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Impact of Integrated Pest Management (IPM) Practices on Tomato Cultivation in Gazipur District of Bangladesh

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Abstract

An experiment was conducted at Nagari union in Kaligonj Upazila of Gazipur district to determine the impact of Integrated Pest Management practices on tomato cultivation. Data were collected by using pre-designed interview schedule from 1st March to 5th August, 2014. The results of the study showed that in the study area farmers cultivated tomato in 14.6% of their land and there are eight IPM practices which are generally used by the farmers in their tomato fields. Regarding the overall adoption of IPM practices in tomato cultivation, 65.0% respondent farmers were in medium to high adoption category. The IPM Practice Use Index (IPUI) was found significantly higher in case of IPM adopters than in case of IPM non-adopters. But "use of pheromone trap", "setting up the bamboo stick in the field" and "cultivation and use of green manure" were ranked as 1st, 2nd and 3rd, respectively in case of IPM adopters whereas "setting up bamboo stick in field", "cultivation and using green manure" and "use quality and resistant seeds" obtained 1st, 2nd and 3rd rank, respectively in case of IPM non-adopters. The average infestation of insect and disease was found significantly lower in the fields of IPM adopter (9.7%) than IPM non-adopter (11.8%). The average frequency of chemical use in the season was also significantly lower in the fields of IPM adopter (2.14 times) than IPM non-adopter (3.44 times). The marketable yield was found significantly higher in the fields of IPM adopter (51.34 t/ha) than in the fields of IPM non-adopter (42.24 t/ha). The average gross return was also significantly higher in case of IPM adopter (526,143 taka/ha) than IPM non-adopter (472,647 taka/ha). The Benefit-Cost Ratio (BCR) of IPM adopter (2.41) was also found significantly higher than the BCR of IPM non-adopter (1.44).

Keywords

Impact, IPM, Practices, Tomato, Cultivation

1. Introduction

Tomato is the most consumable vegetable crop after potato and sweet potato occupying the top of the list of canned vegetables and plays an important role in providing balanced nutrition. Its consumption quantity in recent years increased at an average rate of 3% annually [1]. At present 6.1% area of vegetables is under tomato cultivation, both in winter and summer [2]. It is cultivated all over the country due to its adaptability to a wide range of soil and climate. The total area under tomato cultivation was 67,535 acres and the production was 368,121 MT at 2015-2016 in Bangladesh [3]. However, the yield of the crop is very low compared to those obtained in some advanced country [4]. To meet up local demand, Bangladesh Government has also been importing tomato from the neighboring countries. The government imported 9395.14 MT of tomato in exchange of 1503 million takas from foreign countries in the year 2000-2001 [5]. Insect pests are an important threat to tomato production. In order to fight pests, farmers of Bangladesh heavily rely on pesticides. Pesticides can easily dissolve with water and that is why it pollutes the soil surface water and also contaminates ground water through infiltration and percolation. Besides, rain water also mixes with pesticides which pollute pond/canal/other water bodies and damage natural resources such as fish, beneficial insects, and micro-organisms. Their massive and frequent misuses have led to the problems viz.; resistance of pesticides, the resurgence of pests and residues as well as toxicity hazards to non-target animals. Bangladesh is not exceptional in this general trend of environmental degradation. Agriculture and environment have a close relationship and interact with each other in such a way that the health of agriculture depends on the proper functioning of environmental process and also upon respectful agriculture [6]. Prior to this study, the few IPM (Integrated Pest Management) studies [4] [6]-[11] conducted in tomato cultivation were focused on cost and return only. It needs to consider food safety issues so that it will be safer and healthier. Drawbacks of chemical pesticides emphasized the need to identify alternate eco-friendly methods to manage the pests of tomato. To rely fully on chemical control is not feasible in social, economic and environmental aspect. Therefore, an alternative strategy is needed to control pest in less expensive and environment friendly way. Hence, IPM practices are now being considered as the most appropriate one to control pest. Around the world, IPM has been widely adopted as a rational strategy to manage pests in crop cultivation. There are few studies examining the effectiveness of an IPM program on tomato cultivation. [12] found that IPM farmers reduced the number of pesticide use application up to 89 percent and at the same yield increased to 10 percent. [13] reported that IPM trained farmers reduced the number of pesticide application up to 88% while at the same yield increased to 9%. To minimize the chemical inputs and save environmental damage, thus IPM approach has been globally accepted for achieving sustainability. Keeping this point in mind this study was conducted to know the impact of IPM practices on tomato cultivation in Gazipur district of Bangladesh.

