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Analyzing Impacts of Farmer Field School on the Economic, Social, Production, and Knowledge Status of Greenhouse Owners: Evidence from Tehran Province and its Surrounding Counties

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ABSTRACT

The purpose of this study was to analyze effects of using Farmer Field School (FFS) on the economic, social, production, and knowledge status of greenhouse owners in Tehran Province and surrounding, Iran. The research method was a comparative causal study. The statistical population was composed of 80 greenhouse owners who had participated in FFS program as treatment group and 716 owners who had not participated in this program, as the control group. Sample size for non-participant group was determined to be 152 people using the Cochran formula. They were chosen by simple random sampling method. The results of comparative tests indicate that the two groups significantly differ in crop marketability, job creation, production risk, cooperation, participation in social organizations and entities, use of macro and micro fertilizers, application of organic fertilizers, application of pesticides, and technical knowledge of safe crop production. However, there were no significant differences in annual income, marketing, and crop yield. The structural analysis also indicates that the FFS program has had some positive effects on participants in economic, social, production, and knowledge aspects.

Keywords: Capacity building, Extension approach, Integrated pest management, Sustainable agriculture.

INTRODUCTION

Greenhouse crop production has attracted interest during recent years due to the population growth, the demand for summer crops throughout the year, and the limitations of water resources. Greenhouses allow off-season and highly efficient crop production by providing the appropriate conditions like optimum temperature throughout the year and the protection of the plants against physical and climatic stresses. Quality is a top priority for greenhouse crops, so, more attention should be paid to pests and diseases. Therefore, production technologies and integrated plant protection operations are considered as guidelines to minimize the use of pesticides in greenhouse crop productions (Reddy, 2015).

The best approach to preventing and alleviating damages by pests and diseases in greenhouse production is to emphasize on the principles of sustainable agriculture and integrated pest management practices as the conserving technologies. This approach enables greenhouse owners to reduce the utilization of agrochemicals and pesticides and make the production of safe crops economical. Greenhouse management for pest and disease control depends on a variety of factors, including local climate, exogenous pest and disease outbreaks, greenhouse design, the availability of climate control equipment, and greenhouse owners' skill (Abdel Wali, 2013). Farmer Field School (FFS) is a comprehensive research and learning approach that is the key to realize sustainable agriculture in general and Integrated Pest Management (IPM) in particular. It aims to reduce the application of pesticides and

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fertilizers and to produce safe crops with a close care for the environmental considerations by building capacity among farmers (Thijssen, 2002; Mancini *et al.,* 2008). FFS is an innovative extension approach in response to failures of conventional extension models and linear process of technology transfer in the form of extension messages to farmers. It was first introduced by FAO in Indonesia as a solution to harness the extensive application of pesticides and the subsequent environmental problems. This holistic, farmer-based approach motivates the use of local knowledge and farmers' participation by their mobilization (FAO, 2006, 2016). FFS is based on the precise recognition of pests and diseases, the interactions between farming and ecology, and participation in farms, just to list a few examples. Some argue that the main goal of FFS is a combination of empowering farmers, encouraging their participation, improving their decision making, helping them acquire critical thinking skill, and improving small-scale farmers' subsistence by practical activities (Tripp *et al.,* 2005; Bunyatta *et al.,* 2006).

So far, the experiences of different countries show that farmers' training by FFS approach has brought developmental effects in different dimensions. Impact assessment reveals the success of IPM/FFS approach in enhancing farmers' knowledge and their empowerment in the field of integrated production and pest management. Some major long-term economic and production effects of FFS, known as developmental benefits, can be listed as the improved production management, improved livelihood, farmers' empowerment in dealing with risks, opportunities and ideas, lower groundwater contamination due to lower consumption of chemicals, improved marketability and, finally, alleviated rural poverty. This approach has some short-term consequences, too. Examples include the reduction of pesticide usage, the increase in yield and production profit, and the mitigation of production risk (Van den Berg *et al.,* 2002). According to a review of 25 impact evaluations on IPM/FFS programs in different countries, these programs have succeeded in effectively reducing the use of pesticides and increasing the yield (Van den Berg, 2004). In a study by Tripp *et al.* (2005), it was concluded that there was a significant difference in cropping area, pest control knowledge, and attitudes toward pest control between farmers who had participated in FFS program and those who had not, such that they were higher among farmers who had attended FFS program. However, the two groups of farmers did not differ significantly in yield, income, and education level. Ooi and Kenmore (2005) Found that FFS had a significant impact on the use of biological control methods. Also, this approach improved farmers' income and knowledge. In Thailand, FFS has had environmental impacts, including the reduction of chemical pesticide use in the short and long term, but it has failed to increase crop yields of the trained farmers (Praneetvataku and Waibel, 2006). In a study in India, Mancini *et al.* (2008) concluded that age, literacy level, pesticide application rate, the frequency of pesticide application, knowledge, and decision-making power differed significantly among cotton growers who had participated in FFS and those who had not. However, participation in FFS could not change their average cropping area significantly. A study in Mozambique showed that FFS approach has been effective on empowering participants, improving the interactions between farmers and extension agents towards the development of agriculture potentials for problem analysis, enhancing decision-making, and improving group work. Also, it has been successful in improving the relationship between researchers and farmers. It seems to be effective in boosting the empowerment at individual and organizational levels, too (Dzeco *et al.,* 2010). In a study on the impact of IMP/FFS programs in Jember district of Indonesia, (Rostam, 2010) concluded that the program was effective on farmers' knowledge significantly. Also, FFS improved three aspects of the skills of farmer communities: (a) The ability to design activities to improve the productivity of the agribusiness; (b) Agreeing and implementing agreements with other institutions and the adoption of technology, information, and group work; (c) Adoption and diffusion of IPM by farmers; and d) Farmer-to-farmer diffusion of IPM skills. In Ethiopia, FFS implementation has led to a significant increase in farmers' income, which is attributable to the adoption of modern agricultural practices such as new varieties (Todo and Takahashi, 2011). A study in East Africa revealed that FFS programs could improve the

