Research article

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EFFICACY OF FOUR SELECTED PLANT EXTRACTS AGAINST BEAN BUG, *RIPTORTUS PEDESTRIS* FABRICIUS (HEMIPTERA: ALYDIDAE) UNDER LABORATORY CONDITION

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ABSTRACT

The topical spraying and residual methods were used to measure the toxicity and repellency effect of four plant leaf (neem, crown flower, water peeper and marigold) extracts against bean bug, *R. pedestris*. The plant extracts were prepared in one solvent and applied at three doses viz., 500, 600 and 700 mg L^{-1} of water with 50% ethanol. Results revealed that the maximum mortality (100%) of adults was recorded by topical spraying of Neem and Crown flower @ 700 mg L^{-1} at 48 hours after treatment. These were followed by water pepper and marigold at 54 and 60 hours after treatment @ 700 mg/L of water. At residual method, the maximum mortality (100%) of adults was also recorded while Neem sprayed at 48 hours after treatment @ 700 mg L^{-1}. The result of repellency test showed that all the applied doses of leaf extracts had repellency and direct toxicity effects but Neem showed the best response and it possess the repellency class III followed by water pepper and marigold. Therefore, Neem and Crown flower extracts showed potential to control of bean bug, *R. pedestris* and can be used as alternative of synthetic pesticides.

Keywords: Bean bug, *R. pedestris,* topical spraying, residual application, repellency.

INTRODUCTION

The bean bug, *Riptortus pedestris* Fabricius (Hemiptera: Alydidae) is the most damaging invasive polyphagous pests of different plants including many leguminous crops (Son *et al*. 2000, Kang *et al*. 2003). It is widely distributed in many Asian countries including Japan, China, Korea, Taiwan, Thailand, Indonesia, and India (Kikuhara 2005). It starts to emerge earlier in spring when reproduction is not possible due to scarcity of nutritious food materials (Kim *et al*. 2014). It is a highly mobile pest which colonizes in summer or autumn by moving from

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various habitats (Hirose *et al*. 1996). They infest most of the leguminous crops like mungbean (*Vignaradiata* L.), soybean (*Glycine max* L.), sesame (*Sesamum indicum* L.), red clover (*Trifolium pretense* L.) etc.; fruit trees like persimmon (*Diospyros virginiana*) and jujube (*Ziziphus jujuba*); and grains like barley (*Hordeum vulgare* L.), foxtail millet (*Setari aitalic* L.), and sorghum (*Sorghum nitidum*) (Mainali *et al*. 2014). Both adults and nymphs bore the pods and feed on the juices, so that the pods fail to mature. The pods turn brown, shrivel and die. When such pods are opened, then shrivelled, undersized, and malformed seeds are appeared. Such seeds easily succumb to secondary infections by fungus, and poses problems during post-harvest processes. The adults of *R. pedestris* are shiny brown with spine like projections on thoracic region and their hind legs are elongated and bulged. *R. pedestris* females oviposit not only on host plants but also on non-hosts (Nakajima *et al*. 2010). Distribution of *R. pedestris* eggs within plants were 90% on leaves and 70% on the under leaf surface (Kim and Lim 2010).

Control of *R. pedestris* is generally depends on applying chemical insecticides but difficult to achieve effective coverage by spraying. Frequent and often excessive chemical application has resulted in development of resistance against these chemicals, with subsequent population outbreaks (Palumbo *et al*. 2001). Chemical pesticides are generally persistent in nature. Moreover, the use of chemical pesticides has been restricted because of their carcinogenicity, teratogenicity, high and acute residual toxicity, ability to create hormonal imbalance, spermatotoxicity, long degradation period, and result in toxic residues in food (Feng and Zheng 2007, Pretty 2009, Dubey *et al*. 2011). Thus, there is an urgent need for alternative approaches to pest management that can be completely or partially replace current chemical-based pest management practices (Dubey and Sundararaj 2004).

Plant extracts can contribute towards this goal as alternatives to synthetic chemicals for pest management because of their potency, efficacy and eco- friendly nature (Isman 2000). Botanical insecticide is an attractive pest management method because of eco-friendly nature (Wang *et al*. 2012). Resistance to these botanical compounds is not developed as quickly as synthetic insecticides. Botanical insecticides kill and repel pests, affect insect growth and development, have antifeedant and antifungal, antiviral and antibacterial properties against pathogens (Prokash and Rao 1997) as well as environmentally and toxicologically safer than many of the currently used chemical insecticides. Toxic chemicals derived from pyrethrum (*Tanacetumciner ariifolium* Trev.), neem (*Azadirachta indica* Juss), and other plant species are

traditionally used in many crop pest control operations (Atkinson *et al*. 2004, Liang *et al*. 2003). Neem products, tobacco extracts and rosin soap had been found effective against sucking insects in several countries (Kambrekar *et al*. 2003). Keeping these in views, the present research has been conducted to test the toxicity of four selected plant extracts for the control of bean bug, *R. pedestris.*

MATERIALS AND METHODS

Plant materials used for bioassay: Four plant species (Table 1) were collected from their natural habitats from different locations of the Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur campus. Each plant species was identified and verified by plant morphology, using live specimens and photographs (Karim and Kabir 1995). The English name, botanical name, family name and the used parts of the four botanical plants are given in Table 1.

