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FACTORS INFLUENCING THE BEHAVIOR OF PALM TREE FARMERS TO ADOPT PHEROMONE TRAPS TO CONTROL LESSER DATE MOTH IN IRAQ*

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ABSTRACT

This research was aimed to identify the social and economic factors influencing the adoption of integrated pest control using pheromone traps to control the pests on palm trees in four governorates (Babylon, Karbala, Baghdad, and Wasit). The research is conducted with a sample of 340 farmers using of questionnaire. The research conducts the PROBIT model, to evaluate the suitability of the model we used McFadden R^2 and Likelihood Ratio-LR test, Hosmer & Lemeshow goodness of fit test, Wald test to judge the significant correlation. The results showed a significant correlation at 1%, among (age, damage to animals and bees, orchard location, land type and control costs) and at 5% between (education level, return). The study also showed that the degree of risk ranged between 3.4 - 3.5 degrees for chemical pesticides that are used by farmers in the study area for the five environmental categories. The study recommended to implementing the integrated pest control program in the palm sector, the need to increase financial and guidance support for the program because of its positive impact on the social economic aspect of farmers.

Keywords: biological control, humira pest, potential impact, qualitative response.
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INTRODUCTION

Economic resources and their productive data represent the economics cornerstone of the agricultural development, also the economic use of those resources represents one of the main goals of economic growth (Kadhim et al., 2019). The importance of the date fruits in the Iraqi economy, is evident through their attracting a significant proportion of the workforce, who are professionals in cultivating the date palm, producing, and marketing its many fruits and products. Most estimates of the number of workers in the palm sector in Iraq (cultivation, production and marketing) have shown that they constitute an important proportion of the population size. The importance of the date palm fruits in the Iraqi economy is evident through their attracting a significant proportion of the workforce specialized in cultivating the date palm, producing, and marketing its many fruits or products. Most estimates of the number of workers in the palm sector in Iraq (cultivation, production and marketing) have shown that they constitute an important proportion of the population size. (Al-Qaisi, 2002). Dates are a good source of thermal energy and many essential mineral salts for the human body, such as iron, calcium, magnesium, sulfur, and some vitamins, in addition to the use of dates in many manufacturing industries **(**Kadhim et al., 2013). Exported Iraqi dates have a competitive advantage, as the apparent comparative advantage index showed a noticeable increase, reaching 26.98 in 2008. As for the concentration index, which represents the concentration of exports in one product or a limited number of products, it reached 0.91 in 2010, meaning that, Iraqi agricultural exports are largely concentrated in

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dates (Awida et al., 2016). Iraqi date exports come in second place in the value of Iraqi exports, after oil. A study recommended the necessity of diversifying sources of national income in the local economy, by profiteering all available resources, with the aim of reducing dependence on oil revenues, which constitute a major source of financing imports in the country (Hammadi and Ali, 2022). The country's development plans have emphasized meeting the increasing demand for agricultural commodities with various decisions to ensure the success of this goal (International Trade Centre, 2022). Controlling agricultural pests, which threaten the agricultural production of palm trees, is one of the most important issues that arouses the interest of those responsible for controlling agricultural pests in Iraq, as it leads to serious losses in production, both quantitatively and qualitatively, thus has an impact on date exports**.** In the early 1950s, the world was interested in designing integrated control programs that do not depend on the use of pesticides, but rather depend on the use of other means, such as encouraging the proliferation of parasites and predators in the environment, using some types of bacteria to cause disease in insects, in addition to using insect traps containing attractants. Nationality, cultivation of disease- and insect-resistant varieties, care for servicing the land, getting rid of insects, with other agricultural, mechanical, and biological operations that limit insect infestation**,** not to mention the possibility of benefiting from palm waste, such as fronds and leaves, in local industries, also the possibility of benefiting from it in many advanced industries, as artificial silk is produced from date palm fronds, taken from date palm trees, the Zahdi type, from Iraqi orchards (Al-Hamada, 2025). A study recommended the need to provide support to palm orchards, especially with regard to controlling pests that affect palm trees using innovative and modern control methods (Mansour, 2022). In another study, it is found that the treatment of mixing the pathogen M. anisopliae with the chemical pesticide Force G is superior to the other chemical treatments and pesticides in reducing damage to palm seedlings (Al-Jassani and Al-Sa'adi, 2015). One study showed the efficiency of using bio pesticides as an alternative to chemical pesticides, as the bio pesticide (BT), which is used by spraying, is the most efficient and effective in influencing the palm tree pest (Muhammad and Al-Hayali, 2020). Another study showed that the use of the biological infection, lacewings, is highly efficient in controlling the Dobas pest, and recommended the need to train orchard farmers to adopt better lacewings control technology, which made a significant difference in reducing environmental pollution which led to achieving quality date production (Al-Humaidawi, 2022). In a study that demonstrated the efficiency of some biological factors such as mycorrhizal fungi and bacteria sp. *Azospirillum*, single and interconnected, provide protection for palm seedlings from infection with the pathogenic fungus F. *chlamydosporum* (Al-Tamimi, 2022). The problem of the research comes from the environmental and social damage of chemical pesticides, also there is an interest from the departments affiliated with the Ministry of Agriculture, to protect crops, protect local agricultural production from diseases and pests, thus reduce their impact with the aim of increasing and improving the quality of products while working to disseminate modern technologies**.** Adopting a policy of integrated agricultural pest control, including the use of pheromone traps, as an environmentally friendly method of control, instead of chemical control of the Humira pest on palm trees, thus, working to reduce the use of chemical pesticides and avoid the damage they cause to the environment and human health, which contributes to creating a qualitative shift in agricultural production in terms of quantity and quality (Al-Qiyam et al., 2022). The importance of the research comes with the global trend towards using environmentally safe methods in controlling plant pests, as the concept of integrated management for controlling agricultural pests is becoming an imperative necessity in order to avoid the use of chemical pesticides in quantity and quality, except when necessary, with full care and control over their manufacturing processes to ensure that they are free of the toxic impurities

