Journal of Science and Technology 17 (June 2019): 32-44

BIOACTIVITIES OF FOUR BOTANICAL EXTRACTS AGAINST RICE WEEVIL, *Sitophilus oryzae* L. (CURCULIONIDAE: COLEOPTERA)

M.M. Jahan, M.A.A. Bachchu*, M.H. Rahman, R. Ara and M.M. Al Helal

Department of Entomology, Hajee Mohammad Danesh Science and Technology University, Dinajpur 5200, Bangladesh

ABSTRACT

The study was conducted to evaluate the efficacy of four indigenous plant extracts, namely, custard apple (*Annona reticulata*), neem (*Azadirachta indica*), thorn apple (*Datura stramonium*) and tobacco (*Nicotiana tabacum*) in methanol solvent for the toxicity and repellent effects against the rice weevil, *Sitophilus oryzae* L. in the laboratory conditions (28 ± 2°C and 75 ± 5% RH).Five concentrations (7.07, 3.53, 1.76, 0.88, 0.44 mg/cm^2) of the plant extracts along with control were applied for the toxicity. The result of the present study indicated that all the plant extracts had toxic and repellent effects against rice weevil in storage. The highest toxicity (mortality, 45.76%) was found in neem plant extract whereas tobacco showed the lowest toxicity effect (31.28%mortality) among all the plant extracts. The order of the toxicity of the plant extracts were found as neem >thorn apple> custard apple > tobacco. Mortality percentages were directly proportional to different concentrations and hours after treatments. The LD_{50} values (14.12, 0.36 and 0.13 mg/cm^2 at 24, 48 and 72 HATs) of neem plant extract proved that the highest toxicity against rice weevil. Neem plant extract also showed the highest repellent effect (57.67%) while tobacco extract the lowest (37.67%) effects. It was found that custard apple, thorn apple and neem plant extracts were in the same repellent class i.e. class III but tobacco extracts in class II. Considering the toxicity and repellent effects, neem leaves extract may be used against rice weevil in storage for sustainable grain protection.

Keywords: Botanical extracts, mortality, repellency, *Sitophilus oryzae*

INTRODUCTION

The preserved grains, seeds and their products in stores are damaged by a number of insect pests worldwide. It has been stated that about 15%-20% of the world agricultural production is ruined every year due to insect infestation and the infestation of pests creates a serious problem in grain stocking with its derived industry also (Perez *et al.* 2004).

**Corresponding author:* Professor Dr. Md. Adnan Al Bachchu, Department of Entomology, Faculty of Agriculture, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh, Email:

The principal pests that cause damage are the adult and larval stages of the beetles while larval stage of the moths. Among the stored product pests, rice weevil (*Sitophilus oryzae* L.) is one of the major pests in the world which caused high damage to store cereals grains. Females of rice weevil lay eggs into grain and after hatching, the larvae bore into the grain (Benhalima *et al.* 2004). Feeding by both the larvae and adults can loss nearly 75% grain weight and reduces nutritional as well as aesthetic value of the grain (Bello *et al.* 2001). To reduce the loss of stored grains due to rice weevil and other stored product pests, a good number of devices, principles, practices and control measures are taken by the people of many developing countries of the world. Many researchers suggested using chemical insecticide for the weevil control in storage but creates several serious drawbacks (Khanam *et al.* 1990, Srivastava and Singh 2002). Fumigation with toxic gases for stored grains is also effective for controlling against rice weevil, but not applicable at the farm level because the storage may not be always airtight. To overcome these problems, researchers are trying to adopt alternatives to chemicals for controlling of storage pests.