Table 1. List of plants (fresh leaves) used in the bioassay

English name	Scientific name	Family name
Neem	*Azadirachta indica*	Meliacae
Crown flower	*Calotropis gigantean*	Asclepiadaceae
Water pepper	*Polygonum hydropiper*	Polygonaceae
Marigold	*Tagetes patula*	Compositae

Preparation of plant extracts: The leaf extracts of four plants were obtained and isolated following Abe and Matsuda (2000). For this, 300g of fresh leaves were collected from mature plants (at fruiting stage) for extraction. The leaves were cut into pieces and grinded using a mortar and pester. Then 10 g of each category of grinded leaves were separately mixed with 100 ml distilled water. The mixture was then filtrated through filter paper (Whatman No.1). Then 25 ml filtrated leaf solution were taken separately in a 600 ml beaker and mixed properly with 100ml ethanol solvent. The mixture was shacked for 30 minutes and left stand for separation in separating funnel. The separated extracts was transferred in round bottom flasks and condensed by evaporation of solvent in a rotary evaporator (D 79219, Kika Werke Gmbh and Co. Germany) at 78^0C. Then the crude extract was transferred quantitatively to a clean and weighed vial and kept in the refrigerator until used for toxicological investigation.

Bioassays of plant extracts: All bioassays were conducted in the Entomology laboratory of HSTU from August to September, 2016.

Activity of plant extracts by topical application: One adult of bean bug, *R. pedestris* (7-day old) was placed in a centrifugal tube (50 ml cap.) and sprayed with previously prepared 1 ml of the 500 mg L^{-1} test solution by a hand sprayer. The treated insects were then immediately transferred into a new Petri dish (5.5 D × 1.3 H cm) individually and kept at ambient conditions without food sources. Control Petri dishes were treated similarly with 50% ethanol in water. Each test was replicated thirty times. The treated adults were examined up to the 72 hours at 6 hours intervals after treatment and recorded mortality. Dead insects were confirmed by showing no responses while probed with small brush when did not show any responses. Similarly, all the treatments were examined for mortality at 6 hours after treatments maintained three concentrations of 500 mg L^{-1}, 600 mg L^{-1} and 700 mg L^{-1}.

Activity of plant extracts by residual application: The bottoms of Petri Dishes (5.5 D × 1.3 H cm) were sprayed with 1 ml of the 500 mg L^{-1} test solution by a hand sprayer and the solvent was quickly removed by air-drying. After 1 hour drying, thirty adults of *R. pedestris* (7-day old) were introduced into the treated Petri Dishes. Control Petri Dishes were treated similarly with 50% ethanol in water. The treated adults were examined for mortality up to the 72 hours at 6 hours interval after treatment. Adults that did not show any responses when probed with a small brush were considered dead. All the treatments were examined for mortality at 6 hours interval after treatments maintained three concentrations of 500 mg L^{-1}, 600 mg L^{-1} and 700 mg L^{-1}.

Repellency tests: The petiole of two fully expanded leaves was placed in a Petri Dish facing ventral surface upward. One leaf was dipped in the tested plant extract and another was control dipped in 50% ethanol in water. Twenty adults of *R. pedestris* (7 days old) introduced between the two treated leaves in the Petri Dish and the Petri Dish lid was closed. Number of adults attracted to each leaf was recorded at 3, 6 and 24 hours intervals. The data were expressed as percentage repulsion (PR) as PR (%) = $(N_c - 50) \times 2$; Where, N_c = the percentage of insects present in the control

half. Positive (+) values express repellency and negative (-) values attractancy. The repellency class was classified as class 0 > 0.01-10.1, class I- 0.1- 20.0, class II- 20.1,-40.0, class III- 40.1-60.0, class IV-60.1 -80.0, and class V -80.1- 100.0% repellency (McDonald *et al*. 1970).

Statistical analyses: Mean values were given with the standard error (SE). Differences in mortalities among treatments were analyzed by univariate comparison test (ANOVA) using SPSS software 20.0 version. The Chi-square and LT_{50} values were obtained by using probit analysis (Robertson *et al*. 2007). Significant differences among the pesticides in each assay were recorded when 95% confidence intervals (CI) did not overlap. LD_{50} values of the tested plant extract and confidence limits were calculated for *R. pedestris* with Log dosage-mortality probit regression equation.