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that accompany pesticides during uncontrolled manufacturing, with supervision and attention to the absence of pesticide residues on crops treated at concentrations higher than those permitted to avoid their toxicity to humans and animals. The research objectives is to study the current level of adoption of the integrated agricultural pest management program in controlling the Humira pest using pheromone traps in palm orchards in Iraq, identifying the most important social and economic factors affecting the adoption of integrated pest management and to analysis and measurement of environmental and social risks through a comparison between farmers' use of chemical pesticides and chemical pesticide alternatives in palm pest control operations. The research hypothesis that there is a significant correlation between each of the following independent variables: "farmer's age, educational level, type of tenure, years of experience, non-agricultural profession, control costs, orchard area, how many palm trees, average profits, and orchard reality as a dependent variable" and the variables that are significantly related to the correlation to which farmers adopt pheromone traps as a means of controlling the Humira pest, contribute to explaining the variance occurring in the dependent variable.

MATERIALS AND METHODS

The necessary data is collected to achieve the research objectives through a questionnaire form that is prepared after reviewing the recommendations for integrated pest management with those concerned in the field of controlling the Humira pest in the Ministry of Agriculture/Crop Protection Department.

Data sources

The collected research data is from the following sources:

1. The official sources are represented by the Ministry of Planning, the Central Bureau of Statistics, the Ministry of Agriculture and its affiliated agricultural departments.

2.Questionnaire form: A questionnaire form is prepared to collect data related to this activity, and some, is collected for the purpose of clarifying the form's items and questions, knowing the farmers' response and reactions, which led to preparing its final form.

Terminology on which IPM is built

There are some terms that must be identified to know the integrated control program using pheromone control of the (Humera), and the most important of these terms are:

1. The Pest: the pest is an insect (or organism) that causes harm to humans, their livestock, crops, or workplaces. The keyword is "damage" and is usually interpreted as "damage" that can of course be measured often (often quantitatively). Moreover, damage can usually be equated with economic loss in terms of actual money (Dennis, 2012).

2. Integrated Pest Management: IPM is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment (EPA-US, 2024).

3. Critical Economic Threshold: or level of economic damage: also called the improvement threshold, has been defined by economists as the level of pest infestation that calls for pesticide pest control to be applied when the rate of pesticide use is calculated to maximize farm profit. (Plant, 1986).

4. Agricultural pest control: It is the use of any form of control to reduce the pest and its goal is to reach an ideal control that expresses the full coverage of the economic, social and environmental needs of humans or another definition is that it is a pest group management system that uses all appropriate methods of control with the aim of reducing the pest community and maintaining it below the level where the least economic damage occurs (Ismail, 2009).

