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Social Factors Critical for Adoption of Biological Control Agents *Trichogramma* Spp. Egg Parasitoid of Rice Stem Borer *Chilo suppressalis* in North of Iran

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Abstract: Critical social factors for adoption of biological control agents *Trichogramma* spp. Egg parasitoid of rice stem borer *Chilo suppressalis* by farmer was studied. This investigation carried out by descriptive survey during July-August 2009. Studied cities including Talesh, Rezvanshahr and Masal set in Tavalesh region of Guilan province near to Caspian Sea. The questionnaire validity and reliability were determined to enhance the dependability of the results. The farmers were divided into two groups of adopters and non-adopters. Totally 184 farmers were studied for effective characteristics. Results showed that important effective social characteristics on adoption of biological control in west of Guilan province were education level, family size, experience in rice culture, rate of participation in educational- extensional activities.

Key words: Adoption · Farmer · *Trichogramma* · *Chilo suppressalis* · Iran

INTRODUCTION

Increase of food production is most challenge of new century especially in developing country due to population explosion. Rice is second source of food for many people in world specially Asia. Rice has many pests which decrease its yield significantly. One of most insect pest of rice is rice stem borer *Chilo suppressalis* reported first time from north of Iran in 1972. Rice stem borers are serious pests and of regular occurrence infest the crop at all stages of crop growth. The rice plants can compensate the damage caused by the borers during the vegetative phase up to the stage of maximum tillering. Infestation by stem borers during the reproductive phase, especially during panicle initiation and ear head emergence, causes loss in yield [1]. *Trichogramma* spp. regarded as egg parasitoids of many butterflies and moth pest in world. This parasitoid is rearing in mass production in many insectariums supported by plant protection organization in Iran [2]. Northern provinces of Iran (Guilan, Mazandaran and Golestan) use 60% of pesticide from total usage of them. It is reported that 70% of rice farmer used chemical control for their rice field [3]. Population awareness about food security leads to many changes in feeding behavior of people in world. Better food production is main goal of many agricultural organizations. There is a particular concern about the use of pesticides in developing countries, like Iran, where farmers use pesticides that are restricted in other parts of the world. Rice is a pesticide-intensive crop and an increase in production is correlated with a significant rise in pesticide use. Pesticides are a necessary input to produce high yields, but can result in adverse effects on both health and environment. The negative environmental impacts of chemical application have long been recognized as major public health concerns. By official estimates average of 24,000 ton of pesticides used in Iran each year [4]. Dependency on chemical pest control and improper pesticide use has resulted in crop and environmental contamination and detrimental effects on humans. Hence, many of the techniques or practices collectively referred to integrated pest management (IPM) have been designed to address some of the health and environmental concerns of pesticide use. In general terms,

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IPM is defined as a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks [5]. This system must be effective economically, social acceptable and support by governments. Noorhosseini Niyaki [6] reported that despite the consumption of chemical pesticides among the farmers who adopt the biological control in north of Iran has not been completely stopped but it shows a salient reduction in comparison with the farmers who don't use biological control.

While pesticides are still a significant component of many control programs, their negative environmental and health impacts have stimulated research to develop alternate pest management strategies, such as biological control [7]. At present, seven biological control applying for control of 14 insect pests in some strategic crops such as rice, soybean, wheat, pomegranate, citrus etc. in Iran. Its application lead to decrease of pesticide use to 5000 ton in 2009 year. Most success obtaining and its diffusion to all crops require to correct programming, education of extension expert and farmer, investment in executive methods and quality control of biological control agent, fundamental research and related object. It is clear that for any management approach to be successful, it must not only be economically viable for users but must also, on a much broader scale, be acceptable to the general public.

