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Full Length Research Paper

Assessment of the effectiveness of different botanicals and chemical insecticide in managing Epilachna beetle, *Epilachna dodecastigma* (Wied.)

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Abstract

Neem Oil, Mehagony Oil, Bishkatali Leaf Extract, pithraj seed extract and Diazinon 60 EC were assessed for their effectiveness in managing Epilachna beetle, *Epilachna dodecastigma* (Wied.). A local variety of Sweet Gourd was planted in Entomology Field Laboratory of Bangladesh Agricultural University (BAU), Mymensingh following Randomized Complete Block Design (RCBD) with three replications. The highest incidence of Epilachna beetle/Plant was 7.67 and the highest percentage of infested leaves (11.27%) was observed at 60 DAT. Beetle Population along with percentage of infested leaves declined at fruiting stage due to the maturity of the leaves. The effectiveness of the treatments against the pest was evaluated on the basis of percent reduction of beetle population at 24, 48 & 72 HAT in field level. In all spray intervals, mean reduction percentage of beetle population reached the peak point in Diazinon 60 EC @ 2.5 ml/L treated plots, whereas mean reduction percentage showed a declining trend in Bishkatali Leaf Extract @ 8% other than 2nd spray. Though Neem, mahogany, biskatali, pithraj treated plots showed significant variation over untreated control in aspects of percent population reduction of Epilachna beetle, neem oil at 13% concentration was the most effective among them. Effectiveness of botanicals and synthetic insecticide increased with the increase of concentration.

Key Words*:* Epilachna beetle, Botanicals, Incidence, Effectiveness.

INTRODUCTION

Vegetable cultivation is one of the most important and dynamic branches of agriculture of Bangladesh, a country with sub tropical climate. Among the vegetables cultivated in Bangladesh Sweet gourd (Pumpkin), a cucurbit is now drawing attention to a greater extent. Sweet gourd *Cucurbita moschata* locally known as "MISTY KUMRA**"** is one of the vitamin A rich cucurbitaceous vegetables belonging to family Cucurbitaceae (Anonymous, 1994). It is a delicious and favourite traditional vegetable that contains carbohydrates, minerals and vitamins. Young fruits are cooked as vegetables dish. Young stems and leaves are used as leafy vegetables. In Bangladesh, sweet gourd occupies an area of 27500 acres with an annual production of 218 thousand tons (3.28% of the total annual vegetable production) (BBS, 2010). Sweet gourd production is hindered by a number of insect pests. Among them Epilachna beetle, *Epilachna dodecastigma* (Wied.) is the most destructive especially in South East Asia. Both the grub and adult feed on the epidermal tissues of leaves by scraping and can cause damage up to 80% of plants (Rajagopal and Trivedi, 1989). About 35% to 75% leaves may be severely damaged by the infestation of grubs and adults (Srivastava and Katiyar, 1972). The grubs confine their attack to the lower surface and adults usually feed on the upper surface of the leaves. The plants may completely dry up due to extensive infestation by the insects (Pradhan *et al.*, 1990). For the control of Epilachna beetle, many methods have been adopted but its control is based purely on chemicals especially synthetic insecticides. Non judicial and repeated application of insecticides at improper doses may cause several problems such as disrupting natural enemy complexes, secondary pest outbreaks, pest resurgence, development of insecticide resistance and environmental pollution(Hagen and Franz 1973; Kavadia et al., 1984; Desmarchelier, 1985; Fishwick, 1988). Farmers can shift the practice of sole reliance of insecticide to alternative approaches to solve these problems. In this situation, alternation or biodegradable

Experimental design	
Design Randomized Complete Block Design (RCBD)	Treatments
Replication: 3	Treatments: 6
number of block : 3	T_1- Neem oil @ 13%, 10% & 8%
Number of Plot/block : 18	T_2- Mahogany oil @ 13%, 10% & 8%
Total number of plots: 54	T_3- Bishkatali leaf extract @ 13%, 10% & 8%
Plot Size : 2m × 2 m	T_4 - Pithraj seed extract @ 13%, 10% & 8%
Unit plot area : $4m^2$	T_5 - Diazinon 60 EC @1.5 ml/L, 2 ml/L & 2.5 ml/L
Net area: 0.02ha.	T_6- Control(untreated)
Variety : Local variety of sweet gourd	
Number of seedlings / plot: 3	No. of spray: 3 times