The economic importance of Lesser date moth (Humira) in Iraq: It is considered one of the most important palm pests. This insect is found in all areas of palm cultivation in Iraq. The larvae dig a small hole near the funnel of the immature fruit and then enters inside the fruit to feed on its contents, causing it to

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gradually dry out and its color turns to bright red. Hence the name of the insect as "Humira" (Shammari, 2014). Severe infestation with this insect varies from one variety to another and from one generation to another, as it leads to the infected stems being stripped of their fruits, which drive it to a significant decrease in yield as a result of the fall of a large number of fruits, which also lead to an increase in the infestation rate from (60-100%) (Barabandi, 2007). In a study conducted in one of the palm orchards in Baghdad Governorate, with the aim of estimating the economic loss caused by the insect to palm trees, the palm varieties Khastawi and Zahdi were chosen because they are more sensitive than other palm varieties. The results were losses for the Zahdi at 5.3% and for the Khastawi at 37%. 4%, and the study concluded that the date palm insect causes important economic losses to both the Zahdi and Khastawi varieties (Al-Dulaimi, 2004).

Pheromone traps

Pheromone is a chemical substance released outside the body of an individual and received by another individual of the same species, which in turn shows a specific reaction, either a behavioral or physiological reaction. Pheromone traps are considered one of the control methods adopted by the Ministry of Agriculture/ Agricultural Protection Department. This is due to its effectiveness in attracting and killing insects, as well as being safe for humans and environmentally friendly. Synthetic pheromones are used by placing them in cardboard or cardboard traps, often in different shapes depending on the type of harmful insect to be monitored or controlled. Pheromones are prepared for use in traps, as preparations in which the pheromones are saturated or loaded onto a container, diffuser, or pheromone dispenser, which is like a piece of paraffin wax or a funnel-shaped rubber capsule, and is wrapped in an envelope in order to preserve it for the time of use. Then the coil is removed and the pheromone carrier is hung on the bottom surface of the trap. They are also prepared as liquids and when used, a small piece of cigarette filter is immersed in them and stuck to the adhesive surface.

RESULTS AND DISCUSSION

Estimating model: A questionnaire form is prepared for farmers who implemented the integrated pest management program in the four governorates (Babylon, Karbala, Baghdad, and Wasit) for the agricultural season (2021-2022), where 340 palm grove farmers were surveyed. Two societies are founded, one adopting technology and the other isn't. To find the relationship between the probability of adoption and the factors influencing it, is by estimating a logistic regression model for the factors influencing the adoption decision. Six models are identified based on the IPM program (recommendations for alternatives to chemical pesticides and agricultural processes that are adopted by farmers to control pests according to the type of pest).

Production Costs: The relative importance: Family work in the palm groves of the four governorates ranked first, and constitutes a relative importance 46.9% of the total costs, and the costs of leased work come in second place, and its contribution rate reached 31.2% of the total costs, while pesticides came in third place by 5.7% of the total costs, followed by fertilizers by 5.4%, while (fuel and maintenance, marketing, land rent) came with a contribution rate It amounted to (4, 1.6, 0.5)%, respectively. Table (1) illustrates the relative importance of fixed and variable cost items from total costs.

Table 1. Relative importance of fixed and variable costs

Cost lines	Value of costs (1000 ID)	%
Family work	1,283,698	46,9
Interest on capital	130,184	4,8
Land rent	13168	0,5
Fixed costs	1,433,668	52,1
Leased work	853798	31,2
Fertilizers	148,054	5,4
Pesticides	154,656	5,7
Fuel & Maintenance	108,913	4
Marketing	44,395	1,6
Variable costs	1,309,916	47,9
Total Costs	2,743,584	100

Resource: Prepared by the researcher based on the questionnaire

Producers make their production decisions about production levels in the light of total costs, and then the total costs acquire their

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importance in that they determine the possibility of achieving a net profit, and it was shown from Table (1) that fixed costs constitute 52.1% of the total costs, while variable costs represent 47.9% of the total costs, and the reason behind the high ratio of fixed costs to family work wages, as they constitute a large percentage of costs armers in palm groves depend on their families to carry out the work of serving the palm, especially males, because of the nature of the work that the palm needs from cultivation operations (cleaning, pollination, watering, fertilization, control, harvesting).

Variables description

Adoption: A binary qualitative dependent variable that shows the level of adoption decision for pheromone traps as a means of controlling the Humira pest for palm growers. It takes two values (0, 1), (1 adopter and 0 non-adopter).

Age: A quantitative independent variable that shows the farmer's age in years.

Educational level: an ordinal independent variable that shows the educational level of farmers (0 = illiterate, reads and writes = 1, primary = 2, intermediate = 3, middle school = 4, an institute and higher = 5).

