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Identification of Strategies for Application of Pro-Environmental Technologies to Produce Greenhouse Vegetables

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ABSTRACT

The present study aimed to identify strategies for the application of pro-environmental technologies for greenhouse vegetable production in Tehran Province, Iran. It is an applied research type whose main instrument is a questionnaire. The population of the study consisted of 109 experts in Tehran Province, of which 86 experts were selected by stratified random sampling method (based on Krejcie and Morgan's table). The questionnaire was revised with the help of the experts who had significant experience in crop protection to ensure the validity of the instrument. A pilot study was conducted on 22 experts in Alborz Province to determine the reliability of the questionnaire. Cronbach's Alpha scores were acceptable for different sections of the questionnaire (0.71-0.82), so, the instrument was reliable. The research methodology is descriptive, and the SWOT analysis was used. First, the internal environment was analyzed to prepare a list of strengths and weaknesses in applying pro-environmental technologies, and then, a list of opportunities and threats were identified by analyzing the external environment. Some derived strategies include the development of appropriate mechanisms to control the sale and use of pesticides by removing barriers to registration, mass production, storage, handling, transport and consumption of biological agents, and reinforcement of the knowledge of greenhouse owners regarding biological control.

Keywords: Applied research, Biological control, Pesticides, SWOT analysis.

INTRODUCTION

Environmental impacts of agricultural activities have changed the environmental conditions of soil, water, and food chain (UNEP, 2010). Environmental concerns such as the depletion of natural resources, soil, air and water pollution, and chemical residues in foods have become important topics in agricultural production (Patel *et al*., 2007). While government policies have contributed to improving agricultural practices in some countries, progress has been relatively small in reducing environmental pollution from agricultural sources, reflecting a sector with many diverse actors (Sutton *et al*., 2013).

In recent decades, greenhouses have been widely used to produce agricultural products, greenhouse crops, and especially high consumption vegetables. It is quite possible to increase yield per unit area in a controlled environment like greenhouses because all factors affecting plant growth are under control. Also, greenhouses contribute to saving water use because sunlight is controlled, the rate of surface evaporation is reduced, there are no hot and dry waves in the vicinity of the plant, and new irrigation

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methods can be used, so that the rate of water use efficiency in a typical greenhouse is about 5-10 times that of open-space crops (Rezaverdinejad *et al*., 2017). Vegetable production is one of the most important agricultural activities; however, the growing trend of the use of chemical pesticides in recent years has shown that lack of crop safety has seriously damaged consumers' health (Plazibat *et al*., 2016; Jayasooriyaa and Aheeyar, 2016). Greenhouse crop production is now a growing reality throughout the world with an estimated 405,000 ha of greenhouses spread all over the continents. The degree of technology sophistication depends on local climatic conditions and the socio-economic environment (FAO, 2013).

The use of agricultural pesticides is rapidly increasing in many developing countries (Schreinemachers *et al*., 2017), and this has serious impacts on the environment and human health (Houbraken *et al*., 2016; Schreinemachers *et al*., 2017). Pests' incidence has negatively affected the productivity of agricultural crops. The use of inputs such as pesticides to achieve greater profitability is a serious problem in food production systems. Pesticide residues in fruits and vegetables are one of the highest concerns of consumers that seek to access safe food (Hadian *et al*., 2019). According to Morteza *et al*. (2017), an average of about 14,000 tons of chemical pesticides, expressed in active ingredients, is annually imported to, or manufactured in, Iran (Morteza *et al*., 2017).

Pro-environmental behavior can be defined as a conscious behavior that intentionally pursues the reduction of the negative impact of human activities on the natural world and contributes to environmental sustainability (Sawitria *et al.*, 2015; Valizadeh *et al*., 2018; Unsworth *et al*., 2013). Bijani *et al*. (2017) suggest that pro-environmental behaviors are measures or actions that directly affect the environment and lead to soil and water conservation and environmental sustainability. Many researchers have categorized pro-environmental actions and behaviors into sustainable activity (e.g. creating sustainable products and processes), avoiding harm (e.g. preventing pollution), conserving (e.g. reusing), and influencing others (e.g. educating and training for sustainability) (Sawitria *et al.*, 2015; Unsworth *et al*., 2013). In this study, pro-environmental technologies include technologies such as Integrated Pest Management (IPM) or biological control methods that are consistent with the rational use of resources and are environmentally friendly.

