Bangladesh j. entomol. (2015) 25(1), 15-31 *ISSN 1021-1004*

EFFECT OF SOME INDIGENOUS PLANT EXTRACTS AGAINST BROWN PLANT HOPPER, *NILAPARVATA LUGENS* (STAL.) (HEMIPTERA: DELPHACIDAE)

M. S. RANA[1], M. A. A. BACHCHU[1*], M. A. HOSSAIN[1], R. ARA[1] & H. RAHMAN[2]

[1]Department of Entomology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur. [2] Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU)

ABSTRACT

An experiment was conducted to study the bioefficacy of six indigenous plant extracts against Brown Plant Hopper (BPH), Nilaparvata lugens (Stal.) under laboratory conditions. The methanol extracts of six plants (akanda, biskatali, marigold, castor, chili and nishinda) at 0.5, 1.0 and 1.5 % concentration were evaluated for their effects against nymphs and adults. All plant extracts had different toxic effects against N. lugens. Among the tested plant extracts, chili plant extract showed the highest toxic effect, while castor plant extract showed the lowest toxic effect against the nymphs and adults. Insect mortality was found directly proportional to the level of concentrations of plant extracts and to the exposure period. The lowest LD50 value also indicated that the chili plant extract was highly effective against the nymphs and adults of BPH. The results clearly indicate that the plant based pesticide containing low lethal concentration may be used effectively to control this pest.

Keywords: Plant extract, mortality and BPH.

INTRODUCTION

Rice (*Oryza sativa* L.*)* is a staple food for nearly half of the global population and about 43504000 tons rice is produced in Bangladesh (FAO 2008). Almost 90% of the population in Bangladesh depends on rice as their major food (DAE 2011). In Bangladesh, 266 insect species have been identified so far as pest of rice (Islam *et*

*Corresponding author: Email: adnan_hstu@yahoo.com

al. 2003) and among these, the brown plant hopper (BPH), *Nilaparvata lugens* (Stal.) is widespread and a threat to rice production in many parts of the country specially in Rangpur, Dinajpur, Bogra, Naogaon, Rajshahi. Formerly it was a minor pest in most tropical countries of Asia but its widespread occurance due to adoption of high-yielding cultivars which are susceptible to *N. lugens* (Mollah *et al.* 2011). Both the nymphs and adults cause substantial damage to the rice crop by direct physical damage due to phloem sap removal (Sogawa 1982) and blocking the xylem and phloem by laying egg masses in the midrib of the leaf sheath. This pest also acts as a vector for the economically important ragged stunt, grassy stunt and wilted stunt viruses (Ou 1985). Moreover, the honeydew secreted by nymphs and adults encourages the growth of sooty molds.

Although insecticides were useful for controlling BPH (Mishra 2006), their constant and regular use has resulting in resurgence, insecticide resistance and environmental hazard (Campiche *et al.* 2006). Many types of synthetic insecticides have been used during the last five decades in rice fields to control the hoppers, but they did not fulfill the requirements for rice pest management in Asia (Tanaka *et al,* 2000). Pesticides also have a negative effect on the *N. lugens* predators such as mirid bugs, dryinid wasps, *Anagrus* parasitoids, *Coccinella* predators, and *Miscrapis* sp. (Tanaka *et al.* 2000). Due to the above drawbacks, researchers are trying to adopt alternative methods of pest control (Mahmud *et al.* 2002). Botanical insecticides have long been used as an attractive alternative to synthetic chemical insecticides for pest management. About 2000 plants have been reported to possess pest control properties (Ahmed *et al.* 1984). Botanical pesticides are eco-friendly, economic, target-specific and biodegradable. Such materials have the potential to enhance the management of BPH population in the rice ecosystem (Senthil-Nathan *et al.* 2007). Some laboratory and field studies have found neem extracts to be compatible with biological control (Goudegnon *et al.* 2000, Abudulai & Shepard 2003, Mitchell *et al.* 2004). Few specific research works have been done to explore locally available plant materials for the management of BPH. One reason might be that the insect was generally a minor pest of rice until recently. Considering the importance of eco-friendly approaches to manage the pests and the idea of agro ecosystem, the present study was undertaken to determine the biological activity of different indigenous plant extracts against the nymphs and adults of BPH.

MATERIALS AND METHODS

The present study was conducted to evaluate six indigenous plants extracts viz. akanda (*Caloropis gigantea* L.), biskatali (*Polygonum hydropiper* L.), marigold (*Tagetes erecta* L.), castor (*Ricinus communis* L.), chili (*Capsicum frutescens* L.) and nishinda (*Vitex negundo* L.) against a destructive pest of rice, BPH in the laboratory condition of the Department of Entomology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from June to December 2013 to test their efficacy.

