POTENTIAL OF FOUR BOTANICAL OILS AGAINST THE RED PUMPKIN BEETLE ATTACKING SWEET GOURD

M. I. HASSAN[1], M. ARIFUNNAHAR[2], M. A. ALIM[2], M. A. SARKAR[3] & M. A. HOSSAIN[2*]

[1]Japan Tobacco International, Kushtia, Bangladesh
[2]Department of Entomology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur 5200, Bangladesh
[3]Division of Entomology, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh

ABSTRACT

The study was carried out using four botanical oils such as neem, (*Azadirachta indica*) pithraj, kalozira (Black camin) (*Nigella sativa*) and tishi (Linseed) (*Linum usitatissimum*) to manage red pumpkin beetle *Aulacophora foveicollis* attacking sweet gourd. Data were taken on the number of red pumpkin beetle on a twig per plant and fruits yield. The number of insects reduced with increasing time after spray of botanical oils. The number of insect per plant markedly reduced up to 72 hours of spray but best result was observed at 24 and 48 hours after application of treatments. For every spray the highest number of insect was observed 7 days after spray. The results of the present study revealed that among all the tested botanical oils black cumin had promising effect against the beetle at 7 days after spray. Based on the number of fruits per plant black cumin oil may be used as an effective management option against *A. foveicollis*.

Keywords: Black cumin, neem, Linseed, Pithraj, oils, red pumpkin beetle, Sweet gourd.

INTRODUCTION

The sweet gourd, *Cucurbita moschata* is one of the most important summer vegetables in Bangladesh. The total production of sweet gourd is 1,04,723 mt in Kharif season while 1,86,112 mt in Rabi season (BBS 2016). It is relatively high in energy and carbohydrates and a good source of vitamins, especially high carotenoid pigments and minerals (Bose and Som 1998). The seeds are very nutritious (40-50% oil and 30% protein) and eaten as food is many countries of the world (Trindall 2008).

*Corresponding author : alamgir@hstu.ac.bd

But the production of sweet gourd is severely affected by a number of insect pests. Among them, the red pumpkin beetle*, Aulacophora foveicollis* (Lucas) is one of the most important constraints to cucurbit production. It is polyphagous and losses may reach upto 35-100% at seedling stage in field conditions (Rashid *et al*. 2015). Both the larva and adult cause severe damage to almost all seedlings, young and tender leaves and flowers (Rahaman and Prodhan 2007, Rahman *et al.* 2008).

In the last two decades, efforts have been made to develop new botanical insecticides as alternative to chemicals (Topondjou *et al*. 2002). In Bangladesh, limited work has been done in recognizing the insecticidal potency of plant materials against pumpkin beetle. It is, therefore, necessary to identify locally available indigenous botanicals as insecticide. Botanical oils and their constituents may have potentials as alternative to chemicals (Lee *et al.* 2001, Osman *et al*. 2013) as they are nontoxic to mammals and beneficial organisms, less prone to insect resistance, readily biodegradable and less expensive (Saxena 1992).

Oils of neem, black cumin, linseed and pithraj have extensively been used and has proved pest controlling efficacy against several insect pests (Heyde *et al.* 1983). They have no adverse effects on environment as they are natural and biodegradable (Saxena *et al.* 1981). They also have antifeedant, repellent and growth inhibitory properties (Kumar & Babu 1998). Unfortunately, research on integrated management of red pumpkin beetle in Bangladesh is scanty. Keeping these in views, the present research work was therefore planned and designed to find out the efficiency of plant oils such as neem, pithraj, black cumin and linseed to suppress the incidence of *A. foveicollis* in field conditions.

MATERIALS AND METHODS

The experiment was conducted in the central research farm of Hajee Mohammad Danesh Science and Technology University, Dinajpur during March to July 2017.