IPM, as a pro-environmental practice, is a sustainable approach for managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health, and environmental risks (Geetanjly *et al*., 2015). Considering the high importance of vegetables in the food basket of people, the importance of safe vegetable production with an emphasis on reducing the use of chemical pesticides and using biological products, the issue of sustainable agriculture, and the production of healthy crops in Iran has started since the last decade and has been followed more closely in recent years (Javanmardi and Sattar, 2016). According to the World Health Organization, 1.6 million lives are annually lost due to diseases caused by pesticides (WHO, 2018). So far, there has not been a comprehensive policy document for implementing management interventions to control the use of pesticides in Iran. The use of poor quality pesticides leads to environmental pollution; however, farmers use pesticides for agricultural production inappropriately and irregularly (Damari *et al*., 2015). One of the causes of this problem is the existence of illegal shops of pesticides; other reasons are the lack of adequate supervision over the sale of products containing excessive amounts of pesticides, farmers' lack of awareness, traditional modeling of other farmers, and the sale of pesticides without health plant prescription (Hadian *et al*., 2006; Damari *et al*., 2015).

According to what was stated, the conceptual framework of the present research was adapted from Trivedi and Ahuja (2011), Parsa *et al*. (2014), Ram (2015), Kerdsriseam and Suwanmaneepong (2015), Baudino *et al*. (2017), Schroeder *et al*. (2013), Jovovic and Jankovic (2013), Aubert *et al*. (2013), Dennis *et al*. (2010), and MNP (2013) (Meyers Norris Penny; a leading business consulting in Canada involved in biological control of pests and plant diseases among its various fields of work). They have referred to various factors in four domains of strengths, weaknesses, opportunities, and threats to apply pro-environmental technologies to produce greenhouse vegetables. Many authors have highlighted some of the strengths, weaknesses, opportunities, and threats regarding the use of environmentally friendly technologies in agricultural production with sustainable practices. For example, Ram (2015) concluded that the lack of awareness of environmental pollution, the lack of information about recent pest management strategies, the lack of proper technical knowledge about eco-friendly practices, farmers' unawareness of adverse effects of chemicals and pesticides, the lack of proper training on eco-friendly agricultural practices by related organizations, the lack of knowledge about the balanced use of chemicals and pesticides, the limited availability of organic manures like compost, and the high costs of eco-friendly technologies were the major constraints faced by the majority of growers. The proper training of eco-friendly agricultural practices increases the opportunity for the availability of raw materials for compost, green manures, bio-fertilizer, bio-pesticide, etc., improves farmers' awareness of environmental pollution, and provides technical guidance and subsidy for inputs such as hybrid seeds, bio-fertilizers, bio-pesticides, etc. Greater publicity should be achieved through different media like radio and TV broadcasts and campaign, and the provision of credit facilities has been the major suggestion of farmers (Ram, 2015).

Baudino *et al*. (2017) used the SWOT analysis to formulate strategies and provide potential solutions for environmental, social, and economic issues in the environmental sustainability of kiwifruit and Baby kiwi in Italy. They showed that the strengths included higher crop quality, higher income, the weaknesses included arising from the lack of knowledge, high prices, high labor costs, and the opportunities included the opportunity to implement sustainable agricultural practices of organic production, improve the level of technological innovation, and participate in the fruit market of Europe (Baudino *et al*., 2017). According to Parsa *et al*. (2014), the major threats in applying IPM technologies include the strong influence of pesticide industry, limited access to IPM extension publications and knowledge, and the high price of IPM. Trivedi and Ahuja (2011) pointed out the protection and strengthening of natural enemies as a strength and undesirable effects on non-target organisms as a threat. According to Houbraken et al. (2016), problems regarding residual pesticides, human health and environmental protection form the strength. The opportunities were noted by Ivanova-Peneva (2014) to include increasing demand for healthy products, development of distribution channels, and raising awareness. Khatam et al. (2010) prepared a long list of strengths including reducing production costs, promoting knowledge of farmers, avoiding pesticides, promoting plant protection recipes, increasing managerial skills, increasing trust in the agricultural community, changing farmers' attitudes, providing a better environment, improving socio-economic conditions, increasing income, affordability in nature. They also noted heavy costs and

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time-consuming process as the weaknesses.

