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1.0 Introduction

The new agricultural technologies such as improved crop varieties, use of chemical fertilizers have led to substantial productivity gains. Another factor associated with the growth in productivity is the substantial increase in the use of chemical pesticides, both in terms of area covered by plant protection and quantity of chemicals applied per unit of cropped area (David, 1986; Birthal *et al*, 2000). The use of chemical pesticides was widely adopted, especially by better endowed farmers and in the case of commercial crops, as farming became more market oriented. However, high and indiscriminate use of pesticides has led to problems such as pest resurgence, resistance, health and environmental hazards (Armes *et al*., 1992) on one hand and increased dependence of farmers on external inputs on the other. The market imperfections, as reflected in poor quality of pesticides, high interest rates on borrowed capital, unfavourable out prices etc., also contributed another dimension to the 'crisis' associated with the indiscriminate use of pesticides (Chowdry *et al*, 1998). In response to such a scenario, researchers have been trying to develop alternative means of pest management which are known as Integrated Pest Management (IPM) practices (Pedigo, 1991).

Spedding (1988) defined IPM system as a group of interacting components operating together for a common purpose – to keep the pest populations below the economic threshold levels. These components include cultural, mechanical, physical, biological and lastly chemical measures. The IPM basically involves application/use of a variety of means that aim to manage pest populations below the economic threshold level (Smith and Reynolds, 1966; FAO, 1971). The input requirements, managerial skills and information needs of IPM therefore vary from those of chemical pest control and hence need to be examined more closely. The need for IPM is even more in rainfed agriculture characterized by poor biophysical and socioeconomic environment (Kanwar, 1999).

Though substantial efforts have been under way to get these practices adopted by farmers, adoption has been observed to be limited (Unni, 1996) because of various constraints. These constraints are both technology related and institution related. This research bulletin puts together the major findings of the study that looked into the extent and determinants of adoption and impact of IPM in three crops, viz., cotton, groundnut and pigeonpea. The study was funded by the Indian Council of Agricultural Research.

Study area and background

In order to identify the villages for data collection in view of the project objectives, time-series data on area, production and productivity of the three crops in the target districts were collected. It was observed that variability in production of groundnut in Anantapur district did not show any significant trend. In case of cotton in Guntur district, production was observed to increase at an annual rate of 14 per cent. The area, production and productivity of pigeonpea in Rangareddy district were observed to increase at 3.24, 11.07 and 7.57 per cent, respectively during 1990-2000 (Table 1).

Table 1.Compound Growth rates (%) in Area, Production and Yield 1990-2000

DISTRICT	CROP	AREA	PRODUCTION	YIELD
Anantpur	Groundnut	NS	NS	NS
Guntur	Cotton	-3.53	14.33	17.5
Ranga Reddy	Pigeonpea	3.24	11.07	7.57

NS: Not significant

In order to look into the spatial variability of production of these crops in the districts, mandal-level data were also collected for the year 2000-01. The variability in the share of the crop concerned in the total cropped area of the district was relatively high in case of cotton than in case of other two crops (Fig 1-3).

Fig. 1. Area under Cotton (%) in Mandals of Guntur District

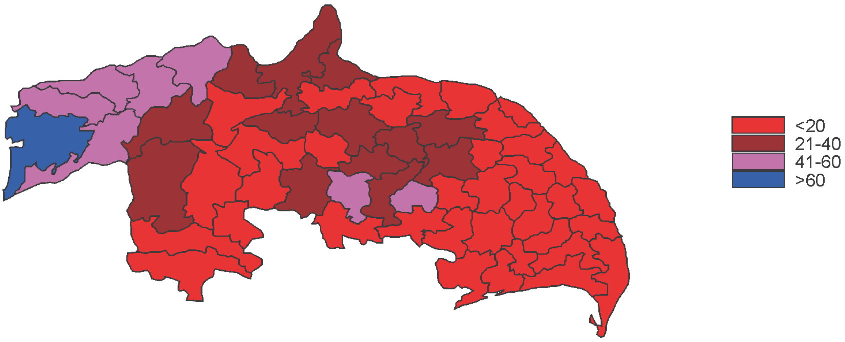


Fig. 2. Area under Groundnut (K) in Mandals of Anantapur District (%)

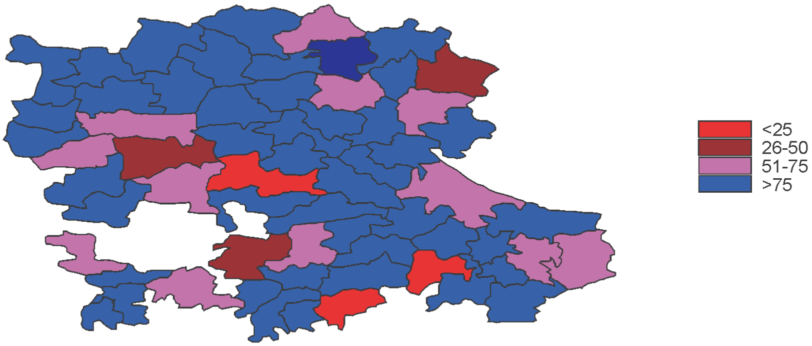
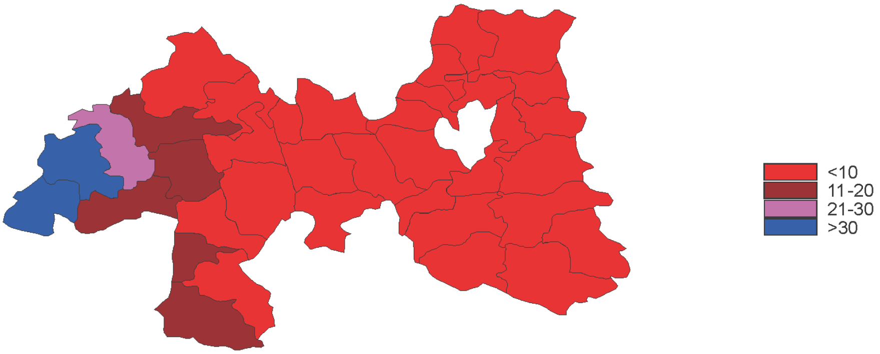


Fig. 3. Area under Pigeonpea (%) in Mandals of Ranga Reddy District



The area under cotton in Guntur district was about more than 40 per cent in eight mandals. In most of the mandals less than 20 per cent of the cropped area was sown to cotton (Fig 1). In Anantapur, groundnut occupied more than 70 per cent of the cropped area in most of the mandals (Fig 2). It was a minor crop with less than 20 per cent of cropped area in only three mandals. The cultivation of pigeonpea was observed to be more prominent in the western parts of Rangareddy district where more than 20 per cent of cropped area was sown to pigeonpea (Fig 3). In a majority of mandals, the crop occupied less than 10 per cent of the cropped area.

A look at the time series data for the 1990 showed that the share of cotton in Guntur district remained at 20 percent. It was however found to decline in the recent period (Fig 4). Groundnut was found to be the most dominant crop in Anantapur district throughout the period (Fig 5). In case of pigeonpea in Rangareddy district, its share in the total cropped area peaked to 16per cent in 1998 and then declined (Fig 6).