Plant based pesticides can be effective and safe which are locally available, cheap, easily processible and eco-friendly. Now–a-day, this is becoming a worldwide interest in the advancement of alternative strategies to find out the new types of insecticides that are using as an age-old traditional botanical pest control agents (Heyde *et al.* 1983). Many plant extracts contain various types of bioactive ingredients which are toxic to stored product insects including *Sitophilus oryzae.* However, there are many research work done on the evaluation of different indigenous plant extracts against stored product pests (Pandey and Brave 2011, Ali *et al.* 2012, Arya and Tiwari, 2013, Bachchu *et al.* 2013, Ghani *et al.* 2014). Therefore, an investigation was undertaken to determine the toxicity, repellency and residual effect of custard apple, neem, thorn apple and tobacco leaf extracts against *Sitophilus oryzae.*

MATERIALS AND METHODS

Collection of botanicals and extracts preparation: The fresh plant leaves of custard apple (*Annona reticulata*), thorn apple (*Datura stramonium),* neem (*Azadirachta indica)* and tobacco *(Nicotiana tabacum)* were collected from the HSTU campus and surrounding area. They were kept in the laboratory for 7 days of air drying followed by one day sun drying before making powder. They were powdered separately by an electric grinder in the laboratory and passed through a 60-mesh sieve. Hundred gram of every plant powders were taken separately in a 500 ml conical flask and mixed with 300 ml of methanol solvent. Then the mixture was stirred for 30 minutes and then allowed to shake in the shaker machine for 24 hours. The mixture was then filtered through a filter paper (Whatman no. 1) and allowed to evaporate the solvents in the vacuum rotary evaporator (Lab Tech EV311H Rotary Evaporator, Manufactured in China) for obtained crude extract. The crude extracts were then preserved in tightly corked vials and stored in a refrigerator (4°C) for future experimental

use.

Mass culture of tested insect: Adult of *Sitophilus oryzae* were collected from naturally infested wheat grains of the local market of Dinajpur town. The adult weevils were mass cultured in separate glass jar (500 ml) with the food medium under ambient laboratory conditions (28 ± 2°C and 75 ± 5% RH). Two hundred weevils were released in each glass jar containing 500 gm of wheat seeds. Then the jars were covered with a piece of white muslin cloth tightly fixed with the help of rubber bands to avoid possible escape of the weevils. The jar were left undisturbed for a maximum period of 7 days for oviposition. After oviposition, the weevils were carefully separated from the seeds by sieving and seeds along with eggs were left in the jar for emergence of adult. After emergence, the newly emerged adults were collected and again released in new seeds allowed in different jars for oviposition to continue and maintained the stock culture. Only 1 to 3 days old adult of *S. oryzae* were used for the experimental purposes.

Dose preparation: The crude extracts were weighted in the electronic balance (Mettler Toledo MS-TS Analytical Balances) and dissolved in methanol solvent for making different doses (7.07, 3.53, 1.76, 0.88, 0.44 mg/cm^2) along with control. Prior to conducting study, a pilot experiment was done to obtain the appropriate dose.

Insect bioassays (mortality test): Direct toxicity test of botanical extracts against rice weevil were performed in the laboratory with ambient conditions (28 ± 2°C, and 75 ± 5% RH)following the residual film method (Busvine 1971).One ml liquid of each dose (7.07, 3.53, 1.76, 0.88, 0.44 mg/cm^2) of plant extracts was dropped separately on the Petridishes (60 mm) with the help of micro pipette. Then the plant extracts were covered uniformly to the whole area of the Petri dishes internally and kept open for 15/30 min. to evaporate the solvent. Two days old 10 weevils were released in each Petridish. Control Petri dishes were treated with methanol solvent only. Three replications were made for each concentration of plant extracts including control treatment. The Petridishes were kept without food for mortality tested of plant extracts. Insect mortality was recorded at 24, 48 and 72 hours after treatments (HAT). The percentage of mortality was corrected using by Abbott's formula (Abbott, 1987)

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

Where,*P*= Percentage of corrected mortality

P'= Observed mortality (%)

C= Mortality (%) at control.

