that takes into account the interests of and impacts on producer, society and environment The latter (IRM) deals with the insecticide resistance among various cotton insects, which results due to the indiscriminate use of insecticides to control insect menace in cotton. Moreover, this insecticide treadmill has resulted in increased cost of pest management and resurgence of new pests. There are many factors like chemical nature of insecticides, frequent sprays, and sequential relationship of chemicals, which influence the development of resistance in the pests. The IRM technology, too, is to be adopted by the cotton growers at all phases of production, viz. pre-sowing, vegetative, reproduction and maturation. For a proper use of insecticides in IRM technology, it is advised to grow only the recommended varieties of cotton, spray only the recommended insecticides in proper doses for control of various insects/

pests, repeat the spray immediately if it rains within 24 hours of the spray and avoid repeated use of the same molecule in subsequent sprays.

Keeping in view the importance of these technologies in controlling indiscriminate use of pesticides for sustaining cotton productivity, an attempt has been made to evaluate the impact of IPM and IRM technologies on selected farmers' cotton fields in the state of Punjab. More specifically, the present investigation was focused on evaluating the impact of these technologies on cotton productivity, cost of production, pesticides use, net returns and labour employment in the cotton belt of Punjab state. The economic viability of these technologies at farmers' field has also been studied.

Methods and Material

The study was undertaken during the year 2004-05 to examine the economic viability of IPM and IRM in Punjab following with & without technology approach. Four villages from the cotton belt of Punjab were selected. Experiments were conducted on 10 farms in the village Kahnewal using IPM technology and on 10 farms in the nearby village Kotra Kalan of district Mansa without IPM technology. Similarly, 10 farms were selected in the village Ghuda for IRM technology and an equal number of control plots in the village Gill Khurd of the district Bathinda. To eliminate the impact of farm-size and variety, these variables were kept constant on the sample farms. For working out gross returns, the actual price of cotton received by the farmers in the market was used. The variable costs included expenditure on seeds, fertilizers, insecticides/pesticides, human/machine/bullock labour and irrigation along with 12 per cent interest on working capital. Comparisons were made by using t-statistics.

Results and Discussion

Cotton Productivity

The main objective of new technologies was to improve the productivity of cotton through a better insect-pest management. Therefore, the data on cotton produced from the experimental and control plots of IPM and IRM technologies were averaged out to estimate their impact on productivity and are given in Table 1.

A perusal of Table 1 reveals that these technologies had a significant positive impact on cotton productivity as 13.36 per cent higher yields were obtained on experimental than control plots. Technology-wise, the increase was 13.59 per cent in IPM and 13.13 per cent in IRM. The differences in

Table 1. Impact of cotton pest management technologies and cotton productivity in Punjab : 2004-05

Technology	Cotton productivity (q/ha)			t-Statistic
	With	Without	Gain	
IPM	23.32	20.53	2.79 (13.59)	4.03*
IRM	22.58	19.96	2.62 (13.13)	2.94*
Overall	22.95	20.24	2.70 (13.36)	4.48*

Notes: Figures within the parentheses indicate percentages.
*Significant at 0.01 probability level

the productivity of experimental and control plots were statistically significant at one per cent level of significance, leading to the conclusion that the alternate hypothesis, i.e. the new cotton production technology would increase the productivity, was true.

Cost of Cultivation/Production and Income

The costs on cotton cultivation along with net income were worked out on the experimental and control plots and have been presented in Table 2.

