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Analyzing the Factors Influencing the Adoption of Integrated Pest Management (IPM) Technology in Cotton in Rajasthan

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ABSTRACT

Background: The model of sustainable agriculture mostly emphasizes on enhancing the efficacy of agrochemical usage by the implementation of Integrated Pest Management (IPM) technology, substitution of various inputs and practices with effective alternative technologies involving low energy utilization and plant/animal integration. Following the sustainable approach towards agriculture, a research has been conducted in the state of Rajasthan to identify the major factors that influence the adoption of IPM technology in Cotton. Cotton being the major crop of Sri Ganganagar and Hanumangarh districts for *kharif* season had an average area of 2.39 lakh hectares and average production of 7.44 lakh bales that constituted 51 per cent and 52 per cent of total area and production of Rajasthan, respectively during last five years ending 2016-17.

Methods: On the basis of pest management strategy, farmers in the area were classified into three categories *viz*. farmers following conventional practice, farmers following IPM practice and farmers following both the practices, for the research. The purpose of the study was to identify the factors influencing adoption of IPM technology in the study area. A total of nine metric socio-economic variables of three groups of a total sample of 90 farmers from both the districts were taken for the study for the crop year 2017-18. The data were analyzed through suitable statistics: linear discriminant analysis and two-step cluster analysis.

Result: It was found that 'years of experience in current practice followed', 'number of workshops attended for current practice', 'years of education', 'years of experience in agriculture' and 'number of trainings attended for current practice' are the major variables that discriminated among the three group of practices followed by the farmers of the study area. Among the selected significant discriminating factors, 'higher education', 'higher number of workshops attended for current practice' and 'higher number of trainings attended for current practice' were found to be the major influencing factors towards the adoption of IPM technology among the cotton growers in the study area. This study would facilitate the stakeholders involved in the dissemination of IPM technology as a measure for sustainable agriculture.

Key words: Cluster analysis, Cotton, IPM, Linear discriminant Analysis, Sustainable agriculture.

INTRODUCTION

Integrated pest management (IPM) technology has become the best economic perspective for developing countries like India. This technology has evolved with the time and transformed the Indian agricultural system. The traditional or conventional system of agriculture is known to be highly dependent on agro-chemical inputs like fertilizers and pesticides which lead to contamination and degradation of the agri-ecosystem. Though the use of synthetic pesticides is the basic principle for pest and disease control in conventional agriculture, it is quite evident that the incessant and injudicious use of chemical pest control methods have far reaching effects on the environment. Human beings that ultimately lead to the deterioration of the soil ecology and structure (Dabrowski *et al*., 2014; Kaith *et al*., 2016), with negative effects on the soil microbiota (Asad *et al*., 2017; Bending *et al*., 2007; Yang *et al*., 2017). The model of sustainable agriculture mostly emphasizes on enhancing efficacy of agrochemical usage by the implementation of IPM technology, substitution of various inputs and practices with effective alternative technologies, involving low energy utilization and plant/animal integration (Alam *et al*., 2016; Lechenet *et al*., 2014; Seufert *et al*., 2012). With an estimated increase in the world population from 7.7 billion people on earth to 9.7 billion in 2050, the demand for food and fiber will also rise, leading to the increase in the need for control of pests. The demand for IPM technology was valued at USD 91.8 billion in 2016, which had been expected to grow at a CAGR of 5.8 per cent, valued at USD 151 billion by 2025. With an anticipated CAGR of 6.4 per cent from 2017 to 2025, the Asia pacific region was expected to witness the fastest growth in IPM technology. In the recent times, farmers are still found to be unaware of IPM technology as