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production and income of low-educated women and smallholder farmers (Davis *et al.,* 2012). An analysis of the FFS project in three countries in East Africa suggests that these programs can enable local people to make decisions and ultimately increase their role in agricultural innovation, access to services, market access, and collective activities (Fariis-Hansen and Duveskog, 2012). In another study on the impact of FFS in East Africa, it was revealed that the implementation of this project has had a positive impact on the production and income of low-educated women and small and medium farmers. In general, participation in the FFS program has led to higher production and income among smallholders and higher crop productivity (Davis *et al.,* 2012). Khatam *et al.* (2014) state that the main goal of FFS is to create capacity in farmers so as to enable them to analyze crop production and production systems, identify and rank issues, test possible solutions, and finally, adopt the most appropriate operations. This is capacity building through the process of FFS cooperative learning that helps farmers adopt the most profitable production technology recommendation in response to different agro-ecological conditions. Training organized through the FFS approach helps farmers improve their capacities to make critical decisions about creating more productive, profitable, and sustainable production systems (Khatam *et al*., 2014). A study in northern Tanzania reported the effectiveness of FFS on food security, but it did nothing to alleviate poverty (Larsen and Lilleqr, 2014). Kariyasa (2014) found that the FFS program on integrated corn management in Indonesia improved farmers' productivity, income, and welfare and, overall, it boosted the competitive advantage of this country in corn production. Farmers participating in FFS programs benefit from outputs improved through causal chain including knowledge and from the adoption of useful operations, crop production, and its profits. Nonetheless, this evidence has been derived more from small-scale projects. There is no evidence of positive impacts for larger FFS programs implemented at a national level and in a longer period (Waddington and White, 2014). Bunyatta *et al.* (2015) concluded that FFS of soil and crop management had a significant effect on knowledge acquired by participants. Also, participants and non-participants of these programs differed significantly in agronomic and utilization systems. In a study in Kenya, Chimotia *et al.* (2015) found that FFS programs influenced tea farmers positively, including the increased production of green tea leaves, farmers' enhanced willingness to engage in collective activities, developed mobilization and interactive participation, transfer and adoption of agricultural technologies, increased access to agricultural information and knowledge, and, overall, improved agricultural productivity. An empirical evaluation of FFS in China indicates that the program has improved the knowledge of farmers about pest management and agro-environmental issues, but it has failed to influence nutrition management and farming knowledge. However, these effects have been marginal on women and the elderly (Guo *et al.,* 2015). An analysis of the impact of FFS in China indicates that this approach has increased farmers' production, especially among safe crops producers with small farms and high education levels (Cai *et al.,* 2016). Bhutto *et al.* (2018) reported that the implementation of FFS among Pakistani cotton farmers improved their decision-making skills and their understanding and knowledge of the standard cotton system and the interactions between pests and beneficial insects through the use of natural enemies and compost technology. Also, farm-wide observations and experiments had significant impacts on the use of environment-compatible biological pesticides.

In Iran, although several years have passed since the implementation of the FFS approach, it has been subject to limited research. The followings are some cases: Musavian and Karamidehkordi's (2015) study in Eastern Azerbaijan Province of Iran showed that the FFS project improved farmers' knowledge of IPM. The farmers, however, were unable to operationally use the recommended knowledge of pest biological control on a large scale at their farm level. The decrease in chemical herbicide use may partially be attributed to the increase in farmers' knowledge, but other factors are involved too. A study in Khuzestan Province, Iran, showed that FFS was partially successful in improving farmers' knowledge of the adverse consequences of overuse of chemical herbicides and pesticides, acquainting them with protective technologies like integrated pest management, reducing pesticide application and costs, and

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producing safe crops (Karami Dehkordi *et al*., 2012).