Residual toxicity test: Residual toxicity effect of plant extracts was carried out according to the method of Talukder and Howse (1993) with slight modifications. Four plant extracts with 3 different concentrations (7.07, 3.53, 1.76 mg/cm^2) were mixed with 20 gram wheat grains separately (1ml / 20 gm wheat) into the plastic pot and air dried for 10 minutes. Five pairs

of seven days old weevils were released into the plastic pot containing plant extracts treated wheat grain and were covered with its lid. Three replications were maintained for each treatment of the individual plant extracts along with control. All treated pots were kept at ambient room conditions (28±2^{o}C) in the laboratory for oviposition. After 7 days, dead and alive beetles were removed from each pot and kept the pots undisturbed in the laboratory for the emergence of adult weevil.Data were recorded on adults emerged after 28, 35 and 42 days in each respectively. Percent inhibition (% IR) was calculated by the following formula:

% IR= Cn-Tn/Cn x 100

Where,

% IR = Percent inhibition

Cn= Number of insect on control treatment

Tn = Number of insect on treated treatment

Repellent test: The repellent activities of plant extracts were evaluated using the filter paper impregnation method (Talukder and Howse, 1994). For this, the filter paper (Whatman no. 1) wascut into two half, and 1 ml solution of each three concentrations were applied to one half uniformly with the help of micropipette. The treated and control papers were then air dried for 20 minutes to evaporate the solvent. The treated half of the paper was attached with the untreated half one in the way that attachment did not interfere with the free movement of weevils from one half to another. The treated and control paper were placed in a glass Petri dish (90 mm) and 5 pair of 5-days old weevils were released at the centre of the filter paper. The Petridish was covered with its lid and kept in undisturbed in the laboratory. Each treatment was replicated thrice and the number of insects on each portion of filter paper was counted at hourly intervals upto the 5th hour with control treatment. The data was expressed as percentage of repulsion (PR) using the following formula: PR= (Nc-50) x 2 where, Nc = % of insects present in the control half. Positive values were expressed repellency while negative attractancy. The average values were categorized as class 0: repellency 0 > 0.01 to 0.1%, class I: repellency 0.1 to 20.0%, class II: repellency 20.1 to 40.0%, class III: repellency 40.1 to 60.0%, class IV: repellency 60.1 to 80.0% and class V: repellency 80.1 to 100.0% (McDonald *et al.* 1970)

Statistical analysis: The data were statistically analyzed by MSTAT computer program. The significance of the mean differences was tested by DMRT. The observed mortality was also subjected to probit analysis. All the graphical works were done by the Microsoft excel program.

RESULTS AND DISCUSSION

Direct Toxicity effects: Toxicity effect of different plant extracts, doses and their interaction differed significantly (P<0.05) among the treatments at different time intervals (HAT) against the rice weevil(Table 1). The average mortality of rice weevil at 24, 48 and 72 hours after

treatment (HAT) indicated that neem plant extract showed the highest toxic effect (45.76%mortality)whereas tobacco plant extract indicated the lowest toxic effect (31.28%mortality) (Table 1). Mortality percentages were increased proportionally with the time intervals. The order of the toxicity effect of four plant extracts against rice weevil were found as neem> thorn apple >custard apple>tobacco. Mortality of rice weevil was also differed significantly among all the doses level at different time interval. The highest average mortality (62.07 %) was found at the maximum dose (7.07 mg/cm^2) of plant extracts but the lowest (33.05 %) was found at the minimum dose (0.44 mg/cm^2). Conversely no mortality of weevils was recorded in untreated control at 24, 48 and 72 HAT. It was also found that the average mortality percentage directly proportional to the level of doses of different plant extracts. The interaction effects of plant, doses and time indicated a significant different among the toxicity of the plant extracts applied against the adult rice weevil. The highest mortality (67.00 %) was recorded in neem plant extracts at the highest dose (7.07 mg/cm^2) whereas tobacco plant extract showed the lowest mortality (22.68 %) at lowest dose (0.44 mg/cm^2), which was statistical different from all other plant extract at different concentrations level. But no adult mortality was recorded at untreated control treatments in the interaction of plant extract doses and time at 24, 48 and 72 HATs.

