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Perceptions of Greenhouse Vegetable Growers Regarding Use of Biological Control Practices: A Case Study in Jiroft County, Iran

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***Abstract*—**The main purpose of this study was to investigate perception of greenhouse vegetable growers regarding use of biological control practices during the growing season. The statistical population of the study included greenhouse vegetable growers in Jiroft county (N=1862). A sample of 137 vegetable growers was selected, using random sampling method. Data were collected via a questionnaire. The validity of the instrument was obtained by the faculty members of the Department of Agricultural Development and Management in the University of Tehran. Cronbach's alpha was applied to estimate the reliability which showed a high reliability for the instrument. Data was analyzed using SPSS/Windows 13.5. The results revealed that greenhouse vegetable growers had moderate level of perception regarding biological control practices. Levels of vegetable growers' perceptions regarding biological control practices were different on the basis of their academic qualifications as well as educational level and job. In addition, the results indicated that about 54.1% of variations in vegetable growers' perceptions could be explained by variables such as awareness of biological control practices, knowledge on pests, annual production and age.

***Keywords*—**Greenhouse, biological control, biological agents, perception, vegetable grower.

I. Introduction

USE of pesticides in crop production has expanded rapidly worldwide since the 1950s [1] and farmers have depended principally on chemical technologies to cope with pests and create profits in their enterprises [2]. Consequently, emergence of pest resistance to pesticides is one of the major negative aspects of pesticide application, compound by a widespread claim that chemicals are harmful to human health and the environment [3]-[5]. The necessity of an ecological-friendly farming system coupled with consumers' desire for food free from synthetic chemicals has made Integrated Pest Management (IPM) as a scientific paradigm in producing safe food [6]. IPM refers to the management of pests by applying different pest control practices [7]. Biological control techniques attract increasing attention as one of the sustainable alternatives to pesticide use in IPM programs [8]. Biological Control (BC) is based on the use of natural enemies of pests, often referred to as BC agents. These are predators and parasitoids of invertebrate pests, and herbivores attacking weed pests [9] to reduce the pests' density and damage to a level lower than would occur in their absence [10].

Decisions on pest control practices including BC are quite subjective and may depend on several characteristics of farmers, including personal beliefs, perceptions, and preferences [11]. Reference [12] found that age, educational level, extension workshops, and video programs had positive and significant correlation with adoption of Trichogramma wasp for BC by farmers. Reference [13] found that income and educational level influenced willingness to use BC. The importance of educational level on adoption of IPM technologies including BC had been cited in previous works [14], [15]. High levels of knowledge about pest and IPM practices had a positive relationship with levels of IPM practices adoption by farmers [16], [17]. Reference [18] indicated that farmers' awareness toward effectiveness of biocontrol agents had positive relationship with farmers' confidence of BC. Land size, annual income, utilization patterns and knowledge of farmers were positively and significantly correlated with level of technology adoption [19]. Level of IPM technologies adoption among farmers who had participated in extension activities and FFS programs was more than farmers who had not participated [20]-[23]. Reference [24] found that the level of adoption of technology was poor because of the poor frequency of extension contact that would have enhanced the adoption of the innovation.

Greenhouse crop production is now a growing reality throughout the world with an estimated 405 000 ha of greenhouses spread over all the continents. The degree of sophistication and technology depends on local climatic conditions and the socio-economic environment. During the last 20 years, countries in the Mediterranean climate area have become increasingly competitive producers of greenhouse vegetables. During this time, there has been a revolution in greenhouse production technology [25]. The world greenhouse area is estimated at approximately 310,000 ha. Vegetable crops are grown in about 65% of greenhouses, and ornamentals in the remaining 35%. Since 1981, the surface areas with greenhouse have increased more than 100%, with an increase of 4.4% per year [26]. Greenhouse production has great importance in Iran, and greenhouse crops are currently grown on 6158 ha mainly in southern and central parts of Iran. The greenhouse area allocated to vegetables is about 3483 ha of which 1150 ha is concentrated in Jiroft county-mainly

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cucumber and tomato with 98.5% ha [27]. Vegetable crops are grown from September to late May in cold and mild climate areas. Due to high value of vegetables in off-seasons, growers are highly interested in producing these crops in greenhouses. Currently greenhouse vegetable growers (GVGs) are consuming more than 64 types of chemical pesticides for producing vegetables including cucumber, tomato, and strawberry [28].

