Academic Journal of Entomology 8 (3): 140-149, 2015
ISSN 1995-8994

DOI: 10.5829/idosi.aje.2015.8.3.95246

Efficacy of Some Botanicals in Controlling Fruit Borer (*Heliothis armigera*) in Tomato

[1]*Smriti Sultana Binte Mustafiz,* [2]*Md. Tazul Islam Chowdhury and* [2]*Ayesha Akter*

[1]Faculty of Medicine, Kagawa University, Japan and Deputy Manager,
Bangladesh Sugar and Food Industries Corporation
[2]Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

Abstract: The experiment was conducted to evaluation of some botanical pest management practices such as neem oil, neem leaf extract, garlic extract and marsh pepper extract against Fruit borer in tomato during the period from November 2007 to April 2008. The results revealed that applying of neem oil @ 3.0 m/l of water at three days interval showed better performance in respect to control of Fruit borer in Tomato than the other treatments. The highest number of total fruit per plant (33.20), number of healthy fruit per plant (32.44) as well as the lowest number of infested fruit (0.17) was obtained when the crop was treated with neem oil @ 3.0 m/l of water at three days interval. The highest yield (66.80 tones) was recorded when the crop was treated with neem oil @ 3.0 m/l of water at three days interval. The controlling of tomato fruit borer were highest against the effectiveness of neem oil @ 3.0 m/l of water at three days interval in different stage of plant growth but other treatments with neem leaf extract, garlic extract were less effective in controlling the pests. The poor performance was found in neem oil and marsh pepper while these treatments have large interval. The other treatments like neem leaf extract and garlic extract also showed better performance in relation to all concern parameters comparing with neem oil and marsh pepper.

Key words: Neem oil. Pesticides · Botanical pest management practices

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) belongs to the family *Solanaceae* is one of the most popular and important vegetable crop. Tomato is susceptible to insect attack from seedling to fruiting stage. All parts of the plant including leaves, stems, flowers and fruits are subjected to attack. This crop is attacked by different species of insects in Bangladesh. Among them tomato fruit borer *Heliothis armigera (*Hub.*)* is one of the major pests of tomato [1]. Damage by this pest may be up to 85-93.7% [2]. With the increasing threat of resistance in *Heliothis armigera* towards a wide range of pesticides, the necessity to design future pest management strategies to control this pest becomes more apparent. Tomato fruit borer *Heliothis armigera* (Hub.) has been identified as a major pest of tomato in many countries of the world and cause damage to the extent of about 50-60 per cent fruits [3]. Tomato fruit borer is a versatile and widely distributed polyphagous insect, belonging to the family Noctuidae of the order Lepidoptera. It has been reported to infest 181 cultivated and uncultivated plant species in India, distributed in 45 families [4]. They bore circular holes and thrust only a part of their body inside the fruit and eat the contents. If the fruit is bigger in size, it is only partly damaged by the caterpillar but later it is invariably invaded by fungi bacteria and spoiled completely. In Bangladesh, few research works have been done mainly on pesticide approaches for the management of tomato insect pests. Use of botanical extract against pest control is however as a recent approach to insect management and it has drawn the special attention of the Entomologist all over the world. In Bangladesh, only a few attempts have been made to evaluate botanical extracts against insects [5]. Many researchers reported botanical extracts having pesticide properties and thus having potential to

Corresponding Author: Md. Tazul Islam Chowdhury, Department of Agricultural Chemistry,
Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.
Cell: +81-9028954542.

be used against many pests. It would help to avoid environmental pollution caused by chemicals and thus become most rewarding one is our existing socio-economic conditions and environmental threat. It was found that Lepidopteran insect is possible to control by botanical substances. Weekly spray application of the extract of neem seed kernel has been found to effective against *Helicoverpa armigera* [5]. The leaf extract of neem tested against the leaf caterpillar of brinjal, *Selepa docilis* Bult. at 5% concentration had a high antifeedent activity [6].

In light of the above back ground, the research work has been undertaken to know the extent of damage against different botanical pesticides against fruit borer pest of tomato and the effect of different botanical pesticides on yield and yield contributing characters of tomato to estimate the economics of tomato cultivation with different botanicals.

MATERIALS AND METHODS

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2007 to April 2008 to evaluate some botanical pest management practices against pest complex in tomato. The materials and methods used for conducting the experiment were presented in this chapter under the following headings-

Planting Materials: In this research work, the seeds of tomato of the variety BR-2 (Ratan) were sown in seed bed. The seedlings were the farm product of Sher-e-Bangla Agricultural Farm and the age of the seedling was 30 days during transplanting.

Treatments of the Experiment: The experiment comprised with eight treatments. The details of the treatments were presented below: T_1: Neem leaf extract (3 days interval), T_2: Neem leaf extract (7 days interval), T_3: Neem oil (3 days interval), T_4: Neem oil (7 days interval), T_5: Garlic extract (3 days interval), T_6: Marsh Pepper extract (3 days interval), T_7: Marsh Pepper extract (7 days interval), T_8: Untreated control.