In the other reviewed literature, the researchers have enumerated the strengths as the protection and strengthening of natural enemies, concerns regarding residual pesticides, human health and environmental protection, reducing production costs, promoting knowledge of farmers, avoiding pesticides, promoting plant protection, improving procedures, increasing managerial skills, increasing trust in the agricultural community, changing farmers' attitudes, providing a better environment, improving socio-economic conditions, increasing income, and affordability in nature (Trivedi and Ahuja, 2011; Houbraken *et al*., 2016; Khatam *et al*., 2010). Khatam *et al*. (2010) have noted high costs and time-consuming processes as the weaknesses. Opportunities have been listed by Ivanova-Peneva (2014) to include increasing demand for healthy products, development of distribution channels, and raising awareness. Trivedi and Ahuja (2011) have mentioned undesirable effects on non-target organisms as a threat.

To the best knowledge of authors, previous studies have sparsely focused on the barriers of technology adoption in the field of sustainable development, with few studies addressing the identification of management approaches to adopting environmentally-friendly technologies for greenhouse vegetable production. This is the contribution of the present research.

Given the increasing use of pesticides in a broad variety of crops in Iran and the importance of public concerns about possible health risks of pesticide residues (Hadian *et al*., 2006; Damari *et al*., 2015), the main purpose of this study was to investigate the major strengths, weaknesses, opportunities, and threats facing the application of pro-environmental technologies to produce greenhouse vegetables in Tehran Province, where these technologies are expected to be extended to a great extent due to proximity to responsible institutions such as the Ministry of Agriculture Jahad, and the development of strategies (competitive, aggressive, defensive, and conservative) to improve adoption of pro-environmental technologies by farmers.

MATERIALS AND METHODS

This study was an applied research work. The research was a descriptive study based on the SWOT analysis. The SWOT technique has been widely used in various fields by researchers because of its simplicity and applicability. After the internal factors (strengths and weaknesses) and external factors (opportunities and threats) are identified, the key factors are distinguished from the non-key factors. At this stage, the strategies are derived from the intersection of the factors (David, 2011). The SWOT analysis can be done in two ways: Quantitatively (by using a researcher-made questionnaire) and qualitatively (by doing interviews with experts).

The entities related to the environmental technologies can be divided into three groups: plant protection, producers of biological products, and plant protection clinics. At the first step, these three groups were specified. Then, their experts were randomly sampled. The items of the questionnaire were developed on the basis of the review of the theoretical and experimental literature as well as expert opinions. According to the statistics of Jihad-e Agriculture Organization of Tehran Province, the statistical population was composed of 109 experts of environmental technologies in the relevant organizations and agencies including Plant Protection Office of Jihad-e Agriculture Organization of Tehran Province (29 individuals), plant protection clinics (62 individuals), and biological products manufacturers (18 individuals). Then, 86 experts were selected based on Krejcie and Morgan (1970)'s table by the stratified random sampling method. Eventually, the data of 83 questionnaires were subjected to analysis.

To collect the data, we developed a questionnaire in four sections for strengths (14 items), weaknesses (17 items), opportunities (16 items), and threats (16 items). A five-point Likert scale ranging from 1 (very low) to 5

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(very high) was used for the measurement, and the final part contained demographic questions about age, educational level and so on. Some items were derived from the literature review and some from interviews with managers and experts of the Ministry of Agriculture Jihad. Content and face validities of the instrument were confirmed by a panel of experts consisting of faculty members of Agricultural Extension and Education Department, Tarbiat Modares University, and some specialists from the Ministry of Agriculture Jahad. A pilot study was conducted in Alborz Province to determine the reliability of the questionnaire, and Cronbach's Alpha ranging from 0.71 to 0.82 was achieved. The initial and follow-up mailings generated 83 usable responses from experts, so the response rate was 96.5 percent.

Descriptive statistics (frequencies, percentages, means, and standard deviations) was used for data analysis to accomplish the objectives of the study. Some wording and structure of the instrument were altered based on the recommendations of the panel of experts. A pretest was conducted with 22 experts to determine the reliability of the questionnaire. Computed Cronbach's Alpha scores were acceptable for different sections of the questionnaire (Table 1), implying the reliability of the instrument.

