

Article

Farmers' Technical Knowledge about Integrated Pest Management (IPM) in Olive Production

Mohammad S. Allahyari ¹ , Christos A. Damalas ^{2,*}  and Mehdi Ebadattalab ¹

¹ Department of Agricultural Management, Rasht Branch, Islamic Azad University, 41476-54919 Rasht, Iran; allahyari@iaurasht.ac.ir (M.S.A.); m_ebadattalab@yahoo.com (M.E.)

² Department of Agricultural Development, Democritus University of Thrace, GR-682 00 Orestiada, Greece

* Correspondence: cdamalas@agro.duth.gr; Tel.: +30-25520-41-116; Fax: +30-25520-41-191

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Abstract: While Integrated Pest Management (IPM) is a sustainable approach of pest control, contributing to reduced use of pesticides and risks on human health and the environment, farmers have shown limited interest in practicing this method. The present study explored the levels of technical knowledge about integrated management of the olive fly (*Bactrocera oleae*) among olive growers in Roudbar County of Iran and factors underpinning olive farmers' technical knowledge of integrated management. Data were collected in a survey of olive farmers, on the basis of a structured questionnaire. Almost half of the farmers (48.4%) had good to excellent levels of technical knowledge of integrated management, while almost a third of the farmers (35.4%) had a moderate knowledge level. However, a noticeable portion of the farmers (15.9%) had poor knowledge of integrated management. Moreover, most farmers showed average knowledge of the adverse effects of pesticides on human health. While most farmers showed good levels of social participation, cooperation with institutes, and participation in extension activities, they showed low levels of community involvement (involvement in a group of people that have and share common interests with each other). Olive imports and the lack of a common action for olive fly control were perceived as the main barriers of IPM adoption among most farmers. Regression analysis revealed that increased community involvement, large area under olive farming, participation in education activities, and high farming experience promoted farmers' technical knowledge of integrated olive fly control. Strengthening growers' technical knowledge of IPM through community involvement and extension services among inexperienced small-scale olive farmers is recommended for reducing possible unnecessary insecticide sprays in olive production.

Keywords: extension services; community involvement; olive fly; olive orchards

1. Introduction

Agricultural crop production depends on certain management factors with important implications for sustainable agricultural production, in addition to climate conditions and unanticipated risks. These factors generally include the management of soil, water, pests, and marketing, each of which has its own problems and challenges. Among these factors, pest management has an important role to play in the process of agricultural production [1]. Integrated pest management (IPM) is an environmentally friendly approach for pest control that relies on a combination of conventional practices. IPM practices use comprehensive and current information on the life cycle of pests and their interactions with the environment [2]. The promotion of IPM requires identifying the major components of IPM for the purpose of policy-making and practical planning with the participation of farmers. Despite extensive efforts for the training of farmers in recent decades, many farmers are still unaware to a great extent of the IPM as a pest control approach in their current pest control practices [3]. This situation implies inefficiency of the employed dissemination practices at the farmers' level.

The success of IPM programs depends largely on farmers' motivations, skills, and knowledge as well as on the participation in local groups and communities [4]. Farmers have their own practices, knowledge, and ideas on how a given problem can be resolved in the most feasible way. Also, to ensure IPM adoption, complexities of local agro-production systems and context-specific folk knowledge need to be appreciated. The knowledge-intensive nature of IPM means that improved knowledge is a key prerequisite for the adoption of IPM practices. Similarly, the literature on agricultural innovation confirms that awareness and knowledge of a new technology is the first step in the adoption process [5]. Thus, the basic knowledge and skills of the farmers needs to be considered along with their needs and current practice. Farmers are the final decision-makers for adoption of any technology and, therefore, it is important for the technology developers to identify how farmers' react to the provided techniques with respect to the adoption process of certain innovations. However, little attention has been paid to farmers' perceptions and knowledge about pests and pest-control practices, when quantifying adoption levels of different IPM components and their determinants.

As a horticultural crop, the olive (*Olea europaea* L.) has a special place in the production of edible oil throughout the world. The olive is an economically important crop in Iran. However, olive production is at stake due to climatic and environmental factors as well as pests and diseases. The tree is attacked by a variety of pathogens, which affect its health, yield, and its oil quality. The olive fly (*Bactrocera oleae*) was first reported in 2004 in Iran and it is now the most important pest of olive trees in the country, particularly in the northern and more humid parts of the country [6]. Since the olive fly is a newly introduced pest in Iran and has a high rate of damage, especially in Guilan, Qazvin, and Zanzan provinces, it is one of the main factors limiting the development of olive cultivation in Iran, especially in Roudbar County [7]. Studies on IPM in olive production are limited in the literature. In addition, no research has been conducted in Iran to identify factors affecting olive farmers' knowledge about the integrated management of this pest.