In Iran, the scheme of reducing chemical herbicide and fertilizer use has been planned and initiated by the Ministry of Agriculture, since 1994. Then, attempts intensified to propose alternative plans. Subsequently, the IPM/FFS model project commenced by the cooperation of the Extension Deputy of the Ministry of Jihad-e Agriculture and the UNDP Global Environmental Finance (UNDP/GEF) first in two provinces of Guilan and Semnan in 2002, and then, in 30 provinces containing about 400 regions (implementation sites) and over 30 topics and crops by 2008 (Farjadnia, 2008). In Tehran Province, the implementation of FFS dates back to 2004 in Varamin County (Heidari *et al*., 2006). Since the development of greenhouse production and reduction and optimization of chemical fertilizer and herbicide use are among the cornerstone strategies of the Ministry of Jihad-e Agriculture for safe crop production, the FFS program is continuously developed for greenhouse crops (Deputy of Agriculture Extension and Training, 2011). In Iran, 9,500 ha of lands are planted by greenhouse summer crops (mostly cucumber and tomato) of which 1,952 ha (20 percent of acreage) is devoted to greenhouse production of summer crops in 1362 modern units and 624 traditional units in Tehran Province. The production rate of these greenhouses amounted to about 524,900 t in 2016 (Organization of Agriculture- Jihad-Tehran, 2016). Also, studies by the Ministry of Jihad-e Agriculture in 2007 revealed that after the plans for reducing the use of chemical herbicides and fertilizes and IPM/FFS were implemented, pesticide use per unit area (ha) decreased from 2.19 L in 2000 to 1.48 L in 2006, but their consumption rate is still higher than the global standards (Maleksaeidi *et al*., 2010). Now, one decade after the implementation of FFS across some greenhouses in Tehran Province, the main question of the present study is what impacts the implementation of the FFS program have had on greenhouses of this province from an economic, social, production, and knowledge aspects. Since some resources and efforts have been spent on implementing FFS in Tehran Province in the recent decade, it is necessary to identify the economic, social and production impacts of the FFS program on the greenhouses of Tehran Province as a center of greenhouses in Iran.

The review of literature leads us to the conclusion that FFS encompasses a long period of crop planting through the design and implementation of training programs with production, economic and social nature. The emergence of FFS is attributed to the focal model that has been adopted for building field schools. According to this model, FFSs are continuously established in the proximity of one another to, finally, shape a cluster. This will foster interaction, exchange, and sharing of contribution and the horizontal flow of information across different groups, resulting in faster sharing of innovation and rich sources of local knowledge. The emphasis on experimental and cooperative learning in FFS will encourage participants to participate and will deepen their understanding of observation skills, crop ecology, and problem analysis and solving. In this method, an individual is not only responsible for her/his own learning, but she/he also helps her/his peers to achieve collective goals. Therefore, the training methodology of FFS helps accomplish the learning based on action and experience via discovery, comparison, and the non-hierarchical relationship among learners and facilitators (Lucia, 2006; Okoth *et al*., 2006). Also, cooperative learning is a learner-based approach that is established on the basis of social learning theory. This theory is related to social growth and group attempts to discover, understand and solve problems. Since FFS is based on the principles of experimental and cooperative learning and learning happens through action, this learning is more effective and sustainable. Accordingly, the theoretical framework of the present study was based on the theory of experimental and cooperative learning encompassing three fields of technical, practical, and empowering/emancipating learning in knowledge, production, economic and social dimensions (FAO, 2016). According to the literature reviewed above and the theoretical framework of the research, the impacts of implementing FFS in economic, social, production and knowledge dimensions are presented within the conceptual framework of the study as below (Figure 1). Accordingly, the major objective was to analyze the effects of adopting FFS on greenhouse owners of Tehran Province

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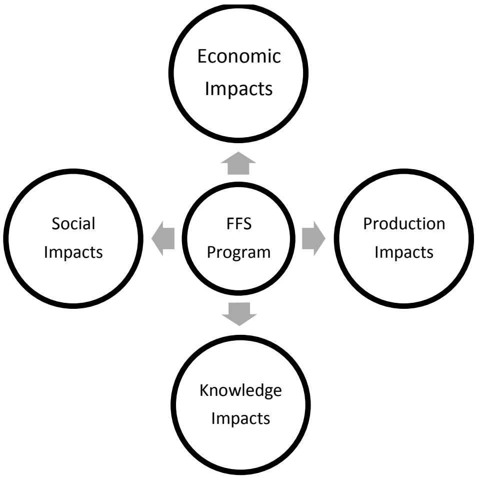

Figure 1. Conceptual framework of the effects of farmer field school on greenhouse owners.

and determining the effect of FFS program on the improvement of economic, social, and production status, and knowledge of the greenhouse owners in Tehran Province.