Cultivation of sweet gourd: Healthy sweet gourd seeds *Cucurbita moschata* were collected from local market near the HSTU campus and the seedlings were raised in the poly bags. Seven days old seedlings were transplanted in the experimental plots of one seedling per pit. The field experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications arranged in the field. The whole experimental plot (33.5 L× 8 W m) was divided into 3 equal blocks. Each block was divided into 13 plots, thus there were 39 plots where 4 treatments and each treatment was divided in 3 different doses including control. The size of a unit plot was 2 m

× 2 m. Distance maintained 0.5 m between blocks while 0.5 m between the plots to facilitate different intercultural operations. Cowdung and other chemical fertilizers were applied according to the fertilizer recommendation guide (FRG 2012). All fertilizers were applied in pits before 5-7 days of planting. Urea were applied around the plant by side dressing at 30 and 50 days after planting and mixed with soil followed by irrigation. Intercultural operations were done whenever necessary.

Doses of oils: Four different oils as neem (*Azadirachta indica*), pithraj (*Aphanamixis polystachya*), black cumin (*Nigella sativa*) and linseed (*Linium usitatissimum*) were collected from local market of Dinajpur town and used in the study. Three doses of 5, 7.5 and 10% of each oil were prepared. A single drop of tween-20 was added as an emulsifier for each concentration of each treatment separately and mixed properly before application.

Application of treatments: Seedlings of sweet gourd were observed regularly. When the plants were infested by red pumpkin beetle then the treatments were applied. The prepared stock solutions were sprayed on the plants by using hand sprayer (2 L).

Data collection: Data were taken from visual observation. The data were recorded at 24, 48 and 72 hours and 7 days after oils application. Second spray was done at 15 days after first spray. Third spray was done similarly 15 days after second spray. Plants were randomly selected and tagged from each plot at different growth stages. Number of insect per twig was counted and recorded from the selected plants. Damage leaves in twig per plant, number of fruits per plant were counted and recorded.

Statistical analyses: Data were analyzed using the one-way analysis of variance (ANOVA) and the mean differences were separated by using Duncan's New Multiple Range Test (DMRT). The analyses were performed using computer package MSTAT-C program.

RESULTS AND DISCUSSION

The numbers of adult red pumpkin beetles per twig of a plant varied after the 1st spray at different hours after treatments (HATs) (Table 1). Among the treatments of oils, the highest (1.25) number of beetles were found from neem while the lowest (0.92) in black cumin at 7 days after the 1st spray but statistically insignificant ($P <$

0.05, $F = 5.16$, $df = 4$). Among the doses, significantly ($P < 0.05$, F = 10.71, $df = 3$) the highest (0.73) number of adult beetles were found in 10% concentration at 7 days after spray but the lowest (0.27) in 7.5% at 24 HATs (Table 1). In the interaction effects of the oils and doses, significantly ($P < 0.05$, $F = 0.83$, $df = 12$) the highest (1.33) number of red pumpkin beetles were observed in 5% concentration but no beetle (0.0) was found in 10% of black cumin oil at 7 days after spray (Table 1). On the contrary, the number of red pumpkin beetles (1.67) was found the highest in the control treatment in all cases.

It is evident from the results that the efficacy of treated oils reduced the number of insects soon after spray but with increasing time the number of insects also increased. All the tested oils significantly effective against the red pumpkin beetle. Higher doses oil of protected the plant properly at 10% dose where no infestation occurred at 7 days after treatment. The results of the present experiment are comparable with Araya & Emana (2009) who opined that the botanicals have good impact in controlling coleopterons beetle. Parallel results also reported by Pankaj & Anita (2009). They concluded that neem extract was most effective against red pumpkin beetle. Our results are also in line with those of Tandon & Sirohi (2009). They cited that red pumpkin beetles was suppressed at 5 and 10% concentrations of the extracts of *Azadirachta indica*, *Annona squamosa*, *Convolvulus microphyllus* and *Melia azedarach*, respectively in laboratory bioassays.