2. Database and Methodology

2.1. Location of the Study

The study was conducted at Nagari union in Kaligonj Upazila of Gazipur district. Out of 14 villages, two villages namely Birtul and Ulukhola were selected randomly on the basis of the intensity of IPM practices in tomato cultivation.

2.2. Data Collection and Data Analysis

The data were collected from 1st March to 5th August, 2014 through interview schedule by the researchers on some selected characteristics of the respondents which were treated as independent variable viz. age, educational qualification, family size, farm size, farming experience, Annual income, Extension agency contact, Organizational participation, Innovativeness and Cosmopoliteness. Adoption of IPM practices was treated as dependent variable of the study. The descriptive and diagnostic research design was used in the present study. 80 farmers who cultivated tomato were randomly selected as the sample for the study. Tomato growers of the selected union were the main unit of analysis of the present study. Data were analyzed with the Statistical Package for Social Sciences (SPSS Inc, Chicago, IL, USA). Descriptive statistics (frequencies, percentages, means, and standard deviations) were used for data analysis to accomplish the objectives.

2.3. Measurement for Adoption of IPM Practices

A survey was designed in order to adopt the IPM practices by the farmers. An index was considering its eight practices. Four point rating scale was used for each of the item statement viz. frequently, occasionally, rarely and not at all and the corresponding score 3, 2, 1 and 0 were assigned, respectively. [14] used IPM Practice Use Index (IPUI) for each practice was developed using the following formula:

$$\text{IPUI} = N_1 \times 3 + N_2 \times 2 + N_3 \times 1 + N_4 \times 0$$

where,

IPUI = IPM Practice Use Index, N_1 = Number of farmers used IPM practices frequently, N_2 = Number of farmers used IPM practices occasionally, N_3 = Number of farmers used IPM practices rarely and N_4 = Number of farmers used IPM practices not at all.

2.4. Performance of IPM Field

Performance of IPM field was measured on the basis of different particulars on

2011-12 and 2012-13 tomato production year. Tomato growers were asked different questions to estimate the value of the particulars like frequency of insecticide use, frequency of fungicide use, damping off, cutworm, fruit borer, leaf blight, leaf miner, white fly, wilting and marketable yield.

2.5. Assessment of Economic Impact

The important impact indicators used were yield, cost of cultivation, cost of production and net returns and benefit-cost ratio (BCR). The significance of difference in the indicators between IPM and non-IPM adopters was studied using the t-test. The IPM technology was considered superior if the profits were higher compared to those in farmers' practice. This could be written symbolically as:

$$TR(I)-TC(I)>TR(N)-TC(N)$$

where, $TR(I)$ = Total returns from IPM practices, $TR(N)$ = Total returns from non IPM practice, $TC(I)$ = Total cost incurred by IPM farmers, $TC(N)$ = Total cost incurred by non-IPM farmers.

$$TR=\sum P_i \cdot Y_i\,,\quad TC=\sum P_j \cdot X_j + a$$

where, P_i = Price of the i^{th} output ($i=1,\cdots,n$), Y_i = Quantity of the i^{th} output ($i=1,\cdots,n$).

P_j = Price of the j^{th} input ($j=1,\cdots,m$), X_j = Quantity of the j^{th} input ($j=1,\cdots,m$).

a = Fixed costs like rental value of land, depreciation, etc.

$$\text{BCR}=\left\{\text{Goss returns}(\text{tk/ha})\div\text{Total operational cost}(\text{tk/ha})\right\}\times 100$$

where, Gross returns (tk) = Actual per ha yield of vegetables × market price (tk/t),

Net returns (tk) = Gross returns (tk/ha) − total operational cost (tk/ha),

BCR = benefit cost ratio (operational cost).

2.6. Advantages of IPM Practices in Tomato Cultivation

Four point rating scale was applied for each the advantages namely high, medium, low and not at all and the corresponding score 3, 2, 1 and 0 were assigned, respectively. Total score of each advantage by different components of IPM practices could range from 0 to 240; 0 indicating no advantage and 240 indicating very high advantage of IPM practices.

$$\text{Mean score of each advantage by IPM practices}=\left(\sum_{i=1}^{N} S_i\right)\div 3N$$

where, S = score given by each farmer, N = total number of farmers.

i = i^{th} advantage, 3 = the maximum score for each advantages.