RESULTS AND DISCUSSION

Toxicity of plant extracts by topical application: Mortalities of bean bug, *R. pedestris* adults, sprayed with various dosages of four plant extracts at different HAT (hours after treatment) under laboratory condition showed significant differences (Table 2). Maximum of 76.67% and 66.67% adult mortality was recorded while sprayed Neem and Crown flower at 700 mg L^{-1} water with 50% ethanol extracted at 24 HAT. Water pepper and Marigold also showed 76.67% and 66.67% mortality at 24 HAT at 700 mg L^{-1} water, respectively. On the other hand, Neem showed the highest mortality of 73.33% at 24 HAT with 600mg L^{-1} water. Crown flower, Water pepper and Marigold also showed 63.33, 53.33 and 30.00% mortality at 24 HAT with 600mg L^{-1} water with 50% ethanol extract, respectively. In single dose response, 700 mg L^{-1} water with 50% ethanol using different plant extracts showed significant results.

Table 2. Mortality of different plant extracts against bean bug, *R. pedestris* by topical spraying at different hours after treatments (HATs)

Plant extracts	Dose (mg L^{-1})	Mortality (%) at indicated hours after treatments (HATs)			
		6	12	18	24
Neem	500	16.67±1.67a	40.00±1.67ab	56.67±1.67ab	70.00±1.33ab
	600	20.00±1.67a	36.67±1.67ab	56.67±1.67ab	73.33± .33ab
	700	20.00±1.67a	40.00±2.33a	63.33±2.33a	76.67±1.33ab
Crown flower	500	20 .00±2.00a	33.33± .33abc	46.67±1.33abc	60.00±1.33ab
	600	16.67±1.67a	36.67±2.00ab	50.00±2.00ab	63.33±1.00abc
	700	16.67±1.67a	36.67 ± 2.00ab	46.67±1.00abc	66.67±2.00a
Water pepper	500	13.33±1.33ab	23.33±1.00abc	33.33±1.00abc	36.67±0.33bc
	600	13.33±1.33ab	26.67±1.33abc	43.33±1.67bc	53.33±1.00abc
	700	16.67±1.67a	33.33±1.67ab	43.33±1.00abc	56.67±1.33ab
Marigold	500	10.00±1.00ab	16.67±1.33abc	23.33±0.67bc	30.33±1.00abc
	600	6.67±0.67ab	16.67±1.00abc	23.33±0.67bc	33.00±0.67bc
	700	10.00±1.00ab	23.33±0.67bc	30.00±0.67bc	33.33±0.33bc
Control		0.0c	0.0d	0.0d	0.0d

Same column followed by different letters indicate significantly different at $P < 0.05$ by Duncan's Multiple Range Test.

All plant extracts showed harmful to *R. pedestris* at different HAT (Fig. 1) using topical spraying method. Neem and Crown flower caused 100% mortality at 48 HAT but water pepper and marigold showed 100% mortality at 54 and 60 HAT, respectively (Fig. 1C). On the other hand, dose 600mg L^{-1} and 500mg L^{-1} water, Neem, Crown flower, Water pepper and Marigold were the most harmful and showed 100% mortality at 66 hours after treatment (Fig. 1A, 1B). Neem and Crown flower were showed the highest toxicity index of 4.76 and 4.01 at 700mg L^{-1} water (Table 3). Statistical analyses of lethal effect are presented in Table 3.