Fig. 4. Share of Cotton in total cropped area in Guntur District

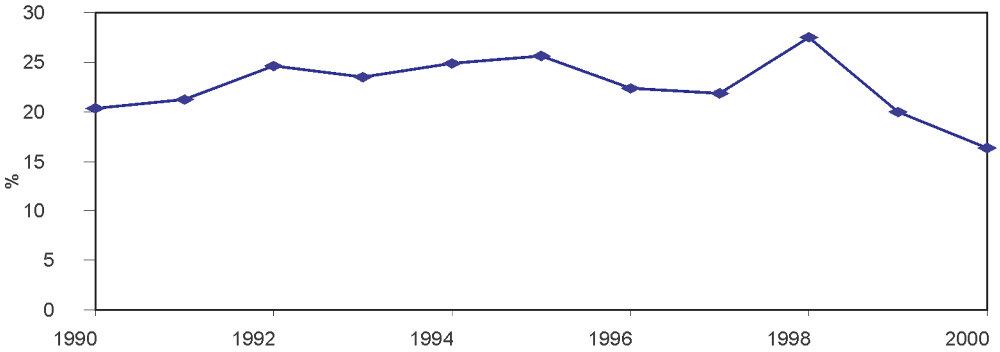


Fig. 5. Share of Groundnut in total cropped area in Anantapur District

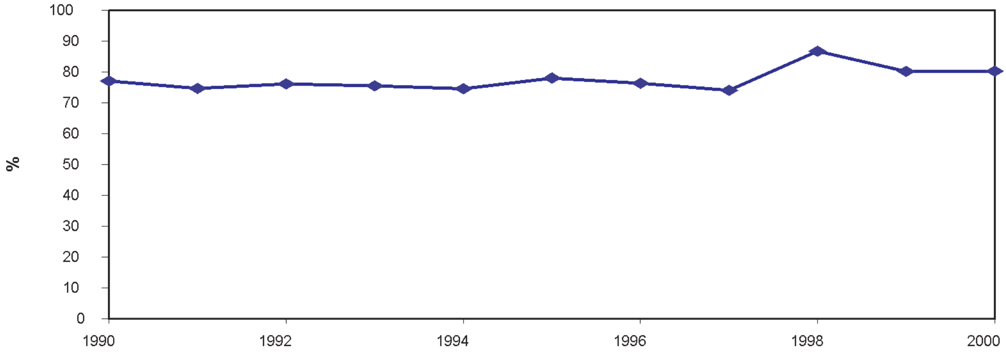
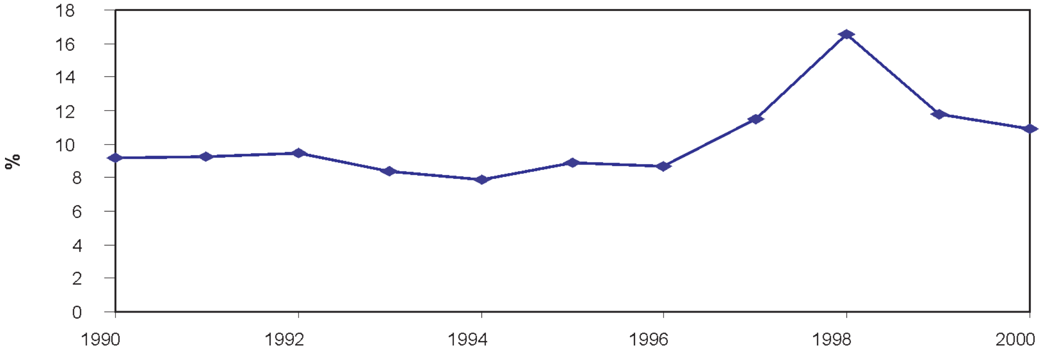
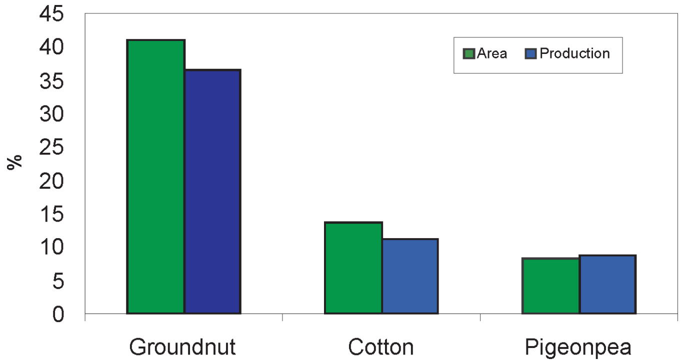


Fig. 6. Share of Pegionpea in total cropped area in Ranga Reddy District



During the triennium ending 2000-01, the three districts accounted for significant proportion of area and production in Andhra Pradesh as can be seen from figure 7. As is evident from the figure, Anantapur district accounted for more than 30 per cent of area and production of groundnut in the state. The shares of Guntur and Rangareddy in area and production of cotton and pigeonpea are not as pronounced.

Fig. 7. Share of Selected Districts in Area and Production of Target Crops during TE 2000-01



After considering the secondary data, consultations were made with the research and extension officers in the target districts to select mandals and villages for data collection. After due deliberations, the following villages were tentatively selected for collecting farmer-level primary data for adoption and impact analysis (Table 2).

Table 2. List of villages selected for data collection

CROP	DISTRICT	MANDAL	VILLAGE
Cotton	Guntur	Vatticherukuru Bollapalli Pedanandipadu	Anantavarappadu Bollapalli Palaparru
Pigeonpea	Rangareddy	Tandur Yalal Peddammul	Saipur Kokat Rudraram
Groundnut	Anantapur	B K Samudram Ramagiri Anantapur rural	Rotarypuram Cherlopalli Krishnamreddypalli

2.0 Analytical methods

2.1Factors influencing adoption of IPM

Adoption can be defined in two ways. First, it can be considered as a dichotomous measure when the number of farmers following a particular technology is considered. Secondly, it can be considered as a continuous variable when viewed as a degree of use (quantity of fertilizer per hectare, percentage of farmers using a technology, percentage of area where IPM is followed). In this paper, we attempted to assess adoption in both ‘whether’ and ‘extent’ terms. We first attempted to analyze the factors that influence the adoption decision. Then, we tried to measure the extent of adoption of the technology, the IPM in this case, by the adopters.

The decision to adopt or not to adopt the IPM essentially takes the form of a binary variable and therefore can be analysed with logit or probit models. These models relate the dependent and the independent variables nonlinearly. The multivariate logistic regression models have been used to analyse the farmers’ adoption decision with respect to different technologies.

The decision of a farmer to adopt or not to adopt a technology is influenced by a variety of factors related to the farmer (decision maker) and the farm. In this study, the decision to adopt IPM was regressed on a set of independent factors viz., farmers’ age (X_1), education (X_2), family labour availability (X_3), participation in social groups (X_4), ability to recognize the pests and natural enemies (x_5), farm size (X_6), proportion of area under the pigeonpea (X_7), and access to irrigation (X_8). The specification of these variables and the descriptive statistics are given in table I. Since the dependent variable, the adoption of IPM, is a binary variable, and the independent variables are a mix of qualitative and quantitative variables, the multivariate logistic regression as given below was used to examine the influence of these factors on the adoption decision.

$$Y = \mathrm{Ln}\ (P/(1-P)) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_5 X_5 + \beta_6 X_6 + \beta 7\ X_7 + \beta_8 X_8$$

where P is the probability that the farmer adopts IPM and (1-P) is the probability that the farmer does not adopt the IPM and the βs represent the regression coefficients estimated by the maximum likelihood method. These coefficients represent the change in the log of odds of adoption of IPM for a unit change in the corresponding independent variable. We computed the e^{β}, which gives the odds ratio, associated with change in the independent variable. The analysis was done using SPSS12.0.

2.2. Measuring the extent of IPM adoption

The adoption can be measured as an extent or degree of adoption also. IPM is a continuum spanning from complete dependence on chemical insecticides at on 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. The weighted scores were computed as follows: First, a list of all the plant protection practices followed by the IPM 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. Thus these four categories were given weights of 0.30, 0.20, 0.35 and 0.15, respectively. These weights were arrived at in consultation with the entomologists working on pest management in the selected crops. 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 the farmer. Thus, the IPM score, Z, of a farmer is given by

$Z = \Sigma w_j n_j$

where w = weight of the j'th category (j=1 to 4)

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

After computing the individual IPM scores, farmers were divided in to three categories – low, medium and high adoption – by taking the 35 and 70 percentile scores as cut-off points. Thus, farmers whose score were equal to or below 35 percentile were categorized as low adopters, those falling between 35 and 70 percentile were categorized as medium adopters and those scoring greater than 70 percentile were classified as high adopters.

2.3 Farm level Impact of IPM

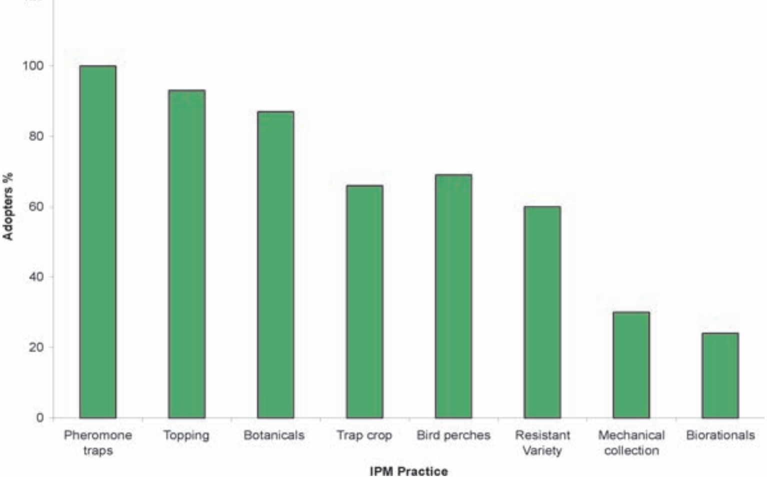
The impact of adoption of IPM technologies is examined by following a 'with and without' approach where in the mean values of the key parameters such as the use of plant protection chemicals, cost of cultivation, yield, net returns, of the 'IPM' farmers were compared with those of the non-IPM farmers. The differences were tested for their statistical significance applying t-test for continuous variables (inputs use, yield etc.) and χ^2 test for categorical variables (number of sick events).

3.0. Results

3.1. Cotton

The different components of IPM recommended for cotton and the frequency of adoption of each practice was depicted in Fig 8. It can be observed that erecting pheromone traps in the crop was adopted by all the IPM farmers. Topping was adopted by 93 per cent and spraying of Neem Seed Kernel Extract (NSKE) and neem oil by as many as 87 per cent. Adoption of biological means of pest management such as NPV and *Bacillus thuringiensis* is not as popular with only 24 per cent adopting because of the constraints in availability. In order for these components of IPM to be effective, time and method of application (e.g. NPV is to be applied during the cooler hours of the day and with adjuvants to reduce photodegradation and enhance efficacy) are very critical. Since many farmers are not aware of these finer aspects of use of biorationals, they often do not obtain the potential benefits. Only 30 per cent of adopters collected the larvae mechanically as it is a labour-intensive practice.