Design and Layout of the Experiment: The experiment was laid out at Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the treatment combinations in each plot of each block. There were 24 unit plots altogether in the experiment. The size of the plot was 2.0 m × 1.5 m. The distance between two blocks and two plots were 1.0 m and 0.5 m, respectively.

Preparation of the Main Field: The selected experimental field was opened in the First week of November 2006 with a power tiller and was exposed to the sun for a week for sun drying. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good condition for the growth of tomato seedlings. Weeds and stubbles were removed and finally obtained a desirable tilth of soil. The experimental field was partitioned into the unit plots in accordance with the experimental design.

Application of Manure and Fertilizers: Well decomposed cowdung as per treatment was applied at the time of final land preparation. The sources of fertilizers used for N, P and K were urea (500 kg/ha), TSP (400 kg/ha), MP (200 kg/ha), respectively (Rashid, 1993). The entire amounts of TSP, MP were applied during final land preparation. Only urea was applied in three equal installments at 30 and 45 and 60 Days after planting (DAT).

Intercultural Operation and Irrigation: After establishment of seedlings, various intercultural operations were accomplished for better growth and development. Light over-head irrigation was provided with a watering can to the plots immediately after germination of seed. Irrigation was also applied two times considering the moisture status of field.

Data Collection: The data were recorded on the incidence of fruit borer infested shoots, infested and healthy fruit and yield contributing characters and yield of tomato.

Fruit Borer Infestation: Total number of fruits and infested fruits were recorded at each harvest and continued up to the last harvest. Infested fruits recorded at each observation were pooled and finally expressed in percentage. The damaged fruits were spotted out by the presence of holes made by the larvae.

The percentage of fruit borer infested fruits was calculated using the following formula:

$$\% \text{ fruit borer infested fruit (by number)} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

$$\% \text{ fruit borer infested fruit (by weight)} = \frac{\text{Weight of infested fruits}}{\text{Total weight of fruits}} \times 100$$

Statistically Analysis: The data obtained for different characters were statistically analyzed to find out the significance for different treatments. The analysis of variance was performed by using MSTAT Program. The significance of the difference among the treatment combinations means was estimated by DMRT (Duncan's Multiple Range Test) at 5% level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant Height: Plant height varied significantly for different treatments. Highest plant height (88.51 cm) was recorded from the treatment Neem oil at 3 days interval (T_3) which was closely followed (85.79 cm) by the treatment Marsh Pepper extract (T_6), while the lowest plant height (67.62 cm) was recorded from untreated control which was closely followed (75.33 cm) by the treatment T_2 (Figure 1).

Number of Flower Bunch per Plant: Different botanical pest management practices showed significant variation for number of flower bunch per plant. Highest number of bunch per plant (10.33) was recorded from the treatment Neem oil at 3 days interval (T_3) which was closely followed (9.67) by the treatment T_6. On the other hand, the lowest number of bunch per plant (7.67) was recorded from untreated control (T_8) which was closely followed (8.33) by the treatment T_2 (Figure 2).

Different botanical pest management practices showed significant variation for single fruit weight. Highest fruit weight (126.33 g) was recorded from the treatment T_3 which was closely followed (119.67 g) by the treatment T_6. On the other hand, the lowest fruit weight (100.33 g) was recorded from untreated control which was closely followed (111.00 g) by the treatment T_2 (Figure 3).

Fruiting Status of Tomato at Early Stage

Healthy Fruit in Number: At early stage, statistically significant variation was recorded in number of healthy and infested fruit, % infestation at early fruiting stage in controlling tomato fruit borer for different botanical pest management practices under the present trial. Highest number of healthy fruit per plant (9.58) was recorded from the treatment T_3 which was statistically identical (9.07 and 9.02) with the treatment T_1 and T_6, respectively (Table 1). On the other hand, the lowest (6.70) number of healthy fruit was recorded from untreated control which was closely followed (7.48) by the treatment T_2. From treatment Neem oil (7 days interval), Marsh Pepper extract

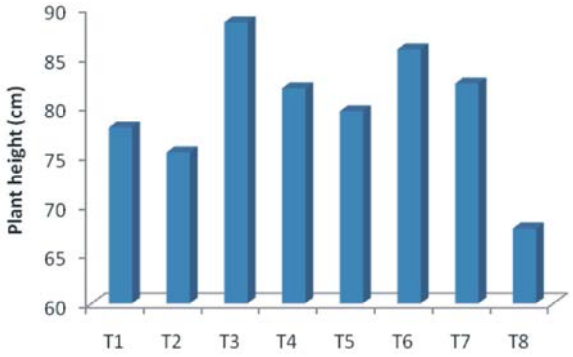

Fig. 1: Effect of different botanical pest management practices, treatment T1-T8 on plant height of tomato

