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Adoption of Integrated Pest Management (IPM): The Case of Iranian Farmers

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Abstract

Determining the influencing factors regarding adoption of integrated pest management (IPM) practices by farmers in Fars province of Iran is the main purpose of this study. Survey research was conducted using stratified random sampling and 151 farmers were interviewed. Data were analyzed using $SPSS_{21}$ software and structural equation modeling based on Smart PLS software. Results revealed that the model presented in this study had a modest predictive power. It also showed the differences in the use of diverse activities of integrated pest management. Based on the findings of structural equation modeling, the comments of the reference group is the most important factor affecting the adoption of integrated pest management. Access to extension services about IPM, recourse availability, educational level and income are the other factors which influence the adoption process. The effective role of reference group, perception should be emphasized in order to increase adoption of IPM among farmers.

Keywords: Integrated pest management, Adoption, Structural equation modeling, Iran.

Introduction

Most Iranian farmers are smallholders. Considering the rising input prices as well as changes in policies, including privatization, decentralization and liberalization of the market and the challenges facing the agricultural sector, improving agriculture requires more attention to achieve food security with regard to sustainable development. One of the main challenges of the agricultural sector in terms of food security is reducing food losses due to pest infestation. Pest infestation is one of the biggest risks for crops. Pests not only reduce the amount of goods, but also reduce the quality of products. Hence, manufacturers are faced with a quality-based price risk. Pest infestations can incur a great deal of damage on agriculture and natural resources, and lead to substantial economic and environmental costs. However, the spread of pests depends largely on how different pests in various regions are managed given the ecological, environmental and social conditions (Rebaudo and Dangles, 2013).

Synthetic pesticides have previously been used, however, excessive use of pesticides threatens food, consumers, the environment, and the security of exported agricultural products. In many countries, sales of pesticides have increased since 1970, and environmental and health costs have been reported in most countries (Hashemi et al., 2008). Inexpensive and environmentally persistent chemicals are used intensively in developing countries. In America it is estimated that environmental and social impacts of pesticide use are about $10 million a year. Iran's annual pesticide consumption is about 27,000 tons (Hashemi et al., 2008). The primary impact of pesticides in many products and primary government support of pesticides to minimize product losses initiated the use of pesticides as a form of insurance against pests. These policies led to greatly increased consumption of these toxins over time, especially banned pesticides, and it has grown out of control.

The use of pesticides has been associated with unfavorable social and environmental consequences. It has been reported that pesticides cause the poisoning of one to two million workers annually. Emergence of resistance to pesticides as another negative aspect of the use of pesticides has created many problems (Rahman, 2013). “It is widely accepted that children are uniquely vulnerable to toxic exposures. Their very rapid metabolic rate, requirement for higher caloric intake and food consumption, as well as high respiratory and heart rates, facilitate absorption of chemicals. Children’s exposure to toxicants is prone to be excessively higher than adults' exposures, due to their mouthing behavior – first and foremost during the oral stage of their mental and emotional development. In addition, as children’s metabolic pathways are not fully formed, their hepatic functions are immature, hence their ability to detoxify and eliminate noxious substances is limited” (Mirr et al., 2010).

This problem exists more in developing countries than in developed countries. Hence, developing countries are struggling with environmental problems resulting from the abuse of chemical such as pesticides. This important problems, has been considered in agricultural policy. Consequently, new biological and ecological methods that simultaneously enhance productivity and reduce negative environmental and societal impacts are necessary (Hashemi et al., 2008). In this context, integrated pest management is recognized as the most appropriate pest control strategy for smallholders (Orr and Ritchie, 2004). Studies confirm the positive impact of these activities on pest management and pesticide consumption and successes, such as 50% reduction in use of pesticides with a 10%-12% increase in production. Also, it is found to reduce costs and increase farm income (Rahman, 2013; Cameron et al., 2009; Moser et al., 2008; Maupin and Norton, 2010).

Integrated pest management is a combination of tactics as a strategic element in an overall plan to manage and protect economic, social and environmental benefits (Ellsworth and Martinez-Carrillo, 2001). The ecological approach is to decrease the negative effects of pesticide with the use of biological control, cropping control and "least toxic" pesticides. Many studies in integrated pest management have described it as an activity or an activity of a group of potential practices. In this study, the adoption of integrated pest management is defined as one or more of the following activities: scouting systems, mechanical control and agricultural control.

It should be noted that the implementation of integrated pest management is not possible everywhere in just one way (Orr and Ritchie, 2004). This variation is not only due to the diversity of culture and place, but also pest management activities are implemented differently due to the variety of new pests and access to new innovations and changes in production practices. Thus pest management systems are dynamic and complex. In other words, an integrated pest management system should fit a certain place and time and be flexible enough to deal with changing conditions (Shennan et al., 2001). Implementation of such a system because of its economic, social and ecological aspects is very difficult. Therefore, development and application of a model that considers various aspects of this system that will lead to greater use of integrated management is necessary. To investigate such a model several dimensions of economic, social and environmental issues affecting the adoption of these activities should be identified and examined. Many studies show the impact of social factors such as attitudes, knowledge, and demographic variables on environmental technology adoption (Mariano et al., 2012).