MATERIALS AND METHODS

The present work was an applied study in terms of purpose and a comparative causal study in terms of methodology and a quasi-experimental research in term of controlling variables. The statistical population was composed of two groups of greenhouse owners producing summer crops in Tehran Province and its surrounding counties (the counties of Varamin, Pakdasht, Savojbolagh and Shahriar). The first group included the greenhouse owners who had participated in FFS programs (80 people), and the second group included those who did not attend these programs (716 people). The sample size was determined by Cochran's formula (Equations 1 and 2).

$$n = \frac{N(t.s)^2}{\mathrm{Nd}^2 + (t.s)^2} \quad (1)$$

Where, n= Sample size; N= Population; t= 1.96; d= Sampling error, s= Standard deviation.

$$n = \frac{716*(1.96*1.42)^2}{716*(0.2)^2+(1.96*1.42)^2} = 152 \quad (2)$$

After the sample size was estimated, it was taken from the population of greenhouse owners who had not already participated in FFS courses using the proportional assignment formula (Equation 3) for each county. In which n is the sample size obtained from Cochran's formula (152 greenhouse owners), Ni represents the statistical population in each county, the denominator shows the total size of the population in the studied counties (716 greenhouse owners), and ni exhibits sample size in each county. Thus, a pre-test was administered to 30 greenhouse owners in Alborz Province outside the main population. Accordingly, the sample size was determined to be 152:

$$ni = \frac{Ni}{\sum_{1=1}^{m} Ni} * n \quad (3)$$

The results of pre-testing did not reveal a high difference and variance in the studied variables within the population of non-participant greenhouse owners, so, the samples were taken by simple randomization with a proportional assignment. The census method was applied to select the group of greenhouse owners who had participated in FFS program as the treatment group given the size of this group. The number of greenhouse owners in different counties of Tehran Province is shown in Table 1.

The research instrument was a questionnaire. Also, in order to study the face and content validity of the questionnaire, some copies of the questionnaire were handed to faculty members of the university and Plant Protection Research Institute, experts of Jihad-e - Agriculture, and facilitators of FFS programs. The reliability of the research instrument was tested by estimating Cronbach's Alpha. The coefficient of internal consistency was calculated to be in the range of 0.84-0.91 for different sections of the questionnaire, indicating the high consistency and stability of the research questionnaire. Due to the drawbacks of Cronbach's Alpha, we applied Composite Reliability (CR) method (Zumbo, *et al.*, 2007). The validity of the questionnaire was estimated by diagnostic validity method using the coefficient of Average Variance Extracted (AVE). Constructs with AVE> 0.5 are said to be valid (Iglesias, 2004). These values are listed in (Table 2).

Data were collected between January and February 2015 by interviews with greenhouse owners. Data were analyzed using descriptive statistics and statistical analysis consisted of *t*-test, Mann-Whitney test, correlation matrix

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Table 1. Statistical distribution of greenhouse owners in Tehran Province.[a]

Sr No	County	Number of greenhouse owners participating in FFS programs (Treatment group)	Number of greenhouse owners not participating in FFS programs (Control group)	Sample size (Control group)
1	Varamin (Pishva)	25	403	85
2	Pakdasht (Filestan)	25	103	22
3	Savojbolagh (Chaharbaq)	15	190	40
4	Shahriar	15	20	5
5	Total	80	716	152

[a] Source: (OAJT1, 2015)

Table 2. Coefficients of Cronbach's Alpha, composite reliability, and diagnostic validity.

Variable	Cronbach's Alpha	Composite reliability	Diagnostic validity
Production impacts	0.84	0.81	0.68
Economic impacts	0.90	0.89	0.90
Social impacts	0.91	0.81	0.91
Knowledge impacts	0.89	0.90	0.81
FFS program	0.92	0.88	0.93

analysis, structural equations modeling, and Multiple Indicators Multiple Causes (MIMIC) models. MIMIC models are complicated models that require the use of latent variables (constructs) that are measured by several observable variables and are predicted or influenced by several other observable variables (Schumacker and Lomax 2010). The statistical analyses were carried out using SPSS V.18 and LISREL V.8.5 software packages.

The variables of the study were divided into two groups: independent and dependent variable. The dependent variables included the economic, social, production and knowledge impacts of FFS by encompassing four characteristics: (1) Production impacts (lower rates of macro-fertilizer use, per 10 m^2 , ratio scale); (higher rates of micro-fertilizer use, per 10 m^2 , Ratio scale); (higher yield per unit area, kg m^2, interval scale); (lower rates of pesticide use, liter per 100 m^2, ratio scale); (higher rates of organic fertilizer use, per 10 m^2, ratio scale); (2) Economic impacts (higher annual income, Rial per year, interval scale); higher marketability (Likert –type scale ranging); higher marketing (Likert –type scale ranging); increased job creation (per 1000 m^2, interval scale); lower production risk (percent, ratio scale); (3) Social impacts (higher participation of greenhouse owners, Likert–type scale ranging); participation in associations and social entities based in the villages, Likert–type scale ranging); and (4) Knowledge impacts (tacit knowledge for the production of safe crops based on sustainable farming patterns and integrated pest management, Likert–type scale ranging); (explicit knowledge for the production of safe crops based on sustainable farming patterns and integrated pest management, Likert–type scale ranging). The independent variable was the implementation of FSS (frequency of participation in the program, ratio scale) and (frequency of contact with facilitators in each period, ratio scale).