2.7. Problems Confronted in Using IPM Practices

Eight problems were selected and arranged in order to real feelings of tomato growers by marking. Four types of rating scale was applied for each problem namely; high, medium, low and no and the corresponding score 3, 2, 1 and 0 were assigned, respectively. Each farmer was given a total score consisting of the sum of the scores for the problems of IPM practicing in tomato field. Thus, importance score of a respondent could range from 0 to 18, while "0" indicating no problem and "18" indicating very high problem. For easy understanding of the problem, the importance score (IS) of each of the problems was expressed in percentage by using the following formula:

$$\begin{aligned}&\text{Important Problem Score Index}\left(\text{IPSI}\right)\\&=\left(\text{Possible Problem Score}\div\text{Observed Score}\right)\times 100\end{aligned}$$

The IPSI for each of the problems range from 0 to 100; 0 indicating nobody faced the problem and 100 indicating all the respondents faced the problem frequencies.

2.8. Suggestions in IPM Practices

To find out solution for overcoming problems in use of IPM practices, several consultation discussions were held with tomato grower. Ten solutions were selected and arranged in order to real feelings of tomato growers by marking. The same procedure used for measuring problems, was adopted to measure the importance of suggestions received from the respondents. Four types of rating scale were applied for each suggestion namely; high, medium, low and no and the corresponding score 3, 2, 1 and 0 were assigned, respectively. Thus the importance score (IS) of suggestions was computed by summing up the weights for each responses of all the respondents and the importance score of any suggestions could, therefore, range from zero (0) to 240. The importance score (IS) of each of the suggestion was then expressed in percentage by using the following formula:

$$\begin{aligned}&\text{Important Solution Score Index}\left(\text{ISSI}\right)\\&=\left(\text{Possible Solution Score}\div\text{Observed Score}\right)\times 100\end{aligned}$$

where, zero indicated no important suggestion for encouraging the IPM practices and 100 indicated very high encouraging suggestion for practicing IPM in rice cultivation by the farmers.

3. Results and Discussion

3.1. Socio-Demographic Profile of the Respondents

In the study area, age of the farmers was ranged from 25 years to 61 years above with an average of 42.19 years and the highest proportion (63.70%) of the respondents felt in middle age. The majority (57.60%) of the respondents was secondary level of education and the highest proportion (71.20%) of the respondents had medium family size. The farm size of the respondents was varied from 0.246 to 1.23 hectares and majority (65%) of the respondents was medium farm size. The highest proportion (71.2%) of the respondents had medium farming experience. The annual family income of the respondents had ranged from 40,000 to 350,000 taka with an average of 137,688 taka and the highest proportion (77.50%) of the respondents had medium annual income. The highest proportion (73.80%) of the respondents was in medium source of information category and majority (66.10%) of the respondents had medium organizational participation. The maximum proportion (63.70%) of the respondents had medium cosmopoliteness and overwhelming majority (62.50%) of the respondents had medium innovativeness (Table 1). Almost similar findings were also reflected in the study of [14] [15] [16] [17].

3.2. Adoption of IPM Practices in Tomato Cultivation

It is observed from Table 2 that average potential land and cultivated land for tomato cultivation were 45.20% and 14.60% of total land, respectively. Although potential land of IPM adopter is slightly lower than IPM non-adopter but their cultivated land is found considerably higher than that of IPM non-adopter. All the respondent farmers followed different IPM practices in tomato cultivation. Some followed completely, some followed poorly. Observed IPM practice adoption score of the respondent ranged from 10 to 22 against the possible range of 0 to 24 with an average of 15.45. Based on the possible score, the farmers were classified into three categories as shown in Table 3.

Table 1. Distribution of respondents based on socio-economic and communication characteristics.