Adoption of any innovation is not a one step process as it takes time for adoption to complete first time. First time adopters may continue or cease to use the new technology. The duration of adoption of a technology vary among social community, economic units, regions and attributes of the technology itself. Therefore, adequate understanding of the process of biological control technology adoption is necessary for designing effective agricultural research and extension program for applied usage in agriculture. Main effective factors on biological agents application was studied to some extent [8, 9, 10, 11, 12]. Salami and Khaledi [10] reported that farmer literacy, farm size and ownership, family size affect on adoption of biological control application in Mazandaran province of Iran. Asghari and Hadi [9] reported that individual education, participation in extension programs and visits, corporation with extension center and experts and relationship with best farmers were main factors on adoption of biological control agent by soybean farmers in northwest of Iran (Ardebil province). Abeydeera [8] reported that IPM and biological control application decrease total control cost compared to farmer that did not use IPM and biological agent. This study presents a single case study on effective social factors of adoption of biological control by rice farmer in north of Iran.

MATERIALS AND METHODS

Construction of the Questionnaire and Survey: There was an initial discussion, involving social scientists and researchers in the field of biological control, about the kind of information the Bio-control network would like to obtain from an independent survey. The questionnaire was pre-tested by interviewing three farmers. After some modifications, it was tested again with 10 other respondents. The dependent variable was the adoption of biological control among farmers of Tavalesh region of Guilan province. Respondents from selected rural areas were categorized into adopters and non adopters of bio-control of *Chilo suppressalis.* A total of 184 farmers including 33 adopters and 151 non adopters were randomly selected to answer the questionnaire (Table 1). This study was carried out by survey during July and August 2009. The study area includes Talesh, Rezvanshahr and Masal set in Tavalesh region of Guilan province near the Caspian Sea (Figure 1).

Data Analysis: Frequency, percent, mean and standard deviation were used for the statistical analysis of data. Chi-square test and logistic regression were used for data analysis, using SPSS ver. 16 software.

The social variables for the two groups were examined using logistic regression model. The dependent variable was dichotomized with a value 1 if a farmer was an adopter of biological control and 0 if non-adopter. SX, EL, MS and EE were entered in the model as dummy variables. The other variables namely AG, FS, EX, SP and ER were entered as continuous variables (Table 2). The model was specified as follows;

Table 1: Total sample size used in the study area

	Talesh	Masal	Rezvanshahr	Total
Adopters Sample Size	14	6	13	33
Non-adopters Sample Size	43	78	30	151
Total	57	84	43	184