To calculate the relative importance of each item, we first averaged the items pertaining to strengths, weaknesses, opportunities, and threats separately. Then, all the averages were summed and divided by their number to yield the overall average. The relative importance of a certain item was obtained from dividing the average of that item by the overall average. Then, the experts were asked to assign weights to the factors. To this end, with respect to the information derived from the questionnaire in the first round, the items of strengths, weaknesses, opportunities, and threats were averaged to give the net score. To obtain the factor score of a certain item, the relative importance of that item (derived from the questionnaire of the first round) was multiplied by the net score (derived from the questionnaire of the second round) to yield the factor score of that certain item. The factor score was the basis of ranking the items.

Table 1. The reliability of the research questionnaire.

Section	Number of items	Cronbach's Alpha
Strengths	14	0.717
Weaknesses	17	0.760
Opportunities	16	0.828
Threats	16	0.743

RESULTS AND DISCUSSION

Demographic and Vocational Characteristics of Respondents

The demographic characteristics of the respondents are presented in Table 2. The average age of experts was about 36.6 years and the majority of them were male (54.2%). Investigation of the educational level of the respondents indicated that 49.4% had a Bachelor's degree. Their experience in plant protection was, on average, 9.6 years with the highest frequency (73.5%) for less than 10 years (Table 2).

Internal and External Environments' Analysis

The present study sought to identify strengths, weaknesses, opportunities, and threats associated with the application of pro-environmental technologies to produce greenhouse vegetables in Tehran Province.

Strengths

According to the results reported by MNP (2013) and Ram (2015), the most important components of strengths were the possibility to protect natural enemies of pests, the lack of chemical residues in vegetable products,

Table 2. The socio-economic characteristics of respondents (n= 83).

Variable	Frequency	Percent	Mean	SD
Age (Year)			36.6	0.66
25-34	33	39.8		
35-44	38	45.8		
45-54	9	10.8		
No response	3	3.6		
Gender				
Male	45	54.2		
Female	38	45.8		
Educational level				
Bachelor's degree	37	44.6		
Master's degree	41	49.4		
PhD.	5	6		
Work experience (Year)			9.6	0.67
≤ 10	61	73.5		
11-20	12	14.5		
21-30	9	10.8		
No response	1	1.2		
Field of study				
Plant protection[a]	27	32.5		
Plant pathology	19	22.9		
Agricultural entomology	14	16.9		
Agronomy and plant breeding	12	14.5		
Horticulture	2	6		
Agricultural management	2	2.4		
Agricultural extension and education	2	2.4		
Other disciplines		2.4		

[a] This field of study focuses on identifying pests and diseases of plants, whereas crop protection constitutes the next step and aims to cope with and control the identified pests and diseases.

and the reduced level of environmental pollution (Table 3).

Weaknesses

Table 4 summarizes the respondents' attitudes towards the weaknesses of adopting pro-environmental technologies. By weakness, we mean a kind of constraint or limitation in resources, skills, facilities, and abilities that evidently hinders the effective performance of an innovation. According to Table 4, major weaknesses included low technical knowledge of some producers about pro-environmental technologies, the lack of greenhouse owners' awareness to access and use environmentally-friendly technologies, and the lack of biological control agent for all pests (Table 4). This is in line with Baudino *et al*. (2017) and Dennis *et al*. (2010).

Opportunities

Opportunity refers to variables that are the drivers of a movement, accelerating its pace. The results showed that the major opportunities included the capacity of collaborations with producers to test environmentally-friendly technologies, creating the necessary conditions for healthy crop production and food security, and feeling the need to increase the producers' knowledge about pro-environmental technologies (Table 5).

Threats

The main threats were found to include the lack of a proper mechanism for controlling the sale and consumption of pesticides, the lack of some greenhouse owners' cooperation for

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Table 3. The strengths of pro-environmental technologies to produce greenhouse vegetables.