Characteristics	Respondents		Characteristics	Respondents	
Age	Frequency	%	Annual income (taka)	Frequency	%
Young age (up to 35 years)	14	17.5	Low (up to 100,000 taka)	8	10.0
Middle aged (36 to 50 years)	51	63.7	Medium (100,001 - 200,000 taka)	62	77.5
Old aged (above 50 years)	15	18.8	High (more than 200,000 taka)	10	12.5
Educational status			**Extension agency contact**		
Primary (up to 5 years schooling)	29	36.2	Low contact (up to 18 score)	14	17.5
Secondary (6 - 10 years schooling)	46	57.6	Medium contact (19 - 29 score)	59	73.8
Higher Secondary (above 10 y. sch.)	5	6.2	High contact (above 29 score)	7	8.7
Family size			**Organizational participation**		
Small (up to 3 person)	4	5.0	Low participation (up to 25 score)	10	12.5
Medium (4 - 5 person)	57	71.2	Medium part (26 - 40 score)	53	66.1
Large (above 5 person)	19	23.8	High participation (>40 score)	17	21.4
Farm size (ha)			**Innovativeness**		
Small farm (up to 0.39 ha)	16	20.0	Low (up to 26 score)	14	17.5
Medium farm (0.40 to 0.89 ha)	52	65.0	Medium (27 - 36 score)	50	62.5
Large farm (above 0.89 ha)	12	15.0	High (36+ score)	16	20.0
Farming experience			**Cosmopoliteness**		
Low experience (up to 7 year)	17	21.2	Low (up to 20 score)	12	15.1
Medium experience (8 - 19 year)	53	66.3	Medium (21 - 26 score)	51	63.7
High experience(above 19 year)	10	12.5	High (26+ score)	17	21.2

Data presented in Table 3 indicate that overwhelming majority (37.60%) of the respondents had medium and 27.50 percent had high adoption as compared to 35 percent had low adoption. Data also revealed that a big majority (65%) of the respondents were under medium to high adoption. It means respondents are well recognized about different components of IPM practice and use those components in their tomato fields. The rank order of IPM practices followed by IPM adopters and IPM non-adopters were assessed and presented in Table 4 and Table 5. The IPUIs of all the eight IPM practices found significantly higher in case of IPM adopters as compared to IPM non-adopter. It may be due to more contact with extension worker, more participation in training and other social program of IPM adopters. Based on IPUI score "use of pheromone trap", "setting up bamboo stick in field", "cultivation and using green manure" and

Table 2. Distribution of potential and average cultivated land for tomato cultivation.

Categories	Potential land in %	Cultivated land in %
IPM adopter	44.60	16.00
IPM non-adopter	45.80	13.10
Average	45.20	14.60

Table 3. Distribution of the respondents according to adoption of IPM practices.

Category	Respondents		Mean	SD
	Frequency	%		
Little adoption (up to 12)	28	35.00	15.45	3.69
Medium adoption (13 - 18)	30	37.60		
High adoption (18+)	22	27.50		
Total	80	100.00		

Table 4. Rank order of IPM practices based on obtained score of IPM adopters.

IPM practices	Extent of adoption (n = 51)								IPUI	Rank
	A_h		A_m		A_l		A_n			
	F	S	F	S	F	S	F	S		
Use of pheromone trap	47	141	4	8	0	0	0	0	149	1
Setting up bamboo stick in field	46	138	4	8	1	1	0	0	147	2
Cultivation and using green manure	39	117	10	20	2	2	0	0	139	3
Use of quality and resistant seeds	36	108	15	30	0	0	0	0	138	4
Seed treatment	10	30	34	68	7	7	0	0	105	5
Use of light trap	4	12	27	54	19	19	0	0	85	6
Use of bait trap	5	15	21	42	25	25	0	0	82	7
Use of yellow pan sticky traps	1	3	25	50	24	24	0	0	77	8

A_h = High adoption, A_m = Medium adoption, A_l = low Adoption, A_n = No adoption, IPUI = IPM Practice Use Index, F = Frequency, S = Score.

Table 5. Rank order of IPM practices based on obtained score of IPM non-adopters.

IPM practices	Score of extend of adoption (n = 29)								IPUI	Rank
	A_h		A_m		A_l		A_n			
	F	S	F	S	F	S	F	S		
Setting up bamboo stick in field	11	33	17	34	1	1	0	0	68	1
Cultivation and using green manure	2	6	21	42	6	6	0	0	54	2
Use of quality and resistant seeds	2	6	16	32	11	11	0	0	49	3
Use of pheromone trap	0	0	9	18	20	20	0	0	38	4
Seed treatment	0	0	4	8	25	25	0	0	33	5
Use of yellow pan sticky traps	0	0	2	4	27	27	0	0	31	6
Use of light trap	0	0	1	2	28	28	0	0	30	7
Use of bait trap	0	0	0	0	29	29	0	0	29	8

A_h = High adoption, A_m = Medium adoption, A_l = low Adoption, A_n = No adoption, IPUI = IPM Practice Use Index, F = Frequency, S = Score.

