Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 16, Issue 2, 2016
PRINT ISSN 2284-7995, E-ISSN 2285-3952

COMPLIANCE ANALYSIS OF INTEGRATED PEST MANAGEMENT IN CHERRY CULTIVATION

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Abstract

Integrated pest management came to Turkey with international projects in 1980s and it has been implemented by Food, Agriculture and Livestock Ministry in various product groups. The present research aims to determine the socio-economic factors affecting the level of integrated pest management methods' implementation of enterprises involved in cherry growing that stands out in the region. In this context, Izmir, Manisa, Konya, Isparta, Afyon and Denizli were taken into the scope of research where intensive growing of cherry in Turkey takes place. Research findings indicate that awareness of integrated pest management concept is at low level. However, the integrated pest management methods have been implemented more since cherry started to be exported. Producers' implementation level of the integrated pest management methods is affected by production scale, spraying schedule, the consultant ownership, compliance with Food, Agriculture and Livestock Ministry provincial / district offices' spraying schedule proposal for brown rot (Monilinia laxa), cherry fruit fly (Rhagoletis cerasi L.), (Dip.:Tephritidae).

Key words**:** *cherry production, IPM, Ordered Probit model, Turkey*

INTRODUCTION

The increase in consumers' request regarding safe food necessitates use of harmless inputs, development and implementation of production techniques in food production and agricultural production. Additionally, Turkey's accession process to EU requires more informed and effective agricultural production. In EU, EUREPGAP Protocol (The Euro Retailer Producer Group Good Agricultural Practices) was prepared in 1997 in order for registration and control of all kinds of fresh fruit and vegetables from production to consumption. The principles of Good Agricultural Practices (ITU-GAP) are found in EUREGAP Protocol. Good Agricultural Practices includes the practices that are required to make agricultural production system socially sustainable, economically profitable and productive and to protect human health and environment. As a reflection, Agriculture and Rural Affairs Ministry prepared and implemented a regulation regarding Good Agricultural Practices in Turkey in 2004.

Given reasons and evaluations emphasize the importance and necessity of integrated pest management (IPM) implemented in cherry growing which is one of the main products providing high added value considering fresh fruit production in Turkey. Within this scope, the starting point of the project is the fact that implementation level of the IPM in cherry growing, which executives and implementers got to know thanks to an international project in 1980s, has not been known. Besides the given problem, farmers' spraying management approaches, factors influencing the implementation level of the IPM and

questions regarding the change requests considering the existing system and developing technology and knowledge level were attempted to be answered.

The research focuses on presenting farmers' agricultural management structure, determination and betterment of the level of farmers' accordance with the IPM program. In this context, demographic, economic and sociological profiles of the farmers applying and not applying the IPM program and how effective these factors are on the adaptation level of the IPM program were determined.

MATERIALS AND METHODS

In this context, Denizli, Isparta, Izmir, Konya and Manisa were taken into the scope of research where intensive cultivation of cherry (41.9 percent of the cherry growing, 52.3 percent of planted areas, 38.5 percent of the number of trees) in Turkey takes place. The primary data constituting the main material of the research were obtained through questionnaire method from the cherry producers found in the given cities. The secondary data related to the research were obtained from institutions and organizations including Provincial and District Food, Agriculture and Livestock Directorates. Additionally, benefitted from the relevant researches conducted at national and international level.

The primary data constituting the main material of the research were obtained through questionnaire method from the cherry producers found in the given cities.

In the model used to determine how effective farmers' socio-economic features are on adaptation level of the integrated pest management, the answers are divided into three categories regarding the dependent variable, which is the implementation level of the integrated pest management, as 0=1-39 percent, 1=40-69 percent and 2=70-100 percent. As the dependent variable gets three discrete values which naturally increase, "ordered probit model" is the optimal model to be used. Age, education level, experience, income, non-agricultural income level, family size and similar characteristics of demographic and socio-economic features were considered as the independent variables in the model.