The aim of the present study was to explore technical knowledge about integrated management of olive fly and factors underpinning knowledge of integrated management among olive farmers of Roudbar County in northern Iran. Findings are expected to explain the most important factors affecting knowledge of integrated management of olive fly and thus reveal opportunities for reducing possible unnecessary insecticide sprays in olive production through better adoption of IPM. Critical points of intervention for the promotion of this method through appropriate policy implementation can be identified.

2. Materials and Methods

2.1. Study Area and Sample Selection

The study was conducted in Roudbar County in northern Iran. The statistical population of this study was composed of all farmers of productive olive orchards in Roudbar County in the districts of Rostamabad, Rahmatabad, Manjil, Loshan, Aliabad, and Central Roudbar. The sample size was estimated by the least sample size table of Bartlett et al. [8], according to which among 17,988 olive growers, 13,000 had productive orchards. So, the least sample size for this study was determined to be 155 olive farmers, which was increased to 171 farmers to mitigate potential refusals of farmers and further enhance the validity of the study.

2.2. Questionnaire and Data Collection

A structured questionnaire was developed for the survey based on published literature on related topics [4,9], including also previous experience in the field from similar projects regarding the research methods and the particular research tools used [10,11]. The respondents were asked to show the extent of their knowledge about olive fly control using 13 statements, along with some demographic and economic variables, including age, number of family members, experience in farming, experience in olive farming, olive area, total farm area, yield, farm income, olive farm income, and off-farm income.

Farmers' were asked to rate their knowledge of each statement on a scale from 0 = none to 4 = very much. For measuring community involvement (the level of involvement in a group of people that have and share common interests with each other), cooperation with institutions, social participation (the level of participation in a community or society), and participation in extension activities several statements were assessed in a five point Likert-type scale and finally farmers were grouped as poor, moderate, good, and excellent, according to the level of each activity. In the final part of the questionnaire, we asked respondents to report the main barriers for IPM adoption. Each respondent could choose the three most important barriers. The face and content validity of the questionnaire was confirmed by a panel of experts, including faculty members of Agriculture and Natural Resources Research Center of Guilan Province. Also, its reliability was estimated at 0.868 by the coefficient of Cronbach's alpha. The questionnaire was administered through face-to-face interviews with the farmers. The interviews were conducted in a friendly way, and good cooperation with the farmers was noted.

2.3. Data Analysis

Data were analyzed with the Statistical Package for Social Sciences (SPSS Inc, Chicago, IL, USA). We used descriptive statistics (frequencies, percentages, means, and standard deviations) for data analysis to accomplish the objectives. Also, stepwise regression analysis was applied to determine the share of each independent variable, i.e., age, number of family members, farming experience, experience in olive farming, total farm area, olive farm area, mean olive yield, annual income of olive production, cooperation with institutes, social participation, and participation in extension activities, in the dependent variable, i.e., the level of farmers' knowledge of integrated management of olive fly.

The following equations were applied to measure community involvement, cooperation with institutes, social participation, participation in extension activities, and technical knowledge of olive growers about integrated management of olive fly and to classify the respondents. In this method, the scores were divided into the following four levels [12], according to the mean value and the standard deviation (SD).

A = weak, $A < \text{mean} - \text{SD}$;

B = fair, $\text{mean} - \text{SD} \leq B \leq \text{mean}$;

C = good, $\text{mean} < C \leq \text{mean} + \text{SD}$;

D = excellent, $D < \text{mean} + \text{SD}$.

To analyze perceived barriers for IPM adoption, multiple choice analysis was used in SPSS.