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an important pest control technique in spite of extensive efforts of training and creating awareness amongst them (Ashraf *et al*., 2012). Certain aspects / factors like skills, motivation and knowledge possessed by the farmers along with their active participation in local groups and communities effect on the success of IPM programs to a large extent (Borkhani *et al*., 2013; Chowdhury and Prabuddha 2023). Hashemi and Damalas (2010) found that the adoption of pesticide safety practices was considered highly significant one among the farmers having higher experience on farming who felt that pesticides were generally effective on agricultural production. Knowledge on IPM and cultural pest control measures were considered highly important by the farmers who felt that pesticides are generally effective whereas farmers with high off-farm income those who considered pesticides as generally effective seemed inclined towards alternative pest control strategies. Zunjar, (2011) found that land holding size of farmers, sources of information available to them, their annual income and social participations were found to have significant effect on the adoption of IPM technology in cotton. Timprasert *et al*. (2014) found that increased concerns over the incessant use of highly toxic pesticides in agriculture had been a result of their adverse effects on environment as well as on human health. The primary reasons responsible for IPM adoption in the study area were higher cost of insecticide (91 per cent), hazardous impact of pesticides on environment and human health (80 per cent) and higher risk of development of resistance to insecticides in pests and insects (28 per cent). On the other hand, the reasons like difficulties in implementation of IPM (80 per cent), unsuitability of IPM on large farms (52 per cent) and faith upon efficacy of synthetic pesticides for target pest control (39 per cent) were the major reasons for the non-adoption of IPM in that area. The IPM farmers possessed better knowledge about various plant extracts, their applications and efficacy in controlling pests about the identification of natural enemies and their benefits in pest control as well as the use and efficacy of pheromone traps in monitoring pests. Khan and Damalas (2015) revealed that training and education as the major determinants of environmentally sound behaviour in the control of diseases and pests as high levels of training and education appeared to suppress high pesticide use in that area. Ma, (2016) indicated a significant and positive impact of cooperative membership on IPM adoption. Likewise, adoption of IPM technology also appeared to have positive impact on yields, agricultural income as well as net returns. In general, the outcome of the study considered the role of agricultural cooperatives instrument in proper transmission/ channelization of efforts to facilitate IPM technology and adoption of IPM can facilitate and develop the economic performance of farm households. Nidhi and Naga (2016) revealed the significant association of educational level of the respondents with the adoption of IPM in the cultivation of cauliflower in Udaipur district of Rajasthan, in their research on the association of selected personal variables with the extent of adoption of IPM in that area. The other variables like age, income, land size, economic motivation, cosmopolitan outlook and extension contact were found to have no significant association with IPM adoption in cultivation of cauliflower. Sharma *et al*. (2016) studied about adoption of IPM in cotton at Ashta village and from the findings of the study; the variables like farmers' active participation and cooperation of developmental agencies, participation of women, training and demonstrations and timely supply of inputs were major factors influencing the adoption of IPM.

Cotton is an international crop grown by about 80 countries across the world. On an average, cotton is planted in an area of 328.62 lakh hectares during 2010-2017. It is well known that Indian cotton production is heavily associated with the intensive use of hazardous pesticides. Cotton cultivation in India consumes the lion's share of 44.5 per cent of the total pesticides used in the country. FAO data revealed that India ranked second after China, with an average production of 180.46 lakh tonnes of cotton during 2010-17. Cotton is the major fibre crop grown in India and plays a dominant role in agricultural and industrial sectors. Cotton contributes 70 per cent of total fibre consumption in textile sector and 38 per cent of the country's export, fetches over ` 42,000 crore. The area and production of cotton during the year 2018-19 was 12 million ha and 362 lakh bales (170 kg of each bale), respectively (Mageshwaran *et al*. 2019). Major cotton growing states are Gujarat followed by Maharashtra, Telangana Andhra Pradesh, Rajasthan and others. The Directorate of Economics and Statistics reported that Gujarat ranks highest in production of cotton with triennial average of 10.21 million bales, followed by Maharashtra (8.22 million bales), Telangana (3.95 million bales) and others. After inception of Bt. cotton, the pest outbreak has been managed upto a great extent. In 2017, the adoption of Bt cotton in India was escalated by 7.5 million farmers among the 10 major cotton growing states. In 2017, India planted 11.4 million hectares of IR (Bt) cotton, recording an increase of 600,000 hectares from 10.8 million hectares in 2016. Bt technology accelerated the adoption of cotton hybrids in India, from 45 per cent in 2002 to 96 per cent in 2017 (ISAAA 2017). It is quite evident that there has been an increasing trend of Bt. Cotton in India. As per the Commissionerate of Agriculture, Government of Rajasthan, cotton being the major crop of SriGanganagar and Hanumangarh districts for *kharif* season with an average area of 2.39 lakh hectares and average production of 7.44 lakh bales that constituted 51 per cent and 52 per cent of total area and production of Rajasthan, respectively during last five years ending 2016-17. The purpose of the study is to identify the factors influencing adoption of IPM technology in cotton in SriGanganagar and Hanumangarh districts of Rajasthan.