The numbers of red pumpkin beetles (RPB) on twig per plant varied due to treatments of oils, doses and interactions after the 2nd spray in different HATs (Table 2). Among the oils, significantly ($P < 0.05$, $F = 9.07$, $df = 4$) the highest (2.33) number of RPB were found in neem oil while the lowest (2.00) in black cumin followed by linseed at 7 days after spray (Table 2). Among the doses, significantly ($P < 0.05$, $F = 16.58$, $df = 3$) the highest (1.73) number of adult beetles were found in 10% concentration at 7 days after spray but the lowest (0.53) in same concentration at 24 hours after treatments (Table 2). In the interaction effects of tested oils and doses, significantly ($P < 0.05$, $F = 1.08$, $df = 12$) the highest (2.33) number of beetles were observed in 5% concentration of neem oil while the lowest (1.00) in 10% concentration in black cumin oil at 7 days after the 2nd spray (Table 2). However, the highest (4.0) number red pumpkin beetle was recorded in the untreated control plot in all cases.

Table 1. Effect of oil treatments, doses and interaction on adult red pumpkin beetles per twig after the 1st spray

	Treatments	After spray (mean number of adult)			
		24 HATs	48 HATs	72 HATs	7 days
Oil effects	Neem	0.67 ^{b}	0.83 ^{b}	1.25 ^{ab}	1.25*
	Tishi	0.50 ^{b}	0.50 ^{b}	0.83 ^{b}	1.08*
	Pithraj	0.50 ^{b}	0.75 ^{b}	0.67 ^{b}	1.00*
	Kalozira	0.58 ^{b}	0.75 ^{b}	0.92 ^{b}	0.92*
	LSD	0.39	0.62	0.55	0.60
	CV (%)	65.21	83.19	61.84	65.45
Dose effects (%)	5.0	0.60 ^{bc}	1.00 ^{b}	1.07 ^{b}	1.40 ^{a}
	7.5	0.27 ^{c}	0.53 ^{bc}	0.80 ^{b}	1.00 ^{ab}
	10.0	0.67 ^{b}	0.40 ^{c}	0.73 ^{b}	0.73 ^{b}
	LSD	0.34	0.55	0.49	0.54
	CV (%)	65.21	83.19	61.84	65.45
Interaction effects	Neem 5.0%	0.67 ^{ab}	1.33 ^{ab}	1.00 ^{abc}	1.33 ^{a}
	Neem 7.5%	0.00 ^{b}	0.33 ^{ab}	1.33 ^{ab}	1.33 ^{ab}
	Neem 10.0%	0.67 ^{ab}	0.00 ^{b}	1.00 ^{abc}	0.67 ^{ab}
	Tishi 5.0%	0.67 ^{ab}	0.33 ^{ab}	0.67 ^{abc}	1.33 ^{ab}
	Tishi 7.5%	0.00 ^{b}	0.00 ^{b}	0.33 ^{bc}	0.67 ^{ab}
	Tishi 10.0%	0.00 ^{b}	0.00 ^{b}	0.67 ^{abc}	1.00 ^{ab}
	Pithraj 5.0%	0.00 ^{b}	1.00 ^{ab}	0.67 ^{abc}	1.33 ^{ab}
	Pithraj 7.5%	0.00 ^{b}	0.33 ^{ab}	0.00 ^{c}	0.67 ^{ab}
	Pithraj 10.0%	0.67 ^{ab}	0.00 ^{b}	0.33 ^{bc}	0.67 ^{ab}
	Kalozira 5.0%	0.33 ^{b}	0.67 ^{ab}	1.33 ^{ab}	1.33 ^{ab}
	Kalozira 7.5%	0.00 ^{b}	0.33 ^{ab}	0.67 ^{abc}	1.00 ^{ab}
	Kalozira 10.0%	0.67 ^{ab}	0.33 ^{ab}	0.00 ^{c}	0.00 ^{b}
Control		1.33 ^{a}	1.67 ^{a}	1.67 ^{a}	1.67 ^{ab}
LSD		0.77	1.24	1.09	1.21
CV (%)		65.21	83.19	61.84	65.45

Different letters in a column are significantly different at 5% level of probability by DMRT, *= Nonsignificant