"use quality and resistant seeds" were ranked as 1st, 2nd, 3rd and 4th respectively in case of IPM adopters.

In another way, comparatively lower adoption obtained by them were in case of "seed treatment", "use of light trap", "use of bait trap" and "use of yellow pan sticky traps" according to their IPUI scores and ranked as 5th, 6th, 7th and 8th respectively. It is observed from Table 5 that "setting up bamboo stick in field", "cultivation and using green manure" and "use quality and resistant seeds" were ranked as 1st, 2nd and 3rd according to IPUI score respectively in case of IPM non-adopters.

In another way, comparatively lower adoption obtained by them were in case of "use of pheromone trap", "seed treatment", "use of yellow pan sticky traps", "use of light trap" and "use of bait trap" according to their IPUI score and ranked as 4th, 5th, 6th, 7th and 8th, respectively.

3.3. Performance of Fields of IPM Adopter

Data contained in Table 6 indicate that average infestation of insect and disease in the fields of IPM adopters and IPM non-adopters were 9.71% and 11.84% and average frequency of chemical use in season were 2.14 and 3.44 showing percent mean differences (−) 22 and (−) 60, respectively. The average marketable yield of tomato in the fields of IPM adopter and IPM non-adopters were found 51.34 t/ha and 42.24 t/ha and average gross returns were 526,143 taka/ha and 472,647 taka/ha showing percent mean differences (+) 22 and (+) 12, respectively. The BCR of IPM adopter and IPM non-adopter were found 2.41 and 1.44, respectively.

It is evident from the quantitative data on the performance of IPM practices that there was reduction in the incidence of diseases and insects with considerably low use of chemicals in the fields of IPM adopter as compared to the fields of

IPM non-adopter which ultimately reduce the variable cost causing higher BCR in fields of IPM adopter.

The t valves presented in Table 7 elucidate that the average infestation of insect and disease was found significantly lower in the fields of IPM adopter (9.71%) than IPM non-adopter (11.8%) and average frequency of chemical use in season was also significantly lower in the fields of IPM adopter (2.14) than IPM non-adopter (3.44). Marketable yield was found significantly higher in the fields of IPM adopter (51.34 t/ha) than in the fields of IPM non-adopter (42.24 t/ha). Average gross return was also significantly higher in case of IPM adopter (526,143 taka/ha) than IPM non-adopter (472,647 taka/ha). The BCR of IPM adopter (2.41) also found significantly higher than the BCR of IPM non-adopter (1.94). The farmers tried to engage with different new techniques and practices. Minimum disease infestation carries maximum productivity and provides maximum profitability. After using different IPM practices in tomato cultivation the farmers earned more benefit. So, it is clear to say that there were significant impacts of IPM practices in tomato cultivation. While studying "Impact of Farmer

Table 6. Performance of fields of IPM adopter over fields of IPM non-adopter.

Parameters		Fields of IPM adopter			Fields of IPM non-adopter			Mean difference
		2011-12	2012-13	Mean	2011-12	2012-13	Mean	
Insect and disease infestation in %	Cutworm	11.04	9.51	9.71	11.62	11.10	11.84	-2.13
	Fruit borer	10.16	7.75		11.31	11.52		
	White fly	11.47	8.25		12.03	12.66		
	Damping off	10.75	6.37		11.34	11.28		
	Leaf blight	12.12	9.63		13.93	11.62		
Freq. of Chemical use	Insecticide	2.76	2.19	2.14	3.23	4.11	3.44	-1.30
	Fungicide	1.98	1.63		3.14	3.26		
Marketable yield (t/ha)		49.29	53.39	51.34	44.34	40.14	42.24	9.10
Variable Cost (taka/ha)		221,094	218,742	219,918	221,833	222,787	222,310	−2392
Gross return (taka/ha)		517,519	534,767	526,143	471,021	474,273	472,647	53,496
BCR		2.34	2.44	2.39	2.12	2.12	2.12	0.47

Table 7. Differences of fields of IPM adopter over fields of IPM non-adopter based on performance parameters.