Source: Survey Results, 2009

$$Y = f\,(SX, EL, MS, EE\ AG, FS, EX, SP, ER)$$

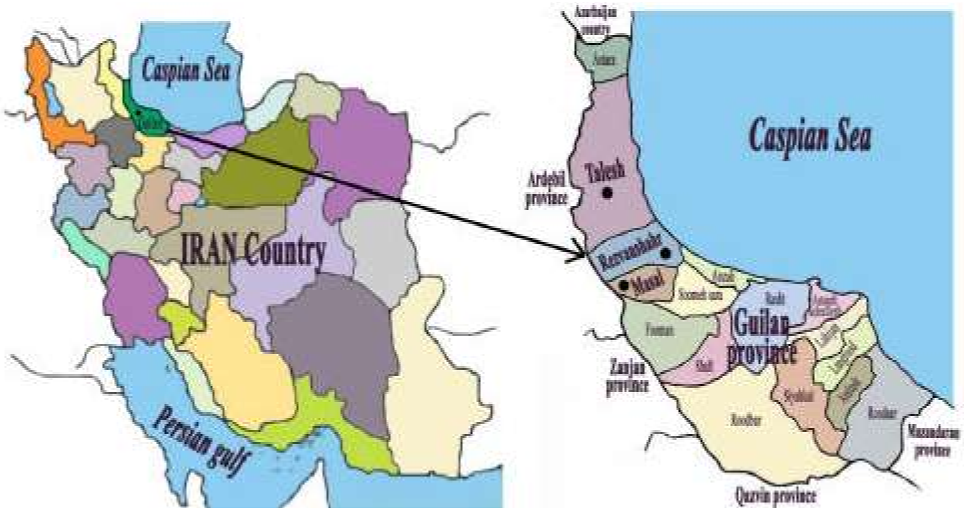

Fig. 1: Site of study in north of Iran

Table 2: Definition of variables included in the regression model

Dependent variable	
Adoption (Y)	Adopters = 1, Non adopters = 0
Independent variable	
Age (AG)	Age of the farmer, measured in year
Sex (SX)	Male = 1, Female = 0
Education level (EL)	High school and highest = 1, otherwise = 0
Marriage status (MS)	Married = 1, Bachelor = 0
Family size (FS)	Number of family members
Extension (EX)	Number of extension contacts during a year
Membership in social institutions (SP)	Number of memberships
Experience in rice culture (ER)	Year farming experience, measured in year
Rate of participation in educational- extensional activities (EE)	Very mach = 5, Much = 4, Intermediate = 3, Little = 2, Very little = 1

RESULTS AND DISCUSSION

Age: The frequency distribution showed that more respondents in the age category were 51 years and older (38.6%) and the lowest frequency in age was category 20-30 years. In this study, results showed that there was no significant relation between adoption and age variable (Table 3). Also, there was no significant difference between the two groups of adopters and non-adopters of bio-control according to the mean age (Table 4).

Sex: The frequency distribution showed that respondents were 95.1% of male and 4.9% female. In this study, the results showed that there was no significant relation between adoption of biological control and sex variable (Table 3). Major respondents were male and it seems that gender of respondent affects on response and it lead to insignificant effects.

Education Level: The frequency distribution showed that 19% of the respondents were illiterate, 26.1% primary-school level, 22.3% guidance level, 26.1% have a secondary education and school diploma and 6.5% a have college degree or higher. In this study, results showed that there was a significant relation ($p<0.05$) between *Trichogramma* application adoption and education level variable (Table 3). Also, there was a significant difference ($p<0.05$) between the two groups of adopters and non-adopters of bio-control regarding the education level variable (Table 5). Positive and significant relations reported from others researches in north (Mazandaran province) and center (Isfahan province) of Iran [13, 14]. Significant difference of education level between two groups of rice producers (participating and none participating) have been approved by Palis [15] and Erbaugh *et al*. [16].

Table 3: Personal and Social Characteristics of rice farmers

Characteristics Groups	Adoption f	Adoption %	Non Adopters f	Non Adopters %	Total f	Total %	Chi-square	Sig.
Age:								
20-30 years	8	4.34	19	10.32	27	14.7	3.101^{ns}	0.376
31-40 years	8	4.34	37	20.10	45	24.5		
41-50 years	6	3.26	35	19.02	41	22.3		
51 year thru highest	11	5.97	60	32.60	71	38.6		
Mean (Std. Deviation)	45.24 (14.93)		46.13 (12.07)		45.97 (1.25)			
Sex:								
Male	32	17.39	143	77.71	175	95.1	0.299^{ns}	0.584
Female	1	0.54	8	3.34	9	4.9		
Education level:								
Illiterate	7	3.80	28	15.21	35	19	10.967**	0.027
Primary school	2	1.08	46	25	48	26.1		
Guidance school	7	3.8	34	18.47	41	22.3		
High school and Diploma	13	7.06	35	19.02	48	26.1		
College degree or highest	4	2.17	8	4.34	12	6.5		
Marriage status:								
Married	31	16.85	147	79.89	178	96.7	0.999^{ns}	0.318
Bachelor	2	1.08	4	2.17	6	3.3		
Family size:								
1-3 person	4	2.17	31	16.85	35	19	3.041^{ns}	0.219
4-6 person	18	9.78	89	48.36	107	58.2		
7 person thru highest	11	5.97	31	16.85	42	22.8		
Mean (Std. Deviation)	5.84 (2.69)		5.03 (1.90)		5.18 (2.08)			
Membership in social institutions:								
In 0 institution	8	4.34	25	13.58	33	17.9	1.790^{ns}	0.617
In 1 institution	19	10.32	89	48.36	108	58.7		
In 2 institution	6	3.26	34	18.47	40	21.7		
In 3 institution	0	0	3	1.63	3	1.6		
Mean (Std. Deviation)	1.93 (0.65)		2.09 (0.68)		2.07 (0.67)			
Rate of participation in educational- extensional activities:								
Very little	17	9.23	104	56.52	121	65.8	10.283**	0.036
Little	4	2.17	23	12.5	27	14.7		
Intermediate	6	3.26	11	5.97	17	9.2		
Much	4	2.17	12	6.52	16	8.7		
Very mach	2	1.08	1	0.54	3	1.6		
Number of extension contacts during a year:								
Lowest thru 5	18	9.78	106	57.60	124	67.4	5.904^{ns}	0.206
6-20	5	2.71	16	8.69	21	11.4		
21-35	4	2.17	5	2.71	9	4.9		
36-50	4	2.17	17	9.23	21	11.4		
51 thru highest	2	1.08	7	3.80	9	4.9		
Mean (Std. Deviation)	26.75 (69.61)		14.98 (42.88)		17.9 (48.73)			
Experience in rice culture (year):								
Lowest thru 15	8	4.34	14	7.60	22	12.0	6.794^{ns}	0.147
16-25	6	3.26	38	20.65	44	23.9		
26-35	6	3.26	30	16.30	36	19.6		
36-45	6	3.26	42	22.82	48	26.1		
46 thru highest	7	3.80	27	14.67	34	18.5		
Mean (Std. Deviation)	30.51 (15.71)		33.66 (13.03)		33.09 (13.56)			