All botanical oils at the highest concentration reduced significantly the number of RPB. However, among the tested botanicals, black cumin oil showed better effectiveness in managing the red pumpkin beetle in field conditions. Present findings are similar to the observations of Das & Ishaque (1999). They concluded that while dusting with ash on plants it repelled the adult red pumpkin beetle in

Table 2. Effect of oil treatments, doses and interaction on adult red pumpkin beetles per twig after the 2nd spray

	Treatments	After spray (mean number of adult)			
		24 HATs	48 HATs	72 HATs	7 days
Oil effects	Neem	0.67 b	0.83 b	1.33 b	2.33 b
	Tishi	1.00 b	0.83 b	1.25 b	2.00 b
	Pithraj	0.83 b	0.92 b	1.08 b	2.08 b
	Kalozira	0.92 b	1.33 b	1.33 b	2.00 b
	LSD	0.57	0.82	0.64	0.79
	CV (%)	68.20	79.68	53.12	38.44
Dose effects (%)	5.0	1.07 b	1.20 b	1.47 b	2.27 b
	7.5	0.80 b	0.87 b	1.20 b	1.93 b
	10.0	0.53 b	0.60 b	0.87 b	1.73 b
	LSD	0.51	0.74	0.58	0.70
	CV (%)	68.20	79.68	53.12	38.44
Interaction effects	Neem 5.0%	0.67 ab	0.67 ab	1.33 ab	2.33 ab
	Neem 7.5%	0.33 ab	0.33 b	1.00 ab	1.67 b
	Neem 10.0%	0.00 b	0.00 b	0.67 b	1.33 b
	Tishi 5.0%	1.33 ab	0.67 ab	1.33 ab	1.67 b
	Tishi 7.5%	0.67 ab	0.33 b	0.67 b	1.33 b
	Tishi 10.0%	0.33ab	0.00 b	0.67 b	1.00 b
	Pithraj 5.0%	0.67 ab	1.00 ab	1.00 ab	1.67 b
	Pithraj 7.5%	0.67 ab	0.33 b	1.00 ab	1.33 b
	Pithraj 10.0%	0.33 ab	0.00 b	0.00 b	1.33 b
	Kalozira 5.0%	1.00 ab	1.33 ab	1.33 ab	1.67 b
	Kalozira 7.5%	0.67 ab	1.00 ab	1.00 ab	1.33 b
	Kalozira 10.0%	0.33 ab	0.67 ab	0.67 b	1.00 b
Control		1.67 a	2.33 a	2.33 a	4.00 a
LSD		1.15	1.65	1.29	1.58
CV (%)		68.20	79.68	53.12	38.44

Different letters in a column are significantly different at 5% level of probability by DMRT

field conditions. Application of neem seed kernel extract and yellow sticky traps was most acceptable control module which showed minimum population of red pumpkin beetle (Rashid *et al*. 2015). Tomar (2018) proved the efficacy of *Cassia fistula* flower essential oils and *Lantana camara* flower and fruit oils in controlling the other coleopterus beetle population.

The numbers of red pumpkin beetles per twig varied after 3rd spray in different HATs and differed significantly among the treatments (Table 3). Along with the oils, significantly ($P < 0.05$, $F = 5.23$, $df = 4$) the highest (3.33) number of red pumpkin beetle was found in neem while the lowest (2.25) in tishi oil at 7 days after 3rd spray. Of doses, significantly ($P < 0.05$, $F = 8.15$, $df = 3$) the lowest (2.33) adult beetles were recorded in 10% concentration at 7 days after spray. The interaction effects of the oils and doses significantly ($P < 0.05$, $F = 0.63$, $df = 12$) the highest (3.33) number of RPB were experienced in 5% concentration of neem oil but the lowest (1.33) in 10% concentration of tishi oil at 7 days after spray. But the highest (4.67) number of beetles were observed in the control treatment.

