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Farmer's Adoption and Effectiveness of Insect Pests Management Strategies in Organic Tomato Fields

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Authors' contributions

This work was carried out in collaboration among all authors. Author MR planned and conducted the work on the field, collected the data, statistical analysis, managed literature searches and wrote the manuscript. Authors MMR, MSH and MEH planned, designed and supervised the research in field as well as edited manuscript. All authors read and approved the final manuscript.

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ABSTRACT

A study was conducted in organic and intensive tomato growing areas located in Manikganj and Narsingdi districts of Dhaka division. A total of 30 organic tomato growers were selected from 5 randomly selected villages of Manikganj and Narsingdi. Data were collected from September 2020 to September 2021. Most frequently used insect pest management strategies by the organic farmers under the study areas were; T_0=Untreated control (Used resistant varieties only), T_1=Pheromone trap (Plastic pot), T_2=Sticky trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval, T_3=Bait trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval, T_4=Light trap+ Mahogany seed powder @ 20gm/L of water at 7 days interval and T_5= Pheromone trap + *Trichogramma evanescens* (100 points ha^{-1} at 500 wasps per point). For the untreated control of tomato fruit borer, T_1=Pheromone trap (Plastic pot) was the most frequently used (52.67%) in the

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study area whereas T_5= Pheromone trap + *Trichogramma evanescens* (16.67%) was used by the least number of organic farmers besides untreated control T_0 (8.67%). The highest benefit cost ratio was 1.51 recorded from the treatment T_5= Pheromone trap + *Trichogramma evanescens*, lowest benefit cost ratio was 1.30 recorded for tomato production from the untreated control treatment T_0. Due to reduced operating costs, the benefit-cost ratio for producing organic tomato was comparable to and close to that of growing high yielding tomato using inorganic methods. The difference between the BCR of organic tomato production procedures and inorganic tomato production practices was eventually eliminated by high market price and rising demand of organic produces.

Keywords: Organic farming; organic tomato; biorational approaches; ecofriendly management.

1. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the most often consumed vegetables in Bangladesh. In terms of the global production of tomato, it comes in third behind potatoes and sweet potatoes [1]. But in Bangladesh, it ranks 2nd which is next to potato [2] and it has great demand throughout the year especially in early winter and summer, but its production is mainly concentrated during the winter season. In Bangladesh, Tomato has been growing as the second horticultural crop after potato which is cultivated in two seasons annually. For tomato cultivation in both winter and summer season, 68,366 acres cultivable land (8.59% of total cultivable land) was dedicated, and the total production was about 4,14,725 metric tons in the year of 2019-2020 [2]. Arthropod pests and diseases are the main drawbacks to sustainable tomato production [3]. The major arthropod pests infesting tomatoes are the leaf miner moth *Tuta absoluta* (Meyrick) (Lepidoptera: Gelichiidae), Western flower thrips *Frankiliniella occidentalis* Pergande (Thysanoptera: Thripidae), whitefly *Bemisia tabaci* Gennadius (Homoptera: Aleyrodidae), leaf miner fly *Liriomyza* spp. (Diptera: Agromizydae), red spider mite *Tetranychus evansi* Baker (Acari: Tetranychidae) and African bollworm *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) [4].

The use of insecticides, however, carries several dangers. The yield loss due to insect pests varies in different environment conditions but can exceed 21% in Bangladesh [5]. Non-optimal and non-judicious use of insecticides may result in serious problems related to crop production and certain externalities like pollution and health hazards. The use of pesticides increased from 7,350 metric tons in 1991 to 16,200 metric tons in 2011, [6] more than doubling over the course of a decade. Among this huge number of pesticides, insecticides accounted for about 90%, and are generally used for tomato [6]. This huge consumption of chemical fertilizers and pesticides applied to 7.32 million hectares of cultivated land represents an over-use of agrochemicals and a waste of foreign currency reserves, as the country imports most of the applied agrochemicals, except for urea fertilizers. Given the challenges that arise from the over-use of agrochemicals, a key policy intervention for sustainable agriculture is to encourage the adoption of agricultural technologies that rely to a greater extent on local or renewable resources.