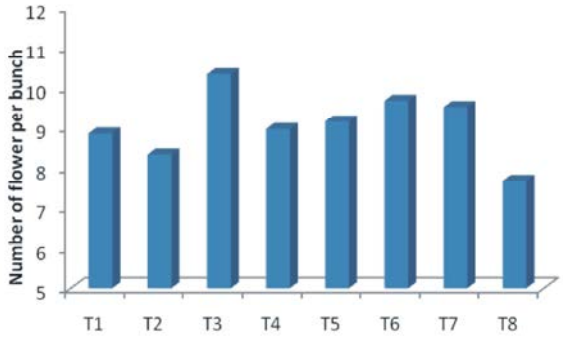

Fig. 2: Effect of different botanical pest management practices (treatment T1-T8) on flower per bunch of tomato

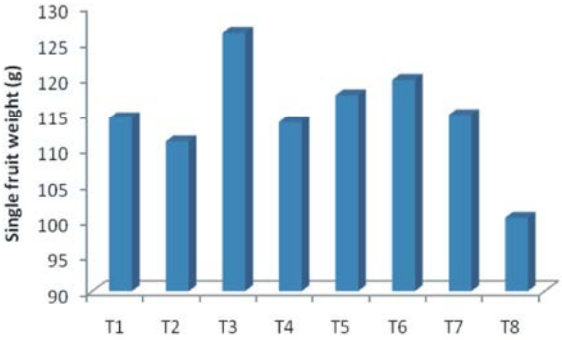

Fig. 3: Effect of different botanical pest management practices (treatment T1-T8) on single fruit weight of tomato

(7 days interval) and Garlic extract (3 days interval) healthy fruits were recorded (Range from 7.71%-8.24%). The lowest % of infested fruit in number (1.77%) was recorded from the treatment T_3 which was statistically similar (2.40% and 2.55%) with the treatment T_6 and T_1, respectively. On the other hand, the highest % of infested fruit in number (11.71%) was recorded from untreated

Table 1: Effect of some botanical pest management practices in controlling tomato fruit borer at early harvesting stage in terms of fruits per plant in number and weight

	Tomato fruit in number				Tomato fruit in weight (g)			
Treatment	Healthy	Infested	% infestation	Increase over control (%)	Healthy	Infested	% infestation	Reduction over control (%)
T_1	9.07 ab	0.24 c	2.55 c	78.22	824.50 b	50.21 e	5.74 bc	50.60
T_2	7.48 cd	0.63 b	7.76 b	33.73	772.38 bc	80.53 b	9.46 ab	18.59
T_3	9.58 a	0.17 c	1.77 c	84.88	901.07 a	32.81 f	3.52 c	69.71
T_4	7.71 c	0.55 b	6.61 b	43.55	805.48 bc	74.65 c	8.53 abc	26.59
T_5	8.24 bc	0.50 b	5.95 b	49.19	798.89 bc	52.23 e	6.12 abc	47.33
T_6	9.02 ab	0.22 c	2.40 c	79.50	880.36 a	51.93 e	5.57 bc	52.07
T_7	7.82 c	0.57 b	6.81 b	41.84	754.97 c	66.30 d	8.06 abc	30.64
T_8	6.70 d	0.89 a	11.71 a	--	693.55 d	90.96 a	11.62 a	--
$LSD_{(0.05)}$	0.884	0.124	1.995	--	54.78	5.193	5.193	--
CV(%)	7.84	15.24	16.38	--	4.69	8.56	10.23	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment. In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

control which was closely followed (7.76% and 6.81%) by the treatment T_2 and T_7, respectively. Moderate results were found (5.95%, 6.61%) from treatment T_4 and T_5 respectively Divakar *et al*. [9], Divakar and Pawar [10] reported that the inundative releases of *T. chilonis* also reduced the larval population of *H. armigera* in tomato which ultimately increased the yield of tomato. It means biological and botanical control is very effective in tomato for *Heliothis armigera.*

Fruit infestation reduction over control in number was estimated and the highest value (84.88%) infestation reduction over control was recorded from the treatment T_3 which was followed by neem leaf extract treated plots (78.22) and the lowest value (33.73%) recorded from the treatment T_2 (Table 1). From the findings it is revealed that treatment T_3 performed maximum healthy fruit and minimum infested fruit as well as lowest % of fruit infestation in number whereas in control treatment the situation is reverse under the present condition.