3. Results

3.1. Olive Farmers' Demographic and Economic Profile

Mean age of the respondents was 54.57 years, and the mean number of family members was four (Table 1). With respect to experience in agriculture, the participants had, on average, 30.84 years of experience with a minimum of five years and a maximum of 65 years. Also, the participants had, on average, 28.43 years of experience in olive growing with a minimum and a maximum of three and 60 years, respectively. Average total land area of olive growers was 2.40 ha. The lowest and highest areas were 0.1 and 15 ha, respectively. The studied olive growers had, on average, 1.68 ha devoted to olive orchards with a minimum farm area of 0.1 ha and a maximum area of 7 ha. Olive growers reported a mean olive yield 2.22 tonnes ha⁻¹. The minimum and maximum yields were 0.15 and 20 tonnes ha⁻¹, respectively. Mean annual farming income was 42.72 million IRR. The lowest income was 1.00 million IRR and the highest was 800 million IRR. Mean annual income of olive growing was 39.56 million IRR with a minimum of 1.00 million IRR and a maximum of 500 million IRR. Mean off-farming income was 36.61 million IRR, with minimum and maximum values 1.00 and 300 million IRR, respectively (Table 1).

Table 1. Olive farmers' demographic and economic profile.

Variable	Mean	SD	Minimum	Maximum
Age (year)	54.57	11.50	25	85
Number of family members	4	1.86	1	11
Farming experience (year)	30.84	14.51	5	65
Experience in olive growing (year)	28.43	14.66	3	60
Total agricultural land area (ha)	2.40	2.18	0.1	15
Olive orchard area (ha)	1.68	1.26	0.1	7
Mean yield (tonnes)	2.22	2.22	0.15	20
Annual farm income (million IRR)	42.72	71.31	1.0	800
Annual olive growing income (million IRR)	39.56	55.03	1.0	500
Annual off-farm income (million IRR)	36.61	55.00	1.0	300

IRR: Iranian Rial; 1 USD = 34,917.19 IRR.

3.2. Olive Farmers' Social Profile

With reference to farmers' social profile, it was found that most participants (56.1%) were in the group of poor or moderate community involvement (Table 2). On the other hand, most participants had good to excellent cooperation with institutes (54.4%), good to excellent social participation (59.5%), and good to excellent participation in extension activities (57.6%) (Table 2).

Table 2. Olive farmers' social profile.

Variable Level	Community Involvement	Cooperation with Institutes	Social Participation	Participation in Extension Activities
Poor	17.1	22.2	20.3	19.6
Moderate	39.0	23.4	20.3	21.5
Good	26.6	37.3	39.2	39.9
Excellent	16.6	17.1	20.3	17.7
No response	0.6	-	-	1.3

3.3. Olive Growers' Technical Knowledge

To measure olive growers' technical knowledge, 13 items were developed as presented in Table 3 in order of priority.

Table 3. Olive growers' technical knowledge in the order of topic.

Rank	Attribute	Mean	SD
1	Awareness of simultaneous implementation of IPM in all olive orchards	3.45	0.811
2	Awareness of quality and quantity loss of olive oil by olive fly damage	3.24	0.928
3	Awareness of olive fly damage on olive fruit	2.94	0.919
4	Identification of olive fly	2.81	0.956
5	Application of sticky yellow cards to manage olive fly	2.76	0.946
6	Collection of fruits from the base of the trees at harvest time	2.66	0.912
7	Awareness of adverse effects of pesticides on human health	2.52	1.225
8	Pruning of olive trees at winter	2.28	1.087
9	On-time harvest of the crop	2.27	1.090
10	Plowing the tree base in winter	2.08	1.081
11	Application of protein traps to control olive fly	1.58	1.315
12	Application of pheromones to trace olive fly	1.13	1.413
13	Baiting the trees as soon as damage by olive fly augments	0.94	1.255
	Average	2.36	0.618

On a scale from 0 = none to 4 = very much.

Awareness of simultaneous implementation of IPM in all olive orchards ($M = 3.45$, $SD = 0.811$), awareness of the loss of olive oil quantity and quality by olive fly ($M = 3.24$, $SD = 0.928$), and awareness of olive fly damage on olive fruit ($M = 2.94$, $SD = 0.919$) were the three top scores of olive farmers' technical knowledge, respectively. On the other hand, baiting trees as olive fly damage is intensified ($M = 0.94$, $SD = 1.255$), application of pheromones to trace olive fly ($M = 1.13$, $SD = 1.413$), and application of protein traps to control olive fly ($M = 1.58$, $SD = 1.315$) were found to be the topics with the lowest levels of knowledge by the olive farmers. Averaged over all statements, the mean score of knowledge was 2.36.