Based on the theory of planned behavior developed by Ajzen, attitude is considered as one of the factors that influences the adoption or non-adoption of technologies. Ajzen suggests that in investigating specific attitudes toward specific technologies should be considered, not just the general attitude towards environmental issues. Farmers' attitudes towards the effects of pesticides have significant impact on the adoption of integrated pest management. Recognizing the environmental and health costs of pesticide use by farmers should be considered as the first step in the adoption of integrated pest management practices. Farmers can perceive the problems caused by pesticides more than others and may adopt integrated pest management activities. This finding is in line with Shojaeis` study (Shojaei et al., 2013). Hence, farmers` experiences with the use of pesticides can be associated with the adoption of integrated pest management practices (Maupin and Nortone, 2010; Ofuoku et al., 2009). Farmers should consider integrated pest management as a convenient and efficient strategy in solving the problems caused by pesticides. Thus, farmers' attitudes towards integrated pest management have an important role in IPM adoption (Shojaei et al., 2013). As previous studies have noted, communication with extension agents and informed people are the factors influencing the adoption of integrated pest management practices and it has been investigated (Munyua, 2003; Erbaugh et al., 2007). Previously, researchers have also emphasized the role of education on the adoption of innovations. Education is considered one of the facilitating factors in gaining information which consequently leads to the decision of whether or not to use integrated pest management (Singh et al., 2008; Erbaugh et al., 2010).

Another topic of interest in the field of technology adoption is economic and agricultural conditions. Probability of technology adoption will increase when technology is available, both physically and through information. Studies have shown that poor and marginal farmers who have limited access to resources are interested in using new technology, but cultural, economic and communication limitations prevent access to innovations (Nazemalsadat et al., 2006). Studies of integrated pest management in particular also highlight the importance of access to facilities by farmers to adopt IPM (Maupin and Norton, 2010). Accordingly, the income of the farmers has always been considered a defining element in the work and decisions of the farmers. The application of integrated pest management activities is not exempt from this rule (Bonabana-Wabbi et al., 2006). “A good extension system should focus on improving the technical and managerial capabilities of farmers” (Mariano et al., 2012).

Finally, summarizing the results of relevant studies about IPM, it should be noted that resource availability, farm income, history of pesticide use, reference group perception, access to extension services, education level and participation in extension classes are the influencing factors of the adoption of integrated pest management practices. Positive Attitude towards IPM has a positive effect and on the contrary negative attitude towards the use of pesticides has a negative effect on the adoption of integrated pest management. There are some components which have positive effect on attitudes towards IPM as well as resource availability including history of pesticide use, reference group perception, access to extension services, education level and participation in extension classes, but negative attitude towards the use of pesticides has negative impact on IPM attitude and resource availability. Regarding farm income, there are some influencing factors such as comments of reference group, access to extension services, education level, and participation in extension classes which have positive effect and on the contrary, negative attitude toward the use of pesticides has negative effect on the farm income.

A theoretical model is presented to investigate the IPM behavior of farmers in Figure 1.

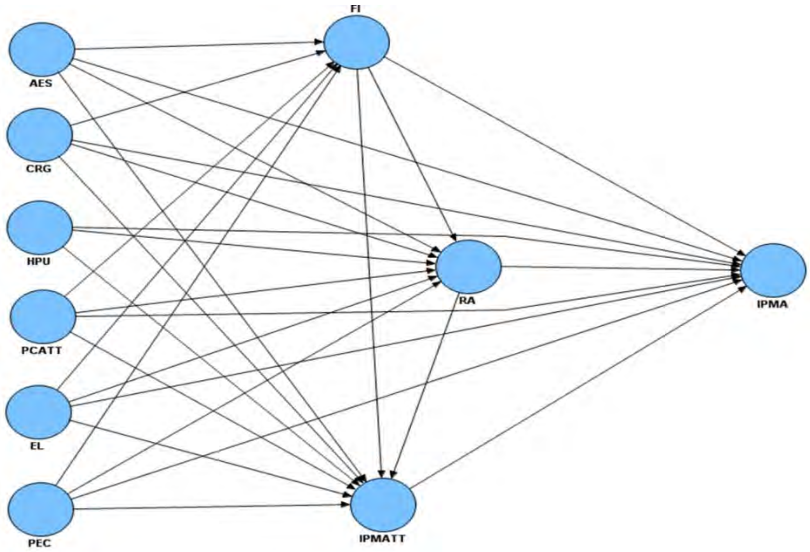

Figure 1. Research model:

IPMA = adoption of integrated pest management
RA = resource availability
IPMATT = integrated pest management attitude
FI= farm income
AES= access to extension services
CRG= reference group perception
HPU = history of pesticide use
PCATT= attitudes toward the use of pesticides
EL = education level
PEC = participation in extension classes

Table 1. Variables of the research

CATEGORY	Sub-category	Brief explanation
Dependent variable	IPM adoption	Use of IPM activities
Moderators variables	Resource availability	Access to the resources needed to implement IPM
	IPM attitude	A settled way of thinking or feeling about IPM
	Farm income	The income obtained by farmers
Independent variables	History of pesticide use	The number of years that farmers have used pesticides
	Pesticide attitude	Understanding the consequences of pesticide use
	Educational level	Farmer education
	Participation in extension classes	The number of extension classes about IPM that a farmer participated in
	Access to extension services	Take advantage of the services extension agents provide; such as consultation, supervision, extension leaflet etc.
	Reference group perception	Amount of communication with and information from informed people.

References: Munyua, 2003; Erbaugh et al., 2007; Maupin and Nortone, 2010.

Methodology

The study was conducted using structural equation modeling. Statistical population of this research consisted of farmers in Far province, Iran. Most of the people in the area are employed in the agricultural and industrial fields. Farmers in this province have paid a lot of attention to IPM activities and they have been a leader in IPM implementation. The stratified random sampling was used to select 151 farmers using Table Takmn sample size and the Cochrane formula (Israel, 2013). The data collection instrument was a questionnaire. The reliability and validity of the instrument have been tested using a pilot study and a survey of informed people. The questionnaire was modified and completed using interviews. Data were analyzed using SPSS version 21 and Smart PLS software. Descriptive statistics and structural equation modeling were used for data analysis.

Results and Discussion

Individual characteristics

Individual characteristics of farmers were investigated, including age, farming experience, education level and amount of land area in this study. The results showed that the mean age of the sample and agricultural experience mean were respectively, 49 and 30 years. Most of the farmers interviewed were more than 52 years of age and have 20 years of agricultural experience. Education level mean of farmers was five years and most of them have six to eight years. Also, the area of farmland mean was about 6 hectares and most of the farmers have fewer than three hectares of land. Hence farmers had low literacy, with considerable agricultural experience and also they were smallholders.

Integrated Pest Management (IPM) activities

As noted in several areas of pest management activities with regard to products, pests, diseases, weeds present, needs and available resources, local conditions, and other factors the period of plant growth and pest activity included different combinations of activities. Accordingly, activities that can be used as alternative to chemical control of pests, diseases and weeds in the study area were identified and utilization of these activities was evaluated by farmers to identify activities that have received little attention or activities that benefit the farmers and were more common. These activities included those appropriate to recommended conditions. That may include one or more of the activities used in the study area. These activities are classified into three groups: integrated pest management practices for pest control, integrated pest management practices for disease control groups and integrated pest management practices for weed control groups. These were evaluated using a Likert scale. Studying the implementation of these activities by farmers shows many differences in the use of IPM activities in each of the studied groups. It was influenced by various factors, which will be analyzed further (Table 2).

Among the activities recommended as alternative to harmful chemical treatments for pest control, timely fertilizing has attracted the most attention from farmers, such that 84.8% of farmers stated that they always timely fertilize and none of the farmers neglected this issue. Then use of "least toxic” pesticides based on ETL (economic threshold level) was considered more than the other activities. 84.8% of farmers always try to use standard-dose and low-risk authorized pesticides. Only 1.3% of the farmers admitted to not using "least toxic” pesticides. Insecticides are classified in several ways but generally they can be divided into two categories: 1) chemical insecticides. 2) biorational insecticides. The traditional classification of pesticides or chemical pesticides is identified with a wider range of actions and is harmful to natural enemies. In contrast, bio-pesticides act more selectively because they affect specific insects with special dietary habits, at certain stages of life or are a special class of insects. These pesticides are known as low-risk pesticides. These insecticides because of their nature are less harmful for beneficial insects and the environment. Despite the advantages of bio-rational insecticides compared with the chemical insecticides, it should be recommended as the last method, when other methods of integrated pest management are not capable of managing pest populations below economic thresholds. Farmers have paid attention to timely spraying pesticides too (80.8% have always chosen the option) and timely spraying pesticides are ranked third in importance (attention). It can be concluded that most farmers have considered and used easier activities that require low education and facilities. However, use of sex pheromone and light traps (2% have chosen the option of always) and release of Trichogramma and Ladybirds (none of them chose the option of always) that need more investment have been used less than the other activities or even have not been used at all.