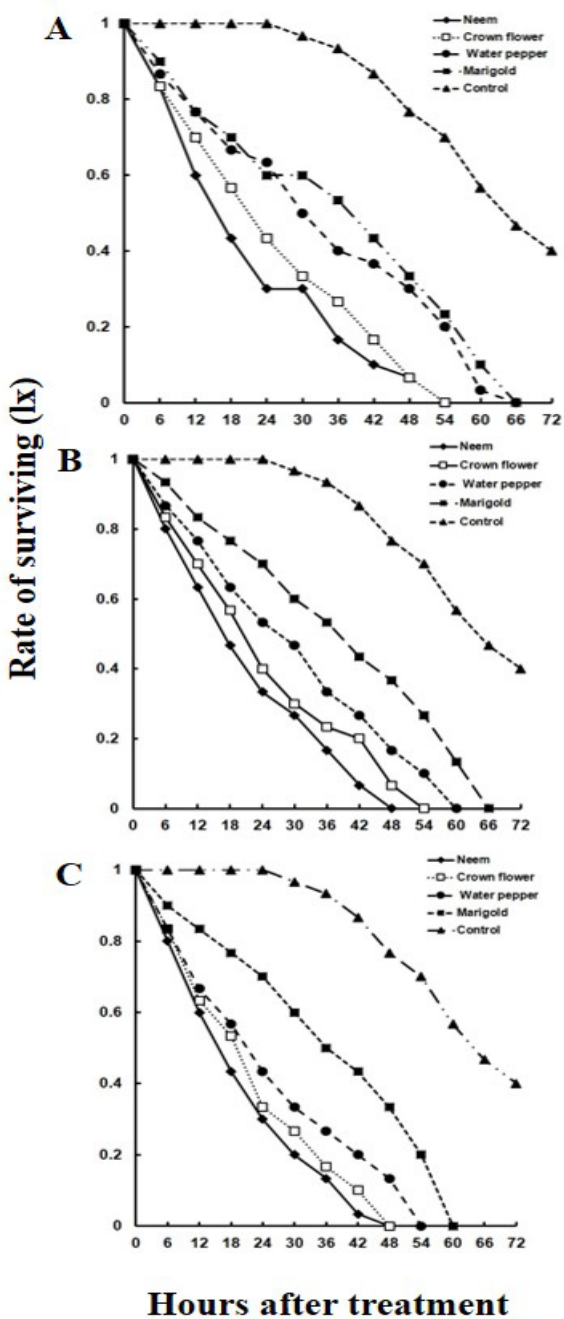

Fig. 1. Survivorship of adult *R. pedestris* while exposed to the tested plant extracts by topical application at 500mg L^{-1} (A) 600mg L^{-1} (B) and 700mg L^{-1} (C)

Table 3. Statistical comparison of lethal effect (topical application) of pesticides on bean bug, *R. pedestris*

Plant extracts	Dose (mg L^{-1})	n	LT_{50}	95% CI limit (lower-upper)	Slop (±) SE	χ^2(df)	TI
Neem	500	30	14.84 b	11.76-17.69	3.29±0.32	12.97(10)	4.32
Crown flower		30	16.33 b	12.30-20.04	3.10±0.30	18.49(10)	3.92
Water pepper		30	24.58 b	18.62-30.45	2.74±0.28	22.78(10)	2.60
Marigold		30	27.49 b	20.89-34.30	2.71±0.28	24.50(10)	2.33
Control	-	30	64.13 a	60.61-69.18	8.48±1.23	1.18(10)	1.00
Neem	600	30	14.95 c	11.87-17.81	3.20±0.31	12.57(10)	3.99
Crown flower		30	16.40 c	12.96-19.02	3.12±0.30	11.59(10)	3.63
Water pepper		30	18.66 c	15.05-22.06	3.33±0.31	14.68(10)	3.19
Marigold		30	30.56 b	24.35-37.12	3.06±0.31	23.14(10)	1.95
Control	-	30	59.69 a	55.02-66.39	5.00±0.66	0.794(10)	1.0
Neem	700	30	13.28 b	11.05-15.37	3.30±0.33	5.75(10)	4.76
Crown flower		30	15.79 b	12.76-18.63	3.30±0.32	12.14(10)	4.01
Water pepper		30	17.91 b	13.95-21.58	2.95±0.30	15.43(10)	3.53
Marigold		30	29.19 b	21.07-37.84	3.18±0.30	41.76(10)	2.17
Control	-	30	63.34 a	58.93-69.91	6.22±0.87	0.65(10)	1.00

Means followed by different letters are significantly different (Robertson et al. 2007)

Results of the present findings revealed that the tested botanical extracts had profound toxic effects against the adult bean bug, *R. pedestris* under laboratory conditions. Mortality of the insect by the tested materials was observed as doses and time exposure dependent. Present outcomes are in parallel to the observations of Lekha *et al*. (2020) who cited that cashew nut shell liquid 0.2% concentration was found to have insecticidal properties against *R. pedestris* caused mortality of 96.67 to 100 % at 72 HATs. Again, Degri *et al*. (2013) reported that neem seed oil and garlic extracts significantly reduced the population of pod sucking bug *Riptortus dentipes*

(Hemiptera: Alydidae) infesting cowpea. Kwon *et al*. (2011) observed that the control effects of Neem extracts were higher than 70% at 120 hours after treatments on *R. pedestris* adults. Sarker and Lim (2018) reported that *Nicotiana tabacum* and *Allium sativum*, and their mixture was found toxic to second instar nymph of *R. pedestris* and they suggested that *N. tabacum* could be potential botanical insecticide against *R. pedestris*. Botanical pesticides as seed powders of *Annona squamosa* and *Jatropha curcas* reduced both nymphs and adults brown stink bug *Riptortus linearis* F. (Hemiptera: Alydidae) population in soybean (Suharsono and Prayogo 2014). Those also decreased the hatched eggs up to 82-84%.