Classification of olive farmers according to knowledge levels showed that almost half of the farmers (48.4%) had good to excellent levels of technical knowledge of integrated management, while almost a third of the farmers (35.7%) had a moderate knowledge level. However, a noticeable portion of the farmers (15.9%) had poor knowledge of integrated management (Table 4).

Table 4. Olive farmers' classification in terms of technical knowledge.

Technical Knowledge	Frequency	Percentage	Cumulative Percentage
Poor	25	15.9	15.9
Moderate	56	35.7	51.6
Good	44	28.0	79.6
Excellent	32	20.4	100
No response	1	0.6	-

3.4. Regression Analysis

We used stepwise multiple regression analysis to figure out the role of individual independent variables that were significantly related to the dependent variable of knowledge about olive fly integrated management. The variables age, number of family members, farming experience, experience in olive growing, total agricultural land area, olive orchard area, mean olive yield, annual income of olive growing, cooperation with institutes, social participation, and participation in extension activities were entered in the stepwise multiple regression analysis.

At the first step, the variable of social participation was included in the equation whose coefficient of multiple correlation (R) was found to be 0.51, and its coefficient of determination (R^2) was found to be 0.26. Therefore, olive growers' social participation can account for 26% of the variance in the dependent variable, i.e., the knowledge of olive fly integrated management. The second step included olive orchard area in the equation, with R and R^2 values 0.61 and 0.38, respectively. This variable, alone, captured 12% of the variance of the dependent variable. In the third step, the variable of farming experience was included in the equation, with R and R^2 values 0.64 and 0.42, respectively. This variable could determine 4% of the variance of the dependent variable. We included participation in extension activities in the fourth step and then R and R^2 were estimated at 0.67 and 0.44, respectively. Hence, this variable accounted for 2% of the variance of the dependent variable. After the inclusion of these four variables, this operation was stopped. These four variables could all together capture 44% of the variance in the dependent variable. Coefficients of the variables included in the regression model are presented in Table 5. According to the results of Table 5, technical knowledge of the olive farmers can be expressed by the linear equation derived from the stepwise regression analysis as below:

Table 5. Regression analysis on factors underpinning olive farmers' technical knowledge of integrated pest management (IPM).

Dependent Variable	B	Beta	t	p-Value	R	R ²	R ² _{Adj}
Social participation	0.191	0.275	3.502	0.001	0.510	0.261	0.256
Olive growing area	0.116	0.237	3.485	0.001	0.613	0.376	0.367
Farming experience	0.010	0.232	3.253	0.001	0.644	0.415	0.403
Extension activities	0.116	0.207	2.725	0.007	0.666	0.443	0.428
Constant	0.953	-	6.681	0.000	-	-	-

Technical knowledge = 0.953 + 0.116 [extension activities] + 0.010 [farming experience] + 0.116 [olive growing area] + 0.191 [social participation].

3.5. Perceived Barriers for IPM Adoption

Olive imports and the lack of a common action for olive fly control were perceived as the main barriers of IPM use among most farmers (Table 6). No insurance coverage of the olive fly damage and lack of tools/equipment for the control of olive fly were also perceived as common problems.

Table 6. Perceived barriers for IPM adoption among olive farmers.

Rank	Barriers	Frequency	Percentage
1	Olive imports	122	26.5
2	Lack of a common action for olive fly control	99	21.5
3	No insurance coverage of the olive fly damage	77	16.7
4	Lack of tools/equipment for the control of olive fly	70	15.2
5	Lack of financial accountability	58	12.6
6	Lack of information on the control of olive fly	23	5.0
7	Farmers' residence away from the village	11	2.4
	Total responses	460	100

Respondents could choose three important barriers for combating olive flies by IPM method.

4. Discussion

The present study explored the levels of technical knowledge about integrated management of the olive fly (*Bactrocera oleae*) among olive growers in Roudbar County of Iran and factors underpinning olive farmers' technical knowledge of integrated management. As studies on this topic are limited in the literature, findings shed some light on the most important factors influencing the knowledge of integrated management of olive fly and thus reveal opportunities for reducing possible unnecessary insecticide sprays in olive production through better adoption of IPM. Almost half of the farmers (48.4%) had good to excellent levels of technical knowledge of integrated management, while almost a third of the farmers (35.7%) had a moderate knowledge level. However, a noticeable portion of the farmers (15.9%) had poor knowledge of integrated management. Lack of information about farmers' knowledge about pest control is a major constraint upon establishing effective pest management approaches for smallholder farmers [11–13]. Participatory research increased farmers' knowledge about pest control in cotton, but farmers were reluctant to adopt labor-intensive strategies of IPM [14].