substitutes are now being strongly considered by all using chemical pesticides. The biologically active natural plant products may play a significant role in this regard as they are environmentally safe, biodegradable and cost effective. A large number of investigators have isolated and identified several chemical compounds from leaves and seeds of many plant species and screened them for insect feeding deterrents and growth inhibitors (Jacobson *et al.*, 1975). Among them neem oil, mahogany seed have extensively been used, They have been proven to be efficacacious against several insect pests both in field and storage (Saxena *et al.* 1981; Heyde *et al.*, 1983). Neem and pithraj seed extract have no adverse effects in the argoecosystem and the cost of production is likely to be less compared to that of chemical insecticides (Saxena *et al.* 1981). However, exploitation on the use of botanicals (neem extract, mahogani seed extract, bishkatali extract and pithraj extract) against vegetable pests is scanty in Bangladesh. Under this circumstance, the present research was undertaken to assess the incidence and infestation of epilachna beetle on sweet gourd plants and to investigate the insecticidal efficacy of four botanicals (neem oil, biskatali plant extract, mahogany oil and pithraj seed extract) compared to a commonly used insecticide (diazinon 60 EC) against Epilachna beetle.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Entomology Field Laboratory of Bangladesh Agricultural University (BAU), Mymensingh located at 24.750N latitude and 90.50E

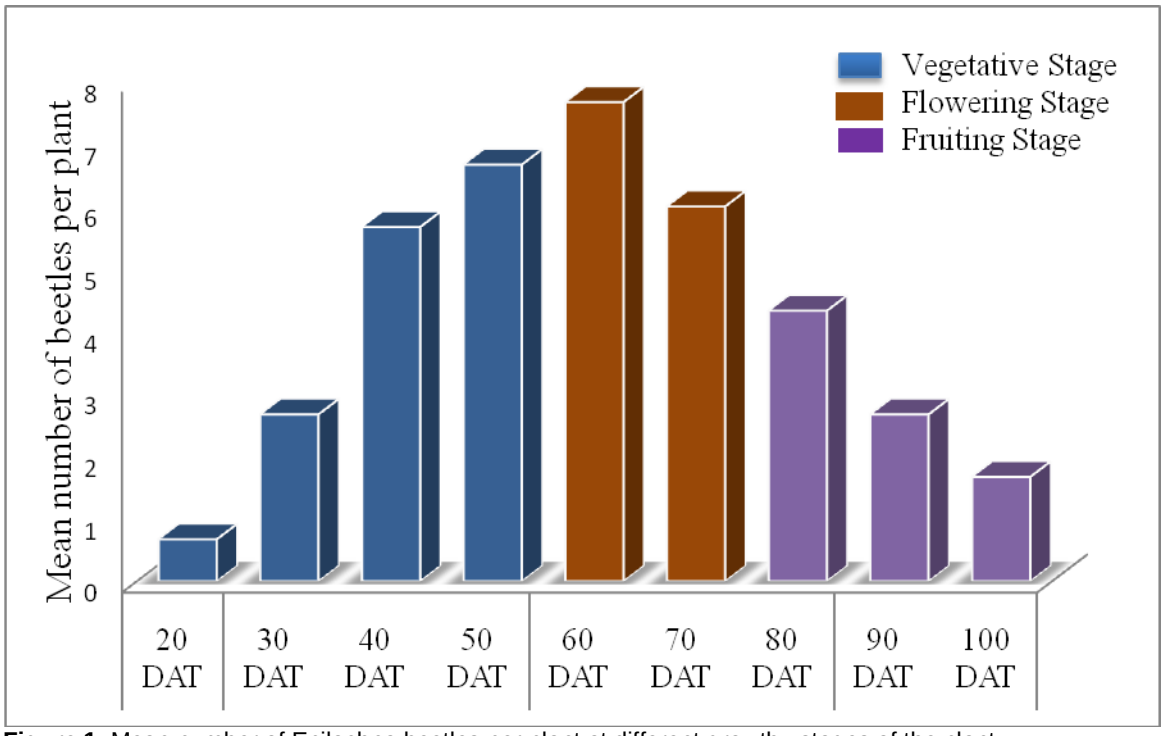

Figure 1. Mean number of Epilachna beetles per plant at different growth stages of the plant

Table1. Number of Epilachna beetle infested Leaf and Percentage of infested leaf per plant.