Tomato Fruit in Weight: Statistically significant variation was recorded in weight of healthy and infested fruit, % infestation at early fruiting stage in controlling tomato fruit borer for different botanical pest management practices under the present trial. Highest weight of healthy fruit per plant (901.07 g) was recorded from the treatment T_3 which was statistically identical (880.36 g) with the treatment T_6 (Table 1). The second highest healthy fruit weight was recorded from T_1 (824.50g) which was followed by T_4 (805.48g) and T_5 (798.89g). On the other hand the lowest (693.55 g) weight of healthy fruit was recorded from untreated control which was closely followed (772.38 g) by the treatment T_2. Thakur *et al*. [11] and Gopal and Senguttuvan [12] reported the efficacy of neem products or botanicals against the tomato fruit borer which has the similarity with this experiment. Fruit infestation reduction over control in weight was estimated the highest value (69.71%) infestation reduction over control was recorded from the treatment T_3 and the lowest value (18.59%) recorded from the treatment T_2. From the findings it is revealed that treatment T_3 performed maximum healthy fruit and lowest % of fruit infestation in weight whereas in control treatment the situation is reverse under the present condition.

Fruiting Status of Tomato at mid Stage

Healthy Fruit in Number: At mid stage, statistically significant variation was recorded in number of healthy and infested fruit, % infestation at mid fruiting stage in controlling tomato fruit borer for different botanical pest management practices under the present trial. Highest number of healthy fruit per plant (10.33) was recorded from the treatment T_3 which was statistically identical (10.01 and 9.42) with the treatment T_6 and T_1, respectively (Table 2). The second highest number of healthy fruits were found in T_5 (8.99) treatment which was followed by T_7 (8.26) and T_4 (7.92). On the other hand, the lowest (7.68) number of healthy fruit was recorded from untreated control which was closely followed (7.82) by the treatment T_2.

Table 2: Effect of some botanical pest management practices in controlling tomato fruit borer at mid harvesting stage in terms of fruits per plant in number and weight

	Tomato fruit in number			Tomato fruit in weight (g)		
Treatment	Healthy	% infestation	Increase over control (%)	Healthy	% infestation	Reduction over control (%)
T_1	9.42 abc	4.57 d	66.52	878.27 a	6.65 c	47.56
T_2	7.82 de	11.09 b	18.75	651.34 d	12.65 a	0.24
T_3	10.33 a	2.55 e	81.32	927.11 a	3.66 d	71.14
T_4	7.92 de	10.70 b	21.61	788.89 b	10.23 b	19.32
T_5	8.99 bcd	7.54 c	44.76	694.21 cd	7.14 c	43.69
T_6	10.01 ab	3.70 de	72.89	900.98 a	6.26 c	50.63
T_7	8.26 cde	8.57 c	37.22	747.15 bc	9.69 b	23.58
T_8	7.68 e	13.65 a		643.14 d	12.68 a	--
$LSD_{(0.05)}$	1.125	1.634	--	66.00	1.313	--
CV(%)	5.74	14.61	--	4.02	6.60	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment. In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

The lowest % of infestation in number (2.55%) was recorded from the treatment T_3 which was statistically similar (3.70%) with the treatment T_6 and T_1 (4.57%). On the other hand, the highest % of infested fruit in number (13.65%) was recorded from untreated control (T_8) which was closely followed (11.09%) by the treatment T_2 and T_4 (10.70%). Percent infestation was lower in treatment T_5 (7.54%) and T_7 (8.57%). Gopal and Senguttuvan [12] also reported the efficacy of botanicals against tomato fruit borer. Fruit infestation reduction over control in number was estimated the highest value (81.32%) infestation reduction over control was recorded from the treatment T_3 and the lowest value (18.75%) recorded from the treatment T_2. Fruit infestation reduction over control ranged from 37.22-66.52) in T_7, T_5 and T_1. From the findings it is revealed that at mid fruiting stage T_3 treatment performed maximum healthy fruit and minimum infested fruit in number as well as lowest % of fruit infestation in number whereas in control treatment the situation is reverse under the present condition. At mid stage infestation level was higher than the early stage.

Tomato Fruit in Weight: Statistically significant variation was recorded in weight of healthy and infested fruit, % infestation at mid fruiting stage in controlling tomato fruit borer for different botanical pest management practices under the present trial. Highest weight of healthy fruit per plant (927.11 g) was recorded from the treatment T_3 which was statistically identical (900.98 g) with the treatment T_6 (Table 2). The second highest weight of healthy fruit was found in T_1 (878.27g) which was followed by T4 (788.89g) and T_7 (747.45g). On the other hand, the lowest (643.14 g) weight of healthy fruit was recorded from untreated control which was closely followed (651.34 g) by the treatment T_2.

The lowest % of infested fruit in weight (3.66%) was recorded from the treatment T_3 which was closely followed (6.26% and 7.14%) with the treatment T_6 and T_5, respectively. On the other hand the highest % of infested fruit in weight (12.68%) was recorded from untreated control which was statistically similar (12.65%) by the treatment T_2. Gopal and Senquttuvan [12], Kulat *et al.*[13], Sundarajan [14] and Sundarajan [15] also reported the botanicals and plant products to control the fruit borer which increased the total yield of production in different crops. Fruit infestation reduction over control in weight was estimated the highest value (71.14%) infestation reduction over control was recorded from the treatment T_3 and the lowest value (0.24%) recorded from T_2 treatment (Table 2). From the findings it is revealed that treatment T_3 performed maximum healthy fruit and minimum infested fruit as well as lowest % of fruit infestation in weight whereas in control treatment the situation is reverse under the present condition.