Among other tested botanical oils, neem and pithraj significantly reduced the red pumpkin beetle infestation but failed to prevent its attack completely after the 3rd spray. Except linseed, none of the other tested oils at 10% concentration checked the absolute protection against the beetle. Varied effectiveness of different tested botanical oils indicated that the pest suppressing properties are not uniformly distributed among the tested oils. Novel innovative research illustrated that diverse plant products have been tried by several researchers with a good degree of success against pumpkin beetle (Tandon and Sirohi 2009, Abed *et al*. 2016). The results of the present study are comparable with Ali *et al*. (2011). They opined that garlic and neem oil strongly repelled the cucumber beetle. Plant oils such as neem, pithraj, black cumin, caster etc are successfully used against red pumpkin beetle (Araya and Emana 2009, Abed *et al*. 2016). However, among the tested botanicals, black cumin oil showed better effectively in managing the red pumpkin beetle in field conditions.

Table 3. Effect of oil treatments, doses and interaction on adult red pumpkin beetles per twig after the 3rd spray

	Treatments	After spray (mean number of adult)			
		24 HATs	48 HATs	72 HATs	7 days
Oil effects	Neem	1.92 ^{b}	1.83 ^{b}	2.42 ^{b}	3.33 ^{b}
	Linseed	1.92 ^{b}	2.00 ^{b}	1.92 ^{b}	2.25 ^{c}
	Pithraj	1.75 ^{b}	1.58 ^{b}	1.92 ^{b}	2.67 ^{bc}
	Black cumin	2.25 ^{b}	2.33 ^{b}	2.50 ^{b}	3.08 ^{bc}
	LSD	0.82	0.85	0.70	0.97
	CV (%)	38.60	43.86	33.18	36.75
Dose effects (%)	5.0	2.20 ^{b}	2.27 ^{b}	2.47 ^{b}	3.07 ^{b}
	7.5	1.80 ^{bc}	1.80 ^{bc}	2.13 ^{bc}	2.73 ^{b}
	10.0	1.27 ^{c}	1.33 ^{c}	1.60 ^{c}	2.33 ^{b}
	LSD	0.73	0.76	0.62	0.87
	CV (%)	38.60	43.86	33.18	36.75
Interaction effects	Neem 5.0%	1.33 ^{bc}	1.67 ^{b}	2.33 ^{bc}	3.33 ^{ab}
	Neem 7.5%	1.00 ^{b}c	0.67 ^{b}	1.67 ^{bcd}	3.00 ^{ab}
	Neem 10.0%	0.33 ^{bc}	1.00 ^{b}	1.67 ^{bcd}	2.33 ^{b}
	Linseed 5.0%	1.33 ^{bc}	2.00 ^{ab}	1.33 ^{bcd}	1.67 ^{b}
	Linseed 7.5%	1.00 ^{bc}	1.33 ^{b}	1.33 ^{bcd}	1.34 ^{b}
	Linseed 10.0%	0.33 ^{bc}	0.67 ^{b}	1.00 ^{cd}	1.33 ^{b}
	Pithraj 5.0%	1.33 ^{bc}	1.33 ^{b}	2.00 ^{bc}	2.67 ^{ab}
	Pithraj 7.5%	0.67 ^{bc}	0.67 ^{b}	1.33 ^{bcd}	2.00 ^{b}
	Pithraj 10.0%	0.00 ^{c}	0.33 ^{b}	0.33 ^{d}	1.33 ^{b}
	Black cumin 5.0%	2.00 ^{b}	2.33 ^{ab}	2.67 ^{ab}	3.00 ^{ab}
	Black cumin 7.5%	1.33 ^{bc}	2.33 ^{ab}	2.33 ^{bc}	2.67 ^{ab}
	Black cumin 10.0%	0.67 ^{bc}	0.67 ^{b}	1.00 ^{cd}	2.00 ^{b}
Control		5.00 ^{a}	4.00 ^{a}	4.00 ^{a}	4.67 ^{a}
LSD		1.64	1.70	1.40	1.94
CV (%)		38.60	43.86	33.18	36.75

Different letters in a column are significantly different at 5% level of probability by DMRT

The interaction effects of the oils and doses, significantly ($P < 0.05$, F =0.39, df = 12) the highest number (9.67) of fruits were observed in 10% concentration of black cumin oil. Conversely, the lowest (3.33) number of fruits were found in 5% concentration of linseed oil (Fig. 1). Results of the present findings are also comparable with those of Fakir *et al*. (2017).