It was observed that the tested four indigenous plant extracts showed toxicity effect on rice weevil but neem plant extracts showed most effective. These findings agreed with Akunne *et al.* (2014) where they found the lethal effects of *Anarcadium occidentale, Carica papaya* and *Azadirachta indica* leaf powders against *Sitophilus oryzae* on rice grains. The result exposed that the leaf powders of *A. indica* and *A. occidentale* caused the highest mortality at 10g concentration in treated rice grains. The major active constituent of neem is azadirachtin which is well known for its antifeedant, toxic and growth regulating effects on insects (Saxena *et al.* 2004). Azadirachtin is also active against stored grain pests, aphids, caterpillars and mealy bugs (Morgan 2009).

Probit analysis for direct toxic effect: The probit analysis for the estimation of LD_{50} values, chi-square values and their 95% fiducial limits at 24, 48 and 72 HAT for the mortality of rice weevil are presented in Table 2. The LD_{50} values of tested extracts at 24 HAT indicated that tobacco plant extract was the most toxic(15.04 mg/cm^2)followed by neem (14.12 mg/cm^2) and thorn apple plant extract (16.58 mg/cm^2).

But the LD_{50} values indicated that neem plant extract was the most toxic (0.36 mg/cm^2) followed by thorn apple (3.14 mg/cm^2), and tobacco(5.24 mg/cm^2) plant extract at 48 HAT. Among the four indigenous plant extracts, neem plant extract also performed the highest toxicity (0.13 mg/cm^2) as compared the LD_{50} values at 72 HAT. The chi-square values were insignificant at 5 % level of probability of different plant extracts at different HATs and mortality data did not show any heterogeneity.

Table 1. Direct toxicity effect of four plant extracts and their doses against adult *S. oryzae* at different HATs (Interaction of plant extracts and time)

	Used botanicals/doses (mg/cm^2)	Insect mortality (%) in different time intervals			Average
		24 HAT	48 HAT	72 HAT	mortality
Plant effect	Custard apple	9.44 c	31.11c	57.22 b	32.59 c
	Thorn apple	21.67 a	38.33 b	59.13ab	39.71 b
	Tobacco	14.44 b	25.56 d	53.86 b	31.28 c
	Neem	24.44 a	48.95 a	63.88 a	45.76 a
	Control	0.00 d	0.00 e	0.00 c	0.00 d
	LSD	3.35	4.90	6.07	3.877
	CV(%)	28.57	20.32	15.48	15.49
Dose effect	Dose 1 (7.07)	39.17 a	58.89 a	88.17 a	62.07 a
	Dose 2 (3.53)	25.00 b	47.13 b	71.25 b	47.79 b
	Dose 3 (1.76)	20.00 c	42.22 bc	67.40 bc	43.21 b
	Dose 4 (0.88)	13.33 d	36.39 cd	63.98 bc	37.90 c
	Dose 5 (0.44)	7.500 e	31.30 d	60.35 c	33.05 d
	Control	0.00 f	0.00 e	0.00 d	0.00 e
	LSD	4.10	6.003	7.44	4.748
	CV (%)	28.57	20.32	15.48	15.49
Interaction effect of plant extracts and doses	CA Dose 1 (7.07)	26.67 bcd	50.00 bcd	90.00 a	55.56 bcd
	CA Dose 2 (3.53)	13.33 fgh	40.00 de	66.67 cde	40.00 f-i
	CA Dose 3 (1.76)	10.00 ghi	36.67 de	60.00 cde	35.56 hij
	CA Dose 4 (0.88)	6.67 hij	36.67 de	66.67 cde	36.67 g-j
	CA Dose 5 (0.44)	0.00 j	23.33 fg	60.00 cde	27.78 jk
	TA Dose 1 (7.07)	43.33 a	60.00 abc	85.92 ab	63.08 ab
	TA Dose 2 (3.53)	26.67 bcd	46.67 cd	72.22 bcd	48.52 c-f
	TA Dose 3 (1.76)	26.67 bcd	46.67 cd	69.26 bcd	47.53 c-g
	TA Dose 4 (0.88)	20.00 def	36.67 de	65.55 cde	40.74 f-i
	TA Dose 5 (0.44)	13.33 fgh	40.00 de	61.85 cde	38.39 f-i
	Tobacco Dose 1 (7.07)	43.33 a	60.00 abc	84.63 ab	62.65 ab
	Tobacco Dose 2 (3.53)	26.67 bcd	40.00 de	69.72 bcd	45.46 d-h
	Tobacco Dose 3 (1.76)	13.33 fgh	26.67 ef	63.05 cde	34.35 ij
	Tobacco Dose 4 (0.88)	3.33 ij	13.33 g	51.02 e	22.56 k
	Tobacco Dose 5 (0.44)	0.00 j	13.33 g	54.72 de	22.68 k
	Neem Dose 1 (7.07)	43.33 a	65.55 a	92.12 a	67.00 a
	Neem Dose 2 (3.53)	33.33 b	61.85 ab	76.38 abc	57.19 abc
	Neem Dose 3 (1.76)	30.00 bc	58.89 abc	77.31 abc	55.40 bcd
	Neem Dose 4 (0.88)	23.33cde	58.89 abc	72.68 bc	51.63 cde
	Neem Dose 5 (0.44)	16.67 efg	48.52 bcd	64.81 cde	43.33 e-i
	Control	0.00 k	0.00 h	0.00 f	0.00 l
	LSD	4.10	6.003	7.44	4.748
	CV (%)	28.57	20.32	15.48	15.49

