Agricultural Economics Research Review
Vol. 20 July-December 2007 pp 273-282

Profitability of Cotton on a Pest Management Continuum in Guntur District of Andhra Pradesh

C.A. Rama Rao*, M. Srinivasa Rao, P. Naraiah, B. Malathi and Y.V.R. Reddy

Abstract

The plant protection response of farmers in the Guntur district of Andhra Pradesh has been examined with particular reference to the adoption of Bt cotton varieties and IPM components. The farmers have been found to follow a wide range of practices to manage the insect pests in cotton. The use of chemical insecticides has accounted for, about 37 per cent of the total variable costs. No significant reduction in plant protection expenditure has been recorded on adoption of Bt varieties without IPM practices. The adoption of IPM practices, however, has led to reduced use of insecticides and increased profitability. The saving on plant protection chemicals has more than compensated the cost of adopting IPM components. Consequently, the net returns have been found increased considerably from cotton cultivation.

Introduction

India is one of the leading producers of cotton in the world. However, its average productivity is far less in India than other leading producers in the world. In India, the state of Andhra Pradesh ranks third in production and fifth in productivity of cotton. Considering it to be a commercial crop with high potential profits, many farmers in different regions have switched over to its cultivation (Rama Rao, 2000). However, the cotton cultivation is subject to high production and price risks, originating from weather vagaries, incidence of pests and diseases and high price fluctuations.

Central Research Institute for Dryland Agriculture (CRIDA), Santoshnagar, Hyderabad 500 059
*Author for correspondence: Email: carrao@crida.ernet.in; chitiprolu@yahoo.com
This paper is based on the work done in the AP Cess Fund Project "Assessment of adoption and impact of IPM in rainfed crops", funded by the Indian Council of Agricultural Research, New Delhi.

Incidence of insect pests is one of the major factors inducing yield risk in cotton. The crop is the single largest insecticide consumer worldwide (Matthews and Tunstall, 1994). It accounts for about 45 per cent of the total pesticide consumption in India and Andhra Pradesh is one of the leading consumers of insecticides (www.fao.org). Recognizing the economic and environmental consequences arising out of high and indiscriminate use of pesticides, efforts were being made to develop and transfer pest management technologies that would protect the crop from various insect pests and minimize the use of chemical insecticides. Different plant protection measures when combined into a package are together called Integrated Pest Management (IPM). It takes advantage of the natural mechanisms to manage pest population below the economic threshold levels with minimum use of chemical insecticides (Perfect, 1992). Another relatively recent development in insect pests management is the breeding of crop varieties with genes that produce incorporated endotoxins. Specifically, varieties with a gene that produces toxins against boll worms are being developed and marketed by various public and private sector companies. In the case of cotton, these genes produce a toxin which is naturally produced by the bacteria, *Bacillus thuringiensis* var. *kustaki* (Bt) and the varieties with the gene responsible for production of this toxin are called Bt cotton varieties.

Efforts were being made to promote Bt cotton as well as different IPM technologies to reduce the plant protection expenditure and cost of cultivation. Though there are specific IPM modules for different cotton-growing regions, farmers generally adopt different combinations of a range of plant protection measures. These combinations form a continuum of pest management in cotton. These measures can be cultural (e.g. adoption of inter-, border-, trap-crops, summer ploughing, etc.), mechanical (e.g. collection and destruction of larvae), biorationals [use of nuclear polyhedrosis virus (NPV), Bt, neem-based preparations, pheromone traps, etc.], and chemical. Thus, IPM does not exclude application of safer chemical insecticides.

This paper has examined plant protection on cotton with the following specific objectives: (i) To examine the plant protection practices being adopted by farmers in cotton, and (ii) To examine the plant protection expenditure and returns at different levels of adoption of plant protection measures.

Data and Methodology

Data

The data for this study were collected as a part of an AP Cess Fund Project "Assessment of adoption and impact of IPM in rainfed crops", funded by the Indian Council of Agricultural Research. Data were collected from randomly selected sixty farmers in each of the three villages, viz. Bollapalli in Bollapalli mandal, Anathavarapadu in Vatticherukuru mandal and Palaparru in Pedanandipadu mandal. Thus, data were collected from 180 farmers in total. The sample constituted about 15 per cent of the total households in each village. The data on farm and household characteristics, crop production and protection practices and use of inputs and prices were collected for the agricultural year 2004-05 by using pre-tested schedules.