RESULTS

Characteristics of Treatments and Control Groups

Table 3 summarizes some attributes of participants including age, experience in

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agricultural activities, yield per unit area, acreage, micro- and macro-element fertilization rate, organic fertilization rate, pesticide application rate, application of non-chemical practices for the control of pests and diseases, and the consideration of pre-harvest interval before crop harvest.

Comparative Impacts of FFS Program

To explore the impacts of FFS programs on greenhouse owners in Tehran Province, we made a comparison in economic, social, production, and knowledge terms between people who participated in these programs and those who did not. Statistical tests showed significant differences between the studied groups in terms of higher crop marketability, increased job creation, lower production risk, higher cooperation, participation in social associations and entities, micro- and macro-fertilization rate, organic fertilization rate, herbicide application rate, and technical knowledge of safe crop production. However, they did not significantly differ in increase in annual income, improved marketing and crop yield (Table 4).

Modeling

Since the comparison unfolds only differences, not impacts, it cannot yield a reasonable model. We tested a type of structural equations model. Thus, the research data were examined to confirm the validity and reliability of the evaluation and two measurement and structural models among research variables.

Measurement Model

To check the validity or reliability of the model, we should examine the level of significance of the paths between each latent variable and the relevant indicators. This was done by a confirmatory factor analysis to test the hypotheses. The results of this analysis are presented in Table 5 as the standardized value of the parameter, t-statistic value, standard error, and R^2. Given the fact that parameters with the values of greater than 2 are considered statistically significant, this table implies that the indicators applied to measure the latent traits of the study match the factor structure and theoretical framework of the research at an acceptable level. The reliabilities of the indicators could be examined by squared multiple correlation (R^2). According to Table 5, pesticide application rate had the highest and crop yield had the lowest R^2 among all indicators.

Table 3. Some characteristics of respondents.

Variable	Treatment group (FFS participant)	Control group (Non-participant)
Age (Mean)	44.5	36.8
Experience in agriculture (Mean)	6.5	5.8
Frequency of contact with facilitators in each period (Mean)	6	-
Production in each period (kg m^2)	15.1	13.8
Acreage (m^2)	5976.3	5064.47
macro-element fertilization use (Per 10 m^2)	2.4	2.7
micro-element fertilization use (Per 10 m^2)	0.42	0.22
organic fertilization use (Per 10 m^2)	9.5	7.94
Rate of pesticide application (Liter per 100 m^2)	1.3	2.66
Application of non-chemical methods for pest and disease control	Yes: 92.5 No: 7.5	Yes: 32.8 No: 67.2
Consideration of pre-harvest period at crop harvest time	Yes: 90.7 No: 9.3	Yes: 40.7 No: 59.3

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Table 4. Comparison of economic, social, production, and knowledge impacts of FFS programs between the treatment and the control groups.

Impact comparison	Variable	Statistical test	Mean		*P*-value
			Treatment group (FFS participants)	Control group (Non-participant)	
Economic	Increase in annual income	*t*-test	5.32	4.99	*t*= 0.93 *p*= 0.35
	Increase in crop marketability*	Mann-Whitney test	124.80	92.88	*Z*= -3.54 Sig= 0.00
	Improvement of marketing	*t*-test	344.3	380.1	*t*= -2.87 ρ= 0.06
	Increase in job creation*	*t*-test	22.8	17.93	*t*= 2.85 ρ= 0.00
	Reduction of production risk*	*t*-test	14.9	25.7	*t*= 17.39 $\rho = 0.03$
Social	Increase in cooperation*	Mann- Whitney test	125.80	98.88	*Z*= -2.91 Sig= 0.00
	Participation in social associations and entities*	Mann- Whitney test	130.56	97.00	*Z*= -3.60 Sig= 0.00
Production	Greenhouse yield	t-test	15.08	13.87	*t*= -1.15 $\rho = 0.25$
	Rate of macro-fertilizer use*	t-test	2.4	2.7	*t*= 2.97 $\rho = 0.00$
	Rate of micro-fertilizer use*	t-test	0.42	0.22	*t*= 6.60 $\rho = 0.00$
	Rate of organic fertilizer use*	t-test	9.5	7.9	*t*= 2.28 $\rho = 0.02$
	Rate of pesticide use*	t-test	1.3	2.66	*t*= -6.3 $\rho = 0.00$
Knowledge	Tacit knowledge of producing safe crops*	Mann- Whitney test	118.27	84.12	*Z*= -3.60 Sig= 0.00
	Explicit knowledge of producing safe crops*	Mann- Whitney test	121.18	83.87	*Z*= -3.56 Sig= 0.00

[*] P< 0.01

Table 5. Coefficient of standardized measurement and significance level of the confirmatory factor analysis for the latent traits.