Days after transplanting	Mean number of infested leaf per plant	Percentage of infested leaf per plant
20 DAT	1.33	5.3
30 DAT	2.33	6.01
40 DAT	6	9.44
50 DAT	8	10.59
60 DAT	9.67	11.27
70 DAT	10	10.53
80 DAT	10	9.15
90 DAT	9.67	8.33
100 DAT	9.33	7.72

Table 2. Effect of botanicals and synthetic insecticide in reduction of epilachna beetle after 1st spray

Treatments	Concentration	Pre-count No.	% reduction or increase of epilachna beetle/ plant at different hours after treatment			
			24 HAT	48 HAT	72 HAT	Mean
Neem oil	8%	5.67	-35.55^{hi} (3.67)	-28.89^{hi} (4)	-28.89^{gh} (4)	-31.11^{i} (3.89)
	10%	6.33	-52.38^{efg} (3)	-47.62^{fg} (3.33)	-47.62^{def} (3.33)	-49.21^{fg} (3.22)
	13%	6	-66.03^{cd} (2)	-66.03^{cd} (2)	-61.27^{c} (2.33)	-64.45^{d} (2.11)
Mahogany oil	8%	5.33	-24.44^{ij} (4)	-24.44^{hi} (4)	-18.89^{h} (4.33)	-22.59^{j} (4.11)
	10%	5.67	-40.95^{gh} (3.33)	-36.19^{gh} (3.67)	-36.19^{fg} (3.67)	-37.78^{hi} (3.56)
	13%	6.67	-54.76^{def} (3)	-54.76^{def} (3)	-50^{cde} (3.33)	-53.17^{ef} (3.11)
Biskatali extract	8%	5.67	-22.86^{j} (4.33)	-18.6^{i} (4.67)	-18.1^{h} (4.67)	-19.68^{j} (4.56)
	10%	5.67	-35.55^{hi} (3.67)	-35.55^{gh} (3.67)	-28.89^{gh} (4)	-33.33^{i} (3.78)
	13%	7	-57.14^{def} (3)	-52.38^{def} (3.33)	-52.38^{cde} (3.33)	-53.97^{ef} (3.22)
Pithraj seed extract	8%	5	-26.11^{ij} (3.67)	-20.56^{i} (4)	-20.56^{h} (4)	-22.41^{j} (3.89)
	10%	6.67	-45.24^{fgh} (3.67)	-50^{ef} (3.33)	-39.68^{efg} (4)	-44.97^{gh} (3.67)
	13%	7.33	-58.93^{de} (2.67)	-63.69^{cde} (3)	-58.93^{cd} (2.67)	-60.51^{de} (2.78)
Diazinon 60 EC	1.5 ml/L	5.67	-77.14^{bc} (1.33)	-77.14^{bc} (1.33)	-77.14^{b} (1.33)	-77.14^{c} (1.33)
	2.0 ml/L	6.67	-84.92^{ab} (1)	-84.92^{ab} (1)	-84.92^{ab} (1)	-84.92^{b} (1)
	2.5 ml/L	7	-96.3^{a} (0.33)	-96.3^{a} (0.33)	-95.83^{a} (0.33)	-96.14^{a} (0.33)
Control		5.67	+3.70^{k} (6)	+3.70^{j} (6)	+5.56^{i} (6)	+4.32^{k} (6)
Level of significant			**	**	**	**
CV%			12.03%	14.42%	14.16%	8.39%

Note: (-) and (+) sign represent % reduction and increase of epilachna beetle
HAT= Hour after treatment

longitudes at a mean elevation of 7.9 to 9.1 m above the sea level.