Methodology

After data collection, farmers were classified into those using Bt cotton varieties, those using non-Bt cotton variesties, adopting IPM practices and those not adopting IPM practices. A farmer was considered to be an IPM adopter if he or she adopted at least four different plant protection measures belonging to all the four categories, apart from scouting for insect pests. Based on the variety sown, farmers were also classified into Bt and non-Bt cotton farmers. Thus, a two-way classification table was developed from which the ϕ coefficient, a kind of correlation coefficient between two categorical variables, was computed to test the association between adoption of Bt cotton and IPM practices. From a 2×2 contingency table, it was computed as the ratio of the difference between the product of diagonal elements to the square root of the product of sums of rows and columns.

IPM is a continuum spanning from complete dependence on chemical insecticides at one end to a combination of a wide range of cultural, mechanical, biological and chemical means at the other end. In order to understand the extent of IPM adoption, we attempted to measure IPM adoption as a weighted score, which was computed as follows. First, a list of all the plant protection practices followed by the farmers was developed. Then, these practices were divided into four categories — cultural, mechanical, biological and chemical. These categories were given different weights, considering their importance in IPM; these were given weights of 0.30, 0.20, 0.35 and 0.15, respectively[1]. These weights were arrived at in consultation with the entomologists working on pest management in cotton. Then, the number of practices followed in each category was multiplied by the respective weight and summed over all the categories to obtain a weighted score of IPM adoption for each farmer. Thus, the IPM score, Z, of a farmer is given by Equation (1):

[1] The weights were arrived at in consultation with the entomologists. More emphasis was given in IPM to biological and cultural components as they are environmentally safe and easy to adopt, especially the latter. Use of chemical insecticides was given the least priority in IPM and hence, least weight. The adoption scores so computed were found to have a significantly negative correlation with the use of chemical insecticides, which is the objective of IPM.

$$Z = \Sigma w_j n_j \qquad \ldots(1)$$

where,

w = Weight of the j'th category (j=1 to 4), and

n = Number of practices belonging to the jth category adopted by the farmer.

After computing individual IPM scores, the farmers were divided into three categories by taking 35 and 70 percentile scores as the cut-off points. Thus, farmers whose scores were equal to or below 35 percentile were categorized as chemical-intensive, those falling between 35 and 70 percentile were categorized as intermediate and those scoring greater than 70 percentile were classified as IPM adopters[2]. The investment on plant protection including chemical and non-chemical measures and net returns from cotton for three different categories of farmers were compared.

The cost of adoption of IPM practices was arrived at the market or imputed prices of the corresponding IPM components. The expenditure on plant protection and net returns from plant protection of these different categories of farmers were compared and the differences were tested using either t-test or ANOVA. In order to see the relationship between the adoption of IPM practices and use of chemical insecticides, regression equations of different forms, viz. linear, quadratic, exponential, and power were fitted and the best fit equation in terms of r^2 has been presented.

Results and Discussion

Cotton is an important commercial crop grown in the Guntur district of Andhra Pradesh. During 2004-05, the crop was sown on about 22.8 per cent of the total cropped area (Directorate of Economics and Statistics, 2006). A look into the data of sample farmers revealed that of the total 180 farmers, only 53 had adopted Bt cotton varieties (Table 1). Seventy-two farmers had adopted more than four plant protection practices and therefore were categorized as IPM- adopters and the remaining 108 farmers were non-adopters of IPM practices. Further, the ϕ coefficient of 0.19 ($p= 0.35$) showed that adoption of Bt cotton varieties and adoption of IPM practices were not associated, which means that farmers adopting Bt cotton might or might not have adopted other IPM components.

[2] IPM advocates integration of different plant protection measures that are locally feasible and hence it is difficult to compute an IPM adoption score comparable across different locations or regions. Therefore, the adoption categories were defined with respect to the 'best farmer' (100 percentile) who adopted all possible pest management practices and minimized the use of chemical insecticides.