Years of experience: A quantitative independent variable that shows the years number of experience in serving and managing the orchard.

Type of tenure: A qualitative, binary independent variable that indicates the type of land tenure (1 = ownership, 0 = contract or lease).

Profession other than agriculture: A binary qualitative independent variable that indicates another source of income for the farmer (0 = does not have a profession other than agriculture, 1 = has a profession other than agriculture).

Abatement costs: A quantitative independent variable that shows the total costs of the control (thousand dinars).

Orchard area: A quantitative independent variable that shows the total area of the orchard (donum).

Profit: A quantitative independent variable that shows the profit from date sales (thousand dinars).

Revenue: A quantitative independent variable that shows the total revenue from date sales (thousand dinars).

Number of palm trees: A quantitative independent variable that shows the number of palm trees per area (palm tree).

Orchard conditions: a binary qualitative independent variable that shows the reality of the orchard in terms of farm service (1 = served, moderate service, 0 = not served).

Hypotheses for using qualitative response models: Regression analysis using the OLS method gives estimates of model parameters that are not effective and will not be useful in analyzing, predicting, or forecasting the results, because this type of regression, and due to the nature of the dependent qualitative variable, will lead to the emergence of the problem of instability of variance homogeneity and the problem of linear correlation between the explanatory variables. To address the problems of not fitting ordinary regression models to binary dependent variables, qualitative response models are used. Some qualitative response models will be clarified. The assumptions for using qualitative response models must be applied. Among these assumptions is that there is no complete correlation between the explanatory variables with each other, as the variables that have a complete correlation between them must be deleted. In addition to the hypothesis that there is no correlation between random error and the explanatory variables, and after the correlation is tested between the six independent variables included in the qualitative response models (age, education, damage to animals and bees, yield, orchard reality, land type, control costs), also, the extent of the relationship between them and the random error, and using the Eviews 10 program, the results showed, as shown in Table (2), the absence of a relationship between the explanatory variables with each other , and with random error.

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Table 2. Correlation test of the models' variables

	Age	Edu	Harm to animals	Rev	Reality	Type of land	Cost	Resid
Age	1							
Edu	-0.381565	1						
Harm to animals	-0.065263	0.109996	1					
Rev	0.052270	0.011071	-0.01416	1				
Reality	0.014373	0.034627	-0.05350	-0.034624	1			
Type of land	-0.1093181	-0.024546	0.05902	0.031061	0.099747	1		
Cost	0.1123608	-0.054929	-0.004028	-0.0434186	-0.131287	-0.0900656	1	
Resid	-0.024313	-0.0490434	0.064146	-0.0314854	0.040947	0.06738855	0.029783	1

Source: By Authors using Eviews 10

According to the results of Table (3). After the hypotheses of using qualitative response models are applied, which showed their consistency, the most important factors influencing the adoption of the integrated pest management program (research sample) are analyzed. Using the three qualitative response models (Logit, Probit, and Tobit), the Probit model is chosen as it gave the best estimated results as follows:

Estimating and interpreting the parameters of the second model using the probit model The model parameters are estimated using the ML maximum likelihood method and using the Eviews 10 program, and thus the results are obtained as shown in Table (3). Adoption takes the symbol (y), which is a qualitative dependent variable (two-valued) that takes two values (1: adopted and 0: not adopted). The number of values of the qualitative dependent variable that took the value of zero reached 97 views, while those that took the value of one are 243 views.

Table 3. Second Probit model and maximum likelihood methods

Dependent Variable: Y
Method: ML - Binary Probit (Newton-Raphson / Marquardt steps)
Sample: 1 340
Included observations: 340
Convergence achieved after 9 iterations
Coefficient covariance computed using observed Hessian

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AGE	0.029402	0.014919	1.970816	0.0487
COST	-0.047936	0.005315	-9.019694	0.0000
EDU	0.826807	0.397800	2.078449	0.0377
HARM_TO_ANIMALS	0.877638	0.356090	2.464655	0.0137
REV	0.000643	0.000314	2.050792	0.0403
EXP01	-0.020548	0.017166	-1.197051	0.2313
REALITY	-0.625028	0.133429	-4.684361	0.0000
TYPE_OF_LAND	1.135478	0.349585	3.248075	0.0012
C	-2.574927	1.021889	-2.519772	0.0117