Parameters	Fields of IPM adopter (mean)	Fields of IPM non-adopter (mean)	t value
Insect and disease infestation	9.71	11.84	−2.085*
Chemical use (No. of times)	2.14	3.44	−2.008*
Marketable yield (t/ha)	51.34	42.24	7.649**
Variable cost (Tk./ha)	219,918	222,310	-0.876^{NS}
Gross return (Tk./ha)	526,143	472,647	2.328*
BCR	2.41	1.94	2.34*

* = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Non-Significant.

Field School in Popularization of IPM Practices in Tomato Cultivation" [18] found that "frequency of insecticides", "frequency of fungicides", "leaf miner in the main field", "Tomato Spotted Wilt Virus", "fruit borer", and "blight" in fields of IPM adopter were significantly lower than those of fields of IPM non-adopter.

3.4. Advantages of IPM Practices

Data contained **Table 8** indicate that the farmers were advantaged in "reduction of seedling mortality" as indicated by its mean score of 0.85. This is the main advantage of the farmers in using IPM practices. The second and third advantages were "reduction of pest infestation" and "less use of insecticides/pesticides" respectively. In this way, comparatively fewer advantages obtained by the farmers are "reduction of diseases infestation", "increased marketable yield", "saving labor " and "increased knowledge and self-confidence" according to their rank 4^{th}, 5^{th}, 6^{th} and 7^{th}, respectively. [19] found that "reduced incidence of insect and disease", "less seedling mortality" and "increased marketable yield" were the main advantages in study of "IPM Practices in Tomato: Participatory Analysis of Impact".

3.5. Relationship between the Selected Characteristics of the Respondents and Their Adoption of IPM Practices

The findings in **Table 9** indicated that education, organizational participation and innovativeness of the respondents showed significant positive relationships with their extent of adoption of IPM practices and the respective r values are 0.299**, 0.222* and 0.412** respectively. Results imply that with the increase in education, organizational participation and innovativeness of the respondents there would be an augmentation in adoption of IPM practices. Almost similar findings were also reflected in the study of [20] [21]. [22] found that education, extension contact and agricultural knowledge of the respondents showed significant positive relationships with their use of IPM practices. Education broadens one's

Table 8. Rank order of the advantages in using IPM practices in tomato cultivation.

Advantages	Score of advantages						
	H	M	L	N	Total score	Mean score	Rank
Reduction of seedling mortality	135	66	2	0	203	0.85	1
Reduction of pest infestation	30	118	1	0	179	0.75	2
Reduction of diseases infestation	54	120	2	0	176	0.73	4
Less use of insecticides/pesticides	60	114	3	0	177	0.74	3
Saving labor	27	76	33	0	136	0.57	6
Increased marketable yield	66	74	21	0	161	0.67	5
Increased knowledge and self confidence	21	78	34	0	133	0.55	7

H = High = 3, M = Medium = 2, L = Low = 1, N = Not at all.

outlook in life and helps understand the social, political, economic, cultural and environmental issues in the society. Similarly higher organizational participation assists in sharing knowledge. Innovativeness, also increase the respondents in knowledge and that knowledge lead to make accurate decision making ability. Other selected characteristics (age, family size, farm size, farming experience, annual income, source of information and cosmopoliteness) of the respondent showed insignificant relationships with their extent of adoption of IPM practices which implied that irrespective of these selected characteristics extent of adoption of IPM practice of the respondents were more or less similar.

3.6. Problems in Using IPM Practices

Data contained in Table 10 indicate that the farmers confronted the highest problem in "Longer duration of IPM practices" as indicated by its PCI of 224.

Table 9. Co-efficient of correlation showing relationships between the selected characteristics of the respondents and their adoption of IPM practices in tomato cultivation.

Selected characteristics (the independent variables)	Co-efficient of correlation (r) (adoption of IPM practices)
Age	0.162^{NS}
Education	0.299**
Family Size	0.113^{NS}
Farm Size	0.145^{NS}
Farming Experience	0.187^{NS}
Annual Income	0.202^{NS}
Source of Information	0.139^{NS}
Organizational Participation	0.222*
Cosmopoliteness	0.028^{NS}
Innovativeness	0.412**

NS = Non significant/insignificant, * = significant at 5% level, ** = significant at 1% level, Tabulated value of 0.05 level = 0.195, Tabulated value of 0.01 level = 0.0.254

Table 10. Rank order of the problems in using IPM practices in tomato cultivation.