MATERIALS AND METHODS

The study was conducted at Institute of Agri Business Management, Swami Keshwanand Rajasthan Agricultural

University as a part of doctoral research during 2016-20. The research was limited to the state of Rajasthan. Multistage stratified random sampling technique was used for the study. Sri Ganganagar and Hanumangarh districts of Rajasthan of zone IB had been purposely selected for the study. It was evident that zone IB covered a considerably higher area and production of cotton as compared to other regions of Rajasthan. For the study, Bt cotton crop had been taken into consideration because of its national and regional importance. Both primary and secondary data were collected for the study. The primary data were collected from 90 sample farmers for the crop year 2017-18 with the help of structured schedule. For the selected crop, Central Integrated Pest Management Centre and Agricultural Technology Management Agency (ATMA), were found to be active in Sri Ganganagar district and Hanumangarh district, respectively and were promoting IPM in these areas. Further, this area was found to be highly irrigated, hence found suitable for the research work. In the respective districts, tehsils, gram panchayats and villages were identified based on the experts' opinion. Sri Ganganagar tehsil from Sri Ganganagar district and Rawatsar tehsil from Hanumangrh district were selected for the study. Two gram panchayats namely, Sahibsinghwala and Nirwal were identified from Sri Ganganagar and Hanumangrh district, respectively. Three villages each from the two selected gram panchayats were considered for the study. From Sahibsinghwala gram panchayat, three villages namely 24Z, 3M and 23Z and from Nirwal gram panchayat, three villages namely, 3 DWM, 2NWM and 1NWM were chosen based on the practices followed *viz*. IPM, conventional and mix of both technologies. Farmers from each village were selected based on Probability-Proportional-to-size (PPS) method based on the land holding of farmers *viz*. small: upto 2 hectare, medium: $> 2 \leq 4$ hectare and large: > 4 hectare. To attain the objective of the study, following statistical techniques were followed.

To identify the important factors that influence on adoption of IPM technology for cotton, nine metric predictors and one categorical non-metric dependent variable had been selected. The farmer centric metric variables were land (hectares), age (years), married (years), education (years), income (rupees per annum), experience in agriculture (years), experience in current practice (years), workshops attended for current practice (numbers) and trainings attended for current practice (numbers). The dependent variable had three categories *viz*. farmers following IPM technology conventional practice and mix of both practices. Linear discriminant analysis and two-step cluster analysis were found suitable for the analysis. With the help of stepwise method, the insignificant factors based on 'Mahalanobis distance' had been eliminated for further analysis. The best function out of the two was selected after calculation of the values of Wilk's Lambda, canonical correlation and eigenvalues. In the analysis, absolute values of correlation coefficients between discriminating variables and standardized canonical discriminant functions were taken into consideration to infer the results. After finding out the discriminating variables, two step cluster analysis was followed to find out the importance of the variables in each group of farmers. Silhouette measure of cohesion and separation was checked for checking whether the cluster analysis was fit or not for the analysis. Two step cluster analysis had created three groups on the basis of practice followed and on the basis of mean and median of the selected discriminant factors, cluster comparison was made.

RESULTS AND DISCUSSION

The data were analyzed and discussed with the help of tables and charts. As shown in Table 1, in cotton, Wilk's Lambda ($\wedge = 0.003$, $\chi^2 = 481.442(10)$, $p < 0.01$) for function 1 was found to be more significant as compared to that of function 2. The value of Wilk's Lambda ranges from 0 to 1, where 0 means total discrimination and 1 means no

Table 1: Linear discriminant statistic (Cotton).

Test statistic	Function 1	Function 2
Wilk's lambda	0.003**	0.302**
Eigenvalue	86.108	2.310
Canonical correlation	0.994	0.835
Structure matrix (Factors)	Values (Function 1)	
Experience in current practice (years)	0.841	
Workshops attended for current practice (numbers)	0.270	
Education (Years)	0.237	
Experience in agriculture (years)	0.199	
Trainings attended for current practice (numbers)	0.172	

Chi-square transformation of Wilk's lambda is used with the degrees of freedom to determine significance; if significance value is less than 0.05, then it indicates that group means differ.