McFadden R-squared	0.771416	Obs with Dep=1	243
S.D. dependent var	0.452220	Mean dependent var	0.714706
Akaike info criterion	0.332157	S.E. of regression	0.166590
Schwarz criterion	0.444773	Sum squared resid	9.158218
Hannan-Quinn criter.	0.377030	Log likelihood	-46.46674
Restr. deviance	406.5612	Deviance	92.93349
LR statistic	313.6277	Restr. log likelihood	-203.2806
Prob(LR statistic)	0.000000	Avg. log likelihood	-0.136667
Obs with Dep=0	97	Total obs	340

Source: By Authors using Eviews 10

Age: A quantitative independent variable that shows the age of the farmer in years. The parameter of this variable appeared with a positive sign and it does not conform to economic logic. Increasing the age of the farmer by one year leads to an increase in adoption by 0.029, holding the rest of the other variables included in the model constant, which may be due to the conviction of older farmers, through their experience, of the futility of chemical control during previous years, and thus their attempt to find or adopt new methods of control. The Z test showed the significance of the variable at the level of 0.01.

Control (COST): A quantitative independent variable that shows the total costs of control

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(thousand dinars). The parameter of this variable appeared with a negative sign, consistent with economic logic. When the costs of control using pheromones decrease by one unit, it leads to an increase in the probability of adoption by 0.047, with all other variables held constant. In the model, the Z test showed the significance of the variable at the 0.01 level. Educational level (EDU): A quantitative independent variable that shows the educational level of farmers (0 = illiterate, reads and writes = 1, primary = 2, intermediate = 3, middle school = 4, an institute and higher = 5), and the parameter of this variable appeared with a positive sign. It is consistent with economic logic, when increasing the educational level of the farmer by one unit leads to an increase in the probability of adoption by 0.82, with the rest of the other variables in the model remaining constant. The Z test showed the significance of the variable at the 0.05 level. Harm to animals and bees (HARM TO ANIMALS): A qualitative independent variable that shows witnessing the death of birds or bees from the use of chemical pesticides (1 = observed) (0 = not observed). The parameter of this variable appeared with a positive sign in accordance with economic logic, so with an increase in witnessing the death of birds or bees by one unit, it increases the probability of adoption by 0.87, with all other variables in the model constant. The Z test showed the significance of the variable at the 0.01 level. Total Revenue (REV): A quantitative independent variable that shows the revenue from selling dates to the orchard (thousand dinars). The parameter of this variable appeared with a positive sign, and it is consistent with economic logic. When the revenues from selling the crop increase by one unit, it leads to an increase in the probability of adoption by 0.0006 with the rest of the other variables in the model remained constant, and the Z test showed the significance of the variable at the 0.05 level. Reality of the orchard (REALITY): A qualitative independent variable that shows the reality of the orchard in terms of farm service (1 = served, medium service) (0 = not served), and the sign of the parameter of this variable appeared negative, and it is consistent with economic logic. The more the orchard is serviced, or the service is moderately serviced, by one unit, this leads to a decrease in the probability of adoption by 0.62, holding all other variables in the model constant. This explains the importance of orchard service, which is reflected in reducing the use of pesticides, whether chemical or environmentally friendly alike, due to the decrease in the incidence of various types of pests. The Z test showed the significance of this variable in influencing the qualitative dependent variable at a significance level of 0.01. Type of land: which is a qualitative variable, measures whether ownership of agricultural land is private property or leased (1: ownership, 0: leased or contract), and it appeared with a positive sign indicating the positive relationship between private land ownership and the adoption of the use of Pheromones traps in controlling and monitoring the Humira pest. The contract farmer or the land leaser has uncertainty about whether he will remain on the land or whether the land will return to its owner, and thus avoids using any new methods or programs to increase and improve the productivity of the orchard. The Z test showed the significance of this variable in influencing the qualitative dependent variable at the level of Significance 0.01. Evaluating the suitability of the probit model to the estimated model There are several tests used to evaluate the suitability of the Probit model to reconcile its data according to the overall evaluation of the model (general evaluation), including:

McFadden R-squared statistic

Table (3). shows that the value of McFadden R^2 reached 0.77, which is an alternative to the coefficient of determination R^2, whose value is misleading and questionable, and its value usually ranges between 0.2 - 0.6 and in the highest cases it reaches 0.8. This happens when the true spread is very close around the points, and in this case the predicted values of the dependent variable are close either to zero or to one. Therefore, McFadden R^2 is used, which showed that each of the variables (orchard reality, number of palm trees, damage to human health, control costs, profession other than agriculture, surveying), it explained

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77% of the fluctuations occurring in the binary dependent variable, so it is considered the most important factor influencing the adoption of the second model (the use of pheromone traps in controlling the Humira pest). The remaining 23% is due to other factors that are not included in the model and whose effect is absorbed by the random variable.