Row	Items	Mean (Net score)	Relative importance[a]	Factor concession[b]	Rank
S1	The consumer's trend to use safe products	4.084	0.999	4.081	6
S2	Possibility of more effective pest control using biological pesticides	3.951	0.928	3.669	11
S3	Possibility of cost savings	4.036	0.911	3.678	10
S4	Non-resistance to pests with pro-environmental pesticides	4.072	1.022	4.164	5
S5	Possibility to prevent the increase in the transitional population of pests	3.698	0.905	3.347	14
S6	Possibility to protect natural enemies of pests	4.132	1.081	4.469	1
S7	Diversify the skills of greenhouse owners by applying pro-environmental technologies	3.819	0.886	3.386	13
S8	Controllability of some generations of resistant pests to poisons by biological agents	3.807	1.034	3.938	7
S9	Lower costs of pest management in the long term	3.903	.975	3.808	8
S10	The lack of chemical residues in vegetable products	3.891	1.093	4.254	2
S11	The reduced level of environmental pollution	3.951	1.069	4.227	3
S12	The protection of the safety of greenhouse workers	3.746	1.116	4.184	4
S13	Possibility of the establishment of biological agents in greenhouses	3.698	.999	3.695	9
S14	More tendency of greenhouse owners to produce safe crops	3.626	.975	3.538	12
Total mean of strengths: 3.86; Source: Research findings (2018)					

[a] Relative importance= (Total mean)/(Mean of each item). [b] Factor concession= Net score×Relative importance.

Table 4. The weaknesses of pro-environmental technologies to produce greenhouse vegetables.

Row	Items	Mean (Net score)	Relative importance	Factor concession	Rank
W1	The need for specific monitoring of the application of biological control	3.771	1.021	3.850	10
W2	The need for high investment (required bio-products and monitoring tools)	4.072	.974	3.969	8
W3	Excessive sensitivity to weather conditions	4.192	.974	4.086	7
W4	The impossibility of easy control of many pests by biological agents	3.337	.928	3.099	16
W5	The lack of biological control agent for all pests	4.216	1.093	4.611	3
W6	Possibility of jeopardizing the efficiency of biological agents due to transportation and delays in entering	3.771	.998	3.765	12
W7	The long-term production of biological agents by some manufacturing companies	3.903	.927	3.619	14
W8	Problems with recording, mass production, storage, transportation and use of biological agents	4.000	1.058	4.233	5
W9	The high cost of initial use of pro-environmental technologies	3.337	.915	3.054	17
W10	Decreasing the benefit margin of some products and negative effect of manufacturers' willingness to invest in production	4.253	1.010	4.297	4
W11	The shorter shelf life of biological agents than conventional pesticides	3.771	.962	3.630	13
W12	Very high levels of biological agents' casualties	4.000	.962	3.851	9
W13	Lack of greenhouse owners' awareness of access and use of environmentally-friendly technologies	4.132	1.129	4.666	2
W14	Contradiction between supply of environmentally-friendly technologies with the demand of producers	4.072	1.034	4.211	6
W15	Complexity of biological control operations in greenhouses	3.566	.915	3.264	15
W16	Low technical knowledge of some producers about pro-environmental technologies	4.397	1.131	4.976	1
W17	The need for the consecutive release of biological agents due to crop rotation in greenhouse	3.987	.950	3.792	11
Total mean of weaknesses: 3.823; Source: Research findings (2018)					

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Table 5. Opportunities of pro-environmental technologies to produce greenhouse vegetables.

Row	Items	Mean (Net score)	Relative importance	Agent privilege	Rank
O1	Existing capacities in society to increase consumer's awareness of healthy crops	3.927	.935	3.675	13
O2	Existing public perception of the value of products produced with pro-environmental technologies	3.819	.879	3.360	14
O3	Greenhouse workers' skills and their experience in the use of pro-environmental technologies	3.565	.913	3.903	9
O4	Feeling the need for pro-environmental technologies by reducing access to conventional pesticides	3.650	.857	3.131	16
O5	Increasing capacity for pro-environmental technologies and finding indigenous sources	4.084	1.013	4.140	4
O6	The advancement of pro-environmental pesticides	3.831	.969	3.712	12
O7	Increasing the effectiveness of pro-environmental technologies by reducing the use of chemical pesticides	4.084	.957	3.912	8
O8	Producers' understanding of how to effectively use pro-environmental technologies	3.831	1.067	4.088	6
O9	Increasing the public health in society	3.879	1.035	4.018	7
O10	Feeling the need to increase the producers' knowledge about pro-environmental technologies	3.759	1.104	4.153	3
O11	Capacity of collaboration with producers to test environmentally-friendly technologies	4.012	1.145	4.594	1
O12	Supporting the pro-environmental technologies of producers	3.397	.957	3.254	15
O13	Increasing the wide range of bio-pesticides	3.831	.980	3.755	11
O14	Creating the necessary conditions for healthy crop production and food security	4.096	1.120	4.590	2
O15	Possibility to provide biological agents by domestic producers	3.951	.980	3.873	10
O16	Simplification of the export process of agricultural products with regional standards	3.807	1.080	4.113	5

Total mean of opportunities: 4.080; Source: Research findings (2018)

monitoring affairs, and widespread activities of chemical pesticides' production and distribution companies (Table 6). This is consistent with the findings of Kerdsriseam and Suwanmaneepong (2015), Parsa *et al*. (2014), and Ram (2015).