HAT= Hour after treatment. Within column values followed by different letter(s) are significantly different by DMRT at 5 % level of probability. CA= Custard apple, TA= Thorn apple

It was observed from the probit results that all the tested plant extracts more or less effective against rice weevil but neem was the most effective. The lowest LD_{50} values of neem plant extract indicated that the highest toxic effects against rice weevil. These results are parallel with the findings of Akunne *et al.* (2014) where they found that the leaf powders of *A. indica* caused the highest mortality at 10g concentration in treated rice grains.

Table 2. Probit analysis of different plant extracts against *S. oryzae* after 24, 48 and 72 HATs

Treatments (botanicals)	Number of insect used	LD_{50} (mg/cm^2)	95 % fiducially limits		χ^2 values with 3 df
			Lower	Upper	
24 HAT					
Custard apple	30	35.52	4.92	256.30	0.47
Thorn apple	30	16.58	2.83	97.15	0.66
Tobacco	30	15.04	4.77	17.12	0.62
Neem	30	14.12	2.35	84.85	0.14
48 HAT					
Custard apple	30	7.95	1.48	42.80	0.57
Thorn apple	30	3.14	1.18	8.35	0.38
Tobacco	30	5.24	2.95	9.32	1.16
Neem	30	0.36	2.51	5.34	0.30
72 HAT					
Custard apple	30	0.27	5.25	1.41	5.02
Thorn apple	30	0.13	1.42	1.67	1.29
Tobacco	30	0.47	0.15	1.46	1.49
Neem	30	0.13	1.54	1.09	0.93

HAT = Hour after treatment. Values were based on five concentrations, three replications of 10 insects each. χ^2= Goodness of fit. The tabulated value of $\chi^2$is 5.99 (d. f = 2 at 5% level)

Probit regression lines

The probit regression lines of four indigenous plant extracts against rice weevil at 24, 48 and 72 HAT are presented in figures 1.The calculated probit regression equation lines for the bioefficacy of different plant extracts against rice weevil at 24 HAT were Y=0.95x+2.53, Y=0.70x+3.44, Y=1.54x+1.93, Y=0.61x+3.67, for custard apple, thorn apple, tobacco and neem plant extracts, respectively. Among the four lines, the regression line for neem plant extract showed the highest probit mortality while tobacco extract showed the lowest probit mortality. Comparing among the four plant extracts at 48 and 72 HAT, neem plant extract also showed the highest probit mortality whereas tobacco plant extract showed the lowest.