Preparation of plant extracts: Fresh leaves of akanda, biskatali, marigold, castor, nishinda and ripe fruits of chili were collected from the HSTU campus, Dinajpur. After collection, they were washed in running tap water and kept in the laboratory for 7 days for air drying followed by one day sun drying before making powder. Upon proper drying, they were made powder separately by an electric grinder. The extracts were prepared according to Chitra *et al.* (1993). For making extracts, 100g of each plant powders were dissolved in 300 ml of methanol solvent and stirred for 30 minutes in a magnetic stirrer. The mixture was then allowed to stand for 72 hours and shaking several intervals. Then, the mixture was filtered through a filter paper (Whatman no. 1) and allowed to evaporate the solvents. After the evaporation of solvent from filtrate, the condensed extracts were preserved in tightly corked-labeled bottles and stored in a refrigerator at 4^0C until their use for insect bioassays.

Mass rearing of BPH: Both the nymphs and adults of BPH were used as test insect in this study. Mass rearing of BPH population was maintained following Biswas *et al.* (2006). The gravid females of BPH were collected from naturally infested rice field around HSTU campus, Sadar Dinajpur with the help of an aspirator. Immediately after collection, the gravid females were placed in a medium sized (15 cm in length) test tube. Then the mouth of test tube was closed with a piece of fine nets and fastened with rubber bands. The collected insects were then brought to the laboratory and reared to build up a large population. Then the gravid females were released on 30 - 40 days old rice plant grown in pots. The potted rice plants were covered with 1.0 m x 0.5 m (height x breadth) rearing cages. The plants were observed for egg laying every day. For egg laying purposes, gravid females of BPH were released in caged-fresh rice plants on every Sunday and Wednesday in every week. On each plant 10 to 12 gravid females were released and allowed to lay eggs for one day and then the insects were transferred to another fresh plant with the help of an aspirator. After hatching of eggs into nymph, they were provided with sufficient food plants for their growth and development. As soon as most of the insects from the new hatching became adults, the females and the males were transferred to another cage with fresh plants twice a week. These insects were preserved in new cages with dates of egg laying marked on them. The BPH population was provided with fresh plants for their food as and when necessary. In this way, BPH population of uniform age were established and within 3 - 4 generations, sufficient numbers of insects became available for the production of required numbers of nymphs and adults for the bioefficacy study.

Evaluation of toxicity of different plant extracts: Bioefficacy tests of six indigenous plant extracts against BPH were conducted following Haque *et al.* (2002). Three different doses (0.5, 1.0 and 1.5 % along with control) were prepared by diluting the crude extracts in methanol solvent prior to insect bioassay. Thirty (30) to forty (40) days old rice plants tillers were cut in small pieces (about 2 – 3 cm) and were treated with different concentrations by dipping for 30 seconds ineach plant extracts. After dipping, 2 – 3 treated cut tillers were kept on the glass Petri dish (9 cm diameter). Ten 4th instar BPH nymphs and adults were released in each Petri dish for each treatment. Equal number of insect with methanol solvent only was treated as control. Each treatment along with control was replicated thrice. Insect mortalities were recorded at 6, 12, 18 and 24 hours after treatment (HAT). The percentage of the mortality was corrected by the Abbott's (1987) formula as under before analysis.

$$P = \frac{P'-C}{100-C} \times 100$$

Where, P= Percentage of corrected mortality, P'= Observed mortality (%) and C= Control mortality (%)

Statistical analysis: The collected data were statistically analyzed by completely randomized design (CRD) using MSTAT statistical software. The treatment mean values were adjusted by Duncun's New Multiple Range Test (DMRT). The observed mortality data were also subjected to probit analysis.

RESULTS AND DISCUSSION

The toxicity effect of six indigenous plant extracts was evaluated against BPH. The results of the study are presented and discussed as follows.

Direct toxicity effect (mortality) on the nymph of BPH: Average mortality percentage of the nymphs of BPH indicated that chili plant extract possessed the highest (mortality, 54.58%) toxic effect followed by marigold (mortality, 45.62%) and biskatali (mortality, 45.00%) plant extract, whereas castor plant extract possessed the lowest (mortality, 38.12%) toxic effect (Table 1). Mortality percentages were directly proportional to the time after treatment. The orders of the toxicity of six plant extracts against the nymph of BPH were found as chili > marigold > biskatali > akanda > nishinda > castor. Chili plant extract showed the highest nymphal mortality at different hours after treatment which was statistically different ($p>0.01$) from all other plant extracts. Mortality percentage of the nymph also differed significantly among all the concentration level

Table 1. Effect of different plant extracts against the nymphs of BPH at different HAT (Interaction of plant extracts and time)

Plant extracts used	Mortality percentage at different time intervals				
	6 HAT	12 HAT	18 HAT	24 HAT	Average mortality
Nishinda	5.00 d	29.17 d	56.67 ab	66.67 bc	39.37 c
Marigold	12.50 b	35.83 bc	54.17 bc	67.50 abc	45.62 b
Castor	10.00 bc	33.33 cd	46.67 c	62.50 c	38.12 c
Biskatali	5.00 d	40.83 b	62.50 ab	71.67 ab	45.00 b
Chili	27.50 a	53.33 a	64.17 a	73.33 ab	54.58 a
Akanda	5.83 cd	35.83 bc	58.33 ab	74.17 a	43.54 b
Level of significance	0.01	0.01	0.01	0.01	0.01
LSD	4.739	5.027	8.036	6.561	6.092
CV (%)	52.62	16.09	17.15	11.53	24.34

HAT= Hours after treatment, within column values followed by different letter(s) are significantly different by DMRT at 5 % level of probability.