LR Statistic (Likelihood Ratio) test

In order to evaluate the quality of the probit model, the value of the LR statistic 313.6 is compared, as shown in Table (3). It follows a distribution with the tabular value at the degree of freedom d.f 9. The value of the LR Statistic appeared greater than the tabular value, with a highly significant degree of less than 0.01, and thus the alternative hypothesis H1, which says the model is appropriate, is accepted and the null hypothesis H0, which says the model is not appropriate, is accepted.

Hosmer and Lemeshow (H & L) test: The H&L goodness of fit test is used to determine whether the probit model represents the observed data well or not, and this is done by testing the hypothesis:

H0 Null hypothesis: The observed values and expected values, match, meaning that the model represents the observed data well.

H1 Alternative hypothesis: Mismatch, that is, the observed values and expected values are not equal, meaning that the model does not represent the observed data well.

Table 4. Hosmer and Lemeshow goodness of fit test probit model for Model II

Goodness-of-Fit Evaluation for Binary Specification
Andrews and Hosmer-Lemeshow Tests
Equation: UNTITLED
Grouping based upon predicted risk (randomize ties)

	Quantile of Risk			Dep=0		Dep=1	Total	H-L
	Low	High	Actual	Expect	Actual	Expect	Obs	Value
1	0.0002	0.0430	34	33.4737	0	0.52626	34	0.53454
2	0.0430	0.1499	33	31.0884	1	2.91159	34	1.37259
3	0.1501	0.4967	28	24.5696	6	9.43043	34	1.72682
4	0.5044	0.8749	1	8.34958	33	25.6504	34	8.57521
5	0.8937	0.9854	0	1.40129	34	32.5987	34	1.46153
6	0.9859	0.9991	0	0.19061	34	33.8094	34	0.19168
7	0.9991	1.0000	0	0.00712	34	33.9929	34	0.00712
8	1.0000	1.0000	1	1.8E-06	33	34.0000	34	544857.
9	1.0000	1.0000	0	1.9E-10	34	34.0000	34	1.9E-10
10	1.0000	1.0000	0	0.00000	34	34.0000	34	NA
		Total	97	99.0803	243	240.920	340	NA

Andrews Statistic 107.9988 Prob. Chi-Sq(10) 0.0000

Resource: By authors using the Eviews 10

Table (4) shows the results of the goodness of fit (H & L) test for the probit model that follows a distribution. It indicated that the value of the H-L statistic reached 93 at a degree of freedom 9 for a level of statistical significance of 0.000. Therefore, it is less than 0.05, i.e. (0,000 < 0.05). This means that it is statistically (significant). Thus, the null hypothesis H1 (alternative hypothesis) is accepted, which states that the Probit model is not appropriate, and does not represent the data well, i.e. the expected (estimated) values in the model are not the observed values of the dependent variable match or are equal, and thus the model's estimators do not fit the data well.

Wald test: The Wald statistic is used to test the significance of the parameters of the explanatory variables for the probit model as a whole, i.e. the significance of the model. This is done by testing the (null hypothesis) that the model regression parameters associated with the explanatory variables X, S are equal to zero, as follows:

$$H0 = b_1 = b_2 = b_3 = b_4 = b_5 = b_6 = b_7 = b_8 = 0$$

Table (5) shows the results of the Wald statistic test, which follows a distribution with a degree of freedom of d. f 8. and the regression parameters of the Probit model as a whole showed significant (0.000<0.05).This is explained by the fact that the explanatory variables (age, education, damage to animals and bees, yield, location of the orchard, land type, control costs) included in the model have a significant (statistically significant) effect on predicting the value of the qualitative dependent variable (adoption) according to

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this test, Thus, the null hypothesis (H0) that the parameters of the explanatory variables (bi's) of the Probit model are equal to zero, is rejected, and the alternative hypothesis H1 is accepted, that the parameters are not equal to zero and are statistically significant in predicting the value of the dependent variable. The values of the following statistical tests (Akaike info criterion, Schwarz criterion and Hannan-Quinn criteria) also indicated the quality of the Probit model, as they are low and their values reached (0.332, 0.444, 0.377), respectively.