Table 2. Impact of cotton pest management technologies on costs and returns in Punjab: 2004-05

Particulars	Cotton production technology		
	IPM	IRM	Overall
Cost of cultivation (Rs/ha)			
With technology	16872	18474	17673
Without technology	20070	19826	19948
Impact	3198 (15.93)	1352 (6.82)	2275 (11.31)
t-statistics	1.30^{NS}	0.65^{NS}	1.24^{NS}
Cost of production (Rs/q)			
With technology	724	818	771
Without technology	977	993	985
Impact	253 (25.89)	175 (17.62)	214 (21.75)
t-statistics	2.42**	2.32**	3.34*
Gross margins (Rs/ha)			
With technology	24303	21231	22767
Without technology	17463	15330	16396
Impact (gain)	6840 (39.17)	5901 (38.99)	6370 (38.86)
t-statistics	4.54*	2.84*	4.82*

Notes: *Significant at 0.01 probability level, ** Significant at 0.05 probability level.
NS= Non-significant
Figures within the parentheses indicate percent change.

The analysis revealed that the per hectare cost of cotton cultivation was lower by Rs 2275 (11.31 per cent) on experimental than control plots. The average cost of producing one quintal of cotton by using these technologies was Rs 771, which was about 22 per cent lower than that from the control plots. Technology-wise, reduction in the cost of cultivation (Rs 3198/ha) as well as cost of production (Rs 253/q) was higher in IPM than IRM technology.

From the farmer's point of view, the most important factor in the adoption of a technology is its impact on the net income. Net returns or returns to fixed farm resources (RFFR) from cotton were worked out after subtracting the variable expenditure incurred in growing cotton from the gross returns received by selling it in the market. It can be seen from Table 2 that the incremental returns with the adoption of these technologies were Rs 6370 per ha, which were about 39 per cent higher than those on the non-adopter farms. The reasons for this significant jump in the net income from cotton were higher productivity and lower cost of production. All the differences were statistically significant.

Labour Use

Cotton plays an important role in the development of Indian economy, especially by providing large employment on farms, textile industry, marketing and processing sectors. The deployment of labour was also estimated with and without IPM/IRM technologies.

It can be seen from Table 3 that the human labour employed per hectare of cotton was for about 63 humandays on IPM and about 65 humandays on IRM experimental plots which was about 11 humandays/ha and 12 humandays/ha more than that on the non-IPM and non-IRM plots, respectively. The analysis revealed that human labour use increased by

Table 3. Impact of cotton pest management technologies on human labour during cotton cultivation in Punjab: 2004-05

(humandays/ha)

Particulars	Labour used		Overall
	IPM	IRM	
With technology	62.74	64.64	63.69
Without technology	51.91	52.34	52.12
Gain in employment	10.83 (20.86)	12.30 (23.50)	11.56 (22.20)
t-statistics	3.94*	2.36**	3.95*

Notes: *Significant at 0.01 probability level, ** Significant at 0.05 probability level. Figures within the parentheses indicate percentage change.

about 22 per cent with the adoption of these technologies. This significant difference in labour-use was due to better crop harvest on the experimental plots. Thus, the adoption of these technologies on cotton could generate more on-farm employment in the Punjab state.

Pesticide Use

The indiscriminate use of pesticides in cotton cultivation has caused several negative externalities in the farm and non-farm sectors (Painuly *et al*., 1998). Although, the main objective of IPM and IRM technologies in cotton was to obtain sustainable cotton production by reducing the use of pesticides, these continue to be a major component of IPM and IRM owing to several constraints such as the use of cultural practices, non-availability of resistant cultivars, effective parasitoids and microbes, etc. On the basis of the experiments, experts recommend the selection of a pesticide along with strict adherence to its dosage, time, and method of application, etc. to control the pest complex of cotton eco-system during vegetative (jassid and white fly) and flowering (bollworms and white fly) phases. The use-pattern of these pesticides in the total pesticide consumption on cotton cultivation is given in Table 4.