(p>0.01) at different time interval (Table 2). The highest average mortality (67.91%) was observed at the maximum concentration (1.5%) of plant extract and it was also found that the mortality percentage was directly proportional to the level of concentration of different plant extracts. The interaction effect of plant, dose and time is presented in the Table 3. Nymphal mortality was also found statistically significant (p>0.05) at different dose level of different plant extracts at different hours after treatment. Average value indicated that the highest (86.66%) mortality was found in chili plant extracts at the highest dose (1.5%) which was statistical different from all other plant extract at different concentration level.

Table 2. Effect of different doses of plant extracts against the nymphs of BPH at different HAT (Interaction of doses and time)

Doses (%)	Mortality percentage at different time intervals				
	6 HAT	12 HAT	18 HAT	24 HAT	Average mortality
0.0	0.00 c	0.00 d	0.00 d	12.78 c	3.19 d
0.5	3.33 c	32.78 c	61.67 c	80.00 b	44.44 c
1.0	16.11 b	53.89 b	79.44 b	90.00 a	59.86 b
1.5	24.44 a	65.56 a	87.22 a	94.44 a	67.91 a
Level of significance	0.001	0.001	0.001	0.001	0.001
LSD	3.869	4.104	4.561	5.357	4.47
CV (%)	52.62	16.09	17.15	11.53	24.34

HAT= Hours after treatment, within column values followed by different letter(s) are significantly different by DMRT at 5 % level of probability.

From the above finding it was observed that all the tested plant extracts possessed the toxicity effect on the mortality of the nymph of BPH. However, the chili plant extract showed the most effective performance while the castor extract was less effective. Tomita and Endo (2007) showed that the chili plant extract was effective to reduce the density of both spider mites and aphids. It is well recognized that capsicin is the material that is extracted from chili plant and used as a botanical insecticide (Xu *et al.* 2005), especially for organic agriculture

(Neumann, 2003). It can be used on ornamentals, outdoors and indoors for control of aphids, spider mites, thrips, whitefly, and other pests. However, neither insecticidal effect nor the range of an effective concentration to a harmful insect of capsicin is clear.

Many studies have been done to investigate the efficacy of powder of *C. frutescens* on the survival of insect pest including *Sitophilus zeamais* and *Callosobruchus maculatus*. Adedire and Ajayi (1996) recorded 100% mortality of *S. zeamais* treated with *C. frutescens* 28 days after treatment on maize grains. Similarly, Asawalam *et al.* (2007) reported *C. frutescens* to have shown 75% mortality of *S .zeamais* 33 days after treatment. They indicated that *C. frutescens* effectively protected maize grains against weevil attack. It exhibited fumigant mode of action since it had a characteristic pungent smell and pepperish in nature. *C. frutescens* and *Nicotiana tabacum* were also reported to affect adult emergence of *S. zeamais* on maize grains revealing 10.0% and 12.0% emergence respectively (Asawalam *et al.* 2007).

Table 3. Effect of different plant extracts of different doses against the nymphs of BPH at different HAT (Interaction of plant, dose and time)

Plant extracts used	Doses (%)	Mortality percentage at different time intervals 6 HAT	12 HAT	18 HAT	24 HAT	Average mortality
Nishinda	0.0	0.00 f	0.00 j	0.00 g	13.33 e	3.33 f
	0.5	3.33 ef	33.33 ghi	70.00 cde	70.00 d	44.16 d
	1.0	6.67 ef	40.00 fgh	76.67 bcd	90.00 ab	53.33 c
	1.5	10.00 def	43.33 efg	80.00 bcd	93.33 ab	56.66 c
Marigold	0.0	0.00 f	0.00 j	0.00 g	16.67 e	4.16 f
	0.5	3.33 ef	26.67 i	53.33 ef	73.33 cd	39.16 d
	1.0	20.00 cd	53.33 cd	73.33 bcd	86.67 abc	58.33 c
	1.5	26.67 c	63.33 de	90.00 ab	93.33 ab	68.33 b
Castor	0.0	0.00 f	0.00 j	0.00 g	10.00 e	2.50 f
	0.5	3.33 ef	26.67 i	50.00 f	70.00 d	37.50 e
	1.0	13.33 de	46.67 ef	63.33 def	80.00 bcd	50.83 c
	1.5	23.33 c	60.00 d	73.33 bcd	90.00 ab	61.66 c