Toxicity of plant extracts by residual application: Spraying of tested plant extracts by residual application against the adults of *R. pedestris* under the laboratory condition showed statistically significant mortality (Table 4). The highest mortality of 73.33% was recorded after 36 HATs of Neem at dose 700 mg L^{-1} water by residual application (Table 4). Crown flower, Water pepper and Marigold caused 53.33, 43.33 and 33.00% mortality, respectively at 36 HATs at dose 700 mg L^{-1} water (Table 4). In dose response, Neem showed 100% mortality at 48 HATs at 700 mg L^{-1} (Fig. 2C). Crown flower, Water pepper and Marigold extracts caused 100% mortality at 54, 60 and 66 HATs, respectively at 700 mg L^{-1} water. Neem resulted in the highest mortality of *R. pedestris* in residual spraying method within 54 hours after treatments at dose 600 mg L^{-1} (Fig. 2B). Water pepper and Marigold extracts caused 100% mortality at 66 and 72 HATs, respectively at dose 600 mg L^{-1} water. On the other hands, Neem caused the highest (100%) mortality of *R. pedestris* in residual spraying method within 60 HATs at dose 500 mg/L (Fig. 2A). Beside, other plant extracts killed the *R. pedestris* adults within 72 hours after treatment. Statistical analyses of lethal effect are summarized in Table 5 where Neem and Crown flower showed the highest toxicity index (2.94 and 1.85) at dose 700mg L^{-1} water.

Results of the present study are comparable with Bharathimeena and Sudharma (2009). They opined that Neem extract at 1% and 0.3% were significantly effective against *R. pedestris* adults until the 7 days after first spraying. Dubey and Sundararaj (2004) reported that fortnightly and three- weekly applications of neem effectively controlled nymphal populations of *A. dispersus*, causing 62% mortality even at 21 days after treatment. Neem extract possess important bioactivities such as insect antifeedant, growth inhibitor, and other insecticidal properties which caused 96.25%

mortality of *R. pedestris* (Joeniarti *et al*. 2020). Significant level of success of potential suppression of *R. pedestris* population was reported by various researchers with different chemicals (Arifunnahar *et al*. 2021, Lee *et al*. 2015).

Table 4. Efficacy of different plant extracts against bean bug, *R. pedestris* by residual application at different doses

Plant extracts	Dose (mg L^{-1})	% Mortality (Hours after treatment)					
		6	12	18	24	30	36
Neem	500	00.00 b	6.67±0.67b	16.67±1.00abc	23.33±0.67bc	33.33±1.00ab	46.67±1.33a
	600	00.00 b	10.00±1.00ab	23.33±1.33ab	33.33±0.67bc	43.33±1.00ab	56.67±1.33a
	700	3.33±0.33a	13.33±1.00a 1.00a	33.33±2.00a	56.67±2.33a	66.67±1.00ab	73.33±1.67a
Crown flower	500	00.00 b	00.00 c	6.67±0.33bc	20.00±1.67bc	36.67±1.67a	43.33±1.33a
	600	00.00 b	00.00 c	10.00±0.33bc	23.33±1.67ab	36.67±1.67a	50.00±1.33a
	700	00.00 b	00.00 c	10.00±1.00abc	26.67±2.33a	40.00±1.00ab	53.33±1.00a
Water pepper	500	00.00 b	00.00 c	00.00 c	6.67±0.00bc	16.67±1.00ab	26.67±1.00ab
	600	00.00 b	00.00 c	10.00±1.00abc	20.00±1.00bc	33.33±1.33ab	36.67±0.00b
	700	00.00 b	00.00 c	10.00±0.67bc	26.67±1.67a	33.33±0.00b	43.33±1.00ab
Marigold	500	00.00 b	00.00 c	00.00 c	6.67±0.67bc	16.67±1.00ab	30.00±1.33a
	600	00.00 b	00.00 c	00.00 c	10.00±1.00bc	20.00±1.00ab	30.33±1.33a
	700	00.00 b	00.00 c	00.00 c	13.33±1.33ab	23.33±1.00ab	33.00±0.67ab
Control		00.00 b	00.00 c	00.00 c	00.00 c	00.00 c	00.00 c

Same column followed by different letters indicate significantly different at $P < 0.05$ by Duncan's Multiple Range Test.