One technology that can lessen the negative effects of agrochemicals is organic farming, which many scientists believe to be the ideal type of agriculture in terms of cost-effectiveness and pollution reduction [7]. The production of food, fiber, and other agricultural products in an environmentally, socially, and economically sustainable manner is promoted by organic farming. The maintenance of soil fertility is seen under this system as essential to effective output. It is exempt from the use of chemo-synthetic insecticides, fertilizers, and medicines. Social factors are also considered [8].

With the right planting strategies, biological untreated control, and natural pesticides, organic farmers may manage pests (mainly extracted from plant or animal origins). The biggest issue for organic producers, untreated weed management, can be handled through cultural approaches such mechanical cultivation, mulching, and flaming. In comparison to conventional agriculture, organic farming is distinguished by greater arthropod fauna diversity and the preservation of natural enemies [9].

In organic farming systems, the basic elements and innate functions of ecosystems, such as the activities of soil organisms, the cycling of nutrients, and the distribution and competition of

species, are used directly and inadvertently as farm management tools to prevent pest populations from reaching levels that are economically detrimental. With tillage and cultivation techniques, crop rotations, and cover crops, soil fertility and crop nutrients are regulated. Manure, composts, crop waste, and other permitted substances are added as needed. The new market group may think that organic foods are the answer to their search for safe and wholesome food sources [10]. In the present study an attempt was made to document the pattern of insect pest management in organic and intensive tomato farming farmers' field. The objective of this work was, to gather baseline information about organic tomato farming and current pattern of insect pest management of farmers field against insect pests, to find out the tomato insect pest's infestation intensity in farmer field, and to estimate the cost and benefit ratio (BCR) of organic tomato farming practices.

2. MATERIALS AND METHODS

2.1 Experimental Site

The survey was conducted in tomato growing areas at Dhaka division in two districts. They were Manikganj and Narsingdi. and under these districts five villages from each district were considered for data collection.

2.2 Experimental method

Technical sample organic farms were divided into thirty (30) small sample plots and each selected farmers were asked to take field walks to observe and collect 10 samples per plot (or as many as possible from early damage to late or completely damaged and/or rotten fruits/ tomatoes by fruit borer and aphid).

2.3 Treatments used for organic farming

Most frequently used treatments were considered to measure the effectiveness of the organic pest management strategies used by the organic farmers under the study area, the following treatments were considered.

2.4 Data Collecting Parameters

Data on tomato insect pest infestation were collected from organic farms under the study area in each region. For this, 10 plants were selected from each organic farmers and tomatoes were observed visually at three (3) harvesting stage. Organic tomatoes with characteristic of damage symptoms of fruit borer and aphid were observed and recorded from each plant. Suspected fruit borer and aphid damaged tomatoes were separated from the undamaged fruits and dissected to confirm the presence of tomato fruit borer and aphids' eggs or larvae. Number of healthy and infested tomatoes were recorded for each plant and percent fruit infestation was calculated using the following formula:

% Fruit infestation by number

$$= \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

The number and weight of infested and total fruit or plant parts for each treated plant and untreated control plant were recorded and the percent reductions of fruit infestation by number and by weight were calculated using the following formula:

Percent infestation reduction over control

$$= \frac{X1-X2}{X1} \times 100$$

Where, X1 = The mean value of the control plant

and X2 = The mean value of the treated plant.

2.5 Benefit Cost Ratio (BCR)

BCR of organic tomato product was used to compare benefit per unit of cost. The BCR was the ratio of gross return to total cost. The BCR was calculated by using following formula:

$$BCR = \frac{\text{Gross Return}}{\text{Total Cost}}$$

2.6 Statistical Package

In a Microsoft Excel spreadsheet, information was gathered and compiled. The data was later subjected to a variance analysis using STATISTIX-10 software. An ANOVA was created using the f variance test, and the Least Significant Difference (LSD) Test was used to compare mean values.