Results of integrated pest management practices related to disease control are as follows: widow seeds are ranked as the first priority (90.7% chose the option always). Disinfected seeds have received the most attention from the farmers, and it is in the second place with 90.1% of farmers always using these seeds. Also, to reduce disease farmers have tried to use resistant/ tolerant varieties (80.1% have chosen the option of always). So it can be concluded that extension agents were successful in promotion of resistant/tolerant varieties appropriate for agricultural conditions. Use of resistant/tolerant varieties ranked third between integrated pest management practices for disease control. While disease resistant varieties are used widely, the insect resistant varieties are less common despite their importance. The advantages of this approach are ease of use, compatibility with other pest management practices, low cost and its impact on pests with minimal environmental impact. Every time, use of resistant/tolerant varieties has led to a reduction in pest levels of later generations. But the development of resistant varieties is expensive and those resistant to pests and diseases are not permanent. Therefore, considering other methods of integrated management is necessary.

To reduce agricultural weeds, farmers try to use more sustainable and safer alternatives to chemical herbicides to produce healthy products with lower risk. To fulfill this, some possible pest management activities are recommended; first of all, try to reduce the use of pesticides. 92.1% of farmers have reported that they always use a standard size of allowable pesticide. Also, 47% of farmers have always used appropriate crop rotation to reduce weeds. Crop rotation is considered one of the oldest and yet most fundamental pillars of sustainable and industrial agriculture. In fact, scientific crop rotation by integrating environmental sustainability issues, the economy and optimal production in the long term, have led to knowledge of crop rotation from a simple sequence to conscious and scientific design of suitable plants. If farmers plant just one crop on their farm, it minimizes the efficiency of production factors in the long term. They will also be faced with the gradual decline of the product performance during consecutive years, proliferation of weeds, plant pests and diseases, erosion and depletion of soil fertility, non-utilization of production factors such as irrigation water, machinery and labor part of the year resulting in a capital loss, fluctuations in product prices, and unfavorable and unforeseen environmental factors. This set of factors causes the failure of the production system in either the short term or long term. To avoid these problems, farmers must produce two or more products on their farm. The farmers should not plant just one crop on a piece of land continually and should comply with the principles of crop rotation. However, based on the results, farmers have little knowledge of the effects of crop rotation to reduce pests and diseases although most of them have used this technique to reduce weeds.

Comparison of IPM adoption behavior due to participation in Extension classes

Comparison of means of IPM adoption behavior implies that there are significant differences between farmers with different participation level in extension classes including three groups with low, average and high participation in the classes (F=5.51, sig.= 0.005) (Table 3). Farmers who have high participation in extension classes applied integrated pest management in their farms less than the other two groups with average and low participation. Insufficient support of scientific, technical, and physical activities for agricultural extension agents and lack of familiarity with the features and facilities that are available in rural areas resulted in in poor coordination of recruiting and employing individuals who are unfamiliar with the extension as agricultural extension agents. Problems in extension programs and activities have reduced the offer efficiency of training.

Table 2. The results of IPM activities (in three dimension and in general)

Items		Always		Most of the time		Sometimes		Never		Rating in each category	Overall Rating
		Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	percent		
Pest Control	Use of Sex Pheromone and light traps	3	2	5	3.3	1	0.7	142	94	10	22
	Monitoring, or sampling-based	81	53.6	12	7.9	25	16.6	33	21.9	6	10
	Scouting	74	49	12	7.9	14	9.3	51	33.8	7	11
	Destruction of crop residues	115	76.2	15	9.9	13	8.6	88	5.3	4	8
	Timely fertilizing	128	84.8	18	11.9	5	3.3	0	0	1	4
	Being coordinated with other farmers to determine when are pests controlled	89	58.9	21	13.9	8	5.3	33	21.9	5	9
	Release of Trichogramma and Ladybirds	0	0	0	0	0	0	151	100	11	23
	Protection of beneficial insects	21	13.9	9	6	8	5.3	113	74.8	8	19
	Timely spraying pesticides	122	80.8	14	9.3	6	4	9	6	3	6
	Release of sterile insects	4	4.6	0	0	0	0	147	97.4	9	20
	Use of "least toxic" pesticides based on ETL[1]	128	84.8	16	10.6	5	3.3	2	1.3	2	5
Disease Control	Crop rotation	73	48.3	22	14.6	26	17.2	3	19.9	4	12
	Reduced irrigation	23	15.2	9	6	37	24.5	82	54.3	5	17
	Disinfected seeds	136	90.1	5	3.3	6	4	4	2.6	2	3
	Timely planting	22	14.6	8	5.3	50	33.1	70	46.4	6	18
	Use of resistant / tolerant varieties	121	80.1	14	9.3	10	6.6	6	4	3	7
	Winnow seeds	137	90.7	4	2.6	4	2.6	6	4	1	2
Weed control	Hand-picking of weeds	4	2.6	2	1.3	32	21.2	113	74.8	6	21
	Preventing the water contaminated weed seeds from entering	25	16.6	4	2.6	14	9.3	108	71.5	5	16
	Crop rotation	71	47	15	9.9	21	13.9	44	29.1	2	13
	Farm irrigation and plowing the field before planting	62	41.1	26	17.2	35	23.2	28	18.5	3	14
	Use of selective herbicides	139	92.1	1	0.7	3	2	8	5.3	1	1
	Timely fighting	52	34.4	13	8.6	31	20.5	55	36.4	4	15

[1] Economic threshold level

Table 3. Comparison of IPM adoption due to participation in extension classes

Participation in extension classes	IPM adoption			
	Mean	SD	F	Sig
Low	54.69[a]	6.41	5.51	0.005
Average	54.85[a]	6.42		
High	49.80[b]	6.07		

*The means with the same letters have no statistically significant difference in the level of 0.05.