Fruiting Status of Tomato at Late Stage

Healthy Fruit in Number: At late stage, statistically significant variation was recorded in number of healthy and infested fruit, % infestation at late fruiting stage in controlling tomato fruit borer for different botanical pest management practices under the present trial. Highest number of healthy fruit per plant (12.53) was recorded

Table 3: Effect of some botanical pests management practices in controlling tomato fruit borer at late harvesting stage in terms of fruits per plant in number and weight

	Tomato fruit in number			Tomato fruit in weight (g)		
Treatment	Healthy	% infestation	Increase over control (%)	Healthy	% infestation	Reduction over control (%)
T_1	11.42 ab	5.00 d	65.35	910.50 bc	7.60 d	57.52
T_2	9.43 c	11.41 b	20.93	829.89 c	16.11 ab	9.95
T_3	12.53 a	3.04 d	78.93	1073.43 a	3.26 e	81.78
T_4	10.35 bc	10.50 bc	27.23	931.53 bc	14.66 bc	18.05
T_5	9.51 c	7.86 c	45.53	942.34 bc	9.08 d	49.25
T_6	11.98 a	3.73 d	74.15	980.82 ab	7.20 d	59.75
T_7	9.75 c	10.35 bc	28.27	893.33 bc	13.61 c	23.92
T_8	8.93 c	14.43 a	--	852.52 bc	17.89 a	--
$LSD_{(0.05)}$	1.360	2.645	--	121.8	1.956	--
CV(%)	7.40	18.22	--	7.50	9.99	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment. In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

from the treatment T_3 which was statistically identical (11.98, 11.42 and 10.35) with the treatment T_6 and T_1 and T_4 respectively (Table 3). On the other hand, the lowest (8.93) number of healthy fruit was recorded from untreated control which was statistically similar (9.43) by the treatment T_2. The lowest % of infested fruit in number (3.04%) was recorded from the treatment T_3 which was statistically similar (3.73%) with the treatment T_6. On the other hand the highest % of infested fruit in number (14.43%) was recorded from untreated control which was closely followed (11.41%) by the treatment T_2. Fruit infestation reduction over control in number was estimated the highest value (78.93%) infestation reduction over control was recorded from the treatment T_3 and the lowest value (20.93%) recorded from T_2 treatment (Table 3). From the findings it is revealed that treatment T_3 performed maximum healthy fruit and minimum infested fruit as well as lowest % of fruit infestation in number whereas in control treatment the situation is reverse under the present condition. At late stage infestation level was higher than the early stage.

Tomato Fruit in Weight: Statistically significant variation was recorded in weight of healthy and infested fruit, % infestation at late fruiting stage in controlling tomato fruit borer for different botanical pest management practices under the present trial. Highest weight of healthy fruit per plant (1073.43 g) was recorded from the treatment T_3 which was statistically identical (980.82 g) with the treatment T_6 (Table 3). On the other hand, the lowest (829.89 g) weight of healthy fruit was recorded from the treatment T_2 which was closely followed (852.52 g) by untreated control. Lowest weight of infested fruit (36.32 g) was recorded from the treatment T_3 which was closely followed (75.71 g) by the treatment T_6, while the highest weight of infested fruit (185.32 g) was recorded from untreated control which was closely followed (158.95 g) by the treatment T_2. The lowest % of infested fruit in weight (3.26%) was recorded from the treatment T_3 which was closely followed (7.20% and 7.60%) with the treatment T_6 and T_1, respectively. On the other hand, the highest % of infested fruit in weight (17.89%) was recorded from untreated control which was statistically similar (16.11%) by the treatment T_2. These results are agreement with the findings of Brown and Bird [16] and Channarayappa *et al*. [17]. Fruit infestation reduction over control in weight was estimated the highest value (81.78%) infestation reduction over control was recorded from the treatment T_3 and the lowest value (9.95%) recorded from the treatment T_2 (Table 3). From the findings, it is revealed that T_3 treatment performed maximum healthy fruit and minimum infested fruit as well as lowest % of fruit infestation in weight whereas in control treatment the situation is reverse under the present condition. At late stage infestation level was higher than early and mid stage and in weight infestation was higher in comparing the other stage in weight.