Four criteria given below were used in the determination of the implementation level of the IPM in cherry cultivation. These are;

(i)The level of compliance to the IPM(the point taken according to the Likert scale) (25 points),

(ii)Farmers' implementation level of alternative methods to chemical fight like biological fight, cultural measures, bio-technological methods, physical and mechanical methods (the point taken according to the Likert scale) (25 points),

(iii)Enterprises' technical applications (pruning method, irrigation, fertilization dose, dilution condition, consultant status, participation in educational activities, chemical drug dosing knowledge, fertilizer application in accordance with soil analysis results, use of suitable plant nutrients) (25 points),

(iv) Proper use of drug in accordance with the integrated pest management, the recognition level of pest and disease (the point taken according to the Likert scale) (25 points),

In the study, Chi-square test was used in order to determine whether there was dependence among the agricultural pest management system used by the farmers, farmers' features and features of the region where growing is done.

The implementation level of the IPM and demographic, economic and sociological profiles of the farmers were determined through the given criteria and how effective these variables were on the adaptation level of the IPM program were determined.

The dependent variable is qualitative in the ordered Probit model. This qualitative dependent variable has a categorical structure as it has a specific order and sequence reflecting the size of data or variables having continuous feature [15]. Ordered response models are presented as the optimum econometric model in the presence of this type of dependent variable [10].

In the ordered probit model, it is presumed that error term is normally distributed and latent dependent variable is a continuous

variable [16]; [18].

It is assumed in ordered probit model that there is an unobservable latent variable behind the observable, intermittent and sequential categories. The unobservable latent dependent variable is explained with explanatory variable vector and error term as shown below [8].

$$y^* = bx + \varepsilon \qquad \varepsilon \sim N[0,1]$$

In this equation, symbols indicate their counterparts;

y*; unobservable dependent variable,

x; explanatory variable vector,

β; parameter vector to be estimated and

ε; error term (normally distributed).

In the below equations, the relationship between dependent variable (y) and unobservable dependent variable (y*) is indicated.

if y = 0, $y^* \leq 0$,

if y = 1, $0 < y^* \leq \mu 1$,

if y = 2, $\mu 1 < y^* \leq \mu 2$,

.

.if y = j, $\mu j\text{-}1 \leq y^*$

Here, y is observed equivalent of y*. μj is the threshold value determining upper and lower limits of the values that are estimated with β and are taken by y. In this study, five different implementation options of the integrated pest management system in growing were taken into consideration. The sequential categories of the dependent variables to be used in the study are as follows;

If Y=0, use of IPM method at 1-39 percent level,

If Y=1, use of IPM method at 40-69 percent level,

If Y=s, use of IPM method at 70-100 percent level.

In ordered probit model, likelihood of farmers' preferring different alternatives (observed y values) is indicated in equations as follows;

P (y=0) = Φ(- β'x)

P (y=1) = Φ(μ1 - β'x) - Φ(- β'x)

P (y=2) = 1 - Φ(μ1 - β'x)

In order for all likelihoods to be positive, μ values should be like 0<μ1<μ2<...<μj-1. Φ(.) Indicates the cumulative normal distribution function.

The likelihood function of the model is formed from the given likelihoods as given below.

L = Πy=0P(y=0) Πy=1P(y=1) Πy=2P(y=2)

If the likelihood equations put into their places in the model,

L = Πy=0Φ(-β'x) Πy=1[Φ(μ1 - β'x) - Φ(- β'x)]Πy=2[1 - Φ(μ1 - β'x)]

Logarithmically indicated like

log L = Σy=0log Φ(- β'x) +Σy=1log[Φ (μ1 - β'x) - Φ(- β'x)]+Σy=2log[1 - Φ(μ1 - β'x)]

The estimate of the model is found with maximum likelihood method. Derivatives taken according to the explanatory variables of the likelihood equation provide the marginal effects of explanatory variables on these likelihoods [18]. Effects of explanatory variables on the likelihoods are not same with the coefficient estimates and they are dependent on the explanatory variables. Marginal effects of the variables are calculated for each likelihood as given below [8].