The insect mortality rate showed positive correlation with the doses in all treatments. The probit regression lines of four plant extracts showed a clear linear relationship between probit

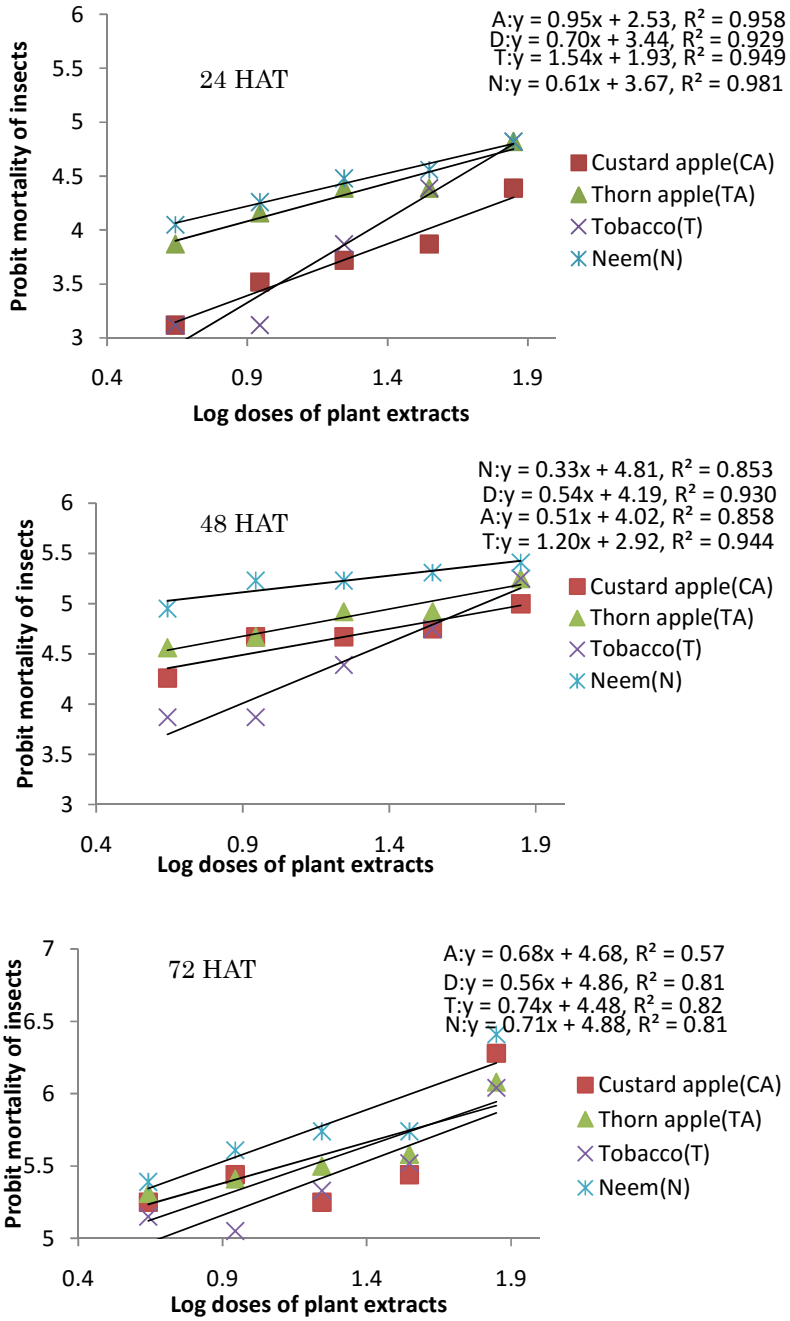

Figure 1. Relationship between probit mortality and log doses of four botanicals against *S. oryzae* at 24, 48 and 72 HATs.

mortality and their log doses. The regression lines become sleeper as doses increased, because the adult insects were treated with more toxins for the same period at higher doses.