Pests are major challenge to greenhouse production. Greenhouse environment represents an isolated ecosystem that can be conducive to outbreaks of arthropod pest population [29]. Spider mites, aphids, thrips, greenhouse whiteflies, and leaf miner are serious greenhouse insect pests [30]. Greenhouse environment, on the other hand, allows natural enemies of pests to be used as effective means of control and thus in many countries BC is now being applied in protected cultivation commercially [31]-[33].

Since the use of BC agents to manage pests in greenhouses has received much attention [34] and in order to have a more effective impact on promoting wide spread use of BC practices, concentrating on growers' perceptions regarding BC practices can be more fruitful. Hence, this study attempts to investigate perceptions of GVGs regarding use of BC practices. The objectives of this study were to investigate:

- GVGs' awareness and use of BC agents,
- GVGs' perceptions regarding use of BC practices,
- Factors associated with GVGs' perceptions regarding use of BC practices.

II. Material and Methods

This study was carried out in Jiroft County, which is located in Kerman province (one of the main site of greenhouse farming in Iran). In Jiroft County the climate is mild for most of the year, except in summer that hot weather prevails. In the sampled greenhouses well and gasoline were the most sources of water supply (97.1%) and used fuel (79.6%), respectively. Greenhouses were mostly protected with plastic covers (95.6%). The statistical population of the study consisted of GVGs (N= 1862) of Jiroft County. By applying Cochran's formula, a sample of 137 vegetable growers was selected, using random sampling method.

From a review of literature, a questionnaire was developed which captured respondents' demographic characteristics, knowledge of pests (35 items), perceptions of BC practices (8 items), awareness about BC agents (9 items), and use of BC agents (9 items). Validity of the questionnaire was obtained by scientific board members at Department of Agricultural Development and Management, University of Tehran. The reliability of the instrument was measured by calculating Cronbach's Alpha coefficient, a measure of internal consistency. The reliability of the instrument for various questions varied from 0.90 to 0.96 that showed a high reliability for the instrument [35].

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 13.5. Descriptive an inferential statistics (e.g. frequency, percentage, mean, standard deviation, correlation coefficient, t-test, Mann-Whitney U test, Kruskal–Wallis test, and multiple regression analysis) were applied to analyze the collected data. Pearson's and Spearman's correlation coefficient were applied to test the relationship between study variables and GVGs' perceptions regarding BC practices. GVGs' perceptions regarding BC practices by academic major, educational level, and job were examined using Mann-Whitney U test, Kruskal–Wallis test, and t-test respectively. In order to measure the influence of the independent variables on a dependent variable (GVGs' perceptions) stepwise multiple regression procedure was conducted.

III. Results and Discussion

A. Demographic Characteristics

Demographic characteristics of the sampled population showed that 94.9% of the respondents were male and 5.1% were female. The respondents were on average 39 years old and the mode was in the age class 31-40 years old (35.8%). Meanwhile, 21.9% of the respondents belonged to age class of under 31 years old followed by 31.4% 41-50 years old and 10.9% above 50 years old. Academic major of 32.8% of the respondents were agriculture. In contrast, 67.2% of those educated at majors except agriculture. More than half of the respondents (57.7%) worked in greenhouses as their main jobs and 42.3% of those worked in greenhouses as their second jobs.

B. GVGs' Awareness and Use of BC Agents

Table I shows GVGs' levels of awareness and use of BC agents. The respondents had the highest awareness on Lady beetle and Trichocard. On the contrary, they were less aware of Nanocide and BTiran. About GVGs' use of BC agents, the findings revealed that Trichocard and Trichoderma were used more than the other biological agents. The respondents' level of awareness regarding biological agents was 8.84 (out of 45) and their level of biological agents use was 5.23 (out of 45), both of those were less than the middle of scale spectrum.

C. GVGs' Perceptions Regarding BC Practices

Items comprising GVGs' perceptions regarding BC practices are presented at Table II. The mean score of GVGs' perceptions regarding BC practices was close to the middle of scale spectrum (20.27 out of 40), signified that the respondents had medium level of perception about BC practices.

The correlation analysis indicated a significant relationship ($p<0.01$) between GVGs' perceptions regarding use of BC practices and variables such as greenhouse acreage (r= 0.490**), extension agents visits of greenhouse (r= 0.312**), attendance in extension workshops (r= 0.246**), and knowledge about pests (r= 0.222**). Moreover, production yield (r= 0.188*), and awareness of BC practices (r= 0.197*) were positively and significantly ($p<0.05$) correlated with GVGs' perceptions regarding use of BC practices. Age was negatively and significantly ($p<0.05$) correlated with GVGs' perceptions regarding use of BC practices (r= -0.169*).