The values of predictors are the correlation values between discriminating variables and standardized canonical discriminant functions Variables ordered by absolute size of correlation within function.

**Significant at one per cent of probability.

Source: Researcher's computation of field data through SPSS.

discrimination. Wilks' Lambda indicates the significance of the discriminant function. Wilk's Lambda for function 1 indicated that 99.7 per cent (*i.e.* $1-\wedge \times 100$) of variance between the discriminating groups was explained by the function 1.

Also, the canonical correlation of function 1 was 0.994 which suggested that the model explained 98.80 per cent (square of canonical correlation) of the variation in the grouping variable. The eigenvalue of function 1 was 86.108 which was much higher than of function 2 *i.e.* 2.310. Therefore, function 1 was selected for analyzing the discriminating factors. It was observed in the structure matrix that, 'years of experience in current practice' (0.841), followed by 'number of workshops attended for current practice' (0.270), 'years of education' (0.237), 'years of experience in agriculture' (0.199) and 'number of trainings attended for current practice' (0.172) were the major variables with significant discriminating ability to differentiate among the three group of technologies, followed by the farmers of the study area. Further to calculate the most important variables that influenced the adoption of IPM technology out of all the selected predictors, two-step cluster analysis was done. Before analyzing, the cluster quality was checked through Silhouette measure of cohesion and separation, which gave a clear picture of the appropriateness of the technique for the study. It is a way to calculate how nearer each factor in a cluster is to the points in its next clusters. Silhouette values lies between -1 to +1, where, +1 indicates the maximum difference and -1 indicates the minimum difference between the clusters. Higher the value, superior is the cluster configuration.

It can be seen from the Fig 1 that, the average 'Silhouette measure of cohesion and separation' value was 'good' (0.6) for the cluster analysis. Further, the clusters were compared among themselves for identifying the influencing factors for different practices based on their arithmetic means and medians.

It can be observed from the Fig 2 that compared to other two practices, 'high education' (15.50), 'high number of workshops attended for current practice' (12.50) and 'high number of trainings for current practice' (4.80) were found to be the influencing factors with high mean value for adoption of IPM technology in cotton cultivation compared to other practices in the study area. Along with this graph, separate SPSS generated graph from the data entered was being analyzed further.

Also it can be observed from the Fig 3 that the median value of 'number of workshops attended for current practice' (12.03) as compared to mix of both (9.03) and conventional (3.02). In 'years of education', the median of IPM (15.52) is showing highest compared to that of mix of both (14.01) and conventional (5.02). In case of 'number of trainings attended for current practice', the farmers following IPM (5.00) technology had highest median value as compared to mix of both (3.01) and conventional (0.01) practice.

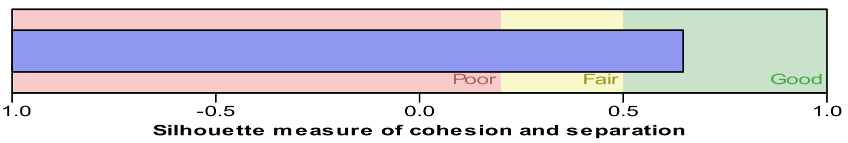
The reason behind the lower mean and median value of IPM as compared to conventional practice in 'years of experience in agriculture and years of experience in current practice followed' is that IPM is a much new concept than conventional method which has been practiced by farmers since long time. It can be observed from the figures that compared to other two practices, 'high education', 'high number of workshops attended for current practice' and 'high number of trainings for current practice' were found to be the influencing factors for adoption of IPM technology in cotton cultivation in the study area.