Table 1. Treatments used by the farmers in organic tomato production

Treatments	Description
T_1	Pheromone trap (Spodo lure)
T_2	Sticky trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval
T_3	Bait trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval
T_4	Light trap+ Mahogany seed powder @ 20gm/L of water at 7 days interval
T_5	Pheromone trap (Spodo lure) + *Trichogramma evanescens* (100 points ha^{-1} at 500 wasps per point)
T_0	Untreated control (Used resistant varieties only)

3. RESULTS AND DISCUSSION

3.1 Pest Management through Untreated Control

In this method, mechanical and bio-insecticides are used during the life cycle of the crops. Most of the farmers from the study area use mechanical untreated control as their primary pest management strategy besides organic farmers under the study area also use some bio-insecticides. Considering the organic pest management methods and its ability to untreated control insect pest of tomato was measured. A total of 6 treatments were considered as most frequently used by the organic farmers under the studied areas were as follows:

3.2 Effect of Organic Management Practices on the Infestation of Insect Pests of Tomato by Number at First Harvest

Management practices of organic tomato farmers in untreated controlling insect pests at first harvest were shown in Table 2. From the survey it was observed that, most of the organic farmers were dependent on the cost-effective mechanical untreated control over bio-pesticides. For the untreated control of tomato fruit borer T_1=Pheromone trap (Plastic pot) was the most frequently used (52.67%) in the study area whereas T_5= Pheromone trap + *Trichogramma evanescens* (16.67%) was used by the least number of organic farmers besides untreated control T_0 (8.67%). Although T_1 untreated control treatment was observed as most infected tomato field (33.337%) and T_5= Pheromone trap + *Trichogramma evanescens* showed best performance against insect pest for the organic tomato field (12.33% infestation) with the highest reduction over untreated control percentage (63.06) against tomato fruit borer. Considering insect pest untreated control of aphid T_4=Light trap+ Mahogany seed powder @ 20gm/L of water at 7 days interval observed as the most effective for reduction of infestation over untreated control (55.19%).

3.3 Effect of Organic Management Practices on the Infestation of Insect Pest of Tomato by Number at Second Harvest

Management practices of organic tomato farmers in untreated controlling insect pests at second harvest have been shown in Table 3. From the survey it was observed that, most of the organic farmers were dependent on the cost-effective mechanical untreated control over bio-pesticides. For the untreated control of tomato fruit borer T_1=Pheromone trap (Plastic pot) was the most frequently used (52.67%) in the study area whereas T_5= Pheromone trap + *Trichogramma evanescens* (16.67%) was used by the least number of organic farmers besides untreated control T_0 (8.67%). Although T_1 untreated control treatment was observed as most infected tomato field (30.33%) and T_5= Pheromone trap + *Trichogramma evanescens* showed best performance against insect pest for the organic tomato field (15.33% infestation) with the highest reduction over untreated control percentage (49.46) against tomato fruit borer. Considering insect pest untreated control of aphid T_4=Light trap+ Mahogany seed powder @ 20gm/L of water at 7 days interval observed as the most effective for reduction of infestation over untreated control (56.29%). Similar result also observed from the study of Islam et al. [11].

3.4 Effect of Organic Management Practices on the Infestation of Insect Pest of Tomato by Number at Third Harvest

Management practices of organic tomato farmers in untreated controlling insect pests at third harvest have been shown in Table 4. From the survey it was observed that, the most of the

organic farmers were depends on the cost-effective mechanical untreated control over bio-pesticides. For the untreated control of tomato fruit borer T_1=Pheromone trap (Plastic pot) was the most frequently used (52.67%) in the study area whereas T_5= Pheromone trap + *Trichogramma evanescens* (16.67%) was used by the least number of organic farmers besides untreated control T_0 (8.67%). Although T_1 untreated control treatment was observed as most infected tomato field (34.31%) and T_5= Pheromone trap + *Trichogramma evanescens* showed best performance against insect pest for the organic tomato field (18.33% infestation) with the highest reduction over untreated control percentage (46.58) against tomato fruit borer. Considering insect pest untreated control of aphid T_4=Light trap+ Mahogany seed powder @ 20gm/L of water at 7 days interval observed as the most effective for reduction of infestation over untreated control (52.50 %). Mainali, et al. [12] also found related findings.