TABLE I
THE EXTENT OF GVGS' AWARENESS AND USE OF BC AGENTS

SD	Mean	Awareness							Use						Mean	SD
		Very much	Much	Moderate	Little	Very little	Not at all		Not at all	Very little	Little	Moderate	Much	Very much		
2.16	2.08	9.4	12.9	24.7	7.2	5.9	38.9	Lady beetle	72.2	10.1	8.9	5.1	3.7	0	0.58	1.09
1.51	1.09	0	11.1	16.0	3.7	8.6	60.6	Trichocard	53.5	14.8	10.2	10.2	10.2	1.1	1.12	1.46
1.41	1.00	1.3	6.4	12.8	9.0	11.5	59.0	Trichoderma	66.7	9.9	8.6	8.6	6.2	0	0.77	1.27
1.32	0.86	0	8.1	8.1	8.1	13.5	62.2	*Chrysoperla carnea*	69.2	16.7	10.2	1.3	2.6	0	0.51	0.92
1.51	0.86	6.8	2.6	6.8	4.1	13.5	66.2	Spinosad	82.9	5.3	2.6	2.6	6.6	0	0.44	1.12
1.27	0.81	0	6.6	6.6	13.2	9.2	64.4	Orocide	78.1	9.0	9.0	2.6	1.3	0	0.39	0.85
1.17	0.75	0	2.7	10.8	10.8	10.8	64.9	BT	71.6	11.1	3.7	9.9	3.7	0	0.63	1.66
1.82	0.71	0	2.7	10.7	10.7	6.6	69.3	Nanocide	80.5	6.5	9.1	1.3	2.6	0	0.38	0.91
1.15	0.68	0	5.4	4.1	10.8	13.5	66.2	BTiran	78.2	7.7	10.2	2.6	1.3	0	0.41	0.87

TABLE II
PERCEPTION OF GVGS REGARDING USE OF BC PRACTICES

practice	Absolutely disagree (%)	Disagree (%)	Medium (%)	Agree (%)	Absolutely agree (%)	Mean	SD
Use of biological control cause human health	0.8	0.0	18.7	24.4	56.1	4.34	0.84
Use of biological control cause increase in vegetable prices	5.1	5.9	28.0	29.6	31.4	3.76	1.11
It is better to combine biological and chemical practices	0.8	3.4	19.8	56.2	19.8	3.90	0.81
Chemical pesticides are more expensive than using biological agents	11.4	16.2	47.2	17.1	8.1	2.94	1.05
Chemical pesticides are more effective than using biological agents	13.3	26.7	42.5	8.3	9.2	2.73	1.09
It is better to use chemical pesticides more than biological agents	17.4	39.6	28.1	12.4	2.5	2.42	0.99
Keeping chemical pesticides for long term is easier than maintenance of biological agents	16.8	24.4	40.3	10.1	8.4	2.69	1.12
Access to chemical pesticides is easier than access to biological agents	23.0	43.4	18.0	4.9	10.7	2.36	1.20

The Mann-Whitney U test for examining probable differences between GVGs' perceptions regarding BC practices with respect to academic major showed significant difference (1427.500, P=0.017*) between perceptions of the two groups so that those farmers with academic education in agriculture had more favorable perception than those did not have academic education in agriculture. The result of Kruskal-Wallis test for examining probable differences in GVGs' perceptions regarding BC practices according to educational level revealed that there were significant differences among various groups of farmers so that the farmers with higher education level had more positive perceptions on using BC practices compared to their counterparts (Table III).

TABLE III
RESULTS OF KRUSKAL-WALLIS TEST

Variable		Mean Rank	Chi-square	Sig.
Educational level	Illiterate	60.35	4.675	0.001**
	Secondary school	63.88		
	High school	73.83		
	Post high school	74.74		
	Bachelor of science	76.16		
	Master of science	84.13		
** p<.01				

The t-test showed that perceptions of GVGs whose main job was growing vegetable in greenhouses (Mean= 20.96) was significantly different (t= 0.871, p<0.01) and higher in terms of mean score than those farmers whose main job was not growing vegetable in greenhouses and followed this activity as second job (Mean= 19.34).

D. Regression Analysis

In order to explain variations in GVGs' perceptions regarding BC practices, a multiple regression analysis was conducted. Among independent variables that have significant correlation with dependent variable, GVGs' awareness of BC practices, knowledge of pests, annual production and age have entered into the regression equation by four steps. These variables explained 54.1% of variation in GVGs' perceptions regarding BC practices.