Biskatali	0.0	0.00 f	0.00 j	0.00 g	10.00 e	2.50 f
	0.5	3.33 ef	30.00 hi	63.33 def	86.67 abc	45.83 d
	1.0	6.67 ef	60.00 d	90.00 ab	93.33 ab	62.50 b
	1.5	10.00 def	73.33 bc	96.67 a	96.67 a	69.17 b
Chili	0.0	0.00 f	0.00 j	0.00 g	6.67 e	1.66 f
	0.5	3.33 ef	43.33 efg	63.33 def	93.33 ab	50.83 c
	1.0	43.33 b	80.00 ab	96.67 a	96.67 a	79.16 a
	1.5	63.33 a	90.00 a	96.67 a	96.67 a	86.66 a
Akanda	0.0	0.00 f	0.00 j	0.00 g	20.00 e	5.00 f
	0.5	3.33 ef	36.67 fghi	70.00 cde	96.67 abc	51.66 c
	1.0	6.67 ef	43.33 efg	76.67 bcd	93.33 ab	55.00 c
	1.5	13.33 de	63.33 cd	86.67 abc	96.67 a	65.00 b
Level of significance		0.001	0.001	0.151	0.199	0.08
LSD		9.478	10.05	16.07	13.12	12.17
CV (%)		52.62	16.09	17.15	11.53	24.34
S_x		3.333	3.536	5.652	4.618	4.28

HAT= Hours after treatment, within column values followed by different letter(s) are significantly different by DMRT at 5 % level of probability.

Direct toxicity effect (mortality) on the adult of BPH: Average mortality percentage indicated that chili plant extract possessed the highest (mortality, 51.25%) toxic effect followed by biskatali (mortality, 51.12%) plant extracts which was statistically identical between the two plant extract but statistically different ($p>0.01$) among all other plant extracts. On the contrary, nishinda plant extract possessed the lowest (mortality, 31.45%) toxic effect (Table 4) against the adults of BPH. Mortality percentages were directly proportional to the time after treatment. The orders of the toxicity of six plant extracts were: chili > biskatali > akanda > castor > marigold > nishinda. The highest adult mortality was found in chili plant extract (10.00%) while the lowest mortality was observed in nishinda plant extract (3.33%) at 6 HAT. Similar trend of adult mortality has been observed at 12 HAT but at 18 and 24 HAT the lowest mortality was observed in marigold plant extract. Mortality of BPH also differed significantly among all the concentration level ($p>0.01$) at different time interval (Table 5). The highest average adult mortality (62.08%) was also observed at the maximum concentration (1.5%) of plant extract while the lowest mortality was observed at control treatment. The interaction effects of plant, dose and time on the adult mortality is presented in Table 6. Adult mortality of BPH treated with different plant extracts of different dose level at different hours was found statistically significant (p>0.01). The adult mortality of chili was 23.33%, 86.67%, 96.67% and 96.67% at 6, 12, 18 and 24 HAT at maximum concentration which statistically differed among all other plant extracts in different concentration levels.

Among the tested plant extracts, chili plant extract was the most effective against the adult of BPH. But rests of the plant extracts were also effective in controlling the BPH. However, information on the use of plant extracts for field pests control is limited. Although this result is in little line with the findings of Stoll (1988) and Panhwar (2002) who independently reported that ginger, chilli pepper and garlic bulb were good biocontrol agents of some insect pests of cowpea.

Table 4. Effect of different plant extracts against the adults of BPH at different HAT (Interaction of plant extracts and time)

Plant extracts	Mortality percentage at different time intervals				
used	6 HAT	12 HAT	18 HAT	24 HAT	Average mortality
Nishinda	3.33 c	10.00 e	44.17 c	68.33 ab	31.45 d
Marigold	8.33 ab	24.17 c	43.33 c	66.67 b	35.62 c
Castor	6.67 abc	15.83 d	60.00 b	71.67 ab	38.54 c
Biskatali	7.50 abc	45.83 b	58.33 b	65.83 b	51.12 a
Chili	10.00 a	55.83 a	66.67 a	72.50 a	51.25 a
Akanda	5.00 bc	44.17 b	56.67 b	66.67 b	43.12 b
Level of significance	0.017	0.00001	0.00001	0.0600	0.019
LSD	3.867	4.537	4.217	5.299	4.48
CV (%)	69.27	16.94	9.36	9.41	26.24
S_x	1.361	1.596	1.483	1.863	1.57

HAT= Hours after treatment, within column values followed by different letter(s) are significantly different by DMRT at 5 % level of probability

Table 5. Effect of different doses of plant extracts against the adults of BPH at different HAT (Interaction of doses and time)