Table 2. Effect of organic management practices on the production of healthy and infested tomato at first harvest

Management practices	Tomato fruit borer			Aphid		
	Practicing organic tomato farmers (%)	Fruit infestation (%)	Reduction over untreated control (%)	Practicing organic tomato farmers (%)	Infestation (%)	Reduction over untreated control (%)
T_0	8.67 e	33.33 a	-	6.67 e	48.67 a	-
T_1	52.67 a	26.67 c	19.98	34.33 c	29.67 b	39.03
T_2	42.33 b	30.00 b	10.00	40.50 b	32.24 b	33.76
T_3	43.33 b	21.33 d	36.00	48.67 a	25.50 d	47.60
T_4	30.00 c	20.00 d	40.01	17.33 d	21.81 e	55.19
T_5	16.67 d	12.33 e	63.06	19.00 d	23.33 c	52.06
LSD (0.05)	5.63	3.37	-	6.31	3.74	-
CV%	9.83	12.47	-	10.31	13.21	-

[In column, means containing same letter(s) are not significantly different by LSD at 5% level of significance; Treatments; T_0=Untreated control (Used resistant varieties only), T_1=Pheromone trap (Plastic pot), T_2=Sticky trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval, T_3=Bait trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval, T_4=Light trap+ Mahogany seed powder @ 20gm/L of water at 7 days interval and T_5= Pheromone trap + Trichogramma evanescens]

Table 3. Effect of organic management practices on the production of healthy and infested tomato at second harvest

Management practices	Tomato fruit borer			Aphid		
	Practicing organic tomato farmers (%)	Fruit infestation (%)	Reduction over untreated control (%)	Practicing organic tomato farmers (%)	Infestation (%)	Reduction over untreated control (%)
T_0	8.67 e	30.33 a	-	6.67 e	36.67 a	-
T_1	52.67 a	23.67 c	21.96	34.33 c	19.98 d	45.51
T_2	42.33 b	28.50 b	6.03	40.50 b	26.50 b	27.73
T_3	43.33 b	19.21 d	36.65	48.67 a	21.30 c	41.91
T_4	30.00 c	18.67 d	38.44	17.33 d	16.03 e	56.29
T_5	16.67 d	15.33 e	49.46	19.00 d	19.81 d	45.98
LSD (0.05)	5.63	3.37	-	6.31	2.98	-
CV%	9.83	12.47	-	10.31	8.42	-

[In column, means containing same letter(s) are not significantly different by LSD at 5% level of significance; Treatments; T_0=Untreated control (Used resistant varieties only), T_1=Pheromone trap (Plastic pot), T_2=Sticky trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval, T_3=Bait trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval, T_4=Light trap+ Mahogany seed powder @ 20gm/L of water at 7 days interval and T_5= Pheromone trap + Trichogramma evanescens]

Table 4. Effect of organic management practices on the production of healthy and infested Tomato at third harvest

Management practices	Tomato fruit borer			Aphid		
	Practicing organic tomato farmers (%)	Fruit infestation (%)	Reduction over untreated control (%)	Practicing organic tomato farmers (%)	Infestation (%)	Reduction over untreated control (%)
T_0	8.67 e	34.31 a	-	6.67 e	39.33 a	-
T_1	52.67 a	27.43 c	20.05	34.33 c	21.81 d	44.56
T_2	42.33 b	29.50 b	14.02	40.50 b	28.50 b	27.54
T_3	43.33 b	22.33 d	34.92	48.67 a	23.33 c	40.68
T_4	30.00 c	19.67 d	42.67	17.33 d	18.67 e	52.50
T_5	16.67 d	18.33 e	46.58	19.00 d	21.19 d	46.12
LSD (0.05)	5.63	3.91	-	6.31	2.61	-
CV%	9.83	11.26	-	10.31	12.38	-

[In column, means containing same letter(s) are not significantly different by LSD at 5% level of significance; Treatments; T_0=Untreated control (Used resistant varieties only), T_1=Pheromone trap (Plastic pot), T_2=Sticky trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval, T_3=Bait trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval, T_4=Light trap+ Mahogany seed powder @ 20gm/L of water at 7 days interval and T_5= Pheromone trap + Trichogramma evanescens]

3.5 Number of Insects per Tomato Plant

The organic tomato farmers were using different combination of mechanical and biological untreated control that have been shown in Table 5. Data revealed that, considering the study area Narsingdi the organic tomato farmers practicing the untreated control treatment resulted the highest number of tomato fruit borer (25.50) and the lowest for T_5= Pheromone trap + *Trichogramma evanescens* (9.89) and Aphid (7.40). For the study area Manikganj the organic tomato farmers practicing the untreated control treatment resulted the highest number of tomato fruit borer (25.50) and the lowest for T_5= Pheromone trap + *Trichogramma evanescens* (7.33) and Aphid (3.50).