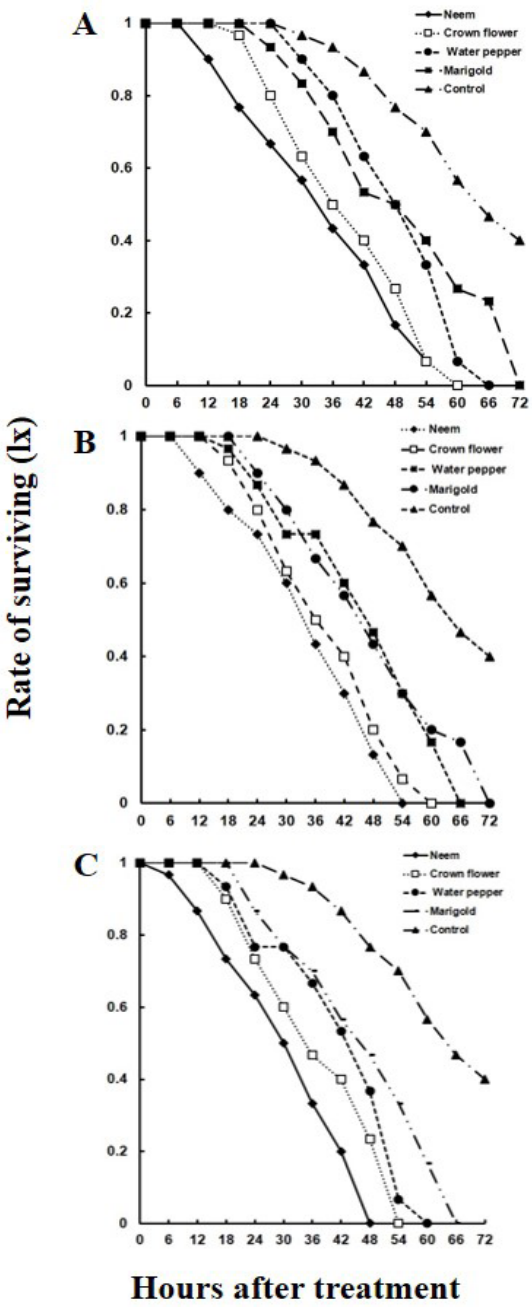

Fig. 2. Survivorship of adult *R. pedestris* while exposed to the tested plant extracts by residual method at 500mg L^{-1} (A) 600mg L^{-1} (B) and 700mg L^{-1} (C)

Repellency effect of plant extracts: The repellency rates of different plant extracts on adult *R. pedestris* are presented in Table 6. Neem showed the highest mean repellency (48.89%) and it belongs to the repellency class III followed by crown flower and water pepper were also belongs to the same class. On the other hand marigold belongs to the repellency class II. Nevertheless marigold showed the lowest mean repellency (35.56%) and it belongs to the repellency class II but all of them are significant. Adult of *R. pedestris* repelled significantly while treated with the tested botanical extracts. Also, the repellency rate increased with increasing of dosage in all treatments. Outcomes revealed that trialed plant extracts diversely repelled the *R. pedestris*. This indicated that the pest repellent properties of all tested products were not distributed uniformly. Novel innovative research proved that diverse plant products including *Jatropha carcus*, neem and *N. tabacum* have been tried by several researchers with a good degree of repellency against bean bug pest and found promising results against *R. pedestris* (Joeniarti *et al*. 2020). They cited that neem extract possess important bioactivities such as insect repellent, antifeedant, growth inhibitor, and other insecticidal properties and caused 96.25% mortality of *R. pedestris*. The present studies of repellency with other chemicals against *R. pedestris* are in conformity with earlier results reported by Maharjan and Jung (2015). They concluded that synthetic chemicals had repellent activities against *R. pedestris*.

Table 5. Statistical comparison of lethal effect (residual method) of pesticides on bean bug, *R. pedestris*

Plant extracts	Dose mg/L	n	LT_{50}	95% CI limit (lower-upper)	Slop (±) SE	χ^2(df)	TI
Neem	500	30	31.76 c	26.94-36.45	5.30±0.48	25.65(10)	2.01
Crown flower		30	34.62 c	32.27-36.89	6.82±0.65	8.79(10)	1.85
Water pepper		30	44.91 b	42.71-47.11	9.67±0.98	9.24(10)	1.42
Marigold		30	45.34 b	42.35-48.49	5.85±0.61	6.99(10)	1.41
Control	-	30	64.13 a	60.61-69.18	8.48±1.23	1.18(10)	1.00

Plant extracts	Dose mg/L	n	LT_{50}	95% CI limit (lower-upper)	Slop (±) SE	χ^2(df)	TI
Neem	600	30	28.65 c	25.05-32.11	4.65±0.43	14.05(10)	2.08
Crown flower		30	37.07 b	34.77-39.31	7.54±0.73	8.54(10)	1.61
Water pepper		30	37.65 b	33.66-41.67	5.39±0.52	15.38(10)	1.58
Marigold		30	43.30 b	40.43-40.25	5.97±0.61	5.76(10)	1.37
Control	-	30	59.69 a	55.01-66.39	5.00±0.66	0.80(10)	1.00
Neem	700	30	21.25 c	18.53-23.82	4.76±0.45	11.09(10)	2.94
Crown flower		30	33.72 b	29.18-38.06	5.40±0.52	21.22(10)	1.85
Water pepper		30	36.86 b	32.40-41.28	6.45±0.61	23.65(10)	1.69
Marigold		30	44.01 b	40.95-47.27	5.42±0.57	8.70(10)	1.42
Control	-	30	62.58 a	58.57-68.32	6.79±0.93	2.04(10)	1.00

Means followed by different letters are significantly different (Robertson et al. 2007).