Doses (%)	Mortality percentage at different time intervals				
	6 HAT	12 HAT	18 HAT	24 HAT	Average mortality
0.0	0.00 d	0.00 d	0.00 d	11.11 d	2.77 d
0.5	4.44 c	33.39 c	59.44 c	78.33 c	43.90 c
1.0	7.78 b	44.44 b	74.44 b	89.44 b	54.02 b
1.5	15.00 a	52.22 a	85.56 a	95.56 a	62.08 a
Level of significance	0.00001	0.00001	0.00001	0.00001	0.00001
LSD	3.159	3.705	3.443	4.326	3.65
CV (%)	69.27	16.94	9.36	9.41	26.24
S_x	1.111	1.303	1.211	1.521	1.286

HAT= Hours after treatment, within column values followed by different letter(s) are significantly different by DMRT at 5 % level of probability.

Table 6. Effect of different plant extracts of different doses against the adults of BPH at different HAT (Interaction of plant, dose and time)

Plant extracts used	Doses (%)	Mortality percentage at different time intervals				
		6 HAT	12 HAT	18 HAT	24 HAT	Average mortality
Nishinda	0.0	0.00 e	0.00 j	0.00 j	16.67 e	4.16 h
	0.5	3.33 de	6.67 ij	43.33 i	73.33 d	31.66 e
	1.0	3.33 de	10.00 i	63.33 gh	86.67 abc	40.83 d
	1.5	6.67 cde	23.33 g	70.00 efg	96.67 a	49.16 c
Marigold	0.0	0.00 e	0.00 j	0.00 j	10.00 e	2.50 i
	0.5	6.67 cde	20.00 gh	43.33 i	73.33 d	35.83 e
	1.0	10.00 bcd	23.33 f	56.67 h	90.00 ab	45.00 d
	1.5	16.67 ab	43.33 e	73.33 def	93.33 ab	56.66 c
Castor	0.0	0.00 e	0.00 j	0.00 j	10.00 e	2.50 i
	0.5	6.67 cde	13.33 hi	66.67 fg	86.67 abc	43.33 d
	1.0	6.67 cde	23.33 g	80.00 cd	93.33 ab	50.83 c
	1.5	13.33 bc	26.67 fg	93.33 ab	96.67 a	57.50 c

Biskatali	0.0	0.00 e	0.00 j	0.00 j	10.00 e	2.50 i
	0.5	3.33 de	53.33 d	63.33 gh	73.33 d	48.33 d
	1.0	10.00 bcd	63.33 c	76.67 de	83.33 bcd	58.33 b
	1.5	16.67 ab	66.67 bc	93.33 ab	96.67 a	68.33 a
Chili	0.0	0.00 e	0.00 j	0.00 j	10.00 e	2.50 i
	0.5	3.33 de	63.33 c	76.66 de	86.67 abc	57.50 c
	1.0	13.33 bc	73.33 b	93.33 ab	96.67 a	69.16 a
	1.5	23.33 a	86.67 a	96.67a	96.67 a	75.83 a
Akanda	0.0	0.00 e	0.00 j	0.00 j	10.00 e	2.50 i
	0.5	3.33 de	46.67 de	63.33 gh	76.67 cd	47.50 d
	1.0	3.33 de	63.33 c	76.67 de	86.67 abc	57.50 c
	1.5	13.33 bc	66.67 bc	86.67 bc	93.33 ab	65.50 b
Level of significance		0.307	0.001	0.001	0.379	-
LSD at 5 %		7.739	9.075	8.433	10.60	8.96
CV (%)		69.27	16.94	9.36	9.41	26.24
S_x		2.722	3.191	2.966	3.727	3.15

HAT= Hours after treatment, within column values followed by different letter(s) are significantly different by DMRT at 5 % level of probability.

Probit analysis of BPH for direct toxic effect: The results of the probit analysis of nymphal and adult mortality for the estimation of LD_{50} values, 95 % feducial limits and their chi-square values at different HAT are presented in Tables 7 and 8. The LD_{50} values of nishinda (15.30 mg), marigold (2.46 mg), castor (3.07 mg), biskatali (15.30 mg), chili (1.19 mg) and akanda (7.79 mg) at 6 HAT indicated that chili plant extract was the most toxic followed by marigold plant extract while nishinda and biskatali plant extract was the least toxic against the nymph of BPH. Chili plant extract also maintained its higher toxicity when the LD_{50} values were compared at 12 (0.55 mg) and 24 HAT (0.001 mg) but at 18 HAT, akanda showed the highest toxicity (LD_{50} value 0.18 mg).

