*J. Agr. Sci. Tech. (2019) Vol. 21(4): 815-828*

# Multi-Dimensional Appraisal of Integrated Pest Management Adoption: Evidence of Pistachio Growers in Kerman Province, Iran

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## ABSTRACT

**Integrated Pest Management (IPM) is well known as a pro-environmental technology in agriculture. Therefore, investigating adoption of IPM mechanisms is crucial for agricultural products such as pistachio in Iran. The main purpose of this study was to assess the role of factors affecting IPM adoption by pistachio growers in Kerman Province. Survey was the research method and it was executed using researchers-designed questionnaire. Totally, 225 pistachio growers were selected as sample size, using two-stages random cluster sampling method. Validity of the questionnaire items was entirely approved by a panel of experts. Cronbach's alpha coefficient was used for reliability approval. Findings revealed that individual factors including age, education, farming experience, motivations, participation and innovative spirit in conjunction with economic factors such as income, and technological costs affect IPM adoption procedure. In addition, educational services along with IPM technical knowledge and environmental attitude positively changed IPM adoption. The result of structural equation modeling illustrated that education, innovative spirit, life motivation, welfare motivation, income, technological costs, educational services and IPM technical challenges can significantly predicte IPM technical knowledge by direct effects. Indeed, IPM technical knowledge promotes environmental attitude and directly improves IPM adoption. Some practical recommendations are presented based on the research findings.**

**Keywords**: Environmental attitude, IPM, IPM adoption, IPM technical knowledge, Structural Equation Modeling (SEM).

## INTRODUCTION

Nowadays, producing organic food is one of the main objectives in conservational policies and environmental sustainability (Naglova and Vlasicova, 2016). Accordingly, pro-environmental technologies such as Integrated Pest Management (IPM) are being designed and developed by the research sector in agriculture (Lamichhane *et al.*, 2015; Kalmar *et al.*, 2014). IPM is introduced as an ecological pest control method to decrease using chemical insecticides (Lamichhane *et al.*, 2015; Eneh, 2011). IPM has been utilized since 30 years ago in Asia (Benjamin *et al.*, 2016). Although IPM has been developed for a long time (Timprasert *et al.*, 2014), it is a new technology in Iran (Hedjazi and Sharifi, 2014), where pistachio is one of the most important agricultural products (Villano and Mehrabi Boshrabadi, 2010) and the main agricultural export (Sedaghat, 2011). Kerman Province covers almost 67.4 percent of pistachio planted area in Iran. Furthermore, using chemical

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pesticides in growing pistachio is common among farmers and threatens the nut healthiness as well as confronts that crop with problems regarding export health standards (Sedaghat, 2011). Accordingly, utilizing conservational technologies in order to reduce chemical pesticides is critically needed in pistachio cultivation among pistachio growers in Kerman Province. Therefore, IPM can be useful for decreasing pesticides use among pistachios' growers. Indeed, Villano and Mehrabi Boshrabadi (2010) imply that pistachio growers need to use new technologies for improving their farm efficiency. Recently, IPM has been presented to replace chemical insecticides among pistachio growers. Thus, IPM is a new technology for pistachio growers in Iran and understanding the procedure of IPM adoption is crucial to design IPM diffusion strategies for policy makers.

Rogers (2010) believes that adopting new technologies is a socio-psychological procedure among farmers. More importantly, the process of adopting new technology could be altered in various communities even for similar technologies (Rogers, 2010). As a result, IPM adoption is not simple among farmers who have used chemical inputs for a long time (Timprasert *et al.*, 2014). The review of literature revealed that a wide range of factors have affected farmers' IPM adoption. Hejazi and Sharifi (2014) emphasize that environmental and technical knowledge, could increase farmers' intention to use IPM. Accordingly, diffusion of IPM needs technical educations. Farmers Field School (FFS) is largely used as an educational method for IPM (Davis *et al.*, 2012) and a number of studies mention that IPM and FFS are accomplished by each other (Mancini *et al.*, 2007). Besides, environmental attitude is an indispensable factor to enhance IPM adoption (Van den Berg and Jiggins, 2007). Educational services including mass media, workshops, and FFS (Mancini *et al.*, 2007; Davis *et al.*, 2012) can significantly enhance environmental knowledge and attitude towards IPM application (Van den Berg and Jiggins, 2007). Knowledge and environmental attitude are assumed to be affected by educational services, then they will affect IPM adoption. In other words, Individual factors such as age, farming experiences, education (Toleubayev *et al.*, 2011), motivation (Sanyal *et al.*, 2008) and farmers' participation in rural activities as well as innovative spirit are effective on IPM adoption (Mancini *et al.*, 2007; Anandajayasekeram *et al.*, 2007). There is also some evidence that confirms that utilizing IPM is influenced by economic factors, including income, technical costs (Meissle *et al*., 2011), farm size, as well as technological factors (a process in conducting IPM, including the number of used workforces, difficulty, etc.) (Kalmar *et al*., 2014). Consequently, IPM adoption is likely related to farmers' individual and productivity setting. As a result, IPM adoption is intricate, because various ranges of factors could be differently related to this process. Therefore, past studies have separately considered factors affecting IPM adoption, while a comprehensive assessment of factors affecting of IPM adoption is undeniably needed for understanding IPM adoption procedures among pistachio growers.