$$\frac{\partial P(y=0)}{\partial x} = -\phi(\beta' x)\beta$$

$$\frac{\partial P(y=1)}{\partial x} = [\phi(-\beta' x) - \phi(\mu_1 - \beta' x)]\beta$$

$$\frac{\partial P(y=2)}{\partial x} = \phi(\mu_2 - \beta' x)\beta$$

Likelihood Ratio (LR) hypothesis test is used to test the ordered probit model's acceptability of general meaningfulness statistically and explanatory of the obtained equation [20]. This test is done by comparing LR values found with the below given equations by using constrained and unconstrained log-likelihood values obtained with the model to χ2 (sd) value.

LR=-2[(LogLconstrained)-(LogLunconstrained)]

If LR value is bigger than χ2 (sd), it is interpreted as the general meaningfulness of the model is statistically acceptable and supports the explanatory of the equation [19].

RESULTS AND DISCUSSIONS

Logit, ordered logit, probit, ordered probit, tobit or possion have been widely used in the empirical studies on compliance with the IPM method [14]; [7]; [5]; [6]; [12]; [13]; [1]; [17]; [9]).

Before the analysis, the optimum variables, which explain farmers' behaviours regarding the compliance with the IPM method in the best way, should be determined. Socio-demographic, economic, behavioural variables influence farmers' compliance with the IPM method.

The explanatory variables for compliance with farmers' IPM method are given at Table 1. A significant portion of the variables are as bivalent variable. Farmers' features like education level and age are included in the model.

In the study, likelihood Ratio (LR) hypothesis test is used to test the ordered probit model's acceptability of general meaningfulness statistically and explanatory of the obtained equation. According to this hypothesis test;

LR=-2[(LogLikelihood constrained)-(LogLikelihood unconstrained)]

LR=-2[(-249.41148)-(-186.31925)]

LR=126.18

Considering the constrained and unconstrained log-likelihood values, LR value obtained in the model is bigger than 27.59 which equals χ^2 (17) critical value at 5 percent level (126.18). In the study, likelihood Ratio (LR) hypothesis test result indicates the ordered probit model's acceptability of general meaningfulness statistically and supports explanatory of the obtained equation.

In the modals containing qualitative dependent variable, the estimated coefficients should be interpreted carefully. If the symbol of the parameter taken as explanatory variable in the model is positive (+), it means that a high value in the explanatory variable can increase the possibility of higher value dependent variable. If the symbol of the parameter taken as explanatory variable in the model is negative (-), it means that a high value in the explanatory variable decreases the possibility of higher value for dependent [2].

Estimated model is;

EMYUD = f (İLKOD, EGTM, YAS, Krzparca, Krzuretda, S33, S30, S42, S40, S48, S76, S75, MAK_DA, ISG_DA, NKAR, MLYT, GRUP).

According to the results of analysis, Pseudo R^2 of the model's shadow certainty coefficients was estimated as 0.2530. The estimated model was found meaningful statistically as a whole (Prob> χ2).