Fruit Bearing Status of Tomato

Tomato Fruit in Number: Statistically significant variation was recorded in number of healthy and infested fruit, % infestation in controlling tomato fruit borer for different botanical pest management practices under the present trial. Highest number of total fruit per plant (33.20) was recorded from the treatment T_3 which was closely followed

Table 4: Effect of some botanical pests management practices in controlling tomato fruit borer in terms of fruits per plant in number during total cropping season

	Tomato fruit/plant in number			
Treatment	Total	Healthy	% infestation	Reduction over control (%)
T_1	31.20 c	29.91 b	4.13 e	69.11
T_2	27.55 f	24.73 cd	10.22 b	23.56
T_3	33.27 a	32.44 a	2.50 f	81.30
T_4	28.68 d	25.97 c	9.44 bc	29.39
T_5	28.79 d	26.74 c	7.13 d	46.67
T_6	32.08 b	31.01 ab	3.31 ef	75.24
T_7	28.30 e	25.83 c	8.73 c	34.70
T_8	26.92 g	23.31 d	13.37 a	--
$LSD_{(0.05)}$	0.341	2.048	0.928	
CV(%)	3.95	4.02	7.21	

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment. In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

(32.08) by the treatment T_6. The next highest total fruit per plant was recorded T_1 (31.20) which was followed by T_5 (28.79) and T_4 (28.68). The lowest (26.92) number of total fruit was recorded from untreated control which was closely followed (27.55) by the treatment T_2 (Table 4). Highest number of healthy fruit per plant (32.44) was recorded from the treatment T_3 which was statistically identical (31.01) with the treatment T_6. Among the treatment T_1, T_4 and T_5 the healthy fruit in number per plant was highest in T_1 (29.91) which was followed by T_5 (26.74) and T_4 (25.97). On the other hand, the lowest (23.31) number of healthy fruit was recorded from untreated control which was statistically similar (24.73) with the treatment T_2. The lowest % of infestation in fruit by number (2.50%) was recorded from the treatment T_3 which was statistically similar (3.31%) with the treatment T_6. In T_1 (4.13) treatment the percent infestation was also lower which was followed by T_5 (7.13).

On the other hand, the highest % of infested fruit in number (13.373%) was recorded from untreated control which was closely followed (10.22%) by the treatment T_2 and T_4 (9.44). Divakar *et al*. [9] reported that controlling of fruit borer infestation by parasitoids increased the fruit number. Fruit infestation reduction over control in number was estimated the highest value (81.30%) infestation reduction over control was recorded from the treatment T_3 and the second highest value (75.24%) infestation reduction over control was recorded from T_6 which was followed by T_1 (69.11%). The lowest value (23.56%) recorded from the treatment T_2. From the findings, it is revealed that treatment T_3 performed maximum healthy fruit and minimum infested fruit as well as lowest % of fruit infestation in number whereas in control treatment the situation is reverse condition. The performance of neem leaf extract and garlic extract was satisfactory compare with neem oil providing more intervals. At late stage infestation level was higher than the early stage.

Tomato Fruit in Weight: Statistically significant variation was recorded in weight of healthy and infested fruit, % infestation in controlling tomato fruit borer for different botanical pest management practices under the present trial. Highest weight of total fruit per plant (3006.01 g) was recorded from the treatment T_3 which was closely followed (2949.94) with the treatment T_6 and T_4 (2849.78). Total fruit weight was also higher in treatment T_1 (2801.77g) (Table 5).

On the other hand, the lowest (2558.85 g) weight of total fruit per plant was recorded from untreated control which was closely followed (2587.40 g) by the treatment T_2 and T_5 (2635.19g). Highest weight of healthy fruit per plant (2901.61 g) was recorded from the treatment T_3 which was closely followed with the treatment T_6 (2762.16 g) and T_1 (2613.27g) (Table 5). On the other hand, the lowest (2189.21 g) weight of healthy fruit was recorded from untreated control which was closely followed (2253.62 g) by the treatment T_2 (2253.62g). The lowest % of infested fruit in weight (3.47%) was recorded from the treatment T_3 which was closely followed (6.37% and 6.72%) by the treatment T_6 and T_1, respectively. On the other hand, the highest % of infested fruit in weight (14.45%) was recorded from untreated control which was closely followed (12.90%) by the treatment T_2. Percent infestation was also higher in T_4 (11.36) and T_7 (10.70) treatments. Dilbagh *et al*. [18] El-Defrawi *et al*. [19] reported the similar results earlier from their experiment.

Table 5: Effect of some botanical pest management practices in controlling tomato fruit borer in terms of fruits per plant in weight during total cropping season

	Tomato fruit per plant in weight (g)			
Treatment	Total	Healthy	% infestation	Reduction over control (%)
T_1	2801.77 c	2613.27 cd	6.72 e	53.49
T_2	2587.40 e	2253.62 a	12.90 b	10.73
T_3	3006.01 a	2901.61 d	3.47 f	75.99
T_4	2849.78 cd	2525.90 ab	11.36 c	21.38
T_5	2635.19 d	2435.44 bcd	7.58 d	47.54
T_6	2949.94 b	2762.16 cd	6.37 e	55.92
T_7	2682.29 d	2395.45 abc	10.70 c	25.95
T_8	2558.85 e	2189.21 a	14.45 a	--
$LSD_{(0.05)}$	137.0	123.8	0.771	--
CV(%)	2.84	2.82	4.79	--