The main purpose of this study was to assess the role of factors affecting IPM adoption by pistachio growers in Kerman Province, Iran, based on comprehensive adoption model.

## MATERIALS AND METHODS

### Theoretical Framework of Study

These factors are divided into individual's factors (age, educational level, farming experience, motivations, participation and innovative spirit), educational factors, economic, and technological factors. In addition, IPM adoption has been





[ DOR: 20.1001.1.16807073.2019.21.4.8.3 ]

significantly influenced by IPM technical knowledge and environmental attitude. Hence, this question arises" how could all of these factors be assigned as a holistic framework in IPM adoption (to be analyzed by SEM)?" The main purpose of this study is to investigate factors affecting on IPM adoption among pistachios' growers based on comprehensive adoption model. Based on theoretical framework, IPM adoption is depend on individual, educational, productivity, economic, technological factors (exogenous variables). The effect of exogenous variables on IPM adoption can be moderated by two moderator variables (IPM technical knowledge and environmental attitude) (Figure 1).

## Study Population and Area

Kerman Province includes the main area of pistachio cultivation (Sedaghat, 2011). Within this province, Rafsanjan County is the main area of pistachio cultivation with 49.14 percent of pistachio gardens in Kerman Province. Pistachio growers utilizing IPM technologies in Kerman Province were purposively selected as the study population (N= 550). Totally, 225 pistachios' growers were selected as sample group using Krejcie and Morgan (1970) estimating sample size method. Two stages random cluster sampling was conducted (based on proper allocation) as sampling method. The first stage was constructed by four clusters, including, Kerman and Zarand counties (10 percent of the sample size, n= 23), Sirjan County (12 percent of the sample size, n= 27), Bardsir County (8 percent of sample size; n= 18) and Rafsanjan County (70 percent of the sample size, n= 157). The second sampling stage was conducted by four clusters of Rafsanjan rural regions. According to Figure 2, pistachio growers were randomly selected from each cluster based on pistachio growers' distribution among those regions.

## Study Design

This study was a quantitative and non-experimental research using survey method. Questionnaire was used as data collection instrument. Extension specialists and researchers of Iran Pistachio Research Institution_were advised to identify those questions which were related to practical IPM techniques. Face and content validity of the questionnaire were confirmed using a panel of experts. Besides, a pilot study was conducted to identify its reliability. The range of Cronbach's Alpha coefficient was between 0.677 to 0.894, which was acceptable (Table 1). IPM adoption as dependent variable refers to the degree of IPM techniques application for at least more than one year. It was measured based on 10 open ended questions. The IPM adoption was scored between 0 (completely not adopted) to 100 (completely adopted). IPM