Table 6. Repellency rates of tested plant extracts against the bean bug, *R. pedestris* at different hours after treatments

Plant extracts	Repellency (%) at three different HATs			Mean repellency (%)	Repellency class
	3	6	24		
Neem	26.60a	50.00a	70.00a	48.89	III
Crown flower	20.00ab	43.33ab	63.33b	42.22	III
Water pepper	23.33b	43.33ab	63.33b	43.33	III
Marigold	16.67c	36.67c	53.33c	35.56	II

Mean followed by different letters in same column indicate significantly difference at $P < 0.05$ by Duncan's Multiple Rang Test.

CONCLUSION

Plant extracts can be explored for developing natural products to use as biodegradable alternatives of synthetic pesticides. Neem and Crown flower produced highest mortality against bean bug, *R. pedestris.* The use of plant extracts for the control of *R. pedestris* could be an important and useful approach instead of using chemical compounds, which are more toxic and increasing their frequency of application.

REFERENCES

ABE, M. & MATSUDA, K. 2000. Feeding deterrents from *Momordica charantia* leaves to cucurbitaceous feeding beetle species. *Appl. Entomol. Zool*. **35**: 143-149.

ARIFUNNAHAR, M. S. T., KHATUN, M. M., HOSSAIN, M. A. & ABDUL, A. M 2021. Toxicity evaluation of different chemical pesticides against *Riptortus pedestris* (Hemiptera: Alydidae) under laboratory condition in Bangladesh. *J. Bangladesh Agril. Univ*. **19**(2): 192-197.

ATKINSON, B. L., BLACKMAN, A. J. & FABER, H. 2004. The degradation of the natural pyrethrins in crop storage. *J. Agri. Food Chemistry*. **52**: 280-287.

BHARATHIMEENA, T. & SUDHARMA, K. 2009. Alternate host range and management of *Riptortus pedestris* F. infesting cowpea. *Indian J. Com*. **17**: 26-31.

DEGRI, M. M., MAINA, Y. T. & SHARAH, H. A. 2013. Neem seed oil and garlic extracts significantly reduced the population of *Riptortus dentipes* on cowpea pods. Control of pod-sucking bug *Riptortus dentipes* (Hemiptera: Alydidae) of cowpea with aqueous plant extracts and Cymbush Super EC in Maiduguri, Nigeria. *Int. Acad. J. Health Med. Nurs.* **2**: 8-12.

DUBEY, A. K. & SUNDARARAJ, R. 2004. Evaluation of neem products against *Aleurodicus dispersus* Russell (Aleyrodidae: Homoptera) on *Bauhinia variegate* and *Michelia champaca*, *Indian J. Plant Prot*. **32**: 126-128.

DUBEY, N. K., SHUKLA, R., KUMAR, A., SINGH, P. & PRAKASH, B. 2011. Global scenario on the application of natural products in integrated pest management programmes. In NK Dubey (Ed.) Natural Products in Plant Pest Management, CAB International. Pp. 1-20.

FENG, W. & ZHENG, X. 2007. Essential oil to control *Alternaria alternate* in vitro and in vivo. *Food Cont*. **18**: 1126-1130.

HIROSE, Y., TAKASU, K. & TAKAGI, M. 1996. Egg parasitoids of phytophagous bugs in soybean: Mobile natural enemies as naturally occurring biological control agents of mobile pests. *Biol. Control*. **7**: 84-94.

ISMAN, M. B. 2000. Plant essential oils for pest and disease management. *Crop Prot.* **19**: 603-608.

JOENIARTI, E., PURWANTI, S., HIDAYATI, S. & NURLINA, N. 2020. Mixed formula of neem leaves extract and curcumin as botanical insecticides for sustainable agriculture. *J. Physics*. Conf ser. **1459**. doi:10.1088/1742-6596/1469/1/012006.

KAMBREKAR, D. N., AWAKNAVAR, J. S. & KULKARANI, K. A. 2003. Insecticidal toxicity against spiraling whitefly, *Aleurodicus disperses* Russell on Acalypha. *J. Enomol. Res*. **27**: 77-80.