The IPM and IRM farmers received expert guidance leading to the judicious use of pesticides by following economic threshold levels (ETL) for different insect/ pests of cotton, especially during the flowering stage, whereas non-IPM and non-IRM farmers used these poisonous materials as

Table 4. Extent and pattern of pesticides used, with and without cotton pest management technologies on sample farms, Punjab: 2004-05

(Per cent)

Pesticides group	IPM		IRM	
	With	Without	With	Without
Synthetic pyrithroids	Nil	2.04	Nil	Nil
Organo-chlorinated (OCA)	12.79	14.61	9.25	9.10
Organo-phosphates (OPS)	74.94	33.13	64.97	58.84
Oxadiazine	2.74	Nil	1.98	Nil
Naturalite	1.75	0.073	0.33	Nil
Confidor/Pride/Ectara	7.77	2.01	23.48	8.83
Mixture	Nil	48.16	Nil	23.23
Total	100.00	100.00	100.00	100.00
Total pesticides* (kg/ha)	3.24	9.83	2.25	4.74
No. of sprays	6	10	4	7
Cost of insecticides used (Rs/ha)	5294	6821	3020	4648

*Total pesticides used in technical grade kg/ha of cotton.

per the recommendations of the traders/dealers, who had profit motives. The main pesticides recommended by the Punjab Agricultural University (PAU) are: Imidacloprid 200SL / Acetamiprid 20SP / Thiametheoxan 200WP for jassid control and Endosulfan 35EC / Chloropyriphos 20EC / Trizophos 40EC / Indoxacarb 15SC / Spinosad 48SC / Quinalphos 20EC / Ethion 50EC / Accephate 75SP, etc. for bollworm control. However, the PAU discourages the use of synthetic pyrethroids and a mixture of insecticides. It was observed that the IPM and IRM farmers mostly used the latest recommended pesticides like Confidor, Avaunt, Tracer, Accephate, etc. About 48 per cent pesticides used by non-IPM and 23 per cent by non-IRM farmers were the mixtures of insecticides, which was not in accordance with the PAU recommendations.

The extent and pattern of pesticides-use in cotton cultivation by an average cotton grower in Punjab indicated that their quantity per unit area was very high. Also, the selection as well as dosages of the pesticides were not proper. Farmers mostly use synthetic pyrethroids/mixtures, which lead to the development of insecticide resistance in the insects and also deteriorate quality of cotton and the environment. The excessive use of synthetic pyrethroids has increased the severity of whitefly and American bollworm which in turn, has adversely affected pest management in cotton in the state of Punjab.

Table 4 also shows the pattern of pesticides-use on the experimental and control cotton plots of IPM and IRM technologies. The quantity of pesticides used in cotton cultivation on IPM-plots (3.24 kg/ha) was less than half of the quantity used on the control plots (9.83 kg/ha). The corresponding figures for IRM and non-IRM plots were 2.25 kg/ha and 4.74 kg/ha, respectively. The number of sprays reduced from 10 to 6 for IPM technology and from 7 to 4 for IRM technology. It could be concluded that the adoption of these technologies significantly reduced the amount of pesticides used and number of sprays, leading to a quality harvest with better returns.

Economic Viability

The economic viability of IPM and IRM technologies was examined by computing benefit-cost ratios (BCR), i.e. the ratio of gross margins (RFFR) to the input expenditure incurred in growing cotton and the results obtained are given in Table 5. The BCR higher than one for the cotton grown on the plots using cotton pest management technologies implies that the returns were more than the expenditure, whereas it was reverse in the case of non-users. This shows that both these technologies are cost effective and economically viable.

Table 5. Benefit-cost ratios for cotton pest management technologies in Punjab: 2004-05

Benefit-cost ratio	Cotton production technology		Overall
	IPM	IRM	
With	1.44	1.15	1.29
Without	0.87	0.77	0.82
Difference (%)	65.52	49.35	57.32

Projection for Punjab State

Since IPM and IRM technologies are economically viable, an attempt was made to study the impact of these technologies over productivity, employment, net returns and pesticides consumption at different levels of adoption in the state (Table 6).