Fig. 8. Adoption of different components of IPM in cotton in Guntur Dist.



Factors influencing adoption

The characteristics of IPM farmers and non-IPM farmers are presented in table 3. It is seen from the table that the IPM farmers were relatively younger, had more years of schooling, had more family labour availability in terms of adults per house hold and were members in some social organizations such as farmers' clubs, user groups, self help groups etc. The IPM farmers also could identify a more number of pests and natural enemies than the non-IPM farmers. However, the IPM farmers have sown about 49 per cent of land to cotton compared to 75 per cent in case of non-IPM farmers. The average farm size of IPM farmers was about 5.1 ac compared to 6.6 ac in case of non-IPM farmers. Further, as many as 59 per cent of IPM adopters also grew chillies, another important commercial crops requiring investments in plant protection, compared to 39 per cent in case of non-adopters.

Table 3. Characteristics of IPM adopters and non-adopters in cotton in Guntur District

VARIABLES	UNIT	COTTON	
		IPM	Non –IPM
Age	Years	39(10)	45 (12)
Literacy	%	70	53
Adults	No/HH	3(0.97)	2 (1.3)
Children	No/HH	0.8(1.0)	0.6 (1.1)
Membership	%	64	30
Pest recognition ability	Score	6.2(1.9)	5.1 (2.1)
Farm size	Ha	5.1(2.5)	6.6(4.7)
Cotton	%	48.8(19.9)	74.5 (17.6)
Irrigation	%	18.6 (25.6)	12.8 (21.5)
Chillie	%	59	39

Figures in parentheses are standard deviations.

The maximum likelihood estimates of the logistic regression model obtained with SPSS 12.0 are presented in table 4. The table gives the estimated regression coefficients along with the significance levels, the odds ratio and the model fit statistics in the form of Negelkerke R^2, log likelihood and the percent correct classification. The model estimated was found to be a significantly good fit as can be seen from all the three criteria mentioned. The Negelkerke R^2 was about 0.66 and the log likelihood (-2 log LL) of 124.71 was significant at one per cent. The model predicted about 83.7 per cent of the cases correctly as either adopters or non adopters. Further, the model predicted 83.1 per cent of adopters and 84.3 per cent of non-adopters correctly.

The results from logistic regression analysis showed that all the variables except irrigated area included in the model significantly influenced the decision to adopt IPM technologies. The farm size, proportion of area under cotton and age of the farmer influenced the adoption decision negatively whereas the other variables influenced positively. AS can be seen from the table, as the farmers' age increases by one year, chances of adoption will decrease by about 4 per cent the odds ratio being 0.94. Similarly, an illiterate farmer has only 44 per cent chances of adoption of a literate farmer. Participation in community based organizations such farmers' clubs also enhanced the probability of adoption of IPM. The IPM technologies require more labour compared to the dependence on chemical insecticides alone. Thus the bigger farms and larger acreage under cotton are less likely to attract IPM, which is reflected in the negative coefficients of the farm size and the area under cotton. The significantly positive coefficient for labour endowment as measured by the number of adults per household only reinforces this observation. Further, chillies is an important commercial crop grown in the area and requires considerable efforts in plant protection against pests and diseases. Farmers are being supported with knowledge on ways of plant protection (including IPM) and the necessary inputs such as pheromone traps. There is a possibility of chillie growers also apply the knowledge and use of IPM to cotton as well. The significantly positive coefficient for the variable 'chillies' confirms such a hypothesis.

Table 4. Logistic regression results for adoption of IPM in cotton, Guntur district, AP

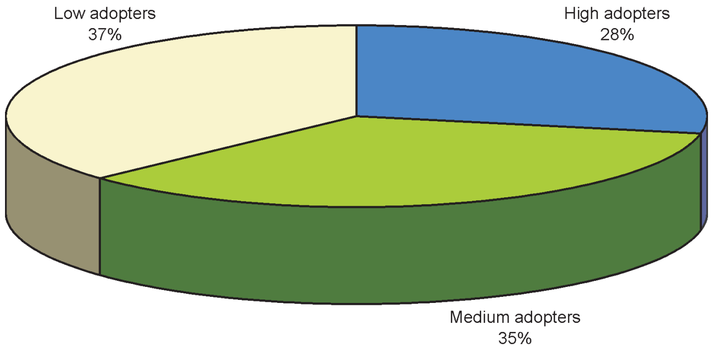
VARIABLE	Â	SE	WALD	OR
Constant	4.37*	1.56	7.80	
Age (yrs)	-0.06*	0.02	7.58	0.94
Education (yrs)	-0.82$^{@}$	0.51	2.61	0.44
Adults (No/HH)	0.67*	0.25	7.34	1.94
Membership (0,1)	2.05*	0.51	15.89	7.77
Ability (score)	0.22$^{@}$	0.12	3.45	1.25
Farm size (ha)	-0.27*	0.09	9.58	0.76
Crop (%)	-0.08*	0.02	31.63	0.92
Irr (%)	0.01	0.01	0.94	1.01
Chillie	1.22*	0.50	6.01	3.41

*and @ indicate significance at 1 and 10%, respectively .
Nagelkerke R^2 :0.66 -2log LL:124.71 Corr.class:83.7%

Extent of adoption

In the above analysis a farmer was considered to be an IPM adopter if he or she adopts at least four different components of IPM. However, there can be variations in the extent of adoption of different components of IPM. In order to measure the extent of adoption, scores were computed for all the IPM farmers. The findings are presented in table 6. Twenty four different components of IPM were observed to be followed by the IPM farmers. As many as fourteen were cultural practices, five were chemical, three biological and two mechanical. A farmer adopting all these twenty four practices in his effort to manage pests below the economic threshold levels, he or would get a score of 6.4. The scores of the farmers were found vary between 2.8 and 3..8 with an average score of 3.3. About 37 per cent of farmers scored below 2.8 (35.5 percentile) and were classified as low adopters. Only 28 percent of farmers were found to achieve high adoption scores (>3.85, the 70 percentile). The remaining 35 per cent of farmers were classified as medium adopters with scores between 2.8 and 3.85. Thus there was observed variation in adoption within the adopters. (Fig. 9)

Fig. 9. Extent of IPM adoption in



As mentioned earlier, the farm-level impact of the IPM in cotton was observed by comparing the key variables of IPM farmers with those of non-IPM farmers (Table 5). As a result of adoption IPM components, there was observed a steep decline in the use of chemical insecticides from about 18 l ha^{-1} in case of non IPM farmers to about 6.5 l ha^{-1} in case of IPM farmers. This also resulted in the saving on expenditure on plant protection chemicals. It is interesting to note that IPM farmers also applied more organic manures compared to the non-IPM farmers. The IPM adopters also harvested more kapas (23 q/ha) compared to 19 q/ha by non-adopters. The cost savings together with the increased yields resulted in obtaining significantly higher net returns (by 370%) from IPM farms compared to non-IPM farms. The cost of production also fell by about 42 per cent in IPM farms compared to non-IPM farms.

Table 5. Farm-level impact of adoption of IPM in Cotton in Guntur district, Andhra Pradesh

PARAMETER	UNIT	IPM FARMS	NON-IPM FARMS
Farm Yard Manure	t ha^{-1}	13.71	9.46
Chemical nutrients	kg ha^{-1}	20.14	20.89
Chemical insecticides	l ha^{-1}	6.48	3217.99
Yield	q ha^{-1}	22.92	19.38
Expenditure on insecticides	Rs ha^{-1}	4244.42	12950.2
Cost of cultivation	Rs ha^{-1}	19622.4	28386.3
Net returns	Rs ha^{-1}	18076.2	3796.83
Cost of production	Rs q^{-1}	856.12	1464.72
Incidence of sick events	%	17	48

Another important benefit of IPM adoption is the reduction in the incidence of health hazards associated with the use of chemical insecticides. It was observed that about 48 per cent of farmers reported incidents of falling sick due to exposure to insecticides. This figure was only 17 per cent in case of IPM farmers. These health hazards would further lead to expenditure on health care as well as loss of wages during the period of illness. Thus, the adoption of IPM also had a desirable effect on the family or hired labour engaged in the application of chemical insecticides. (Fig. 10)