KANG, C. H., HUH, H. S. & PARK, C. G. 2003. Review on true bugs infesting tree fruits, upland crops, and weed in Korea. *Korean J. Appl. Entomol*. **42**: 269-277.

KARIM, S. M. & KABIR, S. M. 1995. Bangladesher Agacha Poricheti. Pp. 25-68.

KIKUHARA, Y. 2005. The Japanese species of the genus *Riptortus* (Heteroptera: Alydidae) with description of a new species. *Jpn. J. Syst. Entomol*. **11**: 299-311.

KIM, E., CHANG, G. P. & LIM, U. T. 2014. Evaluation of three plant seeds as potential pre-season diets for *Riptortus pedestris. J. Asia-Pacific Entomol*. **17**: 521-524.

KIM, S. & LIM, U. T. 2010. Seasonal occurrence pattern and within-plant egg distribution of bean bug, *Riptortus pedestris* Fabricius (Hemiptera: Alydidae), and its egg parasitoids in soybean fields. *Appl. Entomol. Zool*. **45**: 457-464.

KWON, H. R., KIM, S. H., PARK, M. W., JO, S. H., SHIN, H. S., CHO, H. S., SEO, M. J., YU, Y. M. & YOUN, Y. N. 2011. Environmentally-friendly control of *Riptortus pedestris* (Hemiptera: Alydidae) by environmental friendly agricultural materials. *Korean J. Pest. Sci*. **38**: 413-419.

LEE, S. Y., YOON, C., DO, Y.S., LEE, D. H., LEE J. S. & CHOI, K. H. 2015. Ealuation of insecticidal activity of pesticides against hemipteran pests on apple orchard. *Korean J. Pest. Sci.* **19**: 264-271. https://doi.org/10.7585/kjps.2015.19.3.264.

LIANG, G. M., CHEN, W. & LIU, T. X. 2003. Effects of three neem-based insecticides on diamondback moth (Lepidoptera: Plutellidae). *Crop Prot*. **22**: 333-340.

MAHARJAN, R. & JUNG, C. 2015. Insecticide-mediated behavioral avoidance by bean bug, *Riptortus pedestris* (Heteroptera: Alydidae). *Entomol. Res*. **45**: 184-192.

MAINALI, B. P., KIM, H. J. & BAE, S. D. 2014. Infestation of *Riptortus pedestris* Fabricius decreases the nutritional quality and germination potential of soybean seeds. *J. Asia-Pacific Entomol*. **17**: 477-481.

McDONALD, L. L., GUY, R. H. & SPEIRS, R. D. 1970. Preliminary evaluation of new candidate materials as toxicants repellents and attractants against stored product insects. Marketing Research Report, Number 882. Washington.

NAKAJIMA, Y., SAKUMA, M., SASAKI, R. & FUJISAKI, K. 2010. Adaptive traits of *Riptortus pedestris* nymphs (Heteroptera: Alydidae) for locating host plants. *Ann. Entomol. Soc. Am.* 103: 439-448.

PALUMBO, J. C., HOROWITZ, A. R. & PRABHAKER, N. 2001. Insecticidal control and resistance management for *Bemisia tabaci*. *Crop Prot*. **20**: 739-765.

PRAKASH, A. & RAO, J. 1996. *Botanical pesticides in agriculture*. 480 Pp. CRC Press, New Delhi, India. P. 461.

PRETTY, J. 2009. The pesticide Detox, Towards a More Sustainable Agriculture. Earthscan, London. 8-12 Camden High Street, London, NW1 0JH, UK.

ROBERTSON, J. L., PREISLER, H. K. & RUSSELL, R. M. 2007. PoloPlus: Probit and Logit Analysis User's Guide. Leora Software, Petaluna, CA, USA.

SARKER, S. & LIM, U. T. 2018. Evaluation of Two Plant Extracts on Different Life Stages of *Riptortus pedestris* (F.) http ://db.koreascholar.com/Article/Detail/346778.

SON, C., PARK, S. G., HWANG, Y. H. & CHOI, B. 2000. Field occurrence of stink bug and its damage in soybean. Korean. *J. Crop Sci*. **45**: 405-410.

SUHARSONO & PRAYOGO, Y. 2014. Integration of Botanical Pesticide and Entomopathogenic Fungi to Control the Brown Stink Bug *Riptortus linearis* F. (Hemiptera: Alydidae) in Soybean. *J. Trop. Plant Pests Dis*. DOI: https://doi.org/10.23960/j.hptt.11441-50.

WANG, M., LING, J., CAO, X., BAO, S. & ZHANG, M. 2012. Toxicity evaluation of botanical insecticides and their mixture against the *Aleurodicus dispersus*. South China University, *J. Biosaf.* **21**(2): 135-141