Table 1. Variables used in the model

Variables	Definition of variables
Dependent variable	
EMYU	Compliance with IPM method: Y=0, implemented at low level; Y=1, implemented at middle level; Y=2, implemented at high level.
Independent variable	
ILKOD	Cities within the research scope: İzmir=1, Manisa=2, Konya=3, Isparta=4, Afyonkarahisar=5, Denizli=6
EGTM	If enterprise manager's education is over primary school level 1, if not 0 (dummy)
YAS	If enterprise manager is below age 50 1, if not 0 (dummy)
Krzparca	Number of cherry lands of enterprise (continuous)
Krzuretda	Cherry yields of enterprise per decare (continuous)
S33	Marketing channel of cherry: (categorical) 1= Exporter merchant, 2= Middleman, 3= Merchant, 4= Other
S30	Special consultant status regarding the cherry orchard care: (categorical) 1= Yes, 2= No
S42	Good agriculture certificate ownership status in cherry cultivation: (categorical) 1= Yes, 2= No
S40	Compliance with Food, Agriculture and Livestock Ministry provincial / district offices' spraying schedule proposal for brown rot and cherry fruit fly in cherry cultivation: (categorical) 1= None, 2= Little, 3= Middle, 4= Much, 5= Very much
S48	Spraying schedule ownership status in cherry cultivation: (categorical) 1= Yes, 2= No
S76	Satisfaction from cherry cultivation: (categorical) 1= None, 2= Little, 3= Middle, 4= Much, 5= Very much
S75	Insurance status in cherry cultivation: (categorical) 1= Yes, 2= No
MAK_DA	Use of machine power in growing (hour/minute) (continuous)
ISG_DA	Labour use in growing (hour/minute) (continuous)
NKAR	Relative profit in growing (continuous)
MLYT	Cost in growing (TL/kg) (continuous)
GROUP	Classification of enterprises' cherry orchard sizes: (categorical), decares 1-6.99 =1, 7-14.99 =2, 15-29.99 =3, 30 and over =4

Source: Own calculation.

According to the analysis results, education level, age, number of plots, marketing channel, ownership status of good agriculture practice certificate, insurance status, satisfaction from cherry cultivation, use of machine power, labour use, relative profit and cost variables found in the model were found statistically meaningless. Even if socio-economic factors including being under age 50, having an education level over primary school affect compatibility with integrated pest management, variables' being statistically different make interpretation of this level challenging (Table 2).

The group variables including compliance with Food, Agriculture and Livestock

Ministry provincial / district offices' spraying schedule proposal for brown rot (*Monilinia laxa*), cherry fruit fly (*Rhagoletis cerasi L.),* (Dip.:*Tephritidae*), in cherry cultivation, ownership of spraying schedule, size classification of cherry orchards were found statistically meaningful (Table 2).

Table 2. Results of ordered probit model

Variables	Coefficient	Coefficient standard error	Z-value	P-value
İLKOD*	-0.096	0.056	-1.730	0.083
EGTM	0.175	0.180	0.970	0.332
YAS	0.054	0.178	0.300	0.763
Krzparca	-0.004	0.042	-0.110	0.916
Krzuretda*	-0.001	0.001	-1.840	0.066
S33	-0.060	0.084	-0.720	0.472
S30***	-0.601	0.198	-3.030	0.002
S42	-0.128	0.205	-0.620	0.533
S40***	0.381	0.058	6.540	0.000
S48***	1.287	0.178	7.222	0.000
S76	0.060	0.077	0.780	0.437
S75	0.117	0.212	0.550	0.580
MAK_DA	0.004	0.104	0.040	0.967
ISG_DA	0.004	0.005	0.740	0.459
NKAR	0.084	0.132	0.640	0.523
MLYT	-0.233	0.361	-0.650	0.518
GROUP	0.205	0.100	2.052	0.041
/CUT1	-0.534	1.217		
/CUT2	1.109	1.222		

Source: Own calculation.

The coefficient of city group was found meaningful at 10 per cent significance level with negative symbol. For instance, it can be expressed that farmer's being in Izmir and Manisa cities increase the likelihood of compliance with IPM by 0.096 (Table 2).

Another variable found in the model is cherry yield level. The coefficient of this variable was found meaningful at 10 per cent significance level with negative symbol. As the cherry yield increases, the IPM adoption level decreases by 0.001 (Table 2). The coefficient regarding the compliance with Food, Agriculture and Livestock Ministry provincial / district offices' spraying schedule proposal for brown rot (*Monilinia laxa*), cherry fruit fly (*Rhagoletis cerasi L.*), (Dip.:*Tephritidae*), in growing was found meaningful at 1 per cent significance level with positive symbol. Farmer's compliance with Food, Agriculture and Livestock Ministry provincial offices' spraying schedule proposal for brown rot (*Monilinia laxa*), cherry fruit fly (*Rhagoletis cerasi L.*), (Dip.:*Tephritidae*), in growing increases the likelihood of compliance with the IPM by 0.381 (Table 2).