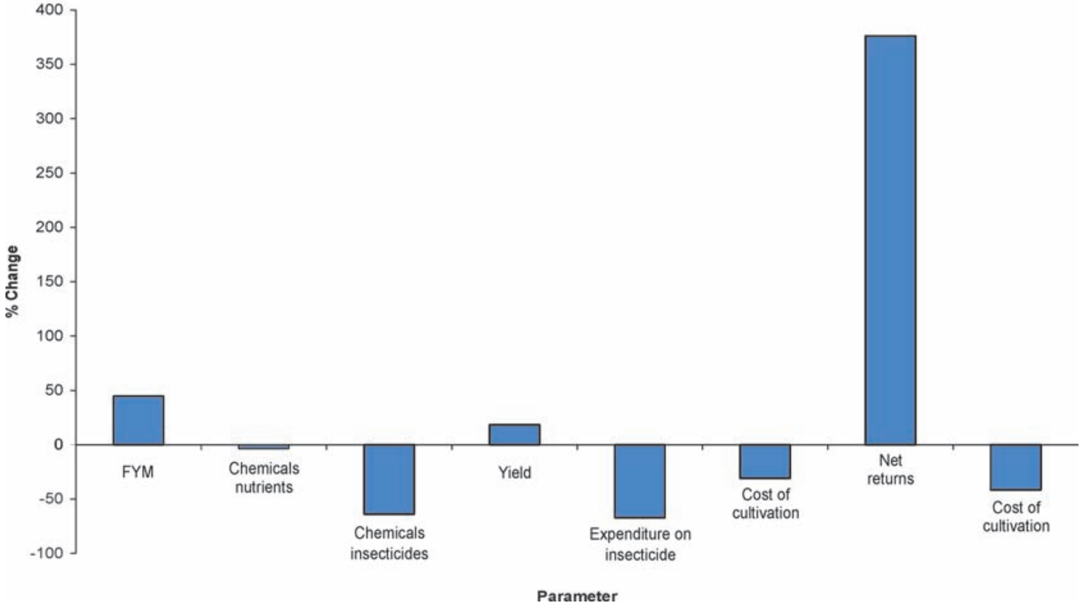
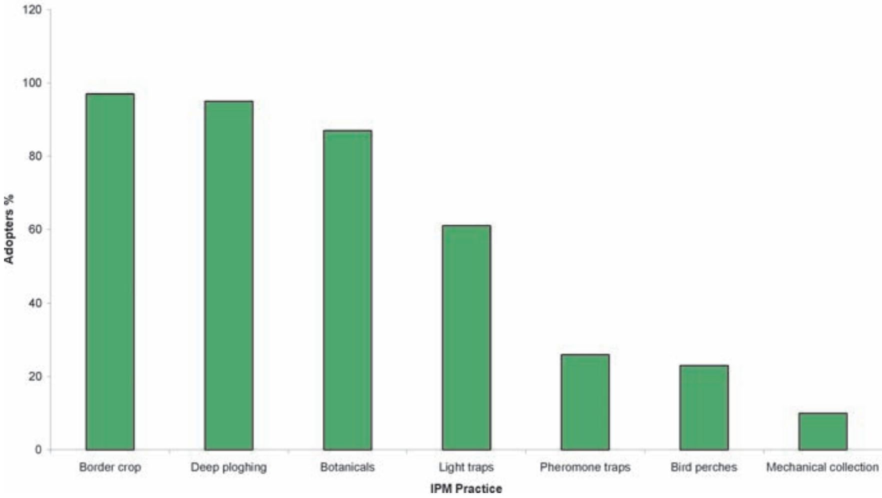


Fig. 10. Farm level impact of adoptin of IPM in cotton in Guntur district

3.2. Groundnut

Different components of IPM recommended for groundnut and the frequency of adoption of each practice are given Fig. 11. It can be observed that growing border or intercrop and deep ploughing during summer before sowing the crop are the most adopted components of IPM adopted by the farmers. Spraying of Neem Seed Kernel Extract (NSKE) and neem oil was found to be adopted by as many as 87 per cent of the sample farmers. The adoption frequencies for pheromone traps, bird perches and mechanical collection were 26, 23 and 10 per cent respectively. Erecting light traps is one of the key recommendations for managing the red hairy caterpillar in ground nut. The practice was found to be adopted by about 61 per cent of IPM farmers.

Fig. 11. Adoption of different components of IPM in Groundnut in Anantapur Dist.



Factors influencing adoption

The characteristics of IPM farmers and non-IPM farmers are presented in table 6. It is seen from the table that the average age of the IPM adopters was about 41 years compared to 46 years in case of non-adopters. The IPM farmers on an average had 5.5 years of schooling. The IPM adopters and not adopters did not differ significantly in terms of farm size and irrigated area. A larger number of IPM adopters were members in some social organizations such as farmers' clubs, user groups, self help groups etc. The IPM farmers also could identify a more number of pests and natural enemies than the non-IPM farmers. No significant difference was observed in the average farm size of IPM adopters and non-adopters. IPM farmers have sown about 96 per cent of land to groundnut compared to 97 per cent in case of non-IPM farmers. The average farm size of IPM farmers was about 8.6 ac compared to 8.9 ac in case of non-IPM farmers.

Table 6. Characteristics of IPM adopters and non-adopters in Groundnut in Anantapur District

VARIABLES	UNIT	GROUNDNUT	
		IPM	Non –IPM
Age	Years	41.2 (8.7)	45.7 (8.7)
literacy	%	5.5 (3.3)	1.6 (2.1)
Adults	No/HH	3.6(1.6)	3.8 (1.6)
Children	No/HH	1.8 (0.9)	1.3 (0.8)
Membership	%	72	62
Ability	Score	6.2 (1.1)	5.6(1.5)
Farm size	Ha	8.6 (9.0)	8.9 (7.2)
Cotton	%	96.4 (9.7)	97.1 (15.0)
Irrigation	%	3.8 (9.7)	2.8 (9.8)

Figures in parentheses are standard deviations

The maximum likelihood estimates of the logistic regression model obtained with SPSS 12.0 are presented in table 7. The table gives the estimated regression coefficients along with the significance levels, the odds ratio and the model fit statistics in the form of Negelkerke R^2, log likelihood and the percent correct classification. The model estimated was found to be a significantly good fit as can be seen from all the three criteria mentioned. The Negelkerke R^2 was about 0.52 and the log likelihood (-2 log LL) of 160.69 was significant at one per cent. The model predicted about 76 per cent of the cases correctly as either adopters or non adopters. Further, the model predicted 77 per cent of adopters and 79 per cent of non-adopters correctly.

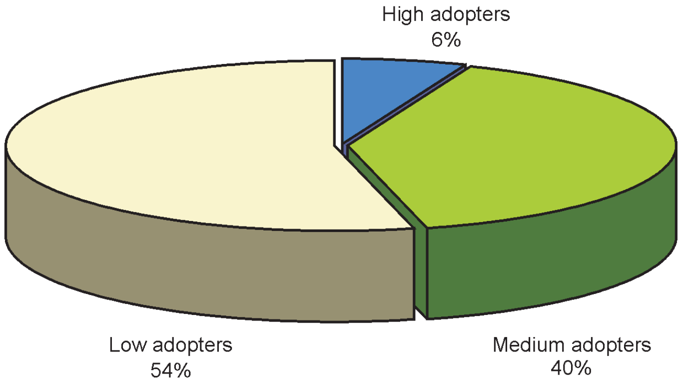
The logistic regression results presented in table indicate that education of the farmer, number of adults in the household, participation in social groups and ability to recognize the pest, natural enemy species and farm size influenced the adoption decision significantly. As can be seen from the table, each year of schooling increased the odds of adoption of IPM by 58 percent. Similarly, as the age of the farmer increased by one year, the odds would decrease by two per cent. Thus, younger and educated farmers are more likely to adopt IPM technologies. The participation in social groups also influenced the adoption decision significantly. A farmer who is a member in some social group is 1.24 times more likely than a farmer who is not a member. The participation of a farmer in social groups enhances his or her social capital in terms of access to information and resources. Further, various development programmes are also emphasizing the technology transfer through self-help groups, user groups etc. to quicken and broad base the uptake of the technologies. Thus, the highly positive and significant influence of the social capital as represented by participation in social organizations is tenable. The IPM technologies require more labour compared to the dependence on chemical insecticides alone. Thus the bigger farms and larger acreage under groundnut are less likely to attract IPM, which is reflected in the negative coefficients of the farm size and the area under groundnut. The significantly positive coefficient for labour endowment as measured by the number of adults per household supports this observation. It may be of relevance to note that farmers with larger farms and more area under the crop concerned are more likely to adopt chemical plant protection measures as observed in case of castor (Rama Rao et al., 1997). The influence of access to irrigation was not found to be significant

Table 7. Logistic regression results for adoption of IPM in groundnut, Anantapur district, AP

VARIABLE	Â	SE	WALD	OR
Constant	0.36	2.47	0.02	
Age (yrs)	-0.03	0.02	2.13	0.96
Education (yrs)	0.46**	0.08	32.36	1.58
Adults (No/HH)	$0.39^{@}$	0.26	2.30	1.48
Membership (0,1)	0.22^{*}	0.14	2.47	1.24
Ability (score)	0.36^{*}	0.15	5.57	0.02
Farm size (ha)	-0.08^{**}	0.03	7.07	0.93
Crop (%)	-0.02	0.02	0.92	0.98
Irr (%)	0.02	0.02	0.55	1.02

**, * and @ indicate significance at 1,5 and 10%, respectively.
Negelkerke R^2 : 0.52 -2log LL:160.69 Corr.class:77.7%

Fig. 12. Extent of IPM adoption in Groundnut in Anantapur district



Extent of adoption

In the above analysis a farmer was considered to be an IPM adopter if he or she adopts at least four different components of IPM. However, there can be variations in the extent of adoption of different components of IPM. In order to measure the extent of adoption, scores were computed for all the IPM farmers. The findings are presented in Fig. 12. Twenty two different components of IPM were observed to be followed by the IPM farmers. As many as eleven of these twenty two were cultural practices, four were chemical, four biological and three mechanical. A farmer adopting all these thirteen practices in his effort to manage pests below the economic threshold levels, he or would get a score of 5.9. The scores of the farmers were found vary between 1.4 and 3.8 with an average score of 2.16. About 54 per cent of farmers scored below 2.05 (35 percentile) and were classified as low adopters. Only 5.6 per cent of farmers were found to achieve high adoption scores (>2.70, the 70 percentile). The remaining forty per cent of farmers were classified as medium adopters with scores between 2.05 and 2.70. Thus there was observed variation in adoption within the adopters.