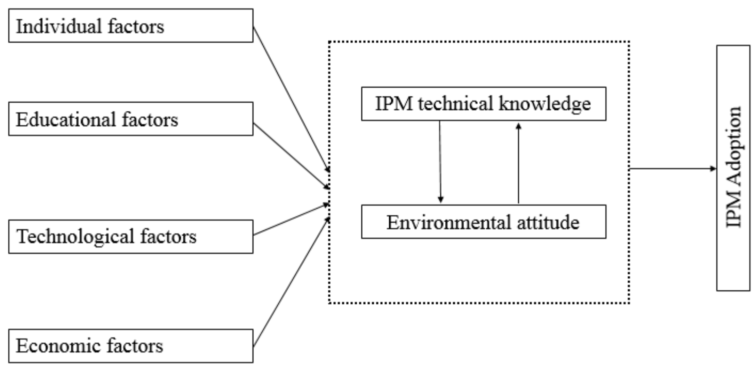


**Figure 1.** Theoretical framework (assumed factors affecting IPM adoption by pistachio growers).

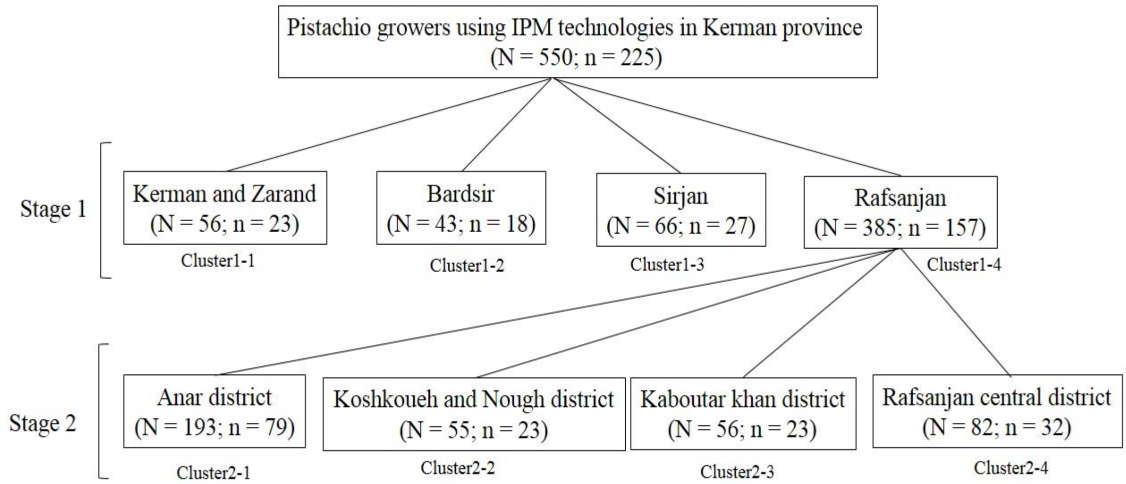


**Figure 2.** The sample size distribution using two stages of random cluster sampling.

**Table 1.** Result of reliability test for related variables.

| Variable name | Cumulative Cronbach's α |
|---|---|
| Innovative Spirit | 0.848 |
| Participation | 0.814 |
| Environmental attitude | 0.826 |
| Life motivation | 0.677 |
| Self-identity motivation | 0.779 |
| Transcendence motivation | 0.891 |
| Welfare motivation | 0.854 |

technical knowledge and environmental attitude were selected as moderator variables. IPM technical knowledge is considered as pistachio growers understanding of the precise utilization of IPM.

This study used twenty-four follow up open-ended questions to measure IPM technical knowledge (it ranged between 0 and 100). Environmental attitude shows the farmers' opinions towards IPM environmental beneficiations. For instance, the role of IPM in decreasing chemical impact on the nature. It was constructed based on Van den Berg and Jiggins (2007) study using eleven ordinal items (Likert's ordinal with 5 levels from 1 (completely disagree) to 5 (completely agree)). The range of environmental attitude was 11 to 55. Individual factors included farmers' age (years), education (years of formal education), farming experience (years), innovative spirit (tendency to use new technologies and methods), participation in rural activities (four Likert ordinal items with five levels). Motivations including four aspects (life motivation, welfare motivation, self-identity motivation, and transcendence motivation) refer to the mental intention of adopting IPM. Life motivation refers to pistachio growers' motivation towards using IPM for providing their life financial requirements. Welfare motivation relates to welfare gained from utilizing IPM. Self-identity motivation implies farmers' use of IPM as a part of their identity among farmers' society. Transcendence motivation refers to farmers' motivation due to transcendence ambition. Likert ordinal was used for measuring those motivations and the range of life and transcendence motivations was 3 to 15 and for other motivations was 4 to 20. Indexing technique was used for free scaling motivations. Operational barriers,





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which means the degree of IPM difficulties for farmers, was presented as technical factors. Economic factors were quantified using income (average of annual income), and technical costs (IPM technologies costs on average). Educational factors were measured by the number of farmers' benefit of educational classes, workshops, FFS, educational movies and publications concerning IPM technologies.

### Data Analysis

Mean scores and standard deviation were applied to describe the variables condition. The Pearson correlation technique was used to show the relationships between variables. Correlational tests were statistically needed prior to test causal relationships (Valizadeh *et al*., 2018) towards applying Structural Equation Modeling (SEM). It is useful to investigate the direct and indirect effects of variables on the dependent variable. In this method, exogenous variables should be determined. Individual factors, economic factors, technical factors, and educational factors were selected as exogenous variables in the model. IPM technical knowledge, environmental attitude as well as IPM adoption were considered as endogenous variables. Based on the theoretical model, SEM was used to show the power of exogenous variables in predicting IPM technical knowledge and environmental attitude. Then, IPM technical knowledge and environmental attitude (moderator variables) were carried out to show the degree of their predictive power on IPM adoption. Statistical software such as SPSS version 21 and Amos version 20 were used for data analysis.

## RESULTS

Pistachio growers were aged about 46 years on average. They had about 22.8 years' experience in pistachio cultivation. Pistachio growers' education was about 8.8 years, on average. Descriptive analysis revealed that pistachio growers identified their motivations on the average level. We used free scaling in order to compare pistachio growers' motivations based on the same range. Motivations recalculated using free scale method was 54.25 (identity motivation), 67 (life motivation), 59.13 (transcendence motivation), 51.1 (welfare motivation) (the range of motivations was between 0 and 100). Accordingly, life motivation was the strongest motivation concerning IPM adoption. Other motivations were reported on the average level. Average participation was scored 13.85 and innovative spirit was 14.2. Results revealed total IPM technical challenges (yellow cards, pheromones' traps, removing damaged branches, moderated chemical pest control) were 0.538 (yellow cards), 0.379 (pheromones' traps), 2.11 (removing damaged branches) and 3.29 (moderated chemical pests control) (the scale of those variables was between 0 and 5). As a result, moderated chemical pest control and removal of damaged branches were more challengeable than other IPM technologies. IPM technical knowledge was evaluated 55.11 (it ranged between 0 and 100). Environmental attitude was scored 52.3 on average. The average of used educational services in order to utilize IPM was 2.63 times per year. Pistachio growers' income was evaluated at 83,430,000 Iran Rials (IRR) per hectare and they spent 17,000,000 IRR for IPM application per hectare. The IPM adoption was scored 56.5 (its range was between 0 and 100). Therefore, the rate of IPM adoption was a little more than average (Table 2).