Parameters of data collection

- Incidence of Epilachna beetle/plant was counted
- Percent of infested leaf/plant was observed
- Reduction of incidence percent of Epilachna beetle/plant

For this particular reserch, two experiments were conducted. The first one occurred naturally as the plot was exposed to natural condition to investigate the population incidence of Epilachna beetle (*Epilachna dodecastigma* Wied.) and number of infested leaf per plant. The incidence of Epilachna beetle and leaf infestation were recorded firstly after 20 days of transplanting (DAT) and continued at 10 days intervals up to 100 DAT. Plants were randomly (3 plants along with 3 branches of ech plant) selected from each plot at different

Table 3. Effect of botanicals and synthetic insecticide in reduction of epilachna beetle after 2nd spray

Treatments	Concentration	Pre-count No.	% reduction or increase of epilachna beetle/ plant at different hours after treatment			
			24 HAT	48 HAT	72 HAT	Mean
Neem oil	8%	5.67	-35.55^{fg} (3.67)	-28.89^{e} (4)	-28.89^{gh} (4)	-31.11^{f} (3.89)
	10%	5.67	-53.33^{de} (2.67)	-53.33^{cd} (2.67)	-46.67^{ef} (3)	-51.11^{d} (2.78)
	13%	6.33	-68.26^{c} (2)	-63.49^{c} (2.33)	-63.49^{cd} (2.33)	-65.08^{c} (2.22)
Mahogany oil	8%	6.67	-19.45^{h} (5.33)	-19.45^{e} (5.33)	-15.28^{h} (5.67)	-18.06^{h} (5.44)
	10%	6.67	-35.36^{fg} (4.33)	-24.52^{e} (5)	-24.52^{h} (5)	-28.14^{fg} (4.78)
	13%	6.67	-54.76^{de} (3)	-60.32^{c} (2.67)	-50^{def} (3.33)	-55.03^{d} (3)
Biskatali extract	8%	5.33	-24.44^{gh} (4)	-24.44^{e} (4)	-18.89^{h} (4.33)	-22.59^{gh} (4.11)
	10%	5.67	-35.55^{fg} (3.67)	-28.89^{e} (4)	-28.89^{gh} (4)	-31.11^{f} (3.89)
	13%	6.33	-52.38^{de} (3)	-52.38^{cd} (3)	-47.62^{ef} (3.33)	-50.79^{d} (3.11)
Pithraj seed extract	8%	6.67	-24.52^{gh} (5)	-19.76^{e} (5.33)	-19.76^{h} (5.33)	-21.35^{gh} (5.22)
	10%	6	-44.29^{ef} (3.33)	-44.29^{d} (3.33)	-38.73^{fg} (3.67)	-42.43^{e} (3.44)
	13%	6.67	-60.32^{cd} (2.67)	-60.32^{c} (2.67)	-54.76^{de} (3)	-58.46^{cd} (2.78)
Diazinon 60 EC	1.5 ml/L	6.33	-79.44^{b} (1.33)	-79.44^{b} (1.33)	-73.89^{bc} (1.67)	-77.59^{b} (1.44)
	2.0 ml/L	7	-85.51^{b} (1)	-85.51^{ab} (1)	-81.35^{b} (1.33)	-84.12^{b} (1.11)
	2.5 ml/L	7.33	-96.3^{a} (0.33)	-95.83^{a} (0.33)	-95.83^{a} (0.33)	-95.99^{a} (0.33)
Control		7.33	+3.70^{i} (7.67)	+4.76^{f} (7.67)	+4.76^{i} (7.67)	+4.41^{i} (7.67)
Level of Significant			**	**	**	**
CV%			11.23%	15.17%	15.64%	8.29%

growth stages and counting of Epilachna beetle (grub and adult) were made with the help of hand counter. Finally, percentage of leaf infestation was determined using the following formula:

% Leaf infestation= (No. of infested leaves/Total No. of leaves) × 100

Second experiment comprised of the application of an insecticide (Diazinon 60 EC) and four botanicals (neem oil, mahoganyoil, bishkatali plant extract and pithraj seed extract) for managing Epilachna beetle (*E. dodecastigma* Wied.).

Preparation and application of the botanicals and insecticide:

Botanical oils were collected from laboratory of the Department of Entomology, Bangladesh Agricultural University, Mymensingh. From the stock of the Neem oil and Mahogany oil, three concentration (13%, 10% and 8%) were prepared with distilled water (i.e.13ml, 10 and 8ml oil/100ml distilled water) containing 0.1% nondiet. Nondiet was used, as an emulsifier, for proper mixing of the oils with water. For the preparation of biskatali leaf

Table 4. Effect of Botanicals and synthetic pesticide in reduction of epilachna beetle after 3rd spray