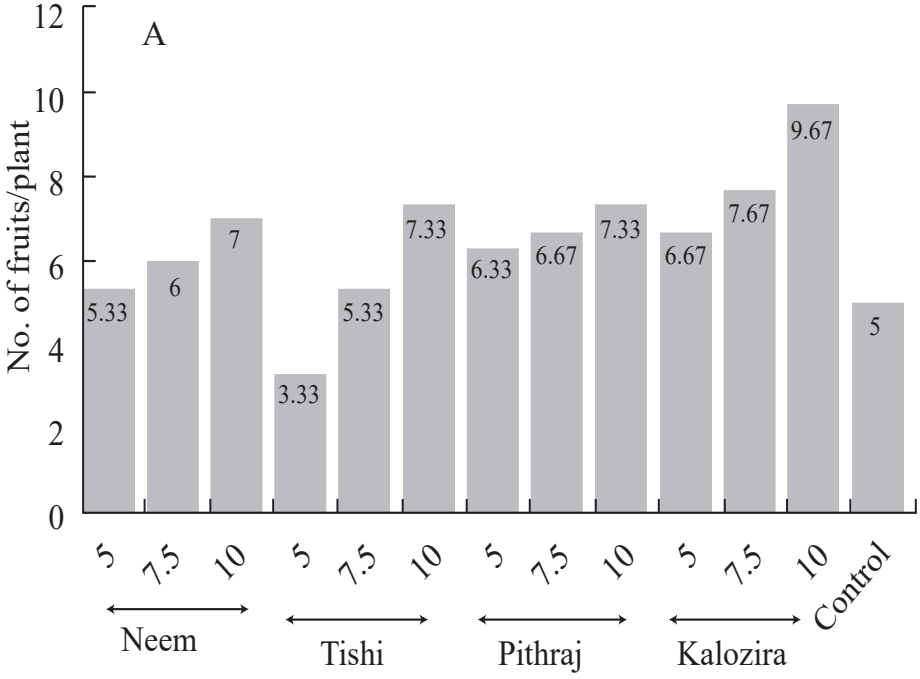

Fig. 1. Number of fruits in different treatments

The results of the present study revealed that among all the tested botanical oils black cumin had promising effect to check the attack against *A. foveicollis*. Therefore, the black cumin oil may be recommended at farmer's level as it is effective, available, easily processable, and ensure for eco-friendly management against *A. foveicollis*.

ACKNOWLEDGEMENT

The authors acknowledge the Institute of Research and Training (IRT), HSTU, for financial support.

REFERENCES

ABED, S. Z., KAZI, M. & BHASHANI, K. A. 2016. Effectiveness of the insecticide treatments against the leaf infestation by red pumpkin beetle. *Afri. J. Agric*. **3**(6), 178-184.

ALI, H., AHMAD, S., HASSAN, G., AMIN, A. & NAEEM, M. 2011. Efficacy of different botanicals against red pumpkin beetle (*Aulacophora foveicollis*) in bitter gourd (*Momordica charantia* L.). *Pak. J. Weed Sci. Res*. **17**, 65-71.

ARAYA, G. S., & EMANA, G. 2009. Evaluation of botanical plants powders against *Zabrotes subfasciatus* (Boheman) (Coleoptera: Bruchidae) in stored haricot beans under laboratory condition. *Afri. J. Agric. Res*. **4** (10), 1073-1079.

BBS (Bangladesh Bureau of Statistics). 2016. Statistical Year Book of Agriculture. Bangladesh Bureau of Statistics, Ministry of Planning, Govt. of the People's Republic of Bangladesh, Dhaka. pp. 249-250.

BOSE, T. K. & SOM, M. G. 1998. Vegetables Crops in India, Naya Prokash, Calcutta, pp. 92-95.