The correlations between independent variables and IPM technical knowledge and environmental attitude (moderator variables) were examined at the first step. The results showed two negative correlations between age and farming experience with IPM technical knowledge. There was a positive correlation between education and IPM technical knowledge. It means those pistachio growers who had more education,





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**Table 2.** Descriptive statistics of variables (n= 225).

| Variables | Mean | *SD* |
|---|---|---|
| IPM adoption (Ranged between 0 to 100) | 56.50 | 23.16 |
| Environmental attitude (Ranged between 0 to 100) | 52.3 | 10.68 |
| IPM technical knowledge (Ranged between 0 to 100) | 55.11 | 19.47 |
| Age (Years) | 45.11 | 12.57 |
| Farming experience (Years) | 22.76 | 11.02 |
| Education (Years) | 8.76 | 4.05 |
| Participation (Ranged between 4 to 24) | 13.85 | 3.48 |
| Innovative spirit (Ranged between 5 to 25) | 14.20 | 5.82 |
| Life motivation | 10.05 | 2.61 |
| Welfare motivation | 11.09 | 2.22 |
| Identity motivation | 10.85 | 2.90 |
| Transcendence motivation | 8.84 | 2.24 |
| Income (IRR) | 8643333.33 | 4792020.43 |
| IPM technical costs (IRR) | 1677615.56 | 505392.43 |
| Farm size (Ha) | 3.23 | 2.46 |
| IPM technical challenge (total) (ranged between 0 to 20) | 6.32 | 2.62 |

had more knowledge about IPM. Life motivation and welfare motivation had positive correlation with IPM technical knowledge. Therefore, pistachio growers with greater life and welfare motivations had the highest IPM technical knowledge compared to the others. Innovative spirit and participation had positive correlation with IPM technical knowledge. A positive correlation between farm size and IPM technical knowledge was obtained. Therefore, pistachio growers with larger farm size had more IPM technical knowledge. IPM technical challenges and used educational services had positive correlations with IPM technical knowledge. Moreover, positive correlations were obtained between income and IPM technical knowledge and between technical costs and IPM knowledge.

Positive correlation between educational services and environmental attitude was explored. Income was positively correlated with environmental attitude and, ironically, technical costs and farm size were not correlated with environmental attitude. There was also a positive correlation between education and environmental attitude. Life motivation as well as welfare motivation had positive correlation with environmental attitude. Accordingly, those pistachio growers with higher life and welfare motivations had higher environmental attitude and vice versa. IPM technical challenges were negatively correlated with environmental attitude. Thus, it is expected that pistachio growers who felt more challenges in operating IPM had less environmental attitude.

The results of correlation analysis between moderator variables illustrated that both IPM technical knowledge and environmental attitude were positively correlated with each other. Thus, those pistachio farmers who had more technical knowledge had higher level of environmental attitude. IPM technical knowledge and environmental attitude were positively correlated with IPM adoption. The findings revealed that educational services had positive correlation with IPM adoption. There was also a positive correlation between income and IPM adoption. Consequently, pistachio growers with higher income had adopted IPM more than others. Age and farming experience had negative correlation with IPM adoption. Pistachio growers who had more education, participation, and innovation spirit had adopted IPM more than others. Pistachio growers with higher life and welfare motivations had higher IPM





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adoption. IPM technical challenge was negatively correlated with IPM adoption (Table 3).

Regarding correlation analysis outcomes, final causal model was extracted to assess logical relationships between variables. All significantly correlated variables (in IPM adoption) including moderator variables (IPM technical knowledge and environmental attitude) and exogenous variables (individual' factors, economic factors, educational factors, technical factors) were inserted into this model. The relationship between IPM technical knowledge and environmental attitude was mutually assumed (Figure 3).

The discrimination of casual variables relationships with IPM technical knowledge showed that education, innovative spirit, life motivation (individual factors), educational services (educational factors) along with income (economic factors) were directly and positively related to IPM technical knowledge. Technical costs (economic factors) were directly but negatively related to IPM technical knowledge (Table 4).

Analyzing casual variables effects on environmental attitude demonstrated that innovative spirit, life and welfare motivations (individual factors) as well as IPM technical knowledge were positively related to environmental attitude based on direct effects. On the other hand, education, innovation spirit (individual factors), and income (economic factor) were positively related to environmental attitude based on indirect casual effects. Technical costs were also negatively related to environmental attitude by indirect effect (Table 5).