Table 5. WALD test of probit model

Test Statistic	Value	df	Probability
F-statistic	11.52623	(8, 330)	0.0000
Chi-square	92.20984	8	0.0000
Null Hypothesis: C(1)=C(2)=C(3)=C(4)=C(5)=C(6)=C(7)=C(8)=0			
Null Hypothesis Summary:			
Normalized Restriction (= 0)		Value	Std. Err.
C(1)		0.031418	0.014838
C(2)		0.046420	0.005121
C(3)		0.809377	0.379960
C(4)		-0.910066	0.348980
C(5)		1.49E-05	3.00E-05
C(6)		-0.025573	0.016892
C(7)		2.35E-05	7.62E-05
C(8)		-0.655112	0.132990
Restrictions are linear in coefficients.			

Resource: By authors using Eviews 10

Social and environmental impact of the implementation of IPM: Public support for IPM derives in part from food safety and environmental concerns, yet there has been no study of the health and environmental benefits of IPM. The effects of IPM on the environmental risks posed by pesticides are assessed by assessing the risks posed by pesticides used in palm pest control in four governorates by assigning one risk level for each active substance in each environmental category using a partial classification system. Risk classifications from WHO studies and databases of pesticide toxicity were used in the American Environment Organization (Table 6), toxicity and potential exposure were considered when the assigned hazards were reached for each one of the 20 pesticides. The overall score of the environment classification with and without the adoption of integrated pest management was then calculated. The difference represents the amount of risk avoided due to integrated pest management. To assessment and application of IPM program in the four governorates, the effects of IPM on the risks posed by pesticides to the environment and human health (hereinafter referred to simply as the environment) were assessed. The implementation of this order requires three basic steps: (a) identify the risks posed by the active components of individual pesticides to humans and the environment, (b) determine the degree of adoption of IPM by farmers in the study sample, and (c) evaluate the effects of the adoption of IPM on the use of pesticides by comparing the effect of active substances for integrated management with chemical pesticides used on palm pests in the study area, as the integrated pest management program for palm was started in 2010. Most of IPM techniques developed in the Farmers' participatory research program and through projects implemented by the Iraqi Ministry of Agriculture were released. Table (6). shows the number of farmers or their family members who were injured due to the use of chemical pesticides in the study sample in the four governorates, and the health symptoms they were exposed to (infection with some poisoning, fatigue, vomiting, eye injury, etc.) in addition to recording the death of bees, fish or some farm animals, and the tables show the highest percentage of human infection was in Karbala by 38.2% of the number of injured in the four governorates, either the highest death rate for birds or farm animals or bees were in Wasit with 31.5% of the total harm cases in the four governorates.

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Table 6. harm indicator of using chemical pesticides

Governorate	Human cases		Birds, farm animals and bees	
	Number	%	Number	%
Baghdad	22	19,4	12	22,2
Babylon	36	31,8	10	18,6
Karbala	43	38,2	15	27,7
Wasit	12	10,6	17	31,5
Total	113	100	54	100

Resource: Based on the questionnaire

Risk and potential impact of pesticides

The study outcomes show the degree of danger for each of the five environmental categories humans, animals, birds, aquatic organisms and beneficial insects. As the degree of danger was extracted by relying on the data of the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) as well as the database of agricultural pesticides and public health pesticides registered and approved - Iraqi Ministry of Agriculture. Through the use of the grading system approved by WHO (Table 7), where the environmental categories were divided into five categories, and each category has a degree of toxicity (low, medium and high) that reflects the degree of danger for each pesticide that is used by farmers in the control of palm pests. The degree of danger of rubella pesticides ranged between 3.4 - 3.8 degrees.

Table 7. Risk and potential impact of pesticides

Active ingredients	Environmental Category /Hazard Class					
	Human	Animals	Birds	Aquatic biology	Beneficial insects	Severity Rating
Deltamethrin 100 g/ L	3	3	3	5	3	3,4
Alpha–Cypermethrin10%	3	3	3	5	3	3,4
Malathion	3	3	3	5	5	3,8
Average	3	3	3	5	3.6	3.5

Resource: By Authors using following:
Database of registered and approved agricultural pesticides and public health pesticides – Iraqi Ministry of Agriculture. World Health Organization (WHO), The Recommended Classification of Pesticides by Hazard 2019,81-92. FAO, specifications and evaluations for agricultural pesticide. 2021.