Treatments	Concentration	Pre-count No.	% reduction or increase of epilachna beetle/ plant at different hours after treatment			
			24 HAT	48 HAT	72 HAT	Mean
Neem oil	8%	6.33	-36.51^{gh} (4)	-36.51^{ghi} (4)	-31.74^{fghi} (4.33)	-34.92^{gh} (4.11)
	10%	6.67	-54.76^{de} (3)	-50^{ef} (3.33)	-50^{cde} (3.33)	-51.59^{e} (3.22)
	13%	6.67	-69.84^{bc} (2)	-69.84^{bc} (2)	-65.08^{b} (2.33)	-68.26^{c} (2.11)
Mahogany oil	8%	7	-31.55^{gh} (5)	-27.38^{ij} (5.33)	-27.38^{ghi} (5.33)	-28.77^{hi} (5.22)
	10%	6.33	-41.91^{fg} (3.67)	-41.91^{fgh} (3.67)	-37.14^{efg} (4)	-40.32^{fg} (3.78)
	13%	6.33	-58.09^{de} (2.67)	-62.86^{bcd} (2.33)	-58.09^{bc} (2.67)	-59.68^{d} (2.56)
Biskatali extract	8%	5	-20^{i} (4)	-20^{j} (4)	-20^{i} (4)	-20^{j} (4)
	10%	6	-38.73^{fg} (3.67)	-33.97^{hi} (4)	-33.97^{fgh} (4)	-35.55^{g} (3.89)
	13%	6	-55.71^{de} (2.67)	-55.71^{de} (2.67)	-44.29^{def} (3.33)	-51.9^{e} (2.89)
Pithraj seed extract	8%	7.67	-26.19^{hi} (5.67)	-26.19^{ij} (5.67)	-21.43^{hi} (6)	-24.6^{ij} (5.78)
	10%	6.33	-47.62^{ef} (3.67)	-47.62^{efg} (3.67)	-36.51fg (4)	-43.91^{f} (3.78)
	13%	7	-62.1^{cd} (2.67)	-62.1^{cd} (2.67)	-56.55^{bcd} (3)	-60.25^{d} (2.78)
Diazinon 60 EC	1.5 ml/L	7.67	-73.81^{b} (2)	-73.81^{b} (2)	-69.64^{b} (2.33)	-72.42^{c} (2.11)
	2.0 ml/L	8	-87.37^{a} (1)	-87.37^{a} (1)	-83.66^{a} (1.33)	-86.13^{b} (1.11)
	2.5 ml/L	7.67	-95.24^{a} (0.33)	-95.83^{a} (0.33)	-95.83^{a} (0.33)	-95.63^{a} (0.33)
Control		8.33	+3.70^{j} (8.67)	+4.17^{k} (8.67)	+7.87^{j} (9)	+5.247^{k} (8.78)
Level of Significant			**	**	**	**
CV%			10.53%	11.24%	14.22%	6.73%

Note: (-) and (+) sign represent % reduction and increase of epilachna beetle
HAT= Hour after treatment

and Pithraj seed extract, fresh biskatali leaf and pitraj seed were boiled with water at13% (130 g of plant parts with 1 L water), 10% (100 g of plant parts with 1 L water) and 8% (80 g of plant parts with 1 L water), where biskatali leaf and pitraj seed were chopped and dipped/soaked in water overnight and then boiled for one hour. The extract was then collected by filtering with the help of fine cloth material.

Diazinon 60 EC was bought from the local market that was sprayed at 1.5, 2.0 and 2.5ml/ L of water.

Assessment of treatment effects

Percent reduction of population: The effect of treatment on epilachna beetle population was assessed by counting the number of epilachna beetle/plant at pre and post (24, 48, 72 hours after application) treatment. The percent reduction of epilachna beetle/plant were calculated using the following way-

% Reduction = $(P_r-P_o)/P_r \times 100$

Where,

P_r = Pre count plant^{-1}
P_o = Post count plant^{-1}

Analysis of data

The data were analyzed statistically using analysis of variance and the treatment means were compared by DMRT (Duncan's Multiple Range Test).

RESULTS AND DISCUSSION

Incidence of Epilachna beetle on sweet gourd plant

The lowest number of Epilachna beetle (0.67) was observed at 20 (DAT) whereas at flowering stage (60 DAT), Epilachna beetle population reached the peak (7.67) due to presence of available leaves in the plant. Population of Epilachna beetle declined at fruiting stage due to the maturity of the leaves.