The investigation of casual relationship between exogenous and moderator variables with IPM adoption illustrated that welfare motivation, IPM technical knowledge, and environmental attitude were positively related to IPM adoption based on direct effects. Furthermore, education, innovative spirit, welfare motivation, educational services, and income had positive but indirect effects on IPM adoption. Moreover, a negative indirect effect was observed between technical costs and IPM adoption (Table 6).

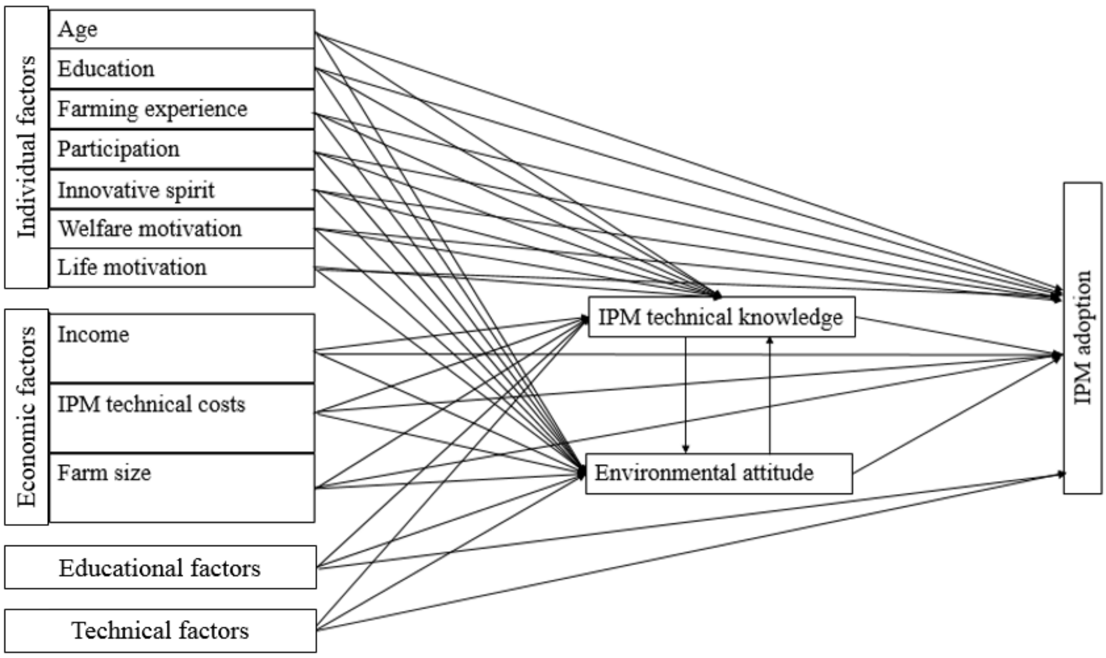


**Figure 3.** Causal IPM adoption model for inserting in SEM analysis.

**Table 3.** Correlation matrix between variables.[a]

| Variables | IPM adoption | Technical knowledge | Environmental attitude | Educational services | Age | Farm size | Education | Farming experience | Innovative spirit | Participation | Life motivation | Welfare motivation | Identity motivation | Transcendence motivation | Income | Technical costs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IPM adoption | 1 | | | | | | | | | | | | | | | |
| Technical knowledge | 0.88** | 1 | | | | | | | | | | | | | | |
| Environmental attitude | 0.61** | 0.59** | 1 | | | | | | | | | | | | | |
| Educational services | 0.71** | 0.68** | 0.44** | 1 | | | | | | | | | | | | |
| Age | -0.19** | -0.21** | 0.002 | -.09 | 1 | | | | | | | | | | | |
| Farm size | 0.13 | 0.21** | 0.04 | 0.14** | 0.12 | 1 | | | | | | | | | | |
| Education | 0.39** | 0.41** | 0.24** | 0.31** | -0.67** | -0.01 | 1 | | | | | | | | | |
| Farming experience | -0.17* | -0.18** | 0.05 | -0.04 | 0.81** | 0.18** | -0.59** | 1 | | | | | | | | |
| Innovative spirit | 0.44** | 0.42** | 0.53** | 0.35** | 0.01 | 0.03 | 0.18** | -0.02 | 1 | | | | | | | |
| Participation | 0.29** | 0.27** | 0.39** | 0.23** | 0.4 | 0.01 | 0.12 | 0.01 | .42** | 1 | | | | | | |
| Life motivation | 0.48** | 0.49** | 0.48** | 0.41** | -0.11 | -0.03 | 0.23** | -0.06 | 0.41** | 0.21** | 1 | | | | | |
| Welfare motivation | 0.26** | 0.19** | 0.29** | 0.11 | 0.01 | -0.07 | 0.05 | 0.02 | 0.24** | 0.22** | 0.32** | 1 | | | | |
| Identity motivation | 0.06 | -0.02 | -0.05 | 0.01 | -0.09 | -0.01 | 0.07 | 0.08 | 0.02 | -0.04 | 0.21** | 0.26** | 1 | | | |
| Transcendence motivation | 0.14* | 0.10 | -0.01 | 0.21** | -0.06 | 0.01 | 0.005 | 0.01 | 0.015 | 0.12 | 0.20** | 0.37** | 0.44** | 1 | | |
| Income | 0.56** | 0.58** | 0.39** | 0.52** | 0.05 | 0.22** | 0.11 | 0.01 | 0.27** | 0.29** | 0.26** | 0.19** | 0.02 | .14** | 1 | |
| Technical costs | -0.52** | -0.54** | -0.35** | -0.34** | 0.16** | 0.09 | 0.31** | 0.12 | -0.27** | -0.20** | -0.29** | -0.04 | 0.14** | .06 | -.04 | 1 |