After extracting the integrated strategies derived from the SWOT matrix in a two-dimensional coordinate table, the mean points on the *x*-axis were summed together and the points of the *y*-axis were summed together and point obtained from their sum was plotted on the axis. Then, the intersection of the two points was plotted on the *x* and *y*-axes. The directional vector was drawn from the coordinates' origin of the graph to the new intersection point, which shows the dominant strategic point (Figure 1).

After identifying the strengths and weaknesses (internal factors) and opportunities and threats (external factors) and identifying the key factors, the strategy suggestions are derived from the SWOT matrix. Finally, in order to provide a suitable strategy, the average Strengths and Opportunities (SO) were calculated with the average of total Weaknesses and Threats (WT) and compared with one another.

Based on this study, most identified strengths, weaknesses, opportunities, and threats have also been reported by previous studies such as Parsa *et al*. (2014), Ram (2015), and Trivedi and Ahuja (2011). According to the findings, the mean of Weaknesses and Threats (WT) was more than the average of Strengths and Opportunities (SO) [(125.63) WT> (119.42) SO]. The proposed strategy for improving the adoption and applying the pro-environmental technologies to produce greenhouse vegetables in Tehran Province

Table 6. Threats to pro-environmental technologies to produce greenhouse vegetables.

Row	Threats	Mean (Net score)	Relative importance	Agent privilege	Rank
T1	Limiting access to pro-environmental pesticides markets by increasing import barriers	3.807	.959	3.653	10
T2	High costs of pro-environmental technologies	3.843	.857	3.365	15
T3	The lack of a proper mechanism for controlling the sale and consumption of pesticides	4.084	1.115	4.556	1
4T	The possibility of the advent of new pests	3.518	.904	3.183	16
T5	The lack of easy access to biological control technologies versus chemical control	3.746	.959	3.595	13
T6	The lack of some greenhouse owners' cooperation with monitoring affairs	4.216	1.079	4.552	2
T7	Slow effects of biological agents	3.951	1.007	3.981	7
T8	Low technical knowledge of public and private sector experts about pro-environmental technologies	4.108	1.043	4.287	5
T9	Probability to limit border access to bio pesticides due to biosecurity and the threat of terrorism	3.686	.980	3.613	12
T10	The possibility of reducing the attractiveness of biological control by introducing affordable chemical pesticides	3.963	1.019	4.041	6
T11	The lack of regulations on the use of chemicals in the production of greenhouse crops	3.783	.959	3.630	11
T12	Measuring the effects of pro-environmental technologies with economic criteria	3.831	1.007	3.860	9
T13	The absence or defect of some protective installations, such as greenhouse lace and cover	3.614	.980	3.542	14
T14	Inadequate technical support by companies producing environmentally-friendly technologies	3.879	1.076	3.909	8
T15	The lack of notification to increase producers' awareness about the benefits of pro-environmental technologies	4.192	1.031	4.325	4
T16	Widespread activities of chemical pesticides' production and distribution companies	4.081	1.067	4.360	3

Total mean of threats: 3.789 Source: Research findings (2018)