Construct	Indicator	Standardized value	*t*-Statistic	Standard error	R^2
Economic (E)	Increase in annual income[a] (E1)	0.85	-	0.28	0.71
	Increase in crop marketability (E2)	0.87	21.18	0.21	0.77
	Improvement of marketing (E3)	0.89	20.09	0.21	0.77
	Increase in job creation (E4)	0.89	18.48	0.20	0.77
	Reduction of production risk (E5)	0.92	22.18	0.17	0.82
Social (S)	Increase in cooperation[a] (S1)	0.87	-	0.24	0.74
	Participation in social associations and entities (S2)	0.94	25.11	0.13	0.87
Production (P)	Greenhouse yield[a] (P1)	0.86	-	0.28	0.69
	Rate of macro-fertilizer use (P2)	0.84	20.11	0.26	0.70
	Rate of micro-fertilizer use (P3)	0.87	21.56	0.21	0.78
	Rate of organic fertilizer use (P4)	0.91	19.88	0.41	0.72
	Rate of pesticide use (P5)	0.92	26.07	0.23	0.89
Knowledge (K)	Tacit knowledge of producing safe crops[a] (K1)	0.86	-	0.16	0.72
	Explicit knowledge of producing safe crops[a] (K2)	0.87	22.36	0.14	0.70
FFS	Frequency of participation in FFS program (F1)	0.92	-	0.11	0.88
	Frequency of contact with facilitators in each period (F2)	0.90	21.56	0.18	0.86

[a] Since these variables were used as reference variables to determine the scale of latent variables and were considered fixed parameters, t-values were not calculated for them.

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Structural Model

After the measurement model was estimated, the second phase was to test the significance of the coefficients of paths assumed in the research model. Before estimating path coefficients, we calculated the coefficient of correlation between the model variables (Table 6).

This demonstrates the significant correlation between the studied latent variables. Accordingly, FFS variables were correlated most closely with the variables of production impacts and least closely with the variables of economic and knowledge impacts. Also, the coefficients in Table 7 demonstrate that implementation of FFS had the highest production impacts.

The direct effect of FFS on production impacts captures the greatest part of the correlation between these two variables (0.937). Also, the path coefficient in Table 7 reveals positive, significant relationship between FFS implementation and all impacts (t-value> 1.96). Thus, all paths are significant. The value of R^2 for economic, social, production, and knowledge impacts that is accounted for by the variable of FFS implementation is 0.85. This means that 85% of the impacts of FFS implementation can be determined by this study. The equation for the Economic Impact (EI), Social Impact (SI), Production Impact (PI), and Knowledge Impact (KI) of FFS Implementation (FFSI) is as in Equation (4), given the impact coefficients of Table 7:

$$FFSI = 0.17EI + 0.20SI + 0.68PI + 0.61KI \quad (4)$$

$$R^2 = 0.85$$

Results of goodness of fit indexes after its simplification and comparison with non-modified indexes indicates some trivial differences among indexes in model fit. Therefore, an acceptable economic model can be obtained by ignoring a very small part of fit, in which R^2= 0.78 for FFS implementation showing a very small loss. Overall, we can say that FFS implementation entailed some economic, social, production, and knowledge impacts on greenhouse owners in Tehran Province (Figure 2). The new equation for the impacts of FFS in economic, social, production and knowledge aspects can be built as in Equation (5), given the new impact coefficients:

$$FFSI = 0.15EI + 0.17SI + 0.67PI + 0.59KI$$

$$R^2 = 0.79$$

Finally, to check the extent to which the whole model was consistent with the applied data, the fit of the whole model was assessed by relevant goodness of fit indexes as listed in Table 8.

As is evident, all reported indexes are acceptable for the fit of overall model. Therefore, we can say that the model at whole is consistent with the data. According to these analyses, the empirical model of the research is presented in Figure 2.

Table 6. Correlation matrix of research constructs.

Constructs	Economic impacts	Social impacts	Production impacts	Knowledge impacts	FFS
Economic impacts	1				
Social impacts	0.913*	1			
Production impacts	0.857*	0.914*	1		
Knowledge impacts	0.828*	0.890*	0.898*	1	
FFS	0.853*	0.850*	0.937*	0.935*	1

* Significance at the 1% level.

Table 7. Coefficient of the impact of constructs on one another as well as significance level.

Path	Path coefficient	*t*-Value	Significance level
FFS → EI	0.17	2.51	0.01
FFS → SI	0.20	2.75	0.01
FFS → PI	0.68	8.89	0.01
FFS → KI	0.61	3.83	0.01

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Table 8. Goodness of fit indexes.