Estimation the IPM adoption model

In this study, PLS modeling was applied using Smart PLS software (Ringle et al., 2006) to estimate measurement and structural model. Partial Least Square (PLS) as a second generation of structural equation modeling technique has opened new horizons for the researchers in the behavioral sciences. It is an appropriate approach for the estimation of the model in this study, given the sample size. Tenehaus et al. (2005) have offered an index for partial least squares path modeling called Goodness-of-fit (GOF). They believed that GOF in PLS modeling is a practical item and can be used to check the validity or quality of PLS models. This index lies between zero and one, and values close to one indicate a good quality model. The GOF of the model is 0.69, which indicates a suitable fit of the model. The first step in the analysis and interpretation of the PLS model is to assess the reliability and validity of the measurement model and the second step is to test the structural model. The measurement model and structural model of this study are described in the following.

Measurement model evaluation

Reliability and validity of research should be checked to test the measurement model. Goodness of fit of data investigation and determining the amount of reliability and validity in economic and social research has an important role. To determine the reliability and validity of data of this study, confirmatory factor analysis (CFA) was used. Ferner and Larker (1981) have suggested three criteria to check the reliability of structures: 1) Reliability of the items, 2) Reliability Composite of each item. 3) Average Variance Extracted (AVE). The reliability of each item load factor of less than 0.6 each item indicates the structure is well-defined in confirmatory factor analysis. Load factor of each item should be significant at the 0.01 level. Dillon- Goldstein has been used to check reliability composite (Shojaei et al., 2013).

Factor loadings indicate the items have been validated so there are well-defined structures. Also with regard to the validity coefficients reported in Table 4, all variables of the model have high validity composite. In other words, Dillon- Goldstein coefficients are larger than 0.7 which is consistent with Nonaly statement. Items with loading factors less than 0.7 were removed from the model to achieve high reliability composite for each variable. The third indicator of reliability is Average Variance Extracted (AVE), which represents the percentage of variance of variables or structures of model that are described by a single item. Upon the recommendation of Fornell and Larcker (1981), the index values must be greater than 0.5 which means the construct represents approximately 50% or more of variance of items. Thus, the values in Table 4 represent sufficient reliability of items.

Resource availability is a formative variable. Constituent indicators are considered causal variables that affect the formation of latent variables. Indicators of recourse availability variable are not related and the presence of one or both of these indicators is sufficient for the formation of recourse availability structures. Interpretation of indicators constituent variables in PLS analysis should be based on weight. In this regard, some have reported acceptable weight is >0.30 (Yorobe et al., 2011). Indicators of formative structures are accepted that are statistically significant. In this study, resistant/tolerant varieties availability and "least toxic" and biorational, pesticides availability are significant at 0.01 and 0.05 respectively.

Table 4. Confirmatory factor analysis (CFA) and reliability assessment of model variables

Variables	Items	Mean	SD	Load Factor	T	Pc (>0.6)	AVE(>0.5)
IPM adoption	$IPMA_1$	0.85	0.07	0.85	10.82	0.74	0.59
	$IPMA_2$	0.65	0.10	0.67	6.26		
IPM attitude	$IPMATT_1$	0.88	0.03	0.89	22.93	0.85	0.75
	$IPMATT_2$	0.83	0.05	0.84	15.7		
Attitude toward use of pesticide	$PCATT_1$	0.68	0.13	0.68	5.14	0.71	0.55
	$PCATT_2$	0.77	0.11	0.80	6.92		
Reference group perception	CRG_1	0.84	0.13	0.87	6.48	0.82	0.70
	CRG_2	0.81	0.7	0.80	10.60		
Access to extension services	AES_1	0.61	0.15	0.60	3.92	0.76	0.63
	AES_2	0.92	0.07	0.94	11.96		
	Items			**Weight**	**T**		
Resource availability	resistant / tolerant varieties availability			0.86	2.21		
	"least toxic" and bio-rational pesticides availability			0.64	5.14		
Note: Load factor of each item is significant at the 0.01 level. (So the items will have sufficient reliability).							