Risk and potential IPM

Pesticides and pesticide alternatives that are used by farmers to extract the degree of danger for each of the five environmental categories (humans, animals, birds, aquatic organisms, beneficial insects), and through the use of the grading system approved by the WHO, where the environmental categories were divided into five environmental categories, and each category has a degree of toxicity (low, medium, high) and environmental security was added to the alternatives that are harmless. Completely on the five environmental categories, as the degree of danger for each pesticide used by farmers in palm pest control reflects the amount of risk to which the environmental and human groups are exposed, and after the degree of danger for each pesticide was extracted and according to the environmental category, the average degree of danger for each pesticide was extracted according to the type of pest that affects palm trees, as Table (8) shows. The average degree of severity of rubella pesticides ranged between 0-0.6 degrees, and this shows that pheromone traps, which are environmentally safe for all environmental groups.

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Table 8. Risk and Impact of IPM

Active ingredients	Environmental Category/ Hazard Class*						
	Human	Animals	Birds	Aquatic	Beneficial insects	Severity Rating	
Pheromone traps	**0**	**0**	**0**	**0**	**0**	**0**	
Oxymatrine 24%	**1**	**1**	**1**	**1**	**1**	**1**	
B. T.**	**1**	**1**	**1**	**1**	**1**	**1**	
Severity Rating	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**	

***The grade used in the table is: 0 = non-toxic (safe), 1 = low toxicity, 3 = medium toxicity, 5 = high or highly toxic.**

**** *Bacillus thurengiensis* 9*10^{7} spor/ m**

Resource: By Authors using following:

Database of registered and approved agricultural pesticides and public health pesticides – Iraqi Ministry of Agriculture. World Health Organization (WHO), The Recommended Classification of Pesticides by Hazard 2019,81-92. FAO, specifications and evaluations for agricultural pesticide. 2021.

CONCLUSIONS

The results of the study showed that the most important factors influencing the likelihood of adopting control using pheromone traps to control the Humira pest are (age, education, damage to animals and bees, yield, orchard reality, land type, and control costs), which showed its significance in contrast to the rest of the other independent variables that are entered into the model. The study recommends that the concerned authorities implement an integrated pest control program, especially the control of the Humira pest by using pheromone traps in the palm sector, there is a need to increase financial and extension support for the program because of its positive impact on the social economic aspect of farmers. The study also recommends the need for coordination with the agricultural directorates in the governorates that implement the control program, using the pheromone traps in which the program has implemented, to work to increase follow-up in disseminating the technology and convincing farmers to adopt it through agricultural extension departments in this governorate. The study showed that the degree of risk ranged between 3.4 - 3.5 degrees for chemical pesticides that are used by farmers in the study in four governorates (Karbala, Baghdad, Babylon and Wasit) and for the five environmental groups humans, animals, birds, aquatic organisms and beneficial insects. The study also showed that the degree of risk ranged between zero - 1 degree for alternatives pesticides that are used by farmers in four governorates and for the five environmental categories.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

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العوامل المؤثرة في سلوك مزارعي النخيل في تبني المصائد الفرمونية لمكافحة فراشة التمر الصغرى في العراق*

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المستخلص

هدف البحث إلى التعرف على العوامل الاجتماعية والاقتصادية المؤثرة في اعتماد المكافحة المتكاملة باستخدام المصائد الفرمونية لمكافحة الآفات على أشجار النخيل في أربع محافظات (بابل، كربلاء، بغداد، وواسط). تم إجراء البحث على عينة مكونة من 340 مزارعاً باستخدام الاستبيان. أجرى البحث نموذج PROBIT، لتقييم مدى ملاءمة النموذج، تم استخدام اختبار $McFadden\ R^2$ واختبار نسبة الاحتمالية–LR، واختبار Hosmer & Lemeshow جودة الملاءمة، واختبار Wald للحكم على الارتباط المعنوي. أظهرت النتائج وجود علاقة معنوية عند 1% بين (العمر، الضرر الذي يلحق بالحيوانات والنحل، موقع البستان، نوع الأرض وتكاليف المكافحة) وبنسبة 5% بين (المستوى التعليمي، العائد). كما أظهرت الدراسة أن درجة الخطورة تراوحت بين 3.4 – 3.5 درجة للمبيدات الكيماوية التي يستخدمها المزارعون في منطقة الدراسة للفئات البيئية الخمس، وأوصت الدراسة بتنفيذ برنامج المكافحة المتكامل في قطاع النخيل، وضرورة زيادة الدعم المالي والإرشادي للبرنامج لما له من تأثير إيجابي على الجانب الاقتصادي الاجتماعي للمزارعين.

الكلمات المفتاحية: المكافحة البيولوجية، حشرة الحميرة، التأثير المحتمل، الاستجابة النوعية.

***جزء من أطروحة دكتوراه للباحث الأول.**