Index	Acceptable value	Reported value
Chi-square	-	259.52, Degree of freedom= 148
Root Mean square Residual (RMSR)	0.08>	0.02
Goodness of Fit Index (GFI)	0.9	0.99
Adjusted Goodness of Fit Index(AGFI)	0.9	0.99
Normed Fit Index (NFI)	0.9	0.93
Non-Normed Fit Index (NNFI)	0.9	0.92
Incremental Fit Index (IFI)	0.9	0.93
Comparative Fit Index(CFI)	0.9	0.93
Relative Fit Index(RFI)	0.9	0.91
Root Mean Square Error of Approximation(RMSEA)	0.08>	0.05

DISCUSSION

The results of the structural analysis indicate that FFS programs had desirable economic impacts on participant group such that they led to an increase in annual income, marketability, marketing, and job creation and a decrease in production risk among greenhouse owners who participated in the program. These findings are supported by Kariyasa (2014), Tripp *et al.* (2005), and Van den Berg *et al.* (2002). At present, it is argued that some issues in the agricultural sector in general and in the greenhouses, in particular, are not purely technical, but social in nature. Coping with these issues including plant pest and disease control, reduction of pesticide application, application of biological practices, and the environmental protection, all require coordinated collective action. FFS programs have the potential to encourage farmers to

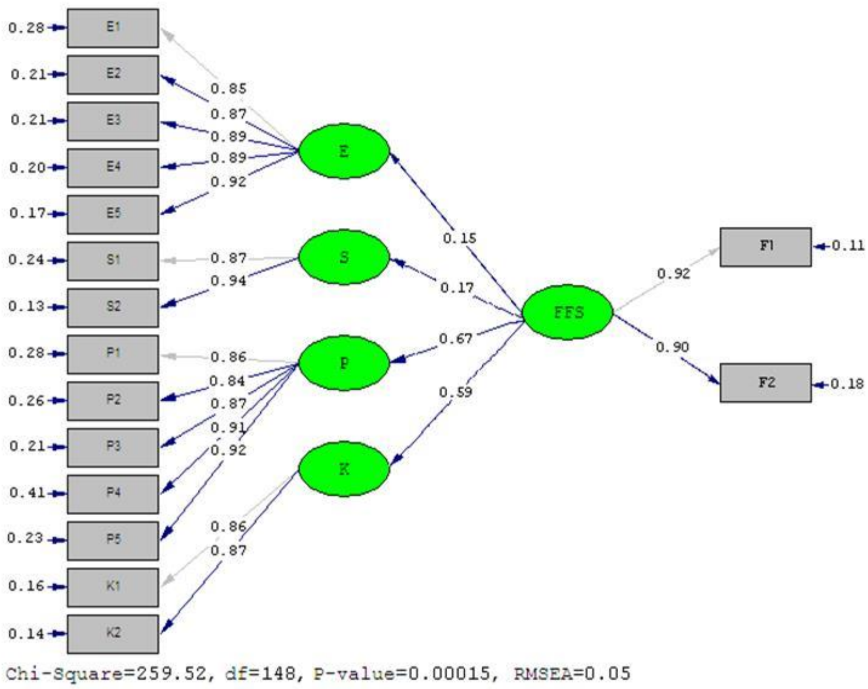

Figure 2. Empirical model of the impacts of FFS on farmers.

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participate in various agricultural and environmental programs. The results of the comparison between the participant and non-participant groups through the Mann-Whitney test unfolded a significant difference between them in the cooperation and participation in social organizations and institutions. Similarly, the structural analysis showed that FFS programs had some positive social impacts and boosted the cooperation and participation in social associations and entities and, in general, increased the participants' socialization. These findings are consistent with Chimotia *et al.* (2015) and Dzeco *et al.* (2010).

In the studied population, greenhouse crop production was their main activity and occupation. In the agricultural sector, the change in production is the main axis of other changes. Improvement of production boosts producers' livelihood. Improvement of production indicators is the result of the promotion of producers' knowledge. One of the greenhouse owners' goals of participating in the FFS program was the improvement of the quality and quantity of greenhouse crops. Comparison between the participant and non-participant groups indicated that they significantly differed in all production-related indicators, except for crop yield. It seems that the insignificant difference in yield between the treatment and control groups was associated with the low consumption of macro-chemical fertilizers by the FFS participant group. It is noteworthy that most studies and experiences around the world show similar finding. Structural analysis reveals the positive impacts of the FFS programs on greenhouse production. Accordingly, the implementation of the FFS program has led to higher yields, lower rates of macro-fertilizer consumption, higher rates of microelement fertilization, higher rates of organic fertilizer use, and lower rates of pesticide use. Therefore, FFS has gained environmental accomplishments in protecting water and soil resources through reducing the use of exogenous inputs including fertilizers and pesticides. This will enable production of safe crops and higher competitiveness in domestic and international markets. Furthermore, manufacturers and their families will not be exposed to chemical pesticides, and the final commodity will have fewer residues of pesticides and chemical fertilizers. These results are in line with the findings of Cai *et al.* (2016) and Van den Berg (2004).