[a] r= 0 (no relationship); -0.3≤ r< 0 and 0< r≤ 0.3 (Weak); -0.7≤ r< 0.3 and 0.3< r≤ 0.7 (Average); -1≤ r< 0.7 and 0.7< r≤ 1 (Strong) (Ratner, 2009). * $P< 0.05$; ** $P< 0.01$.

**Table 4**. Discrimination of exogenous variables effects on IPM technical knowledge.

| Variables | Standard direct effect | Standard indirect effect | Standard total effect |
|---|---|---|---|
| Education | 0.162*** | ns | 0.162*** |
| Innovative spirit | 0.090*** | ns | 0.090*** |
| Life motivation | 0.139** | ns | 0.139** |
| Educational services | 0.315** | ns | 0.315** |
| Income | 0.283*** | ns | 0.283*** |
| Technical costs | -0.235** | ns | -0.235** |

* *P*< 0.05; ** *P*< 0.01; *** *P*< 0.001; ns: Non-significant.

**Table 5**. Discrimination of exogenous variables and IPM technical knowledge effects on environmental attitude.

| Variables | Standard direct effect | Standard indirect effect | Standard total effect |
|---|---|---|---|
| Education | ns | 0.061*** | 0.061*** |
| Innovative spirit | 0.292*** | 0.034** | 0.326** |
| Life motivation | 0.137** | 0.053** | 0.190** |
| Educational services | ns | 0.119** | 0.119** |
| Income | ns | 0.107*** | 0.107*** |
| Technical costs | ns | -0.089** | -0.089** |
| Welfare motivation | 0.109*** | ns | 0.109*** |
| IPM technical knowledge | 0.379*** | ns | 0.379*** |

* *P*< 0.05); ** *P*< 0.01; *** *P*< 0.001, ns: Non-significant.

**Table 6**. Discrimination of exogenous and moderator variables effects on IPM adoption.

| Variables | Standard direct effect | Standard indirect effect | Standard total effect |
|---|---|---|---|
| Education | ns | 0.107*** | 0.107*** |
| Innovative spirit | ns | 0.088*** | 0.088*** |
| Life motivation | ns | 0.106*** | .106*** |
| Educational services | 0.207*** | 0.209** | .416** |
| Income | ns | 0.185*** | .185*** |
| Technical costs | ns | -0.156** | -0.235** |
| Welfare motivation | 0.087*** | 0.011*** | 0.098*** |
| IPM technical knowledge | 0.626*** | 0.037*** | 0.662*** |
| Environmental attitude | 0.098*** | ns | 0.098*** |

* *P*< 0.05); ** *P*< 0.01; *** *P*< 0.001, ns: Non-significant.

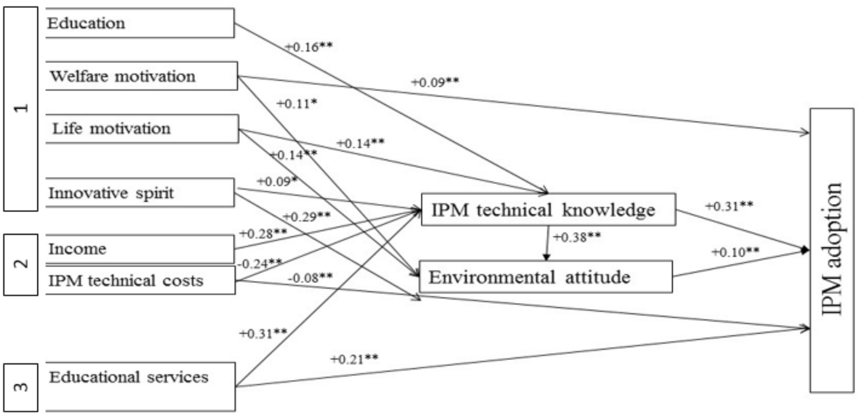


**Figure 4**. Comprehensive IPM adoption models among pistachio growers (Chi square: 4.095, P> 0.05; RMSEA: 0.012; CFI: 1, NFI: 0.996).





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## DISCUSSION

Findings showed that pistachio growers had adopted IPM technologies on an average level. There were also some evidences emphasizing that full adoption of IPM technologies need at least five years (Eneh, 2011; Hedjazi and Sharifi, 2014; Van den Berg and Jiggins, 2007; Meissle *et al.*, 2011). Since in this study, IPM technologies are being currently introduced to pistachio growers, it could be concluded that the procedure of IPM adoption among pistachio growers needs more time to be fully adopted.