Fornell and Larcker (1981) suggest that construct's square of AVE should exceed its correlations with other constructs to examine the divergent validity of structures. This indicates that the correlation of structure with its indicators is more than its correlations with other constructs. These criteria have been presented in Table 5, which indicate the validity of the structures is suitable. According to Table 5, the relationship between the adoption of pest management and education level (0.189), participation in extension classes (-0.244), attitude towards use of pesticide (-0.231), and access to extension services (0.214) are significant. In addition, the relationship between IPM attitude and access to extension services (0.186), reference group perception (-0.203), education level (0.205) and participation in extension classes (-0.216) are statistically significant. Pesticide attitude had significant relationships with access to extension services (-0.249), resource availability (0.192), reference group perception (-0.212) and education level (0.229).

Table 5. Correlation matrix and square root of AVE

	FI	AES	RA	CRG	IPMATT	PCATT	IPMA	HPU	EL	PEC
FI[2]	1.0									
AES[3]	-0.241**	0.79								

[2] Farm Income

	FI	AES	RA	CRG	IPMATT	PCATT	IPMA	HPU	EL	PEC
RA[4]	0.033	-0.092	1.0							
CRG[5]	0.006	0.221**	0.029	0.83						
IP-MATT[6]	-0.148	0.186*	-0.022	0.117	0.86					
PCATT[7]	0.141	-0.249**	0.192*	-0.212**	-0.100	0.74				
IPMA[8]	-0.106	0.214**	0/050	0.158	0.104	-0.231**	0.76			
HPU[9]	-0.023	-0.020	0/021	-0.130	-0.203*	0.022	-0.148	1.0		
EL[10]	0.266**	-0.388**	0/152	0.003	-0.205*	0.229**	0.189*	-0.214**	1.0	
PEC[11]	0.174*	-0.507**	-0.064	-0.054	-0.216**	0.157	-0.244**	0.040	0.192*	1.0

Note: The values on the matrix diameter show the correlation for the square root of AVE p<0.01; ** p<0.05*

Testing the Structural Model

The second stage in estimating the IPM adoption model is to test the path coefficients and R^2 estimation evaluated in each path. The bootstrap method was used to estimate T statistic in order to indicate the significance of path coefficients. According to Vinzi et al. (2010), path coefficients were used as criteria to determine the share of each predictor variable in explaining the variable variance, and the amount of R2 is an indicator of the explained variance of criterion variable by predictor variables. In addition, the coefficient Q2 "Stone - Gysr" was used to investigate the ability to predict the dependent variable and the independent variables. Positive values indicate the predictive ability of this factor (Vinzi et al., 2010).

Consistent with the results reported in Table 6, the agricultural income variable has a negative and significant effect (-0.22) on the IPM adoption. This means that farmers with higher incomes have used integrated pest management practices on their farms less than others. They earn a good and reasonable income from their current farming method compared to the time and money that they spend. Therefore, they tend not to use the new methods. Also, they considered their work process as a valid, tested method, and, given the experience that they have in this process, no longer feel the need to change and try new ways. However, Erbaugh`s (2010) study shows a positive effect of income on use of integrated pest management activities. Participation in extension classes has significant negative effect (-0.089) on IPM adoption. This means that farmers who have participated more in extension classes use these activities in their farm less than the others. This finding is consistent with the Vinzi et al. (2010) study. Training and development of human resources is considered a good investment and a key factor in the agricultural development if properly planned and implemented, and can have significant economic returns. The results showed that human resource management, training and development will lead to increased productivity. One of the main points of the adoption of integrated pest management is the interaction between the learners and extension agents.

In examining other variables, it was found that attitude to pesticides also has significant and negative effect on the IPM adoption (-0.16). Attitudes mean an assessment of the phenomenon so it

[3]Access to extension services
[4]Resource Availability
[5] Reference group perception
[6]IPM attitude
[7] Attitude toward Pesticide use
[8]IPM adoption
[9]History of pesticide use
[10]Education Level
[11]Participation in extension classes

can control and predict future behaviors. The results of Singh et al. (2008) confirm this finding. Reference group perception (0.29), history of pesticide use (0.24) and education level (0.16) have significant effects on IPM adoption. Farmers who have more experience in the use of pesticides, have used more IPM activities. Similarly, more educated farmers have used more IPM activities. Ringle (2006) and Chavez and Riley (2001) confirmed these findings as well. These variables explain 36% of changes in IPM adoption variable in total (R^2= 36%). Positive Q^2 indicates the predictive ability of these variables in predicting the adoption of pest management.

The second step examined in the causal model was to compute the path coefficients between integrated pest management attitude as a moderator variable and independent variables. The results showed that the direct effect of variables such as access to extension services (0.20) and reference group perception (0.12) were significant and positive on IPM attitudes. Hence, farmers who have been able to use the agricultural extension services and get information from knowledgeable people have a more positive attitude toward integrated pest management. As reported in Table 6, variables affecting integrated pest management attitudes predict this dependent variable as much as 15% (R^2= 15%).