FFS is a strategy to accomplish sustainable agriculture development within the global program for food security and safety on the basis of some indicators including bio-safety, economic productivity of production, and crop safety. As an innovative extension and education approach, FFS has been a response to the failure and drawbacks of conventional extension models and the linear process of technology transfer. Its goal has been to enhance farmers' knowledge, attitude, and skills, and it has been designed to empower farmers and turn them into facilitators. In this regard, the results of the Mann-Whitney test show a significant difference between the FFS participant and non-participant groups in term of the tacit and explicit knowledge needed to produce a safe crop. This suggests that the FFS program has been effective in increasing the greenhouse owners' knowledge of the production of safe crops in accordance with the principles of sustainable agriculture, integrated pest management, and environmental considerations. Also, structural analysis reveals that the FFS program has positively influenced the tacit and explicit knowledge required by greenhouse owners to produce safe crops. By upgrading tacit knowledge and changing to explicit knowledge, greenhouse owners will be empowered and will become facilitators and trainers of other farmers. The positive production, economic, and social impacts are the results of greenhouse owners' tacit and explicit knowledge improvement. These results are consistent with the findings of Fariis-Hansen and Duveskog (2012), Mancini *et al.* (2008), and Rostam (2010).

CONCLUSIONS

The present study focused on the impacts of FFS implementation on greenhouse owners in Tehran Province. The findings implied the positive impacts of this program on economic, social, production and knowledge aspects across the study sites. In recent years, Iran has witnessed the development of greenhouse crop production due to water shortages and droughts. On the other

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hand, the demand for the production of safe crops and the consideration of environmental standards in greenhouses through the elimination and reduction of pesticide and chemical fertilizer application has made it necessary to implement FSS programs. Greenhouse crop production is the main activity and source of income for some farmers in some counties of Tehran Province. However, the results of t-test showed that the participants and non-participants of FFS programs did not differ significantly in increase in annual income and marketing improvement. It is, therefore, necessary in FFS programs to emphasize on topics such as marketing methods for products, cost reduction methods, and economical management of farms to help producers improve their annual income. Expanding marketing activities and informing consumers about safe foods will improve their awareness of these commodities, so, they will welcome safer commodities at premium prices, resulting in more profits for producers. Some limitations of the research can be mentioned as the lack of similar studies of FFS on greenhouse crops, the low number of greenhouse owners who participated in FFS, the use of a questionnaire as the research instrument and the likelihood of error in respondents' responding the questions, the cross-sectional nature of the research, the inability to have a full control on unintended variables, and the inability to generalize the results to other regions and other FFSs with similar topics. However, the results of the study can help stakeholders involved in greenhouse production of safe crops, such as managers and those involved in the horticultural sector, agriculture extension, facilitators, and producers, gain an understanding of the impacts of FFS to identify the weaknesses and strengths of the FFS program. Then, they can make the required changes and modification in the program for greenhouse owners to cope with the weaknesses. Also, by knowing the strengths of the program, they can strengthen and develop FFS clusters for summer crop greenhouse owners to accomplish more positive achievements.

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تحلیل اثرات برنامه مدرسه مزرعه کشاورزان بر وضعیت اقتصادی، اجتماعی، تولیدی و دانشی گلخانه داران: شواهدی از استان تهران و حومه

ا. کریمی ، و م. نیک نامی

چکیده

هدف تحقیق حاضر تحلیل اثرات بکارگیری رویکرد مدرسه در مزرعه بر وضعیت اقتصادی، اجتماعی، تولیدی و دانشی گلخانه داران استان تهران و حومه بود. جامعه آماری در این تحقیق شامل ۸۰ نفر از گلخانه داران شرکت کننده در برنامه بعنوان گروه تیمار و ۷۱۶ نفر از گلخانه داران غیر شرکت کننده در برنامه بعنوان گروه کنترل بود. برای محاسبه حجم نمونه برای گلخانه داران غیر شرکت کننده در برنامه مدرسه مزرعه ای کشاورزان از فرمول کوکران استفاده گردیدکه حجم نمونه ۱۵۲ نفر تعیین گردید. برای انتخاب نمونه ها از روش نمونه گیری تصادفی ساده استفاده گردید. نتایج آزمون های مقایسه ای بیانگر آن بود که در بین دو گروه از لحاظ

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افزایش بازار پسندی محصولات، افزایش اشتغال زایی، کاهش ریسک تولید، افزایش مشارکت پذیری، شرکت در تشکل ها و نهادهای اجتماعی، میزان مصرف کودهای ماکرو، میزان مصرف کودهای میکرو، میزان مصرف کودهای آلی، میزان مصرف سموم شیمیایی و دانش فنی برای تولید محصول سالم تفاوت معنی داری وجود داشت. لیکن در خصوص افزایش درآمد سالیانه، بهبود بازار یابی و افزایش عملکرد محصول تفاوت معنی داری مشاهده نگردید. نتایج تحلیل ساختاری نیز بیانگر آن بود که اجرای مدرسه در مزرعه در گروه شرکت کننده در برنامه، اثرات مثبت از ابعاد اقتصادی، اجتماعی، تولیدی و دانشی به همراه داشته است.

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