Farm level Impact of IPM

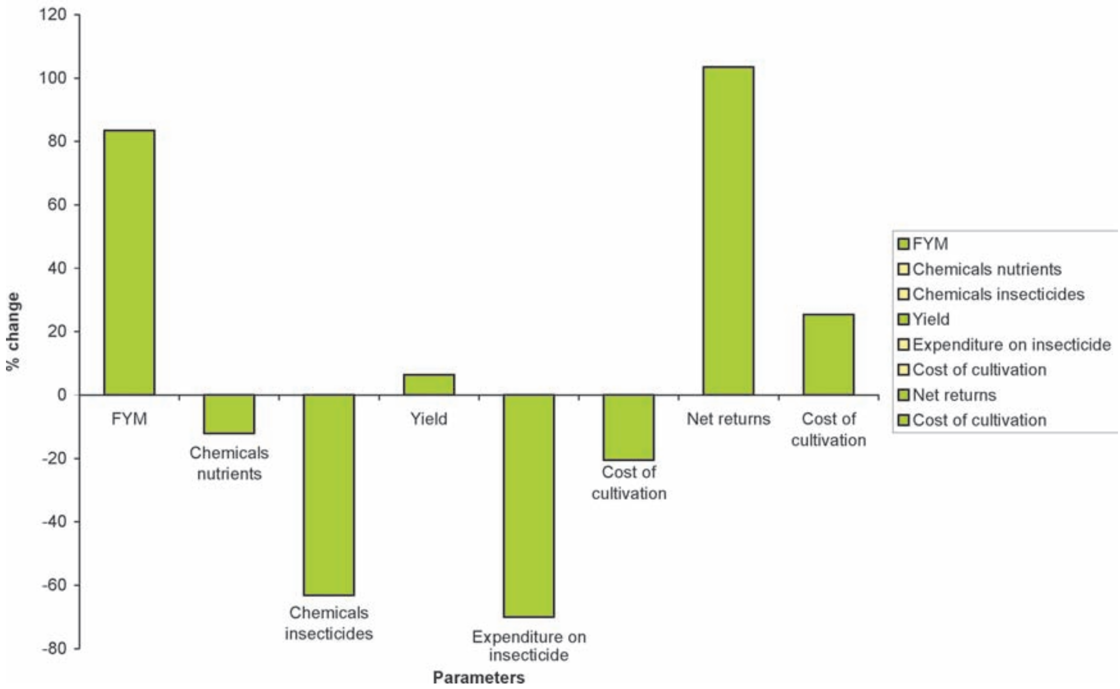
As mentioned earlier, the farm-level impact of the IPM was observed by comparing the use of chemical insecticides, cost of cultivation, nutrient use and yields of IPM farmers with those of non-IPM farmers. As a result of adoption IPM components, there was observed a steep decline in the use of chemical insecticides from about 16 l ha^{-1} in case of non IPM farmers to about 6 l ha^{-1} in case of IPM farmers (Table 8).

Table 8. Farm-level impact of adoption of IPM in Groundnut in Anantapur district

PARAMETER	UNIT	IPM FARMS	NON-IPM FARMS
FYM	t ha^{-1}	193.8	10.56
Nutrients	kg ha^{-1}	77.28	87.98
Insecticides	l ha^{-1}	5.78	15.70
Yield	q ha^{-1}	9.84	9.24
Expenditure on insecticides	Rs^{-1}	1083.58	3619.44
Cost of cultivation	Rs ha^{-1}	9365.91	11790.58
Net returns	Rs ha^{-1}	7246.10	3650.45
Cost of production	Rs q^{-1}	951.82	1276.03
Incidence of sick events	%	5	16

Consequently, expenditure on plant protection chemicals fell from Rs. 3619 to Rs. 1084/ ha. It is interesting to note that IPM farmers also applied more organic manures compared to the non-IPM farmers. The IPM farmers harvested about 9.84 q/ha of groundnuts compared to 9.24 q/ha in case of non-adopters. The reduced cost of cultivation and marginally higher yields together resulted in higher net returns from IPM farms (Rs. 7246/ha) compared to non-IPM farms (Rs. 3651/ha). The cost of production also decreased from Rs. 1276/q to Rs. 952/q. Another important benefit of IPM adoption is the reduction in the incidence of health hazards associated with the use of chemical insecticides. About five per cent of farmers reported pesticide-related health hazards compared to 17 per cent in case of non-IPM farmers. Fig. 13

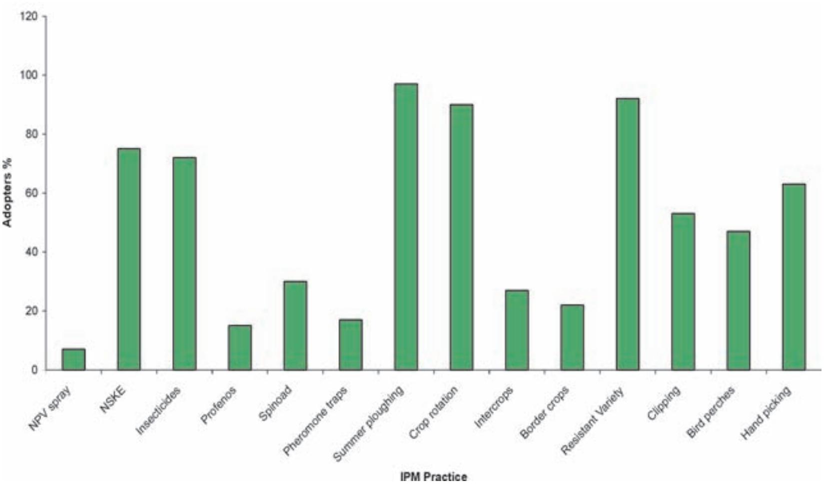
Fig. 13. Farm level impact of adoption of IPM in Groundnut in Anantapur district



3.3. Pigeonpea

The different components of IPM recommended for pigeonpea and the frequency of adoption of each practice was depicted in fig 14. It can be observed that ploughing during summer before sowing the crop is the most adopted component of IPM adopted by the farmers. A majority of IPM farmers (about 90%) also rotate crops such as sorghum, maize, pearl millet with pigeonpea in order to break the pest build up. Spraying of Neem Seed Kernel Extract (NSKE) and neem oil was found to be adopted by as many as 75 per cent of the sample farmers. Adoption of biological means of pest management such as NPV and *Bacillus thuringiensis* is not as popular because of the constraints in availability. In order for these components of IPM to be effective, time and method of application (e.g. NPV is to be applied during the 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 use of bio-rationals, they often do not obtain the potential benefits.

Fig. 14. Adoption of different components of IPM in pigeonpea in Rangareddy Dist.



Factors influencing adoption

The characteristics of IPM farmers and non-IPM farmers are presented in table 9. It is seen from the table that the IPM farmers were relatively younger, had more years of schooling, had more family labour availability in terms of adults per house hold and were members in some social organizations such as farmers' clubs, user groups, self help groups etc. The IPM farmers also could identify a more number of pests and natural enemies than the non-IPM farmers. However, the IPM farmers have sown about 83 per cent of land to pigeonpea compared to 87 per cent in case of non-IPM farmers. The average farm size of IPM farmers was about 10.9 ac compared to 9.1 ac in case of non-IPM farmers.

Table 9. Characteristics of adopters and non-adopters of IPM in pigeonpea, Rangareddy district

CHARACTERISTIC	UNIT	ADOPTERS		NON-ADOPTERS	
		Mean	SD	Mean	SD
Age	Years	42	12.6	43	13.6
Schooling	Years	6.7	11.4	2	3
Adults	No HH^{-1}	3.9	1.6	3.8	1.9
Children	No HH^{-1}	1.2	1.1	0.9	1.2
Membership	1,0	47		41	
Ability	Score	6	1.6	4.4	2.0
Farm size	Ha	10.9	8.5	9.1	8.3
Crop area	%	82.6	19.6	86.7	18.9
Irrigated area	%	6.4	13.9	4.8	13.2

HH: Household

The maximum likelihood estimates of the logistic regression model obtained with SPSS 12.0 are presented in table 10. The table gives the estimated regression coefficients along with the significance levels, the odds ratio and the model fit statistics in the form of Negelkerke R^2, log likelihood and the percent correct classification. The model estimated was found to be a significantly good fit as can be seen from all the three criteria mentioned. The Negelkerke R^2 was about 0.46 and the log likelihood (-2 log LL) of 115.31 was significant at one per cent. The model predicted about 75 per cent of the cases correctly as either adopters or non adopters. Further, the model predicted 72 per cent of adopters and 78 per cent of non-adopters correctly.