There are some factors that facilitate this procedure or make it harder. Consequently, investigating how different factors could accelerate IPM adoption by pistachio growers was the main purpose of this study. It was found that different factors could affect IPM adoption, and this was illustrated through the Empirical model. In fact, previous studies mainly investigated the role of some factors such as income, technical costs (Meissle *et al.,* 2011), farm size (Sheng *et al.,* 2015), education, and farmers' participation. But, almost all those studies ignored to investigate the simultaneous effect of several factors. It was found that individual factors, economic factors, educational factors, and technological factors could predict IPM adoption, significantly.

Although research findings revealed that pistachio growers IPM technical knowledge and their environmental attitude scores are at the average level, they need to enhance their knowledge as well as their attitude towards using IPM appropriately. Davis *et al*. (2012) have also found that farmers' IPM technical knowledge and their environmental attitude are at average level, particularly at the beginning years of adoption process.

Among individual factors, age and farming experience had negative correlation with IPM knowledge, environmental attitude, and IPM adoption. Consequently, elder pistachio growers with great farming experience had more unwillingness towards IPM technologies adoption compared to younger ones. This finding confirms Veisi (2012) study but there is also evidence that shows age is positively correlated with IPM technical knowledge (Mancini *et al.*, 2007).

Although IPM is a knowledge-based technology, education could facilitate IPM knowledge among farmers (Veisi, 2012; Davis *et al.*, 2012). It was approved by this study because education positively affected IPM adoption through increasing IPM technical knowledge. Similarly, another study has also shown the positive relationship between education and IPM technical knowledge (Heong and Escalada, 1997). Therefore, those pistachio growers who had higher education were more capable in adopting IPM.

Albeit participation and innovative sprit had significant positive correlation with IPM technical knowledge, environmental attitude, and IPM adoption, innovative spirit could predict the respondents' environmental attitude ($\beta$= 0.29), IPM technical knowledge ($\beta$= 0.09) directly, and IPM adoption ($\beta$= 0.088), indirectly (Figure 3). Benjamin and Wesseler (2016) confirm that farmers' participation is one of the positive factors engaging farmers to adopt IPM technologies. Therefore, those pistachio growers with adequate innovation spirit and participation were in suitable condition of IPM technical knowledge. It also has been confirmed (Heong and Escalada, 1997) that farmers who actively participate in rural activities and have more tendency to use innovations are at higher level of IPM technical knowledge. Moreover, similar to Veisi's (2012) results, findings revealed that pistachio growers who had larger farm size had more IPM technical knowledge and environmental attitude.

Those pistachio growers who felt more challenge in IPM application process had less IPM technical knowledge. In addition, those pistachio growers who used more educational services than others had more IPM technical knowledge. Davis *et al*. (2012) believe that educational services positively increase IPM technical knowledge.

Amount of educational services benefit has direct causal effect on IPM technical knowledge (β= 0.31) and IPM adoption (β= 0.21). Other studies (Van den Berg and Jiggins, 2007) reflect the positive role of educational factors on IPM adoption procedure.

Life and welfare motivations positively affect IPM technical knowledge. Indeed, they increase knowledge at first and indirectly improve environmental attitude, which means higher rate of IPM adoption. Consequently, motivations could be one of the main reasons for conducting IPM.

Regarding Structural Equation Modeling (SEM) results, the various range of variables including individual factors, economic factors, educational factors, productivity factors, technical factors in conjunction with IPM technical knowledge and environmental attitude can significantly predict IPM adoption, simultaneously. The SEM results (see Figure 4) reveal that knowledge has remarkable positive role in IPM adoption. Some other studies also implied that increasing farmers' knowledge could enhance their ability to apply IPM (Mancini *et al.*, 2007; Veisi, 2012). In other words, IPM technical knowledge is the most important factor in IPM adoption. Environmental attitude could also positively predict IPM adoption among pistachio growers. There are some evidences that approve positive relationship between knowledge and attitude in IPM adoption process (Lamichhane *et al.*, 2015; Kalmar *et al.*, 2014; Mancini *et al.*, 2007). Sanyal *et al*. (2008), Davis *et al*. (2012), and Mancini *et al*. (2007) believe that IPM technical knowledge is essential for adopting IPM. Regarding this finding, those pistachio growers who have high IPM technical knowledge and environmental attitude, would have greater IPM adoption level. Those pistachio growers with higher environmental attitude have adopted IPM more than others. Van den Berg and Jiggins (2007) also found positive relationship between environmental attitude and IPM adoption.