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment. In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Table 6: Effect of some botanical pest management practices on healthy and infested and total fruit in hectare of tomato

	Tomato fruit per hectare (tonnes)			
Treatment	Total	Healthy	Increase over control (%)	Infested
T_1	62.26 d	58.07 c	9.50	4.19 cd
T_2	57.50 g	50.08 e	1.13	7.42 a
T_3	66.80 a	64.48 a	17.48	2.32 d
T_4	63.33 c	56.13 cd	11.38	7.20 ab
T_5	58.56 f	54.12 d	2.99	4.44 bcd
T_6	65.55 b	61.38 b	15.28	4.17 cd
T_7	59.61 e	53.23 d	4.84	6.37 abc
T_8	56.86 h	48.65 e	--	8.21 a
$LSD_{(0.05)}$	0.594	3.045	--	2.751
CV(%)	2.84	2.82	--	6.12

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment. In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Fruit infestation reduction over control in weight was estimated the highest value (75.99%) infestation reduction over control was recorded from the treatment T_3 and the lowest value (10.73%) recorded from T_2 treatment. From the findings, it is revealed that the treatment T_3 performed maximum healthy fruit and minimum infested fruit as well as lowest % of fruit infestation in weight whereas in control treatment the situation is reverse under the present condition.

Tomato Fruit in Hectare: Statistically significant variation was recorded in weight of healthy and infested fruit, % infestation per hectare in controlling tomato fruit borer for different botanical pest management practices under the present trial. Highest weight of total fruit per hectare (66.80 tonnes) was recorded from the treatment T_3 which was closely followed (65.55 tonnes) with the treatment T_6. The second highest total fruit was recorded from T_1 (62.26 ton.). On the other hand the lowest (56.86 tonnes) weight of total fruit per hectare was recorded from untreated control which was closely followed (57.50 tonnes) by the treatment T_2. Highest weight of healthy fruit per hectare (64.48 tonnes) was recorded from the treatment T_3 which was closely followed (61.38 tonnes) by the treatment T_6 (Table 6).

The next highest weight of healthy fruit per hectare was recorded from T_1 (58.07 tonnes) which was followed by T_5 (54.12 tonnes). On the other hand, the lowest (48.65 tonnes) weight of healthy fruit per hectare was recorded from untreated control which was statistically similar (50.08 tonnes) by the treatment T_2. Healthy fruit increase over control was estimated the highest value (17.48%)

Table 7: Cost benefit analysis for different botanical pest management

Treatments	Cost of pest Management (Tk.)	Yield		Gross return (Tk.)	Net Return (Tk.)	Adjusted net return (Tk.)	Benefit cost ratio
		Healthy	Infested				
T_1	34000	58.07	4.19	900380	866380	79160	2.33
T_2	15000	50.08	7.42	803140	788140	920	0.06
T_3	51400	64.48	2.32	983440	932040	144820	2.82
T_4	28000	56.13	7.2	892350	864350	77130	2.75
T_5	28000	54.12	4.44	842880	814880	27660	0.99
T_6	48000	61.38	4.17	949890	901890	114670	2.39
T_7	20000	53.23	6.37	843040	823040	35820	1.79
T_8	0	48.65	8.21	787220	787220	--	--

Price of tomato: Tk. 15 for healthy and Tk. 7 for infested fruit

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment. In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

increase over control was recorded from the treatment T_3 and the lowest value (1.13%) recorded from T_2 treatment (Table 6). Lowest weight of infested fruit (2.32 tonnes) was recorded from the treatment T_3 which was closely followed (4.17 tonnes) by the treatment T_6, while the highest weight of infested fruit (8.21 tonnes) was recorded from untreated control which was statistically similar (7.42 tonnes) by the treatment T_2 treatment. From the findings it is revealed that treatment T_3 performed maximum healthy fruit and minimum infested fruit as well as lowest % of fruit infestation in weight whereas in control treatment the situation is reverse under the present condition.

Economic Analysis: Economic analysis of different botanical pest management were calculated and presented in Table 7. In this study, the untreated control did not require any pest management cost. The cost for the treatment of neem oil was incurred for neem oil, trix liquid detergent, preparation and its application. For leaf extract labor cost also involved. Considering the controlling of tomato fruit borer highest benefit cost ratio (2.82) was recorded in the treatment T_3 as application of neem oil at 3 days interval and next highest BCR was found in T_4 (2.75) which treated with neem oil at 7 days interval. On the other hand, the minimum cost benefit ratio (0.06) was recorded in treatment T_2 as application of neem leaf extract and the application of garlic extract also gave the lower benefit cost ratio (0.99) (Table 7).

From the above findings, it was observed that the yield contributing characters using the botanicals as pest management practices had positive effect. Among the practices, application of Neem oil at three days interval was superior if Tomato yield contributing characters are considered. Neem leaf extract and garlic extract had also significant effect on the yield and the yield contributing characters.