An examination of the logistic regression coefficients indicates that age of the farmer, schooling, participation in social groups and ability to recognize the pest and natural enemy species influenced the adoption decision significantly. As can be seen from the table, each year of schooling increased the odds of adoption of IPM by 37 percent. Similarly, as the age of the farmer increased by one year, the odds would decrease by two per cent. Thus, younger and educated farmers are more likely to adopt IPM technologies. This inference is not surprising because the younger farmers are more ambitious and more receptive to the newer technologies and the education will place them in a better position to obtain the relevant information and the necessary inputs. The participation in social groups also influenced the adoption decision significantly. A farmer who is a member in some social group is 3.77 times more likely than a farmer who is not a member. The participation of a farmer in social groups enhances his or her social capital in terms of access to information and resources. Further, various development programmes are also emphasizing the technology transfer through self-help groups, user groups etc. to quicken and broad base the uptake of the technologies. Thus, the highly positive and significant influence of the social capital as represented by participation in social organizations is tenable. The IPM technologies require more labour compared to the dependence on chemical insecticides alone. Thus the bigger farms and larger acreage under pigeonpea are less likely to attract IPM, which is reflected in the negative coefficients of the farm size and the area under pigeonpea. The positive coefficient for labour endowment as measured by the number of adults per household though not significant only reinforces this observation. It may be of relevance to note that farmers with larger farms and more area under the crop concerned are more likely to adopt chemical plant protection measures as observed in case of castor (Rama Rao et al., 1997). Further, access to irrigation is highly correlated to the access and use of other purchased inputs such as fertilizers, which may influence IPM adoption positively. The relatively more assured returns from irrigated crops may also attract more managerial attention of the farmers as a result of which rainfed crops like pigeonpea might 'suffer' in which case the access to irrigation discourages IPM adoption. The observed non-significant coefficient indicates that the variable acted both ways.

Thus, the variables associated with the human and social capital (age, education, pest recognizing ability and participation in social organizations) and the relative resource endowments (farm size and human labour availability) influenced the IPM adoption decision significantly. It is acknowledged that the IPM components are more knowledge-intensive (CGIAR, 2000) and more labour using. Thus, any effort to transfer IPM technologies should address the communication aspects – giving the right information at right time and in a right way.

Table 10. Logistic regression results for adoption of IPM in pigeonpea, Rangareddy district

VARIABLE	β	SE	WALD	ODDS RATIO
Constant	-2.72*	1.82	2.24	
Age	-0.02@	0.02	1.27	0.98
Schooling	0.32*	0.08	16.84	1.37
Adults	0.17	0.15	1.15	1.18
Membership	1.33*	0.53	6.16	3.77
Ability	0.54*	0.13	16.19	1.72
Farm size	-0.04@	0.03	2.32	0.96
Crop area	-0.02	0.01	1.13	0.98
Irrigated area	-0.002	0.02	0.01	0.99
Negelkerke R^2			0.46	
-2log likelihood[a]			115.31*	
Percent correct classification[b]			74.8	
Sensitivity[c]			71.7	
Specificity[d]			78.0	

* and @ indicate significant at 1 and 10 percent, respectively.

a Follows χ^2 distribution with 9 df.

b Based on a 50-50 classification scheme

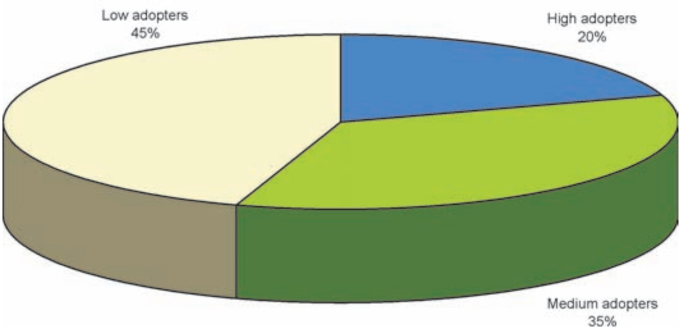
c Prediction of farmers adopting IPM who were classified correctly

d Prediction of farmers not adopting IPM who were classified correctly

Extent of adoption

In the above analysis a farmer was considered to be an IPM adopter if he or she adopts at least four different components of IPM. However, there can be variations in the extent of adoption of different components of IPM. In order to measure the extent of adoption, scores were computed for all the IPM farmers. The findings are presented in Fig. 15. Thirteen different components of IPM were observed to be followed by the IPM farmers. As many as seven of these thirteen were cultural practices, three were chemical, two biological and one mechanical. A farmer adopting all these thirteen practices in his effort to manage pests below the economic threshold levels, he or would get a score of 3.6. The scores of the farmers were found vary between 1.5 and 3.3 with an average score of 1.98. About forty five percent of farmers scored below 1.85 (35 percentile) and were classified as low adopters. Only 20 percent of farmers were found to achieve high adoption scores (>2.15, the 70 percentile). The remaining 35 per cent of farmers were classified as medium adopters with scores between 1.85 and 2.15. Thus there was observed variation in adoption within the adopters.

Fig. 15. Extent of IPM adoption in pigeonpea Rangareddy



Farm level impact of IPM

As mentioned earlier, the farm-level impact of the IPM was observed by comparing the use of chemical insecticides and yields of IPM farmers with those of non-IPM farmers. As a result of adoption IPM components, there was observed a steep decline in the use of chemical insecticides from about 9 l ha^{-1} in case of non IPM farmers to about 5 l ha^{-1} in case of IPM farmers (Table 11).

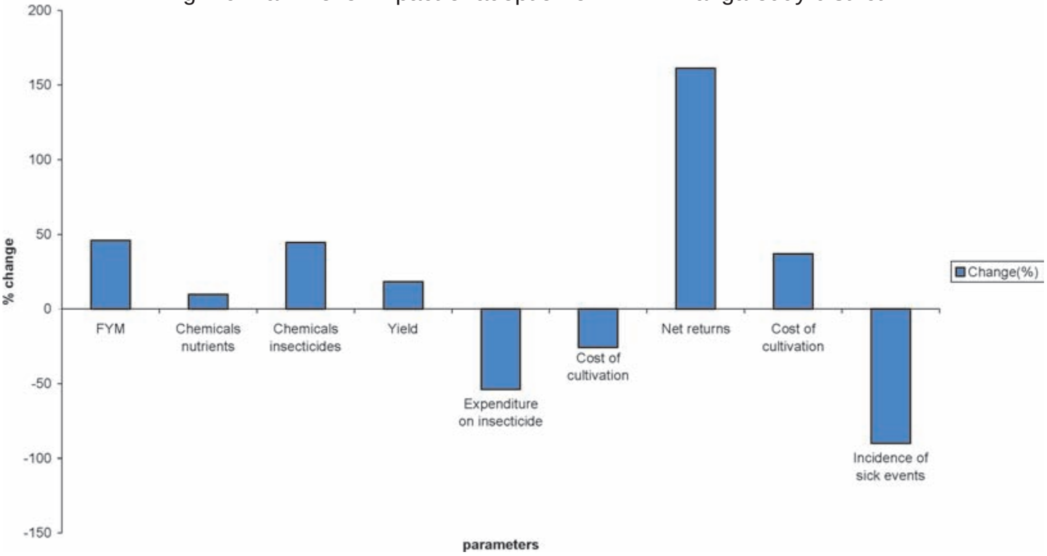
Table 11. Farm-level impact of adoption of IPM in pigeonpea, Rangareddy district

PARAMETER	UNIT	IPM FARMS	NON-IPM FARMS
Farm Yard Manure	t ha^{-1}	5.4	3.7
Chemical nutrients	kg ha^{-1}	67	61
Chemical insecticides	l ha^{-1}	5	9
Yield	q ha^{-1}	13	11
Expenditure on insecticides	Rs ha^{-1}	2500	5400
Cost of cultivation	Rs ha^{-1}	12340	16580
Net returns	Rs ha^{-1}	6268	2400
Cost of production	Rs q^{-1}	949	1507
Incidence of sick events	%	3	30

The differences are significant at 5 per cent probability at least.

This also resulted in the saving on expenditure on plant protection chemicals. It is interesting to note that IPM farmers also applied more organic manures compared to the non-IPM farmers. The adoption of IPM could protect the crop as can be observed from marginally higher yield levels obtained by the IPM farmers. The cost savings together with the increased yields resulted in obtaining significantly higher net returns (by 160%) and lower cost of production (by 37%) from IPM farms compared to non-IPM farms. Fig. 16.