Table 7. Effect of different plant extracts against the nymphs of BPH after 6, 12, 18 and 24 HAT

Plant extracts used	No. of insect used	LD_{50} values	95 % fiducial limits Lower	Upper	χ^2 values	Regression equation
			6 HAT			
Nishinda	90	15.30	0.106	2191.455	0.002	Y = 2.243106 + 1.261814 X
Marigold	90	2.46	1.179	5.146	0.446	Y = 1.257196 + 2.747214 X
Castor	90	3.07	1.134	8.350	0.011	Y = 1.489182 + 2.358965 X
Biskatali	90	15.30	0.106	2191.455	0.002	Y = 2.243106 + 1.261814 X
Chili	90	1.19	1.017	1.414	0.917	Y = 0.251836 + 4.400609 X
Akanda	90	7.79	0.438	138.504	0.029	Y = 1.962182 + 1.605670 X
			12 HAT			
Nishinda	90	2.69	0.211	34.347	0.001	Y = 4.113672 + 0.619486 X
Marigold	90	0.98	.0721	1.349	0.209	Y = 3.035747 + 1.975763 X
Castor	90	1.07	0.760	1.529	0.017	Y = 3.092380 + 1.846907 X
Biskatali	90	0.80	0.615	1.054	0.089	Y = 2.823665 + 2.401941 X
Chili	90	0.55	0.416	0.746	0.933	Y = 2.729373 + 3.042703 X
Akanda	90	1.00	0.638	1.569	0.999	Y = 3.630340 + 1.368995 X
			18 HAT			
Nishinda	90	0.27	0.059	1.231	0.159	Y = 4.501370 + 1.150621 X
Marigold	90	0.48	0.312	0.750	0.484	Y = 3.386216 + 2.356014 X
Castor	90	0.51	0.239	1.127	0.026	Y = 4.12267 + 1.22542 X
Biskatali	90	0.40	0.266	0.604	0.049	Y = 3.052584 + 3.225736 X
Chili	90	0.40	0.283	0.572	1.044	Y = 2.692962 + 3.813741 X
Akanda	90	0.18	0.023	1.480	0.298	Y = 4.698061 + 1.112063 X
			24 HAT			
Nishinda	90	0.33	0.170	0.663	0.065	Y = 3.80132 + 2.272360 X
Marigold	90	0.27	0.101	0.742	0.010	Y = 4.201188 + 1.825491 X
Castor	90	0.28	0.093	0.858	0.361	Y = 4.296521 + 1.557554 X
Biskatali	90	0.10	0.008	1.332	0.007	Y = 4.947377 + 1.521243 X
Chili	90	0.001	0.0008	0. 420	0.046	Y = 6.046458 + 0.608944 X
Akanda	90	0.09	0.006	1.530	0.006	Y = 5.021631 + 1.423906 X

HAT = Hours after treatment, Values were based on three concentrations, three replications of 10 insects each, ^{2} = Goodness of fit, the tabulated value of χ^2 is 5.99 (d. f = 2 at 5% level)

The LD_{50} values of nishinda (94.14 mg), marigold (12.12 mg), castor (71.69 mg), biskatali (4.71 mg), chili (3.07 mg) and akanda (7.79 mg) at 6 HAT for the mortality of adult BPH indicated that chili plant extract was the most toxic followed by biskatali plant extract while nishinda and castor plant extract was the least toxic (Tables 8). Chili plant extract also maintained its highest toxicity when the LD_{50} values were compared at 12 (0.29 mg), 18 (0.25 mg) and 24 HAT (0.11 mg. The highest LD_{50} values of the entire HAT were observed in nishinda plant extract except at 12 HAT. The chi-square values of different plant extracts at different HAT were insignificant at 5% level of probability and did not show any heterogeneity of the mortality data.

Table 8. Effect of different plant extracts against the adults of BPH after 6, 12, 18 and 24 HAT

Plant extracts used	No. of insect used	LD_{50} values (mg)	95 % fiducial limits		χ^2 values	Regression equation
			Lower	Upper		
			6 HAT			
Nishinda	90	94.14	0.0001	8063000	0.263	Y = 2.441889 + 0.860217 X
Marigold	90	12.12	0.1360	1075.368	0.157	Y = 2.721237 + 1.093559 X
Castor	90	71.69	0.0003	1460.000	0.325	Y = 2.971834 + 0.710271 X
Biskatali	90	4.71	0.8240	27.013	0.003	Y = 1.785014 + 1.920682 X
Chili	90	3.07	1.1340	8.350	0.011	Y = 1.489182 + 2.358965 X
Akanda	90	7.79	0.3920	155.146	0.907	Y = 1.741827 + 1.722064 X
			12 HAT			
Nishinda	90	4.84	0.7190	32.662	0.609	Y = 2.319380 + 1.590463 X
Marigold	90	2.02	0.8220	4.962	0.025	Y = 3.183174 + 1.391707 X
Castor	90	5.23	0.4170	65.513	0.027	Y = 3.129407 + 1.088390 X
Biskatali	90	0.39	0.0720	2.102	0.004	Y = 4.555529 + 0.749708 X
Chili	90	0.29	0.0920	0.957	0.448	Y = 4.336190 + 1.402446 X
Akanda	90	0.64	0.2860	1.436	0.397	Y = 4.242444 + 0.938778 X