^{ns} Non significant, **significant at $p<0.05$

Source: Survey Results (2009)

Table 4: Comparison of some characteristics of adopter and non-adopter of biological control using t-test

Characteristics	t	Sig.
Age	0.367^{ns}	0.714
Family size	1.637^{ns}	0.110
Membership in social institutions	1.230^{ns}	0.220
Number of extension contacts during a year	1.260^{ns}	0.209
Experience in rice culture	1.209^{ns}	0.228

^{ns} Non significant **significant at p<0.05

Source: Survey Results (2009)

Table 5: Comparison of some characteristics of adopters and non-adopters of biological control using Mann-Whitney test

Characteristics	Z	Sig.
Education level	2.096**	0.036
Rate of participation in educational-extensional activities	2.253**	0.024

^{ns} Non significant **significant at p<0.05

Source: Survey Results (2009)

Table 6: Logistic regression coefficients of the factors affecting adoption of biological control

Variables	B	S.E.	Wald	Sig.
AG	0.037	0.030	1.607	0.205
SX	1.366	1.305	1.096	0.295
EL	1.106	0.480	5.314	0.021**
MS	-0.639	1.039	0.378	0.538
FS	0.218	0.109	4.000	0.045**
EX	-0.000	0.004	0.045	0.831
SP	-0.451	0.314	2.062	0.151
ER	-0.048	0.026	3.560	0.059*
EE	0.371	0.194	3.668	0.055*
Constant	-3.749	1.889	3.939	0.047**

**significant at p<0.05 and *significant at p<0.10

-2 log likelihood = 151.392

Chi square statistic = 21.717**

Overall Correct predictions = 84.2%

Source: Survey Results (2009)

Marriage Status: The frequency distribution showed that 96.7% of respondents were of married and only 3.3% were single. There is much difference in frequency between single and married status groups and data analysis proved no significant relationship between marriage status and biological control adoption in this study (Table 3).

Family Size: The frequency distribution showed that in terms of family size, about 80% of respondents were more than four people. In this study, results showed that there was no significant relation between *Trichogramma* application adoption and family size variable (Table 3). Also, there was no significant difference between the two groups of adopters and non-adopters of bio-control regarding family size (Table 4).

Membership in Social Institutions: Frequency distribution showed that majority of farmers were members of social institutions (82 percent) and only 17.9% of farmers in social institutions were not members. In this study, results showed that there was no significant relation between adoption and membership in social institutions variable (Table 3). Also, there was no significant difference according mean membership in social institutions between tow group adopters and non adopters of bio-control (table 4). It is reported negative and significant relation between this character and adoption of integrated pest control [14].