The coefficient of farmers' ownership of special consultant in the care of cherry orchards is with negative symbol. It was found statistically meaningful at 1 per cent significance level. The coefficient of farmers' ownership of private consultant in the care of cherry orchards is with negative symbol.

The coefficient of farmers' ownership of spraying schedule in growing is with negative symbol. It was found statistically meaningful at 1 per cent significance level. Farmers' ownership of spraying schedule in growing increases the likelihood of compliance with the IPM by 1.29 (Table 2).

According to group variable regarding the size classification of cherry orchards, the likelihood of compliance with the IPM increases by 0.21 for the enterprises owning bigger orchards. This variable was found meaningful at 5 per cent significance level (Table 2). However, Bonabana-Wabbi et al. [3] found out that the influence of size of orchards on compliance with the IPM was not statistically significant.

Mauceri et al [11] studied adaptation to IPM techniques in potato cultivation in Carchi, Equator. They used ordered probit model in the analysis of data. They listed the factors influencing IPM adaptation as access to Farmer Field School's data, field day, brochures and willingness to participate in farmer field school. According to the findings of the study, increase in the size of household decreases the compliance with IPM. According to the writers, farmer field schools, field days and brochures are effective mechanisms providing IPM knowledge and its adaptation.

According to the study of Singh et al [17], studies about the IPM through applied programs have favourable effects in the long run. Extension services were statistically not significant in the adaptation of integrated pest management. Different relationships were observed between the size of enterprise and adaptation of integrated pest management. It was found out that as the size of enterprises increased in cotton cultivation and decreased in rice plant cultivation, the likelihood of IPM

adaptation increased.

According to the results of study by Li et al. [9], it is more likely in the bigger enterprises cultivating various plants and employing more full-time workers to adapt IPM method. As green housing and arboriculture activities face with diseases more, it is harder to adapt IPM method. Moreover, the biological control agents (i.e., predator and parasite) constrain IPM in green housing and arboriculture enterprises. At the same time, this study emphasizes the difference between measures of IPM and farmers' knowledge.

In the study by Carlberg et al [4], the peanut production level of farmers who apply IPM method and participate in farmer field schools were found statistically to be meaningful and higher in Ghana.

CONCLUSIONS

In the study, suggestions for development and betterment of IPM method in the fight against disease-pests regarding compliance level in cherry growing were studied in Izmir, Manisa, Konya, Isparta, Afyonkarahisar and Denizli samples.

Regarding the influence of farmers' socio-economic characteristics on compliance with IPM, variables found in the model were found to be significant. However, the variables found in the model including education level, age, number of plot, marketing channel, ownership status of good agriculture practice certificate, insurance status, satisfaction from cherry growing, use of machine power, labour use, relative profit and cost variables found in the model were found statistically meaningless. However, the group variables including compliance with Food, Agriculture and Livestock Ministry provincial / district offices' spraying schedule proposal for brown rot (*Monilinia laxa*), cherry fruit fly (*Rhagoletis cerasi L.*), (Dip.:*Tephritidae*), in cherry growing, ownership of spraying schedule, level of satisfaction from cherry growing, the frequency of internet use, taking measures in chemical spraying in cherry cultivation, size classification of cherry orchards were found statistically significant (Table 2).

Besides this study, the studies carried out in the national and international arena indicate that integrated pest management can be adapted through effective communication. The majority of the enterprises request more knowledge and awareness in this subject.

ACKNOWLEDGEMENTS

We would like to thank to Süleyman Demirel University BAP (Scientific Research Projects Coordination Unit, project number: 2829-M-11) for its financial support.

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