			18 HAT			
Nishinda	90	0.62	0.3610	1.076	0.125	Y = 3.862431 + 1.430220 X
Marigold	90	0.67	0.4260	1.073	0.118	Y = 3.700331 + 1.564984 X
Castor	90	0.31	0.1370	0.729	0.526	Y = 4.041982 + 1.915201 X
Biskatali	90	0.35	0.1710	0.717	0.641	Y = 3.897560 + 2.023812 X
Chili	90	0.25	0.1050	0.604	0.001	Y = 4.069696 + 2.396787 X
Akanda	90	0.32	0.1180	0.872	0.106	Y = 4.212641 + 1.552470 X
			24 HAT			
Nishinda	90	0.33	0.1720	0.645	0.462	Y = 3.745027 + 2.395650 X
Marigold	90	0.28	0.1180	0.677	0.110	Y = 4.051365 + 2.099456 X
Castor	90	0.10	0.0087	1.332	0.007	Y = 4.947377 + 1.521243 X
Biskatali	90	0.31	0.1430	0.672	1.350	Y = 3.946211 + 2.141941 X
Chili	90	0.11	0.0012	1.125	0.144	Y = 4.872818 + 1.706030 X
Akanda	90	0.21	0.0560	0.836	0.139	Y = 4.441858 + 1.682005 X

HAT = Hours after treatment, Values were based on three concentrations, three replications of 10 insects each, ^{2} = Goodness of fit, The tabulated value of ^{2} is 5.99 (d. f = 2 at 5% level)

From the above probit results it is clear that all the tested plants would be more or less effective for controlling BPH but chili plant extract will be the most effective. The toxicity of *Capsicum* spp. on insects is thought to be the effects of secondary metabolites including alkaloids, saponins and flavonoid compounds of this plant (Bouchelta *et al.* 2005). Insecticidal property of any plant material would depend on the active constituents of the plant material (Asawalam *et al*. 2007). *C. frutescens* contains capsicin known to have insecticidal properties resulting in BPH mortality. Considering the percent mortality it was found that chili plant extract was the most effective compared to all other tested plant extracts against BPH. The effectiveness of plant-based insecticidal application may be tested against BPH under field condition.

ACKNOWLEDGEMENT

This research was funded by the University Grants Commission and granted by the Institute of Research and Training (IRT), Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh. The authors express gratitude to the Director and Associate Director of IRT, HSTU, Dinajpur for their kind support in this research work.

REFERENCES

ABBOTT, W.S. 1987. A method of computing the effectiveness of an insecticide. *J. American Mosquito Cont. Assoc.* **3**, 302-303.

ABUDULAI, M. & SHEPARD, B.M. 2003. Effects of neem (*Azadirachta indica* A. Juss) on *Trissolcus basalis* (Wollaston) (Hymenoptera:Scelionidae), a parasitoid of *Nezara viridula* (L.) (Hemiptera: Pentatomidae). *J. Entomol. Sci.* **38**, 386–397.

ADEDIRE, C.O. & AJAYI, T.S. 1996. Assessment of the insecticidal properties of some plant extracts as grain protectants against the maize weevil, *Sitophilus zeamais* Motschulsky. *Niger. J. Entomol.* **13**, 93 – 101.

AHMED, S., GRAINGE, M., HYLIN, J.W., MITEHEL, W.C. & LITSINGER, J.A. 1984. Some promising plant species for use as pest control agents under traditional farming systems. In: Proc. *2nd Int. Neem conf*. R. Halzhousen centre, Germany, pp. 565 – 580.

ASAWALAM, E.F., EMOSAIRUE, S.O., EKELEME, F. & WOKOCHA, R.C. 2007. Insecticidal effects of powdered parts of eight nigerian plant species against maize weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae). *Elec. J. Environ. Agricult. Food Chem.* **6** (11), 2526 – 2533.

BISWAS, T.K., RAHMAN, M.A., KHAN, M.M.H., ALAM, M.M. & JAHAN, M. 2006. Toxic Effects of Two Insecticides on Brown Plant Hopper, *Nilaparvata lugens* and its Predators *Micraspis discolor* and *Lycosa pseudoannulata*. *Int J. Zool. Res.* **2**, 192-203.

BOUCHELTA, A., BOUGHDAD, A. & BLENZAR, A. 2005. Effects of biocides desalcaloïdes, des saponines et des flavonoïdes extraits de *Capsicum frutescens* L. (Solanaceae) sur *Bemisia tabaci* (Gennadius) (Homoptera : Aleyrodidae). *Biotechnol Agron Soc Environ*. **9**(4), 259–269.