Table 1. Classification of sample farmers based on Bt and IPM adoption (n=180)

Bt/IPM	IPM	Non-IPM	Total
Bt	29	24	53
Non-Bt	42	84	127
Total	72	108	180

A study of plant protection behaviour of farmers showed that they followed 24 different plant protection measures in cotton. These have been listed in Table 2 along with the frequency of their adoption. It was observed that all the farmers resorted to application of chemical insecticides to manage the pests. Among other practices, topping and seed treatment were adopted by most of the farmers. About 64 per cent of farmers used pheromone traps. Among cultural practices, more than half of the sample farmers rotated cotton with other crops in their cropping sequence in order to break the pest build-up. Bt cotton was adopted by about 29 per cent of the farmers. Application of NPV and Bt sprays was not popular with only about 12 per

Table 2. Adoption of different plant protection practices by cotton farmers in Guntur district: 2004-05 (n=180)

S.No	Practice	Adopters (%)
1	Sparying of insecticides	100.00
2	Pheromone traps	63.89
3	NPV, Bt, Trichogramma, etc.	12.22
4	Spraying of botanicals (Neem oil, NSKE)	49.44
5	Seed treatment	78.33
6	Digging trenches around field and lindane dusting	2.22
7	Poison baiting with monocrotophos or thiodicarb	6.67
8	Stem application with monocrotophos	35.00
9	Bt seed	29.4
10	Yellow traps	20.00
11	Trap crops-castor, marigodetc	33.33
12	Alternate crop	39.44
13	Inter-crop with setaria/ groundnut/soybean/cluster bean	24.44
14	Border crops — sorghum, bajra, etc.	35.56
15	Crop rotation	53.33
16	Proper spacing	18.33
17	Topping	82.22
18	Erection of bird perches	35.56
19	Erection of light traps	5.56
20	Hand-picking of 4^{th} instars and above stag	15.00
21	Leaving goat or sheep in field after last picking	45.56
22	Collection and destruction of pest infested leaves	24.44

cent of the farmers adopting such practices because of the constraints in their availability. To make these components of IPM effective, time and method of application (e.g. NPV is to be applied during cooler hours of the day and with adjuvants to reduce photodegradation and enhance efficacy) are very critical (Ravindra and Jayaraj, 1988). Since many farmers are not aware of these finer aspects of the use of biorationals, they often do not obtain the potential benefits. Spraying of neem-based preparations was adopted by about 49 per cent farmers. Only 15 per cent farmers collected the larvae mechanically as it was a labour-intensive practice. Thus, farmers follow many combinations of different means of crop protection, depending on the knowledge, access and resources.

Plant Protection Investments and Profitability

The cost of cultivation and net returns in cotton, given in Table 3, reveal that cotton is as an investment-intensive crop with cost of cultivation as Rs 24010/ha. Plant protection was the most dominant cost item, accounting for about 37 per cent of total variable costs. Cotton is also labour-intensive crop with an expenditure of Rs 6695/ha on labour. When the interest on working capital, depreciation of implements and land revenue were taken (cost A), the gross returns exceeded the costs by Rs 12556/ ha. The net returns from cotton were just Rs 6481/ha when all the costs, rental value of land and imputed value of family labour were included (cost C). The cost of production worked out to be Rs 1349/q.

Table 3. Cost of cultivation and net returns from cotton cultivation in Guntur district: 2004-05

Cost/return	Rs/ha	
Seed	2703	(11.26)
FYM	1180	(4.91)
Fertilizers	3560	(14.83)
Plant protection	8822	(36.74)
Labour	6695	(27.88)
Others (tractor, transport, etc.)	1050	(4.37)
Total variable costs	24010	
Yield (q/ha)	21.6	
Gross returns	35623	
Returns over variable costs	11613	
Cost A	23067	
Cost B	27267	
Cost C	29142	
Net returns	6481	
Cost of production (Rs/q)	1349	