Most farmers showed average knowledge of the adverse effects of pesticides on human health. While most farmers showed good levels of social participation, cooperation with institutes, and participation in extension activities, they showed low levels of community involvement (involvement in a group of people that have and share common interests with each other). Perceptions of the advantages and disadvantages of pesticides could predict and support more environmentally friendly pest control methods among farmers [15]. Several previous studies have shown that the levels of farmers' awareness concerning pesticide effects on human health and on the environment varied from one region to another [16–19]. Awareness about pesticide effects inherently

influences farmers' methods of pest control. Perceived beneficial and harmful effects of pesticides or perceived needs of farmers were major determinants of implementation of alternative methods of pest control in previous studies [11,20]. Farmers who felt that pesticides are harmful to the environment and human health were concerned of the negative effects and were more hesitant to use pesticides in their pest control practices [21].

Findings of this study also showed that as olive growers participate more in extension activities, they gain more knowledge of olive fly integrated management. Many researchers have already focused on educational activities when studying factors underpinning farmers' knowledge. For example, a positive relationship between farmers' participation in educational courses and the dependent variable of knowledge was reported [22–25]. Given the positive relationship between olive farmers' extension activities and their knowledge of olive fly integrated management, it is imperative to give a close consideration to the training of olive farmers about olive fly pest. Thus, we can enhance farmers' awareness of olive fly integrated management and relevant agronomic practices by holding educational courses, holding farm day's training courses specific to olive fly, and encouraging young farmers to attend these courses. Previous training in the use of pesticides was connected with high levels of farmers' knowledge about pesticides and beliefs about pesticide hazard control and thus was linked with lower occupational exposure to pesticides [26].

Moreover, farming experience and large area under olive farming were linked with high knowledge levels of olive fly integrated management. Farming experience has been reported to demonstrate a positive impact on technology adoption in previous studies [22,27,28]. Experience improves farmers' skills at production, which implies that more experienced farmers may have a lower level of uncertainty about innovations performance and also be able to evaluate the advantage of the technology being considered. Thus, farming experience can be considered as an indication of the practical knowledge that farmers have acquired on how they can overcome certain inherent farm production and adoption problems [29]. Farming experience is particularly effective in the early stages of technology adoption when the potential benefits of the technology are still tested. Similarly, large area under olive farming implies increased experience in olive farming, with the same benefits described above. These findings demonstrate that extension activities should target inexperienced small-scale olive farmers for promoting IPM adoption.

As the results show, olive farmers with higher social participation were more aware of olive fly integrated management practices. As an example of similar studies on factors influencing farmers' knowledge, Motamed [30] showed that experience in agricultural jobs as an independent variable had a positive and significant impact on technology adoption. With respect to the positive and significant relationship of olive farmers' social participation and their knowledge of olive fly integrated management, the responsible institutions in Roudbar County are recommended to actively use olive farmers in rural guide plans, production cooperatives, service centers of Jihad-e Agriculture, local associations, and Islamic councils of the villages with the aim of acquainting them with the activities pertaining to the integrated management of olive fly. Also, future training courses should be designed in accordance with olive farmers' requirements to familiarize them with integrated management of olive fly. Moreover, it is recommended to conduct the study in other provinces of Iran where the olive fly occurs as a serious pest, especially in Qazvin and Zanjan provinces, and to compare the results.

5. Conclusions

This study brings to light useful information for better understanding common problems in olive production in the area of Roudbar County of Iran and farmers' knowledge of integrated management of fruit fly. Some farmers had adequate knowledge about the impact of the olive fly on olive yield and quality in the area, but there were significant gaps in farmers' knowledge concerning the integrated management of this pest. Farmers needed training in integrated pest management strategies to ensure sustainable olive production, as there is still great room for farmers to improve their knowledge on olive

fly control issues. Investment of public resources in providing information about integrated control methods of olive fly can be highly effective. The extension services should be certainly strengthened, particularly on issues related to IPM. Promoting new concepts, such as IPM, for environmentally friendly crop protection to farmers is crucial, but not sufficient. Training and extension services related to the new concepts are also essential. Knowledge can make farmers become more aware of pesticide risks and subsequently lead to changes in misleading attitudes in olive production.

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