Education has been the utmost important element in motivating the young farmers to adopt innovative technology in agriculture. Without proper education, farmers may feel reluctant in accepting any type of alterations in the conventional forms of agriculture. The awareness through training programs and workshops may become a facilitating tool for the mass adoption of IPM technology. The trainings also need to be very effective and monitored by proper

Model Summary

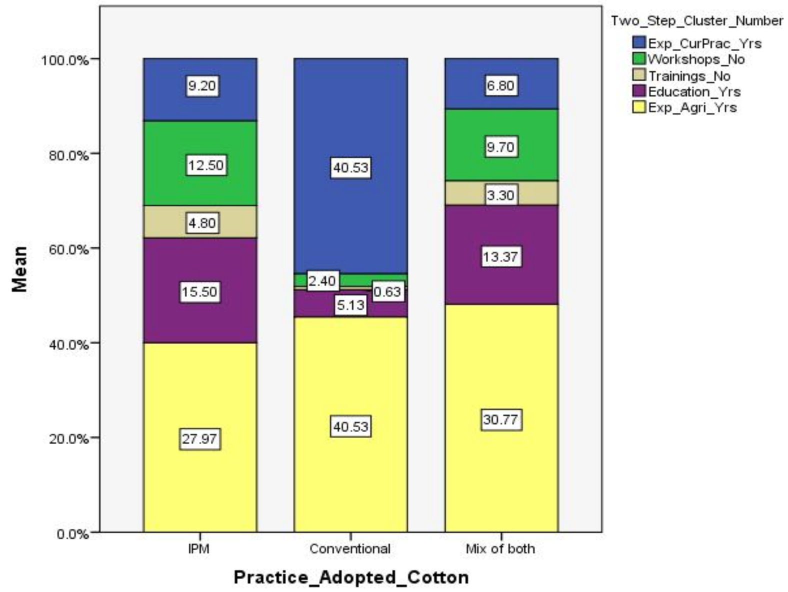
Algorithm	TwoStep
Inputs	6
Clusters	3

Cluster Quality



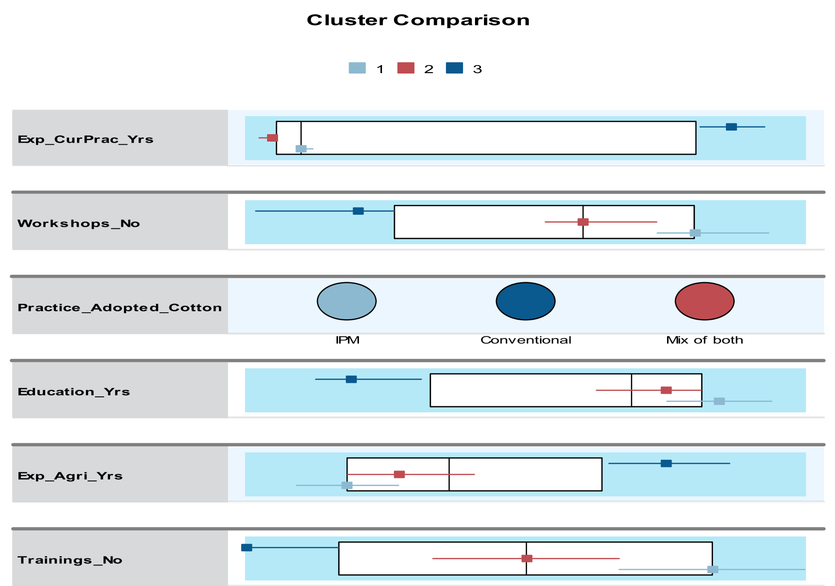
Source: Researcher's computation of field data through SPSS

Fig 1: Silhouette measure of cohesion and separation.



Source: Researcher's computation of field data through SPSS

Fig 2: Two step cluster analysis for cotton farmers.



Source: Researcher's computation of field data through SPSS

Fig 3: Cluster comparison of cotton farmers.

follow-up by the extension personnel. For the effective dissemination of IPM technology, CIPMC and ATMA have been functioning successfully but there is a need of synergic team effort of all organizations to join hands and work together under one approach system.

CONCLUSION

Higher education, higher number of workshops attended and higher number of trainings attended for current practices were found to be the major influencing factors in cotton for the adoption of IPM among the growers in the study area. As number of trainings and workshops related to IPM technology are found to be the major influencing factors, these should be increased with large amount of participation of farmers. To attract uneducated farmers for adoption of IPM technology, field demonstrations can prove to be more effective by providing first hand experience unlike lectures. The government extension personnel should focus on these influencing factors to promote the IPM technology.

Conflict of interest: None.

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