Note: Figures within the parentheses are percentage of total variable cost

The variations in plant protection expenditure as influenced by adoption of Bt cotton varieties and other plant protection measures have been presented in Table 4. The hypothesis was that the plant protection expenditure, especially on plant protection chemicals, would be least when Bt cotton variety is adopted along with different components of IPM adopted. The ANOVA showed that the effect of Bt was not significant ($F_{1,174} = 2.02$). However, the effect of adoption of IPM practices was found significant ($F_{1,174} = 145.09$). The results presented in Table 4 show that the total plant protection expenditure was the least (Rs 6682/ha) when IPM practices were adopted on the non-Bt varieties. Compared to this, the plant protection expenditure with Bt and IPM were higher (Rs 8337/ha). More importantly, the expenditure on plant protection chemicals was Rs 5022 /ha. The adoption of other components of IPM costed on an average Rs 3315/ha. Compared to this, farmers who adopted neither Bt varieties nor any other non-chemical pest management practices, had to spend Rs 13987/ha towards plant protection measures, a large part (Rs 12913) of which was spent on chemical insecticides. In the absence of IPM practices, even the Bt varieties were applied with higher levels of insecticides. The expression of Bt toxin in Bt varieties is known to decrease as the plants approach maturity, resulting in reduced levels of resistance to boll worms (Greenplate, 1999). This, together with increased incidence of sucking pests against which Bt varieties are not resistant, might be the reason for such an observation. It is not unusual for cotton farmers in this region to spray insecticides about 20-25 times during a crop season to protect the crop. Even the so-called IPM farmers spray the crop about 10-12 times to manage the insect pests. Some of the cultural practices such as summer ploughing and inter- or trap-cropping, were followed

Table 4. Plant protection expenditure and profitability as influenced by Bt cotton and IPM practices

(Rs/ha)

Expenditure/profit	Chemical-intensive pest management	Bt + chemical intensive pest management	Non-Bt + IPM	Bt + IPM
Expenditure on insecticides	12913	13761	3759	5022
Expenditure on other plant protection measures	1074	1656	2923	3315
Total plant protection expenditure	13987	15417	6682	8337
Cost of cultivation	27585	28323	18830	22021
Net returns	5745	6987	17973	20537
Yield (q/ha)	20.2	21.4	22.6	23.3
Cost of production (Rs/q)	1365.6	1323.5	833.2	945.1

universally which was reflected in the expenditure on 'other plant protection measures' even by the non-IPM farmers. The reduction in plant protection expenditure was possible with the adoption of IPM components such as biological practices on both Bt and non-Bt varieties. Though some additional expenditure was incurred on implementing these integrated pest management practices, the consequent reduction in expenditure on chemical insecticides justified it. The reduction in the plant protection expenditure was also reflected in the cost of cultivation. The adoption of Bt cotton varieties and IPM practices resulted in increased yields. As a result, the net returns were high compared to the situation where no Bt and no IPM practices were adopted. Thus, the analysis has shown that IPM practices are more effective in reducing plant protection expenditure than are Bt varieties.

It is possible that farmers adopting Bt cotton may or may not be adopting other components of IPM, and hence IPM adoption scores were computed for all the farmers. While computing the adoption score, adoption of Bt cotton varieties was considered as a cultural pest management practice. The plant protection expenditure and profitability details for the three categories of farmers, presented in Table 5, reveal that as the farmers moved away from the chemical-intensive pest management towards the IPM, the cost of plant protection decreased and the net returns increased. The cost of plant protection chemicals and total plant protection in a chemical-intensive situation were Rs 13856/ha and Rs 14874/ha compared to Rs 2770/ha and Rs 5565/ha in an IPM situation, respectively. In the latter, the total plant protection costs also included an expenditure of Rs 2795/ha towards such practices as spraying of NPV, neem-based preparations, and other cultural and mechanical practices. In the intermediate situation, the low adoption of

Table 5. Plant protection expenditure and profitability at different levels of IPM adoption

(Rs/ha)

Expenditure/profit	Chemical-intensive ($z<1.28$)	Intermediate ($1.28>z<1.96$)	IPM ($z>1.96$)
Expenditure on insecticides	13856	8636	2770
Expenditure on other plant protection measures	1018	2667	2795
Total plant protection expenditure	14874	11303	5565
Cost of cultivation	29310	26157	16620
Net returns	2767	12441	19880
Yield (q/ha)	19.5	23.3	22.1

Note: The differences are significant at 10 per cent level, at least.