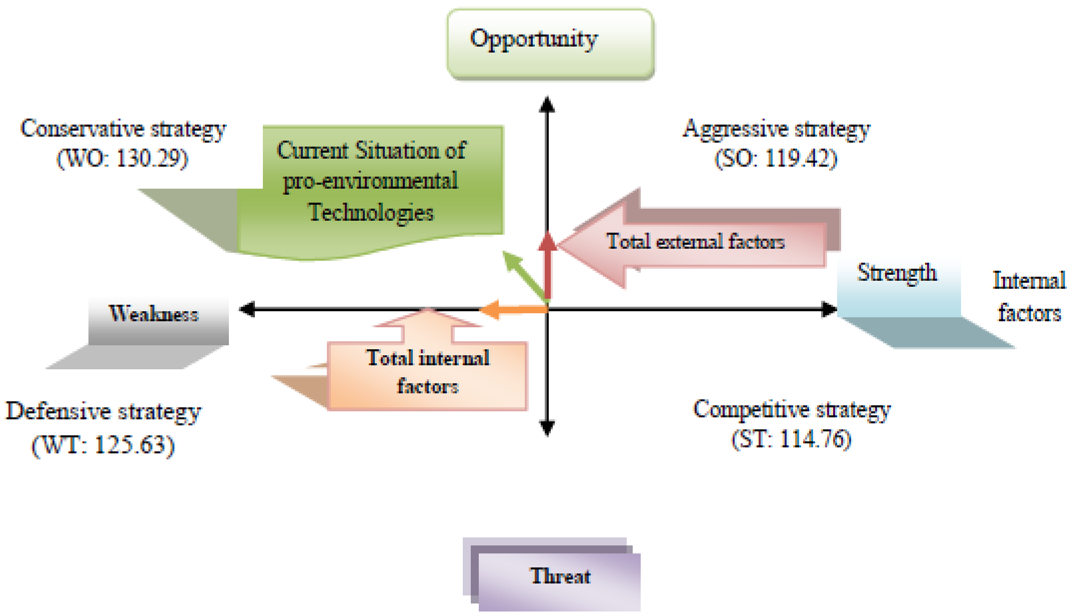

Figure 1. The strategic area of applying pro-environmental technologies such as IPM in greenhouse vegetables in existing conditions (Source: Research findings).

will be the combination of conservative and defensive strategy. In strategies' formulation, the internal and external factors in the SWOT matrix were compared with each other to prepare possible strategies as a result of the SWOT analysis. Since the average of total weaknesses and opportunities is greater than the average of total strengths and threats in this research, the most important strategy used to improve applying pro-environmental technologies such as IPM is the conservative strategy. In this strategy, we try to overcome the internal weaknesses using external opportunities. In other words, a major component of this strategy is to take advantage of the benefits of opportunities to compensate for the weaknesses.

The findings reveal that informed use of pesticides can prevent serious incidents for the environment, farmers, and consumers. Accordingly, the more informed the farmers are about the harmful side-effects of pesticides, the less unnecessary use they make of them. Therefore, a strategy recommendation is to increase their knowledge and awareness. Other strategies that can be effective in improving the use of pro-environmental technologies such as IPM, as well as those that are less effective, are discussed below (Table 7).

Table 7. The SWOT matrix and the suggested strategies.

		Strengths	Weaknesses
Internal factors / External factors		1. Possibility to protect natural enemies of pests; 2. Lack of chemical residues in vegetable products; 3. Reduction of environmental pollution 4. Protection of the health of greenhouse workers 5. Non-resistance to pests with pro-environmental pesticides	1. Low technical knowledge of some producers about pro-environmental technologies; 2. Lack of greenhouse owners' awareness of access and use of environmentally-friendly technologies; 3. Lack of biological control agent for all pests; 4. Decreasing the benefit margin of some products and negative effect of manufacturers' willingness to invest in production; 5. Problems with recording, mass production, storage, transportation and use of biological agents
Opportunities	1. Capacity of collaborations with producers to test environmentally-friendly technologies; 2. Creating the necessary conditions for healthy crop production and food security; 3. Feeling the need to increase producers' knowledge about pro-environmental technologies; 4. Capacity growth of pro-environmental technologies and finding indigenous sources; 5. Simplification of the export process of agricultural products with regional standards	**Aggressive strategies (SO)** 1. Reduction of the amount of pollution with pesticides by creating the necessary conditions for healthy crop production and food security; 2. Simplification of the export process of agricultural products that have regional standards 3. The use of growth capacity of pro-environmental technologies and local resources to protect the natural enemies of pests	**Conservative strategies (WO)** 1. Reinforcement of the knowledge of the greenhouse owners regarding biological control; 2. Enhancement of the greenhouse owners' awareness of access and use of pro-environmental technologies by strengthening cooperation and the implementation of pilot projects in greenhouses; 3. Establishment of arena for healthy crop production and food security by supporting manufacturers to use pro-environmental technologies
threats	1. Lack of proper mechanism for controlling the sale and consumption of pesticides; 2. The lack of some greenhouse owners' cooperation with monitoring affairs; 3.Widespread activities of chemical pesticides' production and distribution companies; 4. The lack of notification to increase producers' awareness about the benefits of pro-environmental technologies 5. Low technical knowledge of public and private sector experts about pro-environmental technologies	**Competitive strategies (ST)** 1. Attracting greenhouse owners' participation in monitoring the chemical residues in vegetables in cooperation with public sector and plant protection clinics. 2. Establishing the appropriate mechanisms to monitor the sales and use of pesticides to reduce pollution by pesticides 3. Promotion and extension of pro-environmental pesticides	**Defensive strategies (WT)** 1. Development of appropriate mechanisms to control the sale and use of pesticides by removing barriers to registration, mass production, storage, handling, transport and consumption of biological agents 2. Enacting legislation on monitoring by experts and appointing a technical crop protection expert in greenhouses 3. Inform to increase producers' awareness regarding benefits of pro-environmental technologies 4. Reinforcing and supporting the private sector producers for research and development activities regarding biological pesticides especially on the production and registration of new products