Educational services related to IPM are the second important factor towards enhancing IPM adoption among pistachio growers. Davis *et al*. (2012) believe educational services could provide adequate information to improve farmers' knowledge about IPM. It is expected that providing educational services by focusing on low literacy of pistachio growers along with motivating them could be effective in their IPM adoption. Therefore, preparing educational services and supporting educational programs concerning IPM should be the main part of IPM diffusion programs. We found that environmental attitude was also an important factor for improving IPM adoption. Therefore, increasing environmental attitude could enhance IPM adoption. Knowledge could also make positive change towards environmental attitude among pistachio growers. Subsequently, diffusing IPM among pistachio growers is entirely dependent on knowledge and attitude based on some individual, economic, educational, and technical factors. Findings show that pistachio growers' income could positively affect their IPM technical knowledge and environmental attitude. As a result, IPM is favorable for pistachio growers who have higher income. As Eneh (2011) mentions, farmers with proper income have more tendency to receive knowledge about IPM. There is also some evidence that implies that income is not related to IPM technical knowledge (Sanyal *et al.*, 2008; Timprasert *et al.*, 2014). In contrast, IPM technical costs negatively affect IPM adoption. Sometimes, farmers with high IPM knowledge have paid more for IPM technologies (Veisi, 2012).

Individual factors such as motivations, education, and innovative spirit positively affect IPM adoption process. As a result, localizing IPM technologies based on pistachio growers' individual factors could positively improve their adoption for a long period. It is also necessary to motivate them by some advices by extension specialists.





[ DOR: 20.1001.1.16807073.2019.21.4.8.3 ]

The SEM model not only shows IPM adoption is a simple procedure but also it could be affected by the various range of factors. Moreover, concentration on economic, educational, technical, and individual factors is crucial for agricultural researchers and extension services towards diffusion of IPM.

## CONCLUSIONS

This is the first time that IPM adoption procedure among pistachio growers has been investigated using SEM analysis to show the predictive power of all variables in different factors to understand their direct and indirect effect on IPM adoption. Since pistachio is one of the most important agricultural export products, understanding the procedure of IPM adoption is crucial for policy makers. One of the strength points of this study is investigation of the role of different factors among pistachio growers who are adopting IPM in Kerman Province as the main area of pistachio cultivation in Iran. Notably, because of vast geographical distribution of pistachio gardens and farmers' sensitivity to participate in data gathering process, accessibility to pistachio growers were the limitations and difficulties of this study. Based on the research results, it can be concluded that IPM adoption rate is mainly dependent on pistachio growers' technical knowledge and their environmental attitude. In fact, pistachio growers who had higher IPM technical knowledge and stronger environmental attitude had adopted IPM more than others. Considering that technical knowledge toward IPM could lead to stronger environmental attitude, it is recommended that extension programs be concentrated on enhancing pistachio growers' IPM technical knowledge. Such programs should take their clients' conditions into consideration. It is recommended that the growers be classified based on their income, education level, life and welfare motivations, and innovative spirit.

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## تحلیل چندگانه پذیرش مدیریت تلفیقی آفات: شواهدی از تولیدکنندگان پسته در استان کرمان، ایران

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## چکیده

مدیریت تلفیق آفات به خوبی به عنوان فناوری محیط زیستی شناخته می شود. بنابراین، بررسی سازوکارهای پذیرش این فناوری برای محصولات کشاورزی نظیر پسته ضروری است. هدف اصلی این مطالعه، تحلیل نقش عوامل تاثیرگذار بر پذیرش مدیریت تلفیقی آفات در میان پسته کاران استان کرمان است. پیمایش با استفاده از پرسشنامه محقق ساخت مورد استفاده قرار گرفت. در نهایت، ۲۲۵ پسته کار به عنوان جامعه نمونه بر اساس روش نمونه برداری خوشه ای دو مرحله ای تصادفی انتخاب شدند.روایی

پرسشنامه توسط پانل متخصصان تایید شد. آلفای کرونباخ برای تایید پایایی پرسشنامه استفاده شد. نتایج نشان داد عوامل فردی نظیر سن، تحصیلات، تجربه کشاورزی، انگیزش ها، مشارکت و روحیه نواوری به همراه عوامل اقتصادی نظیر درآمد و هزینه های فنی بر روند پذیرش مدیریت تلفیقی افات تاثیر می گذارد. به علاوه، خدمات آموزشی به همراه دانش فنی مدیریت تلفیقی آفات و نگرش زیست محیطی نقشی مثبت در پذیرش مدیریت تلفیقی آفات دارند. مدل معادلات ساختاری نشان داد تحصیلات، روحیه نوآوری، انگیزه زیستی، انگیزه رفاهی، درآمد، هزینه های فناوری، خدمات آموزشی و چالش های اجرای فناوری می توانند به طور معناداری دانش فنی مدیریت تلفیقی آفات را از طریق اثرات مستقیم پیش بینی نمایند. در واقع، دانش فنی مدیریت تلفیقی آفات منجر به توسعه نگرش زیست محیطی شده و پذیرش مدیریت تلفیقی آفات را به طور مستقیم افزایش می دهد. برخی پیشنهادات عملیاتی بر مبنای یافته های مطالعه در پایان مقاله ارائه شده است.



[ DOR: 20.1001.1.16807073.2019.21.4.8.3 ]