Table 6. Estimated regression equation between plant protection expenditure and adoption of IPM practices

Dependent variable	Intercept	Adoption score	(Adoption score)^2	R^2
Total plant protection cost	8296.30	-2433.49	254.41	0.35
	(12.93)	(4.15)	(2.26)	
Expenditure on insecticides	8583.63	-3246.75	338.12	0.57
	(15.81)	(6.48)	(3.52)	
IPM cost	-438.85	1006.11	-147.34	0.46
	(3.33)	(8.31)	(6.40)	

Note: Figures within parentheses are t-values. The coefficients are significant at 5 per cent level, at least

IPM practices could not result in reduced use of insecticides which was reflected in the high insecticide cost and low returns. It was also observed that farmers receiving advice on plant protection measures also received advice on other crop production practices such as fertilizer use, inter-culture, etc. which could be one of the reasons for the observed yield gains. Thus, adoption of IPM practices led to cost reduction, decreased use of plant protection chemicals and increased profitability.

It has been observed that the net returns from cotton cultivation and adoption of IPM measures were significantly correlated with a correlation coefficient of 0.28 (p= 0.01). The adoption of IPM was found negatively correlated with the use of chemical insecticides. The relationship between adoption score and plant protection expenditure was examined by fitting linear, quadratic, exponential and power functions. Based on the coefficient of determination (r^2), quadratic equation was found to be a better fit (Table 6). As can be seen from this table, the expenditure on insecticides and total plant protection expenditure decreased and the cost of IPM adoption increased with the increase in adoption score. The coefficient of the square term was also significant, indicating that at very high levels of adoption score the marginal saving on cost of plant protection tended to decline.

Summary and Conclusions

The study on plant protection practices of cotton farmers in the Guntur district has revealed that farmers follow a wide range of practices to manage the insect pests in cotton. Adoption of chemical insecticides has been the most dominant means of pest management, followed by topping and seed treatment. Investment on plant protection has been found to constitute the largest component in cost of cultivation in cotton. No significant reduction in plant protection expenditure has been observed when Bt varieties are adopted without IPM practices. The adoption of IPM practices, however, has led to reduced use of insecticides and increased profitability. The saving on plant protection chemicals has more than compensated the cost of adopting IPM components. Consequently, the net returns from cotton cultivation have increased considerably. It is to be noted that due caution is needed as these findings are based only on one year data. Such studies need to be extended over time and space so that policymakers could be provided with more reliable information.

Acknowledgements

The authors thank the referee for his constructive suggestions. They are thankful to the ICAR for supporting this work in the form of an AP Cess Fund Project. They thank Dr Y S Ramakrishna, Director, CRIDA, and Dr K P R Vittal, Project Coordinator, AICRPDA, CRIDA for their support and encouragement. The support and inputs from Dr Hariprasada Rao, RARS, Lam, and staff of KVK, Vinayasramam and Mr Srinivasa Rao, ASSIST in identification of villages and collection of data are thankfully acknowledged.

References

Directorate of Economics and Statistics (2006) *Statistical Abstract – Andhra Pradesh 2006*. Department of Economics and Statistics, Government of Andhra Pradesh. 534 p.

Greenplate, J. T. (1999) Quantification of *Bacillus thuringiensis* insect control protein Cry1Ac overtime in bollgard cotton fruits and terminals. *Journal of Economic Entomology,* **92**: 1379-1383.

http://www.fao.org/DOCREP/ARTICLE/AGRIPPA/658_en-02.htm (viewed on 3/8/2006)

Matthews, G. A. and J. P. Tunstall (Eds) (1994) *Insect Pests of Cotton.* Wallingford, CAB International Publication.

Perfect, T.J. (1992) IPM in 2000. In: *Pest Management and Environment in 2000*. Eds: Abdul Azeez, S.A. Qadir and Henry S. Barlow. CAB International Publication, pp. 47-53.

Rama Rao, C.A. (2000). *Growth and Efficiency in Crop Production in Andhra Pradesh*. Ph.D. Thesis, Acharya NG Ranga Agricultural University, Hyderabad.

Ravindra R.J. and S. Jayaraj (1988) Efficacy of NPV with adjuvants as high volume and ultra-low volume applications against *Heliothis armigera* in chickpea. *Tropical Pest Management,* **34**: 441-444.