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CONCLUSIONS

The increasing acreage of greenhouses in recent years has been accompanied by the increasing significance of their pests and diseases, and producers attempt to control them by chemicals. However, this approach growingly jeopardizes the health of greenhouse vegetable consumers who usually consume them fresh. This study identified conservative and defensive strategies to be the most important strategies in pro-environmental technologies. It seems that increasing knowledge and awareness of producers is an effective strategy requiring urgent attention. Since the high costs of pro-environmental technologies will hinder the application of such pro-environmental technologies as IPM, incentives for applying them should be well emphasized.

According to the findings, policymakers and planners should try more to implement short-term strategies like training and extension of pro-environmental technologies to improve production management and pests and diseases control practices. Also, emphasis should be placed on long-term strategies including strengthening the private sector that produces pro-environmental technologies and making regulations for technical monitoring to pave the way for the replacement of conventional approaches to production management with pro-environmental-based methods.

The fact that the study was innovative caused fewer resources at researchers' disposal. Therefore, a major limitation of the research was the lack of internal resources to compare the results. With respect to the assessment of the effects, consequences, and effectiveness of the strategies, it should be remembered that these analyses are the limitation of the present study. In future research, it is recommended to analyze the cost-effectiveness of these strategies and consider the opinions of farmers and greenhouse owners in addition to experts.

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شناسایی راهبردهای بکارگیری فناوری های زیست محیط‌گرایانه در تولید سبزیجات گلخانه‌ای

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چکیده

پژوهش حاضر با هدف شناسایی راهبردهای استفاده از فناوری های زیست محیط‌گرایانه در تولید سبزیجات گلخانه ای در استان تهران انجام شده است. تحقیق از نوع کاربردی و ابزار اصلی آن پرسشنامه است. جامعه آماری پژوهش، شامل ۱۰۹ نفر از کارشناسان استان تهران بودند که ۸۶ کارشناس

به روش نمونه گیری تصادفی طبقه بندی شده (بر اساس جدول رجیس و مورگان) انتخاب شدند. برای اطمینان از اعتبار ابزار، پرسشنامه با کمک کارشناسانی که دارای تجربه قابل توجهی در حفظ نباتات بودند؛ مورد تجدید نظر قرار گرفت. برای تعیین پایایی پرسشنامه آزمون مقدماتی بر روی ۲۲ کارشناس در استان البرز انجام شد. میزان آلفای کرونباخ برای بخش‌های مختلف پرسشنامه قابل قبول (۰/۸۲–۰/۷۱) و گویای قابلیت اعتماد ابزار بود. روش تحقیق، توصیفی و از تحلیل SWOT استفاده شده است. ابتدا با تحلیل محیط داخلی، فهرستی از نقاط قوت و ضعف پیرامون پذیرش فناوری‌های زیست محیط-گرایانه در تولید سبزیجات گلخانه‌ای تهیه و سپس با واکاوی محیط بیرونی فهرستی از فرصتها و تهدیدها شناسایی گردید. برخی از راهبردهای استخراج شده شامل ایجاد سازوکار مناسب برای کنترل فروش ومصرف سموم با رفع موانع مربوط به ثبت، تولید انبوه، نگهداری، حمل و نقل و مصرف عوامل بیولوژیک؛ و تقویت دانش گلخانه‌داران در زمینه کنترل بیولوژیک است.

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