Infestation of leaf

The number of infested leaves by epilachna beetle varied in almost all the growth stages of sweet gourd plant. Lowest number of infested leaves and percentage of infested leaves were found at 20 DAT whereas at flowering stage (60 DAT) the highest number of infested leaves was recorded due to available leaves in the plant. At fruiting stage percentage of infested leaf decreased probably because the maturity of the leaves did not support the Epilachna beetles.

Effect of botanicals and synthetic insecticide in reducing of Epilachna beetle population after 1st spray.

Significant variation ($p<0.05$) was found in the percent reduction of Epilachna beetle population after 1st spray (Table 2). It ranged from 22.86 to 96.3% at 24 HAT, 18.1 to 96.3% at 48 HAT and 18.1 to 95.83% at 72 HAT. Mean percent reduction of Epilachna beetle population ranged from 19.68 to 96.14%.

At 24 HAT, the highest percent reduction of beetle population (96.3%) was observed in diazinon 60 EC @ 2.5 ml/L followed by Diazinon 60 EC @ 2.0 ml/L (84.92%). The lowest percent of Epilachna beetle population (22.86%) reduction was found in biskatali leaf extract @ 8% concentration treated plot.

Both At 48 & 72 HAT, the highest percent of Epilachna beetle population reduction (96.3% & 95.83%) was observed in diazinon 60 EC @ 2.5 ml/L where the lowest reduction (18.6% &18.1%) was found in biskatali leaf extract at 8% concentration treated plot. Mean Epilachna beetle population increased up to 4.32% in the control condition.

Among the botanicals, Neem oil @ 13% hit the maximum mean reduction percentage (64.45) of beetle population followed by Pithraj seed extract @ 13% (60.51%).

This present finding more or less agrees with Islam and Shahjahan (2000) findings. They evaluated the toxicity of five botanicals, neem (*A. indica*), marigold (*T. erecta*), durba (*Cynodon doctylon*), castor (*R. communis*), pittraj (*Aphonamixis polystachya*) and one insecticide (Malathion) against rice weevil (*S. oryzae* L.) and red flour beetle (*T. castaneum* Herbst). The results showed that the water extracts of all the five botanicals were effective in controlling the rice weevil and red flour beetle infesting stored grains. Among the botanicals, neem was found to be the most toxic ranking next to Malathion. The order of toxicity was as follows: Malathion> neem>pithraj> marigold> durba.

Effect of botanicals and synthetic insecticide in reduction of Epilachna beetle at 2nd spray

Significant variation ($p<0.05$) was found in the percent reduction of Epilachna beetle population at 2nd spray (Table-3). It ranged from 19.45 to 96.3% at 24 HAT, 19.45 to 95.83% at 48 HAT and 15.28 to 95.83% at 72 HAT. Mean percent reduction of epilachna beetle population ranged from 18.06 to 95.99%. The highest percent reduction of Epilachna beetle population (96.3%) was observed in diazinon 60 EC @ 2.5 ml/L at 24 HAT, In contrast the lowest percent reduction of Epilachna beetle population (15.28%) was found in mahogany oil at 8% concentration treated plot at 72 HAT. Diazinon 60 EC at 2.5 ml/L concentration was the most effective against Epilachna beetle incidence, whereas among the botanicals, neem oil at 13% concentration was the most effective against epilachna beetle incidence ranking next to diazinon 60 EC. Effectiveness of botanicals and synthetic insecticide increased with the increase of concentration. Mean Epilachna beetle population increased up to 4.41% in the control condition.

The present finding is consistent with that of Taraquzzaman,(2004) who reported that Malathion 57 EC was most effective against the epilachna beetle incidence. Neem and karanja oil were effective against the epilachna beetle in prior to chemicals whereas mahogany oil was less effective against epilachna beetle than other treatments.

Effect of botanicals and synthetic pesticide in reduction of Epilachna beetle after 3rd spray

Significant variation ($p<0.05$) was found in the percent reduction of Epilachna beetle population at 3rd spray (Table 4). It ranged from 20 to 95.24% at 24 HAT, 20 to 95.83 % at 48 HAT and 20 to 95.83% at 72 HAT. Mean percent reduction of Epilachna beetle population ranged from 20 to 95.63%.