Fig. 16. Farm level impact of adoption of IPM in Rangareddy district

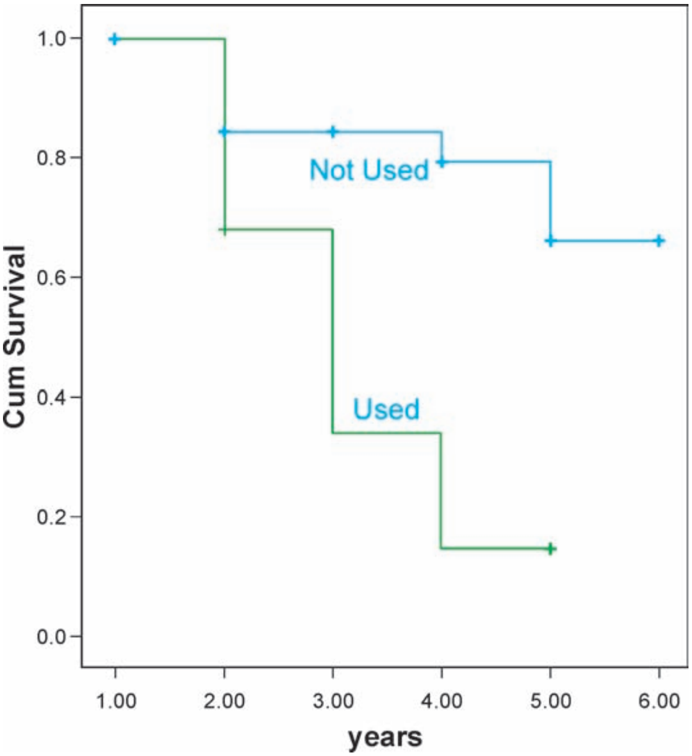


Another important benefit of IPM adoption is the reduction in the incidence of health hazards associated with the use of chemical insecticides. It was observed that about one half of farmers reported at least one incident of falling sick because of exposure to insecticides compared to three out of 60 IPM farmers. These health hazards would further lead to expenditure on health care as well as loss of wages during the period of illness. Thus, the adoption of IPM also had a desirable effect on the family or hired labour engaged in the application of chemical insecticides.

3.4. Discontinuance of IPM in pigeonpea

One of the important reasons for farmers adopting IPM is the failure or ineffectiveness of chemical insecticides as an effective means of pest management. However, the insecticides manufacturers are trying hard to develop and make available more effective insecticides. The IPM also does not exclude chemicals insecticides altogether. While doing the field work in the villages, it was observed that some of the IPM adopters discontinued IPM following their use of more effective insecticides such as spinosad, indoxocarb, thiodicarb, which are recently being made available to the farmers through market. These are selective against the pod borers and are found to be highly effective and have the potential to obviate the need for any other pest management effort. In order to test the hypothesis that use of such highly effective insecticides would lead to discontinuation of IPM via strong economic incentives (For example, it was observed that one spray of spinosad is equivalent to 3-4

Fig. 17. Survival curves of IPM adoption for users and non-users of new chemical insecticides



sprays of conventional chemicals such as endosulfan and adoption of IPM needs more labour and continual attention towards the crop). The data collected was subjected to the Kaplan-Meier survival analysis in order to examine whether the IPM practices survived for shorter time with farmers using the above insecticides. The results showed that out of 50 sample farmers, 22 had used the new chemicals. Eighteen farmers (82 %) in the former group discontinued IPM compared to six (21%) in the latter group (Table 12). Further 79% of the farmers who have not used the new chemicals are still continuing IPM compared to 18 % in the users of new chemicals. It was also observed that the farmers who used these chemicals adopted IPM for an average 3 years compared to 5 years in case of farmers who never used them. The log rank value was found to be 14.88, which was significant at less than one per cent. Thus, use of more effective chemical insecticides was found to lead to discontinuation of IPM by the farmers. It is also observed that the application of these chemicals is so effective that no larvae of pod borer (*Helicoverpa armigera*) are available subsequently and thus affecting the on-farm preparation of NPV solution, which is an important component of IPM. While farmers have a strong economic rationale in doing so, it is important for researchers to examine the possible consequences of such chemicals and educate the farmers on the same. Continued use of these chemicals and discontinuation of IPM practices may result in a changing pest scenario which requires altogether a different strategy requiring a lot of resources to develop and get adopted by the farming community.

Table 12. Results of Kaplan-Meir Survival analysis for survival of IPM vis-à-vis use of new insecticides

GROUP	NO	EVENTS (NO)	CENSORED (NO)	CENSORED (%)	MEAN (YEARS)	SE	95% CI
Users of new insecticides	22	18	4	18	3.17	0.22	2.73-3.61
Non-users of new insecticides	28	6	22	79	5.15	0.30	4.56-5.75

3.5. Relationship between IPM adoption and plant protection expenditure across three crops

As mentioned earlier, IPM is a continuum and the expenditure on plant protection responds to the adoption of IPM. The response depends on the efficacy of IPM which results in saving on plant protection chemicals and on the labour requirements associated with adoption of IPM. Therefore, it was examined how different levels of IPM adoption, measures as described in the previous section, affect plant protection expenditure by regression the plant protection expenditure on the IPM adoption score (Table 13).

Table 13. Relationship between plant protection expenditure and IPM adoption

CROP	DEPENDENT VARIABLE (RS/HA)	CONSTANT	ADOPTION SCORE	R^2
Cotton	Chemical insecticides	6856.0	-1503.6	0.52
	Non-chemical components	275.5	257.1	0.35
	Total plant protection	6946.7	-1134.8	0.33
Groundnut	Chemical insecticides	1839.4	-595.6	0.44
	Non-chemical components	367.6	278.5	0.64
	Total plant protection	2207.0	-317.1	0.12
Pigeonpea	Chemical insecticides	2632.1	-702.5	0.36
	Non-chemical components	1075.3	305.8	0.18
	Total plant protection	3707.4	-396.7	0.12

The coefficients are significant at 10 per cent, at least.

As is evident from the table, adoption of IPM led to a conspicuous reduction in expenditure on chemical insecticides. For example, for every unit increase in the IPM adoption score, the expenditure on insecticided decreased by about Rs. 1504/-/ha in cotton. Similar reductions were observed in other two crops as well. However, adoption of IPM also involved expenditure on human labour and other materials (NSKE etc) which was reflected in the positive coefficient for the non-chemical components of IPM. Considering both the chemical and non-chemical components of IPM, the net effect of IPM on total plant protection expenditure was negative indicating the cost-saving effect of adoption of IPM. As expected, the effect was more in case of cotton which suffers from heavy pest infestation and where the level of adoption of IPM was also relatively higher.

3.6. Constraints to adoption of IPM

Identification of important constraints to wider scale adoption of IPM is the final objective of the study. Since farmers, researchers and extension agents are the three important stakeholders in promoting IPM adoption, the view points of these groups are very important to identification of constraints so that the necessary policy and other measures can be designed to ameliorate the constraints.

Constraints – Farmers' perspective

In order to identify the constraints as seen by the farmers, all the farmers were asked to rank different constraints (some are included in the interview schedule and some are added by the farmers). Thus, for each crop twelve different constraints were listed and each farmer gave a rank to these constraints. Thus, for each crop a 180 X 12 matrix was developed. Then the percent of farmers giving a particular rank was computed. Then, it was established that the rankings were not given randomly and farmers agreed with one another by and large with respect to the ranking order for the constraints by applying Kendall's concordance test. Then, Garrett's scores were computed for all the constraints based on which the constraints were ranked. The constraint with the highest Garrett score is considered as the most important constraint. The results of are presented in table 14 for the three crops.

Table 14. Constraints to adoption of IPM and their ranking – Farmers' perspective

CONSTRAINTS	COTTON	PIGEONPEA	GROUNDNUT
Pesticide use by neighbours	1	5	9
Non-availability of inputs	2	1	2
Labour intensive	3	2	3
Unsure about the effect	4	3	6
Difficult to prepare	5	8	10
Low crop yield	6	4	5
Short shelf life	7	9	4
Quality uncertainty	8	10	7
Lack of timely expert advice	9	6	1
Unsynchronized supply	10	7	11
Host specificity	11	11	8
Costly inputs	12	12	12

As can be seen from the table, use of insecticides by the neighbours is the most important impediment to adoption of IPM in cotton. It is widely believed that IPM is most adopted when adopted on a larger contiguous area than when adopted on small patches in isolation.

Non-availability of the inputs (NPV, Bt etc) was ranked high (1 or 2) in case of all the three crops and so was the case of requirement of high labour. Difficulty in preparation of some of the IPM components, especially NPV and NSKE, was another important constraint in adoption of IPM. In case of groundnut, lack of timely advice was the most important constraint indicating the need for strengthening the advisory services to farmers in this region. A significant number of farmers were not sure of the effect of IPM (ranks 3,4 and 6) in managing the pests farmers which implies that some more effort is needed to demonstrate the effect of IPM in farmers' own situations. Short shelf life of the IPM components like NSKE and NPV was found to be among the relatively more important constraints in case of groundnut. Interestingly, cost of the inputs was found to be least important constraint in case of all the three crops. It follows that if the farmers are convinced about effect of a technology, have access to it and have the labour endowments, then the cost or price of the input is not an insurmountable constraint to adoption.

Constraints- Input dealers' perspective

Since non-availability of the IPM inputs is identified as one of the key constraints to adoption, this was further examined in a survey with the commercial input dealers selling various farm inputs. The survey was conducted by taking a random sample of ten dealers from each of the nine mandals where the sample of farmers was taken. Thus, a total sample of ninety input dealers was considered for the study. The survey was conducted with a view assess the role and capacity of the dealers in promoting the adoption of IPM. The results are presented in tables 15 and 16.