Rate of Participation in Educational-Extensional Activities: The frequency distribution showed that about 80% of respondents have participated in very little level and little in educational- extensional activities. In this study, results showed that there was a significant relation (p<0.05) between adoption and rate of participation in educational- extensional activities variable (Table 3). Also, there was a significant difference (p<0.05) between the two groups of adopters and non-adopters of bio-control as regards the rate of participation in extension activities variable (Table 5). It is clear that participation in educational classes will increase doing new technology normally which lead to innovation adoption. Different results reported that there is no significant difference between farmers participating in *Trichogramma* application extension classes and non participating [13]. Significant difference of adoption of biological control between two groups of rice producers participating in educational school have been approved by Huan *et al*. [17].

Number of Extension Contacts During a Year: The frequency distribution showed that more respondents, less than 5 times in years were associated with extension agents (67.4 percent). In this study, results showed that there was no significant relation between adoption and number of extension contacts during a year variable (Table 3) Also, there was no significant difference according mean numbers of extension contacts during a year between tow group adopters and non adopters of bio-control (Table 4). While farmers studied in Amol (Mazandaran province, Iran) showed positive and significant relation between this parameters and adoption of *Trichogramma* application for pest control [13].

Experience in Rice Culture: The frequency distribution showed that average experience in the cultivation of rice among studied farmers was 33 years that in comparison with the average age of respondents (45 years) indicated that the majority of farmers in the study area since childhood and adolescence have been involved in rice cultivation are. In this study, results showed that there were no significant relations between adoption and experience in rice culture variable (Table 3). Also, there was no significant difference between two groups of adopters and non-adopters of bio-control regarding the mean Experience in rice culture (Table 4). Certainly, equal experience among farmers could not affect on their mind related to adoption innovation in this field while different results reported in center of Iran (Isfahan province). It is reported positive and significant relation between agricultural activities experience variable and integrated control of *Chilo suppressalis* [14].

Factors Determining Adoption of Biological Control of *Chilo Suppressalis*: The results of the Logit likelihood regression model indicated that the overall predictive power of the model (84.2%) is quite high, while the significant Chi square ($p<0.05$) is indicative of strength of the joint effect of the covariates on probability of adoption among farmers in the zone. The results also showed that the decision on application of biological control agent against *Chilo suppressalis* is determined by education level (EL), family size (FS), experience in rice culture (ER) and rate of participation in educational-extensional activities (EE) which have significant influence. Also, the Wald indicating the relative contribution of individual variable to probability of adoption of biological control of *Chilo suppressalis* showed that EL (5.314) was the one most important factor determining choice of application of biological control agent for control of *Chilo suppressalis* among the rice farmers (Table 6).

CONCLUSION AND RECOMMENDATION

According to results of this investigation main important factors of adoption of biological control including education level, family size, experience in rice culture, rate of participation in educational- extensional activities. Hosseini and Niknami [13] reported that 1-There was not any significant relationship between the adoption of innovations by farmers and variables of watching T.V programs, size of land-holding, cost of chemical inputs and recommendation of family members. 2- There was significant statistical relationship between educational level, type of land ownership, easy access to *Trichogramma*, low cost of biological control, complexity of spraying, contact with extension agent and adopting *Trichogramma*. Educational level play important role on this innovation adoption in many studies. According to results recommend that the first need to promote training for farmers with high potential in various adoption of biological control that can increase the tendency to new technology. Second, propagator must be attending to the economic characteristics and conditions of the farm associated to social characteristics of farmers. It should ultimately improve the usefulness of biological control in rice fields. Economic analyses of biological control programs are a valuable input into the decision-making process for biological control programs [18]. The basic criterion is that a biological control program should be considered when the benefits are greater than the costs. However, assessing all benefits and costs to a biological control program presents a challenge due to the different ways that uncertainty enters the analysis. Uncertainty is present in both the technical aspects of completing a biological control program and in the values of the costs and benefits. Detail studies on these aspects seem essential in future. The results of this study indicates that advancing the knowledge of diffusion process in Iran would be useful in developing extension programs and their effectiveness specially in new strategies as sustainable agriculture.

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