The other moderator variable was resource availability. Attitude towards the use of pesticides is the most effective variable with a path coefficient of 0.24 on resource availability. Similarly, more educated farmers have greater access to the resources needed to implement IPM because the results demonstrated a significant positive effect of education on resources availability (0.22). Explained variance for this variable is 0.16 (R^2). This means that the variables explain 16% of changes in resource availability variable.

Farm income is the third variable. The effects of the variables showed that effect of access to extension service is -0.21, in other words, this variable has significant and negative effect on agricultural income. The education variable has a significant and positive impact on farm income (0.21). Since access to extension services cost money (costs include sweep transportation, class tuition and use of experts, supervision), this variable has a negative effect on the income variable. These variables predicted 6% of changes in farm income variable.

Given the amount of redundancy, checking account-related latent variable is positive, so the quality of the structural model is appropriate. This means that the independent variables have the ability to predict the dependent variables.

Table 6. Direct effects, total effects and explained variance of variables

Relations	Path	Direct effects	Total effects	T	Explained variance (R^2)	Q^2
On IPM adoption	IPM Adoption				**0.36**	0.14
Farm income	FI → IPMA	-0.22	-0.21	2.04*		
Access to extension services	AES →IPMA	0.07	0.15	0.77		
Resource availability	RA → IPMA	0.078	0.08	0.70		
Reference group perception	CRG → IP-MA	0.394	0.41	0.76**		
IPM attitude	IPMATT → IPMA	0.124	0.12	1.80		

Relations	Path	Direct effects	Total effects	T	Explained variance (R^2)	Q^2
Pesticides attitude	PCATT → IPMA	-0.161	-0.16	2.21*		
History of pesticide use	HPU → IPMA	0.246	0.24	3.39**		
Education level	EL → IPMA	0.169	0.15	2.09*		
Participation in extension classes	PEC → IPMA	-0.089	-0.11	1.22*		
On IPM attitude	IPM attitude				**0.15**	**0.06**
Farm income	FI→ IPMATT	-0.034	-0.03	0.33		
Access extension services	AE→ IP-MATT	0.208	0.21	2.53*		
Resource availability	EA→ IP-MATT	0.015	0.015	0.16		
Reference group perception	RA → IP-MATT	0.124	0.12	2.28*		
Pesticides attitudes	PCATT→ IPMATT	-0.121	-0.11	1.44		
History of pesticide use	HPU → IP-MATT	-0.107	-0.10	1.52		
Education level	EL→ IP-MATT	0.111	-0.10	1.21		
Participation in extension classes	PE → IP-MATT	-0.124	-0.02	1.51		
On resource availability	Resource availability				**0.16**	**0.010**
Farm income	EI → RA	0.111	0.11	1.36		
Access extension services	AES → RA	0.156	0.13	1.80		
Reference group perception	CRG → RA	0.031	0.03	0.48		
Pesticide attitude	PCATT→ RA	0.248	0.25	2.91**		
History of pesticide use	HPU → RA	0.140	0.14	1.38		
Education level	EL → RA	0.225	0.24	2.74**		
Participation in extension classes	PEC → RA	-0.028	-0.023	0.39		
On farm income	Farm Income				**0.12**	**0.06**
Access extension services	AES → FI	-0.217	-0.21	2.41*		
Reference group perception	CRG → FI	-0.004	-0.004	0.08		

Relations	Path	Direct effects	Total effects	T	Explained variance (R^2)	Q^2
Pesticides attitudes	PCATT → FI	0.043	0.04	0.50		
Education level	EL → FI	0.211	0.21	2.97**		
Participation in extension classes	PEC → FI	0.036	0.036	0.35		