3.6 Cost of Pest Management of Organic Tomato

Total cost of production: It was observed that the lowest total cost of production of organic tomato obtained from the treatment T_0 was 60,000.00 Tk./ ha, and the highest total cost of production T_4=Light trap+ Mahogany seed powder @ 20gm/L of water at 7 days interval was 73,000.00 Tk./ ha.

Benefit cost ratio (BCR): Considering the untreated control of insect pest of organic tomato, the highest benefit cost ratio was 1.51 recorded from the treatment T_5 = Pheromone trap + *Trichogramma evanescens* (Table 6). On the other hand, the lowest benefit cost ratio was 1.30 recorded from the untreated control treatment T_0 (Fig. 1). From these results it is revealed that the trend of the benefit cost ratio was observed due to application of the different organic pest management practices against tomato. The initial cost of production was very low compared to traditional production methods, but the relatively high price of organic tomato leads farmers to a profitable BCR. Relevant results were also observed and comparable BCR related to organic farming by Hoque, [13].

3.7 Comparison of Economic Analysis of Inorganic and Organic Pest Management

Results from Fig. 2 revealed that the trend of the comparison between inorganic and organic tomato production for organic tomato production benefit cost ratio was found relatively similar compared with inorganic tomato production. The difference was minimum due to low operational cost and high market price combined with high demand so, insect pest susceptibility and less yield per hector was eventually minimized the gap in BCR for high priced organic and high yielding inorganic tomato [14].

Table 5. Effect of tomato growers' practices on insect pest abundance and management of insect pests

Management practices	Number of insect pest/plant			
	Narsingdi		Manikganj	
	Tomato fruit borer	Aphid	Tomato fruit borer	Aphid
T_0	25.50 a	18.33 a	24.60 a	36.50 a
T_1	21.67 b	13.78 b	21.33 a	31.41 b
T_2	17.31 c	13.40 b	19.33 b	29.67 b
T_3	13.67 d	12.67 c	13.23 c	21.20 c
T_4	10.50 e	9.89 c	6.33 d	13.40 d
T_5	9.89 e	7.40 d	7.33 e	3.50 e
LSD (0.05)	3.61	2.46	3.98	4.91
CV(%)	9.41	11.19	14.52	12.73

[In column, means containing same letter(s) are not significantly different by LSD at 5% level of significance; Treatments; T_0=Untreated control (Used resistant varieties only), T_1=Pheromone trap (Plastic pot), T_2=Sticky trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval, T_3=Bait trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval, T_4=Light trap+ Mahogany seed powder @ 20gm/L of water at 7 days interval and T_5= Pheromone trap + Trichogramma evanescens]

Table 6. Organic pest management for tomato with their effects on production cost, net return and benefit cost ratio (BCR)

Management practices	Cost of pest management (Tk. ha^{-1})	Total cost of production (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Net Return (Tk. ha^{-1})	Benefit Cost Ratio (BCR)
T_0	00.00	60,000.00	78,000.00	18,000.00	1.30
T_1	10,000	70,000.00	98,480.00	28,480.00	1.40
T_2	10,000	70,000.00	98,480.00	28,480.00	1.40
T_3	10,000	70,000.00	101,000.00	31,000.00	1.44
T_4	13,500	73,000.00	104,500.00	31,500.00	1.43
T_5	10,500	70,000.00	105,500.00	35,500.00	1.51

[Treatments; T_0=Untreated control (Used resistant varieties only), T_1=Pheromone trap (Plastic pot), T_2=Sticky trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval, T_3=Bait trap+ Neem leaf powder @ 1kg/10L of water at 7 days interval, T_4=Light trap+ Mahogany seed powder @ 20gm/L of water at 7 days interval and T_5= Pheromone trap + Trichogramma evanescens]