Presently, the area under cotton is about 5 lakh hectares in Punjab. The adoption of IPM technology on 10 per cent, 15 per cent and 25 per cent of area under cotton in Punjab would lead to the increase of about 82 thousand, 123 thousand and 205 thousand bales of cotton, respectively. This would enhance the net income of the cotton growers by Rs 342 million, Rs 513 million and Rs 855 million and human labour employment by 541 thousand, 812 thousand and 1354 thousand humandays. Similarly, the pesticides consumption would decline to 329 Mt, 494 Mt and 824 Mt, respectively.

The adoption of IRM technology on 10 per cent, 15 per cent and 25 per cent area under cotton production in the state would increase production by 77 thousand, 115 thousand and 192 thousand bales, leading to the increase in net income by Rs 295 million, Rs 443 million and Rs 738 million, respectively. At these levels of adoption about 615 thousand, 922 thousand and 1537 thousand humandays employment would be generated and pesticides consumption would be reduced by about 124 Mt, 187 Mt and 311 Mt with the adoption of IRM technology in the state.

The analysis revealed that the pest management technologies would overall increase the state cotton production by 79 thousand, 119 thousand and 199 thousand bales assuming its adoption on 10 per cent, 15 per cent and 25 per cent area, respectively. This increase in production would increase the net income to Rs 318 million, Rs 478 million and Rs 796 million and would generate the human labour employment of 578 thousand, 867 thousand and 1445 thousand humandays in the state.

The overall pesticides consumption would be reduced by 227 Mt, 340 Mt and 567 Mt by adopting these technologies on 10 per cent, 15 per cent and 25 per cent area under cotton in the state.

Table 6. Projection of important cotton production technologies in cotton-based cropping system of Punjab: 2004-05

Technology	Economic parameters	Adoption (assuming 5 lakh hectares of area under cotton)		
		10%	15%	25%
IPM	Incremental production (thousand bales)	82	123	205
	Additional income of cotton growers (million Rs)	342	513	855
	Incremental employment (thousands humandays)	541.5	812.25	1353.75
	Reduction in pesticides consumption (Mt)	329.5	494.25	823.75
IRM	Incremental production (thousand bales)	77	115.5	192.5
	Additional income of cotton growers (million Rs)	295	442.58	737.63
	Incremental employment (thousands humandays)	615	922.5	1537.50
	Reduction in pesticides consumption (Mt)	124.5	186.75	311.25
Overall	Incremental production (thousand bales)	79.5	119.25	198.75
	Additional income of cotton growers (million Rs)	318.5	478	796.31
	Incremental employment (thousands humandays)	578	867	1445
	Reduction in pesticides consumption (Mt)	227	340.5	567.5

Conclusions

Insects/ pests pose serious problems, from sowing to harvesting stages, in the cultivation of cotton crop. For the sustainable production of cotton and judicious use of pesticides, new cotton pest management technologies, namely IPM and IRM have been developed in the Punjab state. The study has revealed that the adoption of these technologies has increased the cotton productivity by about 13 per cent. These technologies are cost-effective (decrease production cost) and more remunerative (increase the net income of the farmer). Both the technologies are environment-friendly as pesticides-consumption could be reduced to less than half of that used in non-IPM/ IRM farms. All the parameters used for the evaluation have conferred that these technologies are economically viable at the farmer's field. The study

has projected that the use of pest management technologies would increase cotton production by 79 thousand, 119 thousand and 199 thousand bales on its adoption on 10 per cent, 15 per cent and 25 per cent cotton area in the state, respectively. It would increase the net income to Rs 318 million, Rs 478 million and Rs 796 million and would also generate employment for 578 thousand, 867 thousand and 1445 thousand humandays in the state. The study has suggested that the state, researchers and extension workers should launch a mass campaign to educate the farmers about these technologies. It would improve the economic condition of cotton-growers and check the environmental deterioration due to excessive use of insecticides. Above all, it would sustain and enhance the productivity of cotton in the state on a long-term basis.

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