At all spray intervals, The highest mean percent of epilachna beetle population reduction (95.63%) was observed in Diazinon 60 EC at 2.5 ml/L followed by Diazinon 60 EC @ 2.0 ml/L (86.13%).On the other hand, The lowest mean percent of Epilachna beetle population reduction (20%) was found in biskatali leaf extract at 8% concentration treated plot followed by population reduction was at 8% pithraj seed extract (24.6%). Epilachna beetle mean population increased 5.25% in the control condition.

In all cases, among the botanicals, neem oil at 13% concentration was the most effective against epilachna beetle incidence ranking next to diazinon 60 EC. Effectiveness of botanicals and synthetic insecticide increased with the increase of concentration.

Hussain (1995) observation on some toxicity of bishkatali (*P. hydropiper*) leaf powder and extract on the larvae of *T. castaneum* under laboratory condition, is in agreement with present finding to some extent.

In addition it is to mention, Neem, mahogany, biskatali, pithraj treated plots showed significant variation over untreated control in aspects of percent population reduction of Epilachna beetle.

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REFERENCES

Anonymous (1994). Agricultural marketing information bulletin of Bangladesh Dept. Agril. Marketing. Min. Agric. Govt. of Bangladesh Dhaka.125 p.

BBS Bangladesh Bureau of Statistics (2010). Bangladesh Bureau of Statistics. Monthly Statistical Bulletin, Planning Division, Ministry of Planning, Govt. Republic of Bangladesh, Dhaka.

Desmarchelie RYM (1985). Bolivian of pesticide residues on stored grain, Aciar Prof. Series, Australian Centre. *Int. Agril. Res*. 14: 19-29.

Fishwick RB (1988). Pesticide residues in grain arising from post harvest treatments. *Aspects Appl. Biol*. 17(2): 37-46.

Hagen KS, Franz JM (1973). A history of biological control. In: *History of Entomology* Annual Rev. Inc., California. 872 p.

Heyde JV, Saxena RC, Schmuttere RH (1983). Neem oil and neem extracts as potential insecticides for control of Hemipterous rice pests. Proc. 2nd Int. Neem Conf., Rauisch-holzhausen, FRG, 25-28 May 1983. pp. 377-390.

Hussain MM (1995). Response of Bishkatali (*Polygonum hydropiper* Linn.) and nogos on *Tribolium castaneum* Herbst. *Bangladesh J. Sci. Ind. Res.* 30(4): 107-111.

Islam MS, Shahjahan M (2000). Insecticidal effects of some plant extracts against rice weevil, *sitophilus oryae* L. and red flour beetle, *Tribolium castaneum* (Herbst). *Progress. Agric.* 11 (1&2): 123 -129.

Jacobson M, Reffern RE, Mills GD (1975). Naturally occurring insect growth regulators. II Screening of insect and plant extracts as juvenile hormone mimics. *Lioydia* 38: 455-472.

Kavadia VS, Sharma KP (1984). Residues of malathion and carbaryl in stored sorghum. Bull. Grain Tech. 22(3): 247-250.

Pradhan S, Jotwani MG, Prakash S (1990). Comparative toxicity of insecticides to the grubs and adults of *Epilachna vigintioctopunctata* (Fab.) (Coleoptera: Coccinellidae). *Indian J. Entomol.* 24(4): 223-230.

Rajagopal D, Trivedi TP (1989). Status, biology and management of epilachna beetle, *Epilachna vigintioctopunctata* (Fab.) (Coleoptera: Coccinellidae) on potato in *India. Trop. Pest. Manag.* 35(4): 410-413.

Saxena RC, Liquido NJ, Justo HD (1981). Neem seed oil an antifeedant for the control of the rice brown plant hopper *Nilaparvata lugens*. Proc. 1st Int. Neem Conf., held on 16-18 June 1980, Rottach- Egern., FRG. pp. 171-188.

Srivastava AS, Katiyar SSL (1972). *Epilachna vigintioctopunctata* (Fab.) and *E. dodecastigrna* (Muls.) (Coleoptera: Coccinellidae) as a pest of cow pea. *Zeits-fur Angew. Entornol.* 71(2): 169-172.

Talukder FA, Howse PE (1993). Deterrent and insecticidal effects of extract of Pithraj, *Aphanamixis polystachya* against *Tribolium castaneum* in storage. J. Chem. Ecol. 19 (11): 2463-2471.