Table 15. Role of inputs dealers in IPM promotion

PARTICULARS	GUNTUR	ANANTAPUR	RANGAREDDY
Dealers advise to farmers	100	100	100
Dealers get information from			
Experience	79	100	100
Brochures	74	90	100
Magazines etc	52	57	42
TV/Radio	45	50	50
Training	19	10	17
Department of Agriculture	47	30	46

As observed from the table 15, all the dealers advise the farmers in pest management when ever the farmers approach them for buying the insecticides and often farmers follow their advice what chemical to spray. It was observed that the input dealers seldom recommend IPM and their 'recommendations' are often driven by profit margins and the promotional efforts of the manufacturers. The dealers depend either on their own experience or the information brochures made available by the insecticide manufacturers for getting the information. In such cases it is very likely that they promote those insecticides whose sales will fetch more margins to them. The number of dealers getting any training from any agency or even from the department of agriculture is least.

Table 16 lists various important components of IPM and the number of dealers aware about and selling the same. Pheromone traps, Bt formulations, NPV formulations and neem formulations find place in IPM modules of many different crops. However, not all the dealers were aware and sell these inputs. Only 78 per cent of dealers in Guntur district were aware of pheromone traps and only 10 per cent actually sell them The figures are much smaller in other two districts. Similar is the case with all other inputs. In this context, there is a need to make available these inputs at the local level. There are however certain constraints like the quality of these inputs and commercial viability of local preparation units. Even the experience of NGO championing the cause of IPM suggest that the arrangements to make available NPV, NSKE etc at local level are not viable without support from outside agencies. Even farmers were skeptical about the quality of locally prepared inputs. Another important issue here is that if the poor quality of inputs is the reason for the ineffectiveness of IPM, them dependence on such arrangements in fact may turn out to be impediment as it is difficult to get farmers' faith in IPM once they lose it because of poor quality. Further research in making the inputs available is therefore the need of the hour. Use of chitin inhibitors, mating disruptors and chrisopella eggs are sometimes used in pest management of crops such as cotton and chillies. However, very few dealers are aware about them let alone sell them.

Table 16. Awareness and sale of IPM inputs by dealers (%)

IPM INPUT	GUNTUR		ANANTAPUR		RANGAREDDY	
	Aware	Sell	Aware	Sell	Aware	Sell
Pheromone Traps	78	10	50	3	42	8
Bt formulations	40	12	33	17	25	0
NPV formulations	40	2	20	3	75	5
Neem formulations	78	20	96	93	91	58
Trichogramma eggs	7	57	3	3	8	0
Chitin inhibitors	24	14	0	0	0	0
Mating disruptors	7	0	0	0	0	0
Chrisopella eggs	0	0	0	0	0	0

Constraints- Researchers' and Extension agents' perspective

As mentioned earlier, constraints to adoption of IPM as seen by the researchers and extension agents were examined. Feedback and responses were obtained from researchers and extension agents working on IPM and ranked (Table 17)

Table 17. Constraints to adoption of IPM and their ranking (reseacrhers' and extension agents' perspective)

S No.	CONSTRAINT	RANK
1	Farmers' mindset (habituation, quick knock-down effects)	1
2	Changing pest dynamics, more knowledge and expertise required	2
3	Not fully convinced about effectiveness	3
4	Labour-intensive and knowledge intensive	4
5	Adopt if suffered pest shocks in the recent past	5
6	Not readily available, to be prepared well before actual time of application	6
7	Newer insecticides	7

As against the farmers' view point, the researchers and extension agents believe that farmers' mind set is the most important impediment to adoption of IPM on a larger scale. They believe that farmers got used to application of insecticides and would only be convinced only when they saw the insect pests getting 'knocked down' by the insecticides. It takes quite an effort to convince them about the IPM which are more preventive than responsive in their nature and effect. This observation support the earlier finding that many farmers were unsure of the effect of IPM. Next important constraint, which has the implications to the way extension agents work, is the need to adapt to the changing pest dynamics and lack of expertise. It was expressed that the nature of pest attack vary across locations, seasons and the experts need to work in a given area for a minimum period of 3-5 years if farmers were to pick up necessary skills and expertise, and more importantly develop a conviction towards IPM. The next two constraints flow from these phenomena only. Another important observation was that farmers adopted IPM more readily when they had suffered pest outbreaks in the recent past. Higher adoption of IPM was reported in pigeonpea in the late nineties after the outbreak of pod borers and following the whitefly epidemic in cotton. Similarly, farmers religiously put 'bonfires' to control red hairy caterpillar in groundnut a few years ago. In response to changing pest dynamics, different manufactures were trying to making available insecticides with more effectiveness and shorter residual effects which were found to have an impact on IPM adoption. (see earlier section 2.1.4).

Case studies of successful IPM campaigns taken up by some NGOs, KVKs in Anantapur and Guntur reflected how those agencies took care to ease some of these constraints. In most of these programmes, efforts were made to make available the key IPM inputs (neem preparations, NPV formulations, pheromone traps, etc) available to the farmers. In that process different institutional arrangements with varying degrees of people's participation were attempted. The agencies tried to work with the communities closely and advise them properly. Some agencies moved further and tried to promote non-pesticidal management (NPM) also. The efficacy of some of the methods often included in NPM needs to be scientifically tested. Inadequacy of the scientific expertise is one of the constraints faced by the agencies involved in transfer of IPM technologies and therefore a stronger interaction with the research organizations is very critical as the IPM is knowledge-intensive. Considering the farmers' mindset in favour of use of insecticides and the difficulties in making available IPM inputs readily to the farmers, some of these agencies even admitted that the IPM adoption would fall down once they (the external agency) left the community. There are some genuine constraints in terms of economic viability, technical expertise with the community, maintaining quality and shelf life, in making these biological inputs readily available to the farmers when needed. In the absence of that farmers are having to prepare them well in advance. Moreover, the preparation of these inputs is sometimes not a very pleasant task and cumbersome too and as a result only those farmers with abundant family labour and have high conviction levels are resorting to these practices. It is however to be mentioned that the cultural components of IPM (inter-cropping, trap crops etc) are widely accepted by farmers. Finally it can be concluded that the difficulties in terms of expertise inadequacy, institutional bottlenecks, limited availability of inputs and farmers' mindset, the successful campaigns remained 'islands of salvation' without getting converted into a larger scale adoption that was often expected from such programmes.

4.0. Conclusions

Research on and extension of IPM is a response to the changing ecological, economic and biological environment that the farming community is confronted with. In spite of the increasing emphasis on research and extension of IPM technologies, there are still some knowledge and information gaps that need to be filled for enhancing the adoption of IPM technologies. Farmers growing the three target crops, viz., cotton, groundnut and pigeonpea, were found to follow a wide range of practices to manage the pests. The adoption of different components of IPM was found to be varying. On the whole the cultural components of IPM such as summer ploughing (more than 90% of IPM farmers), intercropping were adopted by more farmers. The adoption of biological components such as NPV, Bt was observed to be limited because of the constraints in availability as well as the lack of proper understanding on the application methods and efficacy of these components. All the IPM farmers were found to use pheromone traps in case of cotton. Apart from age and education of the farmers, the ability to recognize the insect pests and participation in CBOs were found to influence IPM adoption positively. Adoption of IPM was observed to be more in case of cotton where the incidence of insect pests is high compared to other two crops. The adoption of IPM was found to lead to reduction in use of insecticides, reduced cost of cultivation and increased net returns. Another important benefit associated with adoption of IPM was the reduction in incidence of sick events arising from exposure to insecticides. Use of new generation insecticides was found to discourage IPM adoption as farmers find them more effective. The adoption of IPM was found to have desirable impact on plant protection expenditure, use of chemical insecticides and profitability of crops and more importantly on the incidence of health hazards to farm labour.

Whereas the non-availability of certain inputs and difficulties in preparation of the inputs were the two most important constraints to adoption as revealed by the farmers, mindset of farmers was reported as the most important impediment to IPM adoption by the researchers and extension agents. All the three groups of stake holders believed that lack of conviction about IPM and knowledge-and labour-intensive nature of IPM were other potent constraints to IPM adoption on a wider scale. The role of input dealers need to be harnessed to promote IPM as at present their participation in terms of advice and sale of IPM inputs is quite negligible.

The findings of this study bring out the following policy implications.

- The information being passed on to the farmers need to be more complete in terms of details of what, when, how much and how to follow certain IPM practices. The changing pest-dynamics and relative occurrence of different pests need to be better understood.
- Since human capital and social capital related variables were found to be positively associated with IPM adoption, it is important that farmers are given necessary information and skills. The effectiveness and coverage of Farmers' Field Schools need to be strengthened further. Farmers growing a crop in contiguous area can be dealt with as a single group for enhancing IPM adoption.
- The conviction of farmers regarding effectiveness of IPM is to be enhanced by appropriate demonstrations and continuous interactions with the farmers.
- The agencies working on IPM promotion need to work with the community closely and for long enough (at least three years) so that farmers will get enough hand-holding.
- The extension agencies should also have a strong backward-linkage with researchers working on the pest management of the crops concerned.
- Appropriate institutional arrangements have to be made to make available the biological inputs to the farmers without compromising on the quality of these inputs.
- Farmers should be made aware about the expanding market for residue-free agricultural produce and efforts are to be made to connect farmers to such markets so that they get some price premium for 'clean' produce.
- Possibilities to include the dealers of agricultural inputs to promote IPM have to be explored.

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