DAS, S. K. & ISHAHAQUE, N. M. M. 1999. Control of red pumpkin beetle, *Aulacophora foveicollis* (Lucas). *J. Agri. Sci. Soc*. **12**, 112-117.

FAKIR, O. A., RAHMAN, M.M., ROKON, G. M., ALAM, M. K., & MILLAT, M. N. 2017. Comparative performance of botanical pesticides for controlling red pumpkin beetle in cucumber over chemical approach. *Bangladesh J. Environ. Sci*. **33**, 55-58.

HEYDE, J. V., SAXENA, R. C. & SCHMUTTERER, H. 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.

KUMAR, S. P. & BABU, P. C. S. 1998. Toxicity of neemazal formulations to pupae and adults of *Epilachna vigintiocto* punctata Fab. (Coleoptera: Coccinellidae). *Insect Environ.* **3**(4), 93-98.

LEE, B., CHOI, W., LEE, S. & PARK, B. 2001. Fumigant toxicity of essential oils and their constituent compounds towards the rice weevil*, Sitophilus oryzae*. *Crop Prot.* **20**, 317-320.

OSMAN, S., UDDIN, M. M. & ADNAN, S. M. 2013. Assessment of the performance of different botanicals and chemical insecticides in controlling red pumpkin beetle *Aulacophora foveicollis* (Lucas). *Int. J. Agric. Sci. Res*. **2**(8), 258-264.

PANKAJ, T. & ANITA, S. 2009. Laboratory assessment of the repellent properties of ethanolic extracts of four plants against *Raphidopalpa foveicollis* Lucas (Coleoptera: Chrysomelidae). *Int. J. Sustain. Crop Prod*. **4**(2), 1-5.

RAHAMAN, M. A., PRODHAN, M. D. H. & MAULA, A. K. M. 2008. Effect of botanical and synthetic pesticides in controlling epilachna beetle and the yield of bitter gourd. *Int. J. Sustain. Crop Prod*. **3**(5), 23-26.

RAHMAN, M. A. & PRODHAN, M. D. H. 2007. Effects of net barrier and synthetic pesticides on red pumpkin beetle and yield of Cucumber. *Int. J. Sustain. Crop Prod*. **2**(3), 30-34.

RASHID, M. A., KHAN, M. A., ARIF, M. J. & JAVED, N. 2015. Intensive management of red pumpkin beetle (*Aulacophora foveicollis* Lucas) in different ecological regions. *Pak. J. Zool*. **47**(6), 1611-1616.

SAXENA, R. C., LIQUIDO, N.J. & JUSTO, H. D. 1981. Neem seed oil an antifeedant for the control of the rice brown plant hopper *Nilaparvata lugens*. Proc. 1st Int. Neem Conf., 16-18 June 1980, Rottach- Egern., FRG. pp. 171-188.

SAXENA, S. C. 1992. BIOLOGY of Insects. Published by Raju Primlanifor Oxford and IBH Publishing Co. Pvt. Ltd., 66 Janapath, New Delhi 110001. p. 366.

TANDON, P. & SIROHI, A. 2009. Laboratory assessment of the repellent properties of ethanolic extracts of four plants against *Raphidopalpa foveicollis* Lucas (Coleoptera: Chrysomelidae). *Int. J. Sustain. Crop Prod*. **4**(2), 1-5.

TOMAR, D. 2018. Study of *Epilachna varivestis* life cycle after essential oil treatment. *J. Env. Bio-Sci*. **32** (1), 1-8.

TOPONDJOU, L. A., ADLER, C., BOUDA, H. & FONTEM, D. A. 2002. Efficacy of powder and essential oil from *Chenopodium ambrosoides* leaves as post harvest grain protectant against six stored product pest. *J. Stored Prod. Res*. **38**, 395-402.

TRINDALL, H. D. 2008. Vegetables in the Tropics. Macmillan Education, Landon. p. 166.

(MS Received for Publication 15 January 2022)