Considering the results shown in Table IV, regression equation in standard situation will be as:

$$Y = \text{constant} + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4$$

where: Y= score of GVGs' perception, X_i = independent variable, B_i = coefficient of independent variable. Consequently, the final equation of regression is:

$$Y = 578.425 + 8.734\ AOBCP + 40.222\ KOP + 13.385\ AP - 8.921\ AGE$$

Results of regression analysis showed that growers' awareness of BC practices (Beta= 0.428) could explain the most variation of GVGs' perceptions regarding use of BC practices.

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TABLE IV
REGRESSION ANALYSIS FOR VARIABLES ASSOCIATED WITH GVGS' PERCEPTIONS REGARDING BC PRACTICES

Description	Label	Unstandardized coefficients	Standardized coefficients	t	Sig.
		B	Beta		
Constant		578.425	-	3.115	0.002
GVGs' awareness of BC practices	AOBCP	8.734	0.428	8.462	0.000
GVGs' knowledge of pests	KOP	40.222	0.289	5.470	0.000
Annual production	AP	13.385	0.236	4.360	0.000
Age	AGE	-8.921	-0.149	-2.733	0.007

IV. DISCUSSION AND CONCLUSION

BC is one of the important tools for all countries to tackle existing and future pest problems. This study examined GVGs' perceptions regarding use of BC practices as an influential element toward adoption and application of biological agents for pest management in greenhouses. GVGs with an agricultural academic degree had more favorable perception regarding BC practices as compared to their counterparts who graduated from non-agriculture academic disciplines. In addition, perception of GVGs who adopted growing greenhouse vegetables as their main job was more favorable than those who adopted this activity as their second job. Accordingly, it is concluded that academic education as well as experience and dependency to this job are main sources of forming perception of the respondents about growing vegetable in greenhouse conditions. They went field trip in farms and greenhouses during the academic period, and they participated in training courses at farms or greenhouses for a semester. They were more knowledgeable of side effects from pesticide use, IPM and different pest control methods including BC. Vegetable growers who greenhouse farming is their main job are more familiar with market competition. They know that for a healthy and balanced living, one has to consume basic food products, which fresh and healthy fruit and vegetables are a part of, it. It was also cited by [36] in their study. They know more than their counterparts that people pay more for healthy vegetables and the fact that chemical pesticides create serious acute health problems. So, they had more positive perceptions regarding use of BC practices and also, they applied biological agents compared to their counterpart.

In this study, GVGs had medium level of perception regarding BC practices. Hence, it is imperative that extension agents' state advantages of using biological agents to GVGs. Delivery methods such as workshops, field demonstration, and preparation and distribution compact discs, journals, and video programs regarding BC and its related matters are proper methods to achieve this goal. Awareness of BC practices, knowledge of pests, and attendance in extension workshops were significantly correlated with GVGs' perceptions regarding BC. These results are consistent with the results of [17], [18], [12]. There was significant correlation between extension agents visits of greenhouses and GVGs' perceptions regarding BC. Frequency of extension contact can enhance the adoption and use of the innovation. GVGs showed low level of awareness on biological agents. They were the least aware of Nanocide and BTiran. Also, they showed low level of biological agents use. Trichocard was applied more than the other biological agents. Therefore, GVGs need additional knowledge and awareness as a necessity in the use of BC agents. They must be knowledgeable about BC and its related subject matters including useful biological agents, their maintenance and so forth. Therefore, it is recommended to establish extension workshops to increase GVGs' knowledge and awareness regarding BC practices.

The findings revealed that GVGs' perceptions regarding BC were correlated with their Internet skills and computer use. This finding refers to the fact that information is a powerful tool in addressing agricultural needs and if it is used appropriately, it can radically change a nation's economy [37]. The Internet provides the means for access to valuable information, which vegetable growers can access to valuable data in the shortest time and minimal costs. Growers for access to any required information should be well skilled about computer and the Internet. Hence, it is imperative to enhance computer and Internet skills of vegetable growers by establishing educational courses about computer and the Internet. Age was negatively correlated with GVGs' perceptions regarding use of BC practices. To explain the finding we can say the older growers had lower educational levels. Therefore, their knowledge and awareness on BC practices was less than younger and more educated growers. GVGs' perceptions regarding BC and production yield were correlated. To explain the finding we can say growers who are more familiar with market situations should produce better crops to thrive in the complex markets. Consumers desire for healthy crops. Producing vegetables free from synthetic chemicals and acquainting consumers with non-toxic crops will result more demand for these crops and therefore, growers' production yield and their final profits will be increased. Consequently, this cycle will repeated and growers use biological agents to control pests and producing healthier vegetables again. Finally, it is recommended to provide incentives such as easy access to biological agents for improving adoption and application of BC practices by GVGs.

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