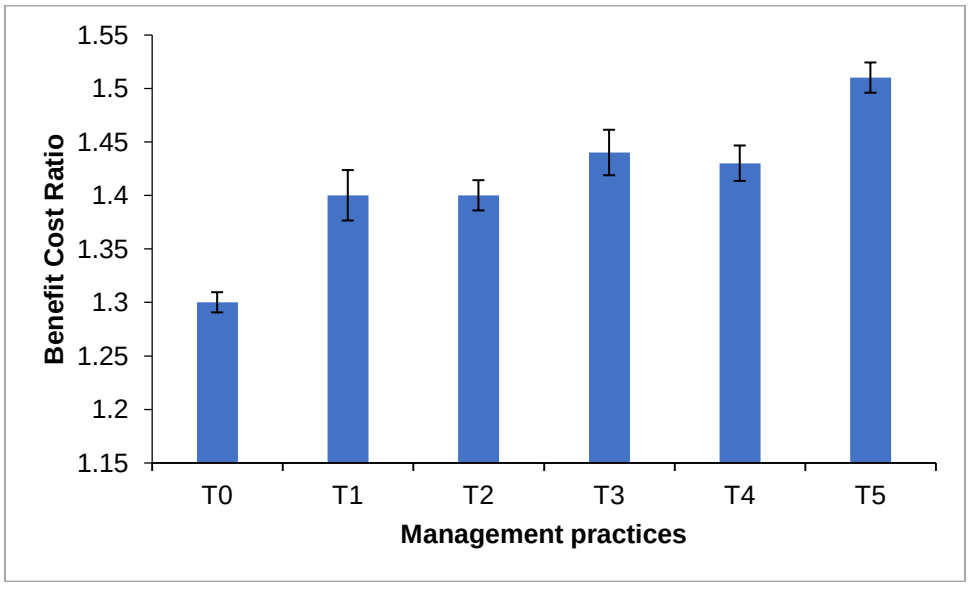

Fig. 1. Benefit cost ratio (BCR) of organic tomato production

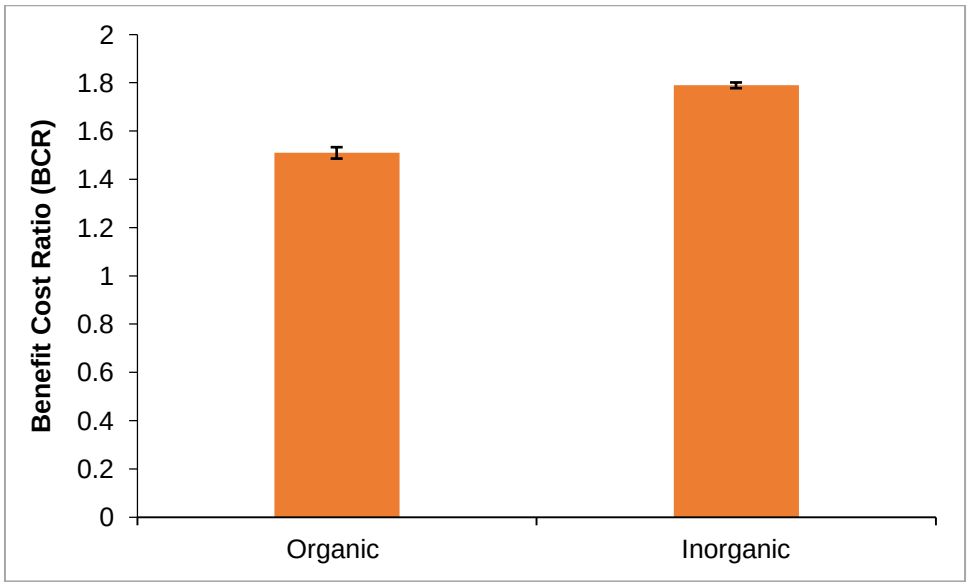

Fig. 2. Comparison of economic analysis of inorganic and organic tomato production
(Source: Inorganic production: YASB [15])

4. CONCLUSION

From the results, it was observed that, most of the organic farmers were dependent on the cost-effective mechanical untreated control over bio-pesticides. Pheromone trap (Plastic pot) was the most frequently used (52.67%) in the study area whereas T_5= Pheromone trap + *Trichogramma evanescens* (16.67%) was used by the least number of organic farmers Pheromone trap + *Trichogramma evanescens* showed best performance against insect pest for the organic tomato field (15.33% infestation) with the highest reduction over untreated control percentage (49.46) against tomato fruit borer. From the result of the BCR analysis, it can be concluded that the highest benefit cost ratio (1.51) was recorded from the treatment T_5= Pheromone trap + *Trichogramma evanescens*, lowest benefit cost ratio 1.30 was recorded for tomato production from the untreated control treatment T_0.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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