Various categories of problem	Score of confrontation extent of problem					
	H	M	L	N	PCI	Rank
Longer duration of IPM practices	195	28	1	0	224	1
Lack of preservation and cold-storage facilities	150	56	2	0	208	2
Lack of knowledge about beneficial and harmful insects	117	66	8	0	191	3
Lack of sufficient inputs (seeds, technologies)	117	64	9	0	190	4
Lack of sufficient publicity through different media	78	98	5	0	181	5
Non-availability of extension personnel in time	66	102	7	0	175	6

H = High, M = Medium, L = Low, N = Not at all, PCI = Problems Confronting Index.

This is the main problem of the farmers in using IPM practices. The second and third problems confronted by them are "lack of preservation and cold-storage facilities" and "lack of knowledge about the beneficial and harmful insects" respectively. In this way, comparatively fewer problems confronted by the farmers are "lack of sufficient inputs (seeds, technologies)", "lack of sufficient publicity through different media" and "non-availability of extension personnel in time" according to their rank 4th, 5th and 6th, respectively. [19] found that "heavy loss due to pest and disease", "poor knowledge of pest and disease" and "high cost of inputs" were the main problems in study of "IPM Practices in Tomato: Participatory Analysis of Impact". [22] found that "soil is unfit for cultivation", "severe pest attack" and "excessive rainfall" were the main problems in study of "Farmers Problem Confrontation towards Vegetable Cultivation".

3.7. Suggestions to Overcome the Problems in Using IPM Practices

Data contained in Table 11 indicate that the farmers offered highest suggestion in "extend of IPM Club activities" as indicated by its ISSI of 95.4 percent. This was the main suggestion by the farmers in using IPM practices. It was interesting that the second, third and fourth rank of ISSI obtained by arranging practical training for farmers, ensuring availability of quality and resistant seeds and developing local leadership among the farmers, respectively. The other remarkable suggestions that filled the next ranks from 5 to 10 were increasing co-ordination between the farmers and extension workers; arrangement of award for the successful adopter of IPM practices, ensuring much more publicity of IPM practices

Table 11. Ranking of the suggestions to overcome the problems in using IPM practices.

Suggestions	Score of Solution				IS	ISSI	Rank
	H	M	L	N			
Extend of IPM Club activities	213	14	2	0	229	95.42	1
Arranging practical training for farmers	162	48	2	0	212	88.33	2
Ensuring availability of quality and resistant seeds	165	60	5	0	210	87.50	3
Developing local leadership among the farmers	153	54	2	0	210	87.08	4
Increasing of co-ordination between the farmers and extension workers	138	64	2	0	204	85	5
Arrangement of award for the successful adopter of IPM practices	141	50	8	0	199	82.92	6
Ensuring much more publicity of IPM practices through mass media	108	68	10	0	186	77.50	7
Ensuring proper supervision of extension worker	90	86	7	0	183	76.25	8
Increasing the farmers' awareness on environment pollution	81	90	8	0	179	74.58	9
Formation of effective organization for the farmers	69	90	12	0	171	71.25	10

H = High, M = Medium, L = Low, N = Not at all, IS = Importance Score, ISSI = Important Solution Score Index.

through national media, ensuring proper supervision of extension worker, increasing the farmers' awareness on environment pollution and the formation of effective organization for the farmers.

4. Conclusion

This study reveals useful information for better understanding common problems in tomato production in the study area and farmers' knowledge of integrated pest management. Some farmers had adequate knowledge about the impact of IPM practices in tomato production, but there were significant gaps in farmers' knowledge concerning IPM practices. Farmers needed training about integrated pest management strategies to ensure sustainable tomato production, as there is still great room for farmers to improve their knowledge. On issues related to IPM, the extension services should be certainly strengthened. Promoting new concepts, such as IPM for environmentally friendly crop protection to farmers is crucial, but not sufficient. Related to the new concepts training and extension services are also needed. In tomato, production knowledge can make farmers become more aware of pesticide risks and subsequently lead to changes in misleading attitudes.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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