CAMPICHE, S., SLOOTEN, K.P., RIDREAU, C. & TARRADELLAS, J. 2006. Effects of insect growth regulators on the nontargets oil arthropod *Folsomia candida* (Collembola). *Ecotoxicol. Environ. Saf.* **63**, 216–225.

CHITRA, E.R., XIE, I.M., VISALAKSHI, M.M. & GOUR, T. B. 1993. Impact of insecticide resistance on the biology of *Rhyzopertha dominica* in maize. *Insect Environ.* **10**(1), 3-4.

DAE (Department of Agricultural Extension). 2011. Krishi Dairy Published by Agriculture Information service, Khamarbari, Dhaka. pp. 214.

FAO (Food and Agricultural Organization of the United Nations). 2008. The State of World's Plant Genetic Ressorces for Food and Agriculture. Food and Agricultural Organization. Rome. pp. 511.

GOUDEGNON, A.E., KIRK, A.A., SCHIFFERS, B. & BORDAT, D. 2000. Comparative effects of deltamethrin and neem kernel solution treatments on diamond back moth and *Cotesia plutellae* (Hym., Braconidae) parasitoid populations in the *Cotonou peri*-urban area in Benin. *J. Appl. Entomol.* **124**, 141–144.

HAQUE, N.M., RABBI, M., KARIM, M.F., HAQ A.N. & CHOWDHURY, M.A. 2002. Resistance and resurgence studies of neem oil 50% EC against rice brown planthopper, *Nilaparvata lugens* (Stal.). *Pak. J. Biol. Sci.* **5**(8), 858 – 861.

ISLAM, Z., RAHMAN, M.A., BARRISON, A.T., POLASZEK, A., CHANCELLOR, T., HEONG, K.L., AHMED, N., HAQ, M. & KAMAL, N.Q. 2003. Diversity of arthropods in irrigated rice in Bangladesh. *Bangladesh J. Entomol.* **13**(2), 1-25.

MAHMUD, M.K., KHAN, M.M.H., HUSSAIN, M., ALAM, M.I. & AFRAD, M.S.I. 2002. Toxic effect of different plant oils on pulse beetle, *C. chinensis* L. (Coleoptera: Bruchidae). *J. Asiat. Soc. Bangladesh.* **28**(1), 11-18.

MISHRA, H.P. 2006. Chemical management of the white backed plant hopper, *Sogatella furcifera* Horvath infesting rice. *Indian J. Entomol*. **68**(4), 338-340.

MITCHELL, P., GUPTA, R.K., SINGH, A.K.K. & KUMAR, P. 2004. Behavioral and developmental effects of neem extracts on *Clavigralla scutellaris*

(Hemiptera: Heteroptera: Coreidae) and its egg parasitoid, *Gryon fulviventre* (Hymenoptera: Scelionidae). *J. Econ. Entomol.* **97**, 916–923.

MOLLAH, M. L. R., HOSSAIN, M.A., SAMAD, M.A. & KHATUN, M.F. 2011. Settling and feeding responses of brown plant hopper to five rice cultivars. *Int. J. Sustain. Crop Prod.* **6**(1), 10-13.

NEUMANN, R. H. 2003. Capsicum based pesticide and method of use. U.S. Patent No. 6523298.

OU, S. M. 1985. Rice diseases. Second Edition. Commonwealth Agriculture Bureau, Commonwealth Mycological Institute, UK. pp. 360.

PANHWAR, S. B. 2002. Farmers adoption of plant materials for insects control. International Service for National Agricultural Research, Haque, Netherland. **4**, 61-68.

SENTHIL-NATHAN, S., CHOI, M.Y., PAIK, C.H., SEO, H.Y., KIM, J.D. & KANG, S.M. 2007. The toxic effects of neem extract and azadirachtin on the brown planthopper, *Nilaparvata lugens* (Stal) (BPH) (Homoptera:Delphacidae). *Chemosphere.* **67**, 80–88

SOGAWA, K. 1982. The rice brown planthopper: feeding physiology and host plant interactions. *Annu. Rev. Entomol.* **27**, 49-73.

STOLL, G. 1998. Natural Crop protection in the Tropics. AGRECOL. Margraf Publishers, Switzerland, pp. 188.

TANAKA, K., ENDO, S. & KAZANO, H. 2000. Toxicity of insecticides to predators of rice planthoppers: spiders, the mirid bug and the dryinid wasp. *Appl. Entomol. Zool.* **35**, 177–187.

TOMITA M. & ENDO, H. 2007. Using capsaicin as a less toxic insecticide. *International Plant Propagators' Society, combined proceedings* **57**, 728-734.

XU Q., BARRIOS, C.A., CUTRIGHT, T. & NEWBY, B.Z. 2005. Evaluation of toxicity of capsaicin and zosteric acid and their potential application as antifoulants. *Environ. Toxicol*. **20**(5), 467–474.