CONCLUSION

The experiment was conducted to evaluation of some botanical pest management practices such as neem oil, neem leaf extract, garlic extract and marsh pepper extract against pest complex in tomato. Data on fruit borer infestation and their effect of yield contributing characters and yield were recorded. Controlling of tomato fruit borer highest benefit cost ratio (2.82) was recorded in the treatment application of Neem oil at 3 days interval. On the other hand, the minimum cost benefit ratio (0.06) was recorded from neem leaf extract in treatment at 3 days interval. Among the different treatments, neem oil application at 3 days interval was most effective than other treatment. The other treatments like neem leaf extract and garlic extract also showed better performance in relation to all concern parameters comparing with neem oil and marsh pepper. The poor performance was found in neem oil and marsh pepper while these treatments have large interval. Considering the situation of the present experiment, further studies in the following areas may be suggested: Similarly study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.

REFERENCES

1. Haque, M.M., 1995. Insect pest of tomato in: Curriculum Outline and Training Support Materials, Training Manual: Winter Vegetables and Spices Production. Horticulture Research and Development Project, DAE, BADC, Dhaka, pp: 180-181.
2. Tewari, G.C., 1984. Field efficacy of synthetic pyrethroids against *Heliothis armigera* (Hubner) infesting tomato. Singapore Journal of Primary Industries, 13(1): 51-56.

3. Singh, H. and G. Singh, 1977. Biological studies on *Heliothis armigera* Hubner in Punjab. Indian Journal of Entomology, 37(2): 154-164.
4. Manjunath, T.M., V.S. Bhatnagar, C.S. Pawar and S. Sithanatham, 1985. Economic importance of Heliothis sp. in India and an assessment of their natural enemies and host plants. Proc. Workshop Biol. Contr. *Heliothis*, ICRISAT. Nov., pp: 11-15.
5. Karim, M.A., 1994. Insect pest management of vegetable crops. Proceeding of a symposium on resent advances in vegetable development of Bangladesh, 24-25 April, pp: 198-199.
6. Jacob, Y. and K. Sheila, 1992. Comparison of capsules of sex pheromone of *Heliothis (Helicoverpa) armigera* (Hubner) (Lepidoptera: Noctuidae). Boletin de Sanidad Vegetal Plagas, 18(2): 427-434.
7. FAO, 1988. Production Year Book. Food and Agricultural of the United Nations. Rome, Italy, 42: 190-193.
8. Gomez, A.K. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research, Second edition. John Wiley and Sons, pp: 680.
9. Divakar, B.J. and A.D. Pawar, 1987. Biocontrol of tomato fruit borer, *Heliothis armigera* (Hb) in Karnataka. Indian Journal of Plant Protection, 15(1): 57-61.
10. Divakar, B., P. Solans and J. Vitalle, 1987. Parasitoids and predators of *Heliocoverpa armigera* (Hubner) on table tomato crops. Boletin de Sanidad Vegetal Plages, 20(2): 521-530.
11. Thakur, S.S., K.S. Chandel and N.P. Kashyap, 1998. Field evaluation of tomato varieties against *Helicoverpa armigera* (Hubner) in the higher hills of Himachal Pradesh. Insect Environment, 4(2): 51-52.
12. Gopal, S. and T. Senguttuvan, 1997. Integrated management of tomato fruit borer with insecticides, neem products and virus. Madras Agricultural Journal, 84(2): 82-84.
13. Kulat, S.S., V.N. Nandanwar, N.N. Zade and S.S. Tirthkar, 2001. Evaluation of some indigenous plant products for the management of *Helicoverpa armigera* Hubn. on chickpea. Journal of Applied Zoological Researches, 12(2-3): 96-98.
14. Sundarajan, G., 2001. Evaluation of some plant extracts against *Helicoverpa armigera* (Hubner). Environment and Ecology, 19(1): 210-212.
15. Sundarajan, G., 2002. Control of caterpillar *Helicoverpa armigera* using botanicals. Journal of Ecotoxicology and Environmental Monitoring, 12(4): 305-308.
16. Brown, J.K. and J. Bird, 1992. Whitefly-transmitted geminiviruses and associated disorder in the Americans and the Caribbean Basin. Plant Disease, 76(3): 220-225.
17. Channarayappa, S.G., V. Muniyappa and R.H. First, 1992. Resistance of Lycopersicon species to B. tabaci, a tomato leaf curl virus vector. Canadian J. Bot., 70: 2184-2192.
18. Dilbagh, S., D.D. Narang and D. Singh, 1990. Control of tomato fruit borer, *Heliothis armigera* Hubner with synthetic pyrethroids. Indian Journal of Entomology, 52(4): 534-540.
19. El-Defrawi, G.M., A.K. Emam, I.A. Marzouk and L. Rizkalla, 2000. Population dynamics and seasonal distribution of Aphis craccivora Koch and associated natural enemies in relation to virus disease incidence of faba bean fields. Egyptian J. Agric. Res., 78(2): 627-641.