* Significant at the 0.05 level and ** - significant at the 0.01 level

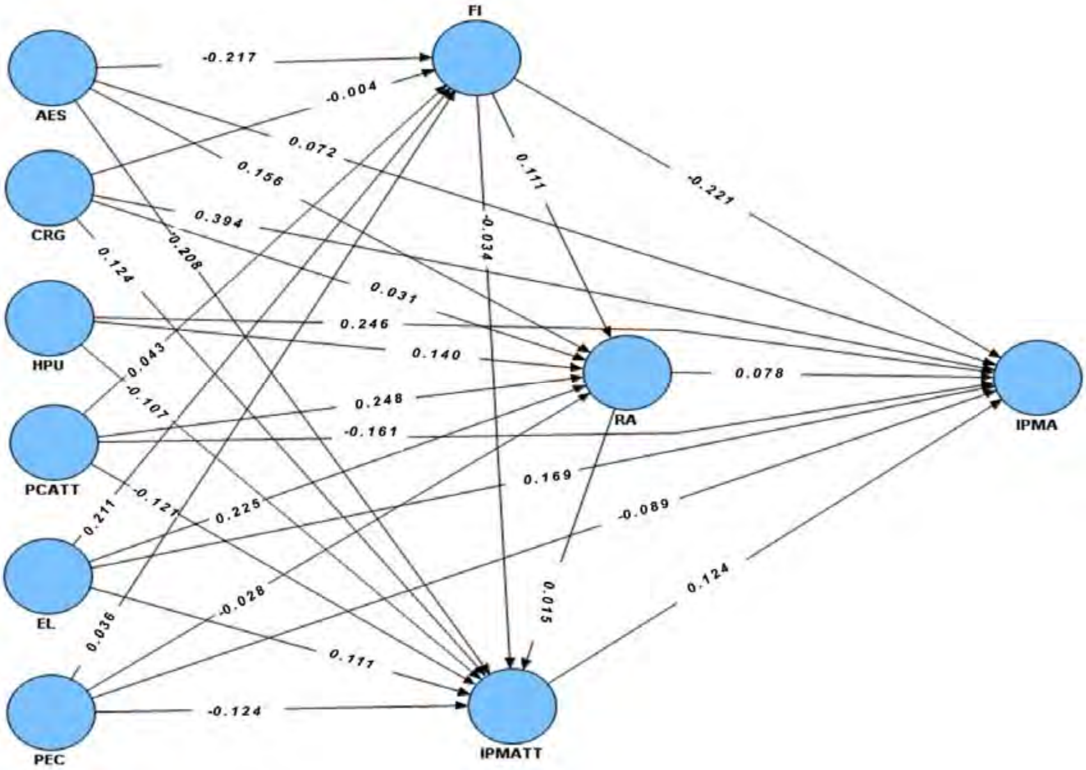

Figure 2. Results of causal Model

IPMA = integrated pest management adoption
RA = resource availability
IPMATT = integrated pest management attitude
FI= farm income
AES= access extension services
CRG= reference group perception
HPU = history of pesticide use
PCATT= attitudes toward pesticides
EL = education level
PEC= participation in extension class

Conclusion and recommendations

The purpose of this study was to investigate and identify the parameters influencing the adoption of integrated pest management practices among farmers in Fars province, Iran. The findings were examined in two parts. In the first part, adoption of integrated pest management activities percentages, was examined and in the second part, the factors affecting the adoption of these activities were studied.

Based on the results, adoption of integrated pest management practices among farmers have been different. Some activities are more interesting than others. Many reasons can be enumerated in examining the causes of differences in the implementation of integrated pest management practices including uncertainty, which is associated with the use of integrated pest management practices from the perspective of farmers. Since pest management practices are new, farmers are faced with uncertainty due to lack of knowledge of IPM activities. The compatibility of knowledge with technology should be considered as one of the essential requirements in the innovation process. Designing a learning process with the implementation and strict control of all its stages to improve knowledge can be a useful step in technology transfer. Education programs appropriate to age and educational level of the target group, along with selected trainers who are aware of the needs, possibilities and limitations of technology in target area has a considerable impact on the success of the transition process. Hence, the choice of appropriate enforcement system, consultant and extension agent training, identifying local conditions and use of local knowledge and its promotion should be considered by the enforcement officials. Manpower to be able to supply the highest productivity requires knowledge, skills and motivation.

There are many obstacles in the implementation of integrated pest management activities, such as both technical constraints and those related to technology, economic and fiscal deficits, officials' attitude, executive agencies and farmers, characteristics of members, local conditions and etc. Therefore, measures and programs are required to change attitudes in this regard. Results related to factors influencing the adoption of integrated pest management showed that reference group perception has had the greatest impact on the adoption of these activities. Hence farmers are impressionable; working with informed people who have social acceptance is considered a strategy to reduce uncertainty and increase farmers' knowledge. Determining of activities is one of the characteristics likely to be effective in influencing the reference group perception. Also, if the communication and interaction with the reference group increases, adoption of these activities will increase. So primarily, teaching activities to those of the reference group or trusted people and partnership of reference group in the introduction, and recommending activities can provide an appropriate field in order to increase the adoption of integrated pest management practices. As previously described, one of the factors that seems to have an effect on these activities is advertising the introduction of these methods by chemical pesticides vendors. Therefore, training vendors and getting assistance from them to spread awareness of these activities in place where chemical pestisifeds are sold can be considered practical solution in the development of IPM activities.

Given that classes and workshops can be effective in increasing awareness of the hazards of chemical pesticides and the development of alternative activities, extension classes should be revised and some changes made to increase the efficiency of these classes. Range and variety of recommended extension activities should be expanded. Training on the farm according to local farming conditions, and farmers participating in the selection of activities and their active participation in education programs have always been the most effective ways. “Policy-makers concerned with reducing the adverse environmental and health effects of insecticide use should consider further subsidies to agricultural institutions involved in transferring IPM technologies through FFS” (Yorobe Jr. et al., 2011). Such activities provide farmers with the opportunity to learn, understand, apply and adopt improved technologies. Since extension has significant impact on implantation of such activities and the resulting adoption of new technologies, investment in extension should be encouraged.

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