Residual toxic effects onrice weevil

The result of residual toxic effects of custard apple, thorn apple, neem and tobacco plant extracts on *S. oryzae* are presented in Table 3.The average adult emergence and the

percentage of infestation inhibition among all the plant extracts in all level of concentrations were statistically significant. The lowest residual effect was found on 1.76 mg/cm^2 dose of custard apple extract (26.10)where as the highest on 7.07 mg/cm^2 dose of neem and tobacco extract (10.80 and 10.80).Considering the interaction of plant extracts, doses and time, neem plant extract possessed the highest residual effect followed by tobacco against rice weevil at maximum dose. The study of residual effect of plant extracts are comparable with the findings of Rajendran *et al.* (2008), who found that neem plant extracts possessed the highest toxicity against rice weevil. The study of residual effect of plant extracts are also closed proximity by the observation of Mamta and Ruchira (2013) on the same pest.

Table 3. Residual toxicity effect of different plant extracts against *S. oryzae*

Treatments (botanicals)	Doses (mg/cm^2)	Adult emergence (DAT)			Mean		Inhibition (%)
		28 DAT	35 DAT	42 DAT			
Custard apple	7.07	5.333 efg	14.67 b	19.67 d	13.20	cd	76.57
	3.53	9.667 de	31.33 b	41.67 b	27.57	b	51.06
	1.76	16.33 b	24.67 b	37.33 bc	26.10	bc	53.67
	Control	28.33 a	62.67 a	78.00 a	56.33	a	-
Thorn apple	7.07	7.667 d-g	15.33 b	17.67 d	13.57	bcd	75.90
	3.53	14.00 bc	18.33 b	24.67 bcd	19.00	bcd	66.27
	1.76	15.33 bc	22.33 b	26.00 bcd	21.23	bcd	62.31
	Control	28.33 a	62.67 a	78.00 a	56.33	a	-
Tobacco	7.07	5.000 fg	9.333 b	15.33 d	10.80	d	82.43
	3.53	11.67 cd	18.00 b	23.00 cd	17.53	bcd	68.87
	1.76	16.33 b	24.00 b	30.33 bcd	23.57	bcd	58.15
	Control	28.33 a	62.67 a	78.00 a	56.33	a	-
Neem	7.07	4.667 g	11.67 b	16.00 d	10.80	d	80.83
	3.53	9.333 def	13.00 b	14.33 d	12.20	cd	78.34
	1.76	15.33 bc	18.00 b	29.33 bcd	20.87	bcd	62.95
	Control	28.33 a	62.67 a	78.00 a	56.33	a	-
LSD		4.003	19.78	15.40	12.19		
CV (%)		15.78	40.37	24.40	26.60		

Repellent effect: The repellency effect of four indigenous plant extracts differed significantly among the treatments against rice weevil (Table 4). Among the four extracts, neem showed the highest repellent effect (57.67 %) followed by custard apple (49.0 %) whereas tobacco showed the lowest mean (37.67 %).On the basis of repellency rate, it was found that custard apple, thorn apple and neem plant extracts were in the same repellency class i.e. class III but tobacco extracts in class II.

Table 4. Repellent effect of different plant extracts against *S. oryzae* at different HATs (Interaction of plant extracts and time)

	Used botanicals / doses (mg/cm^2)	Repellency rate (%)					Mean repell (%)	Repellent classes
		1 HAT	2 HAT	3 HAT	4 HAT	5 HAT		
Plant effect	Custard apple	26.67 b	55.00 a	45.00 b	58.33 a	60.00 a	49.0 ab	III
	Thorn apple	33.33 b	40.00 b	40.00 b	56.67 ab	61.67 a	46.33 bc	III
	Tobacco	23.33 b	36.67 b	40.00 b	41.67 b	46.67 b	37.67 c	II
	Neem	48.33 a	61.67 a	61.67 a	55.00 ab	61.67 a	57.67 a	III
	LSD	14.00	13.15	14.99	14.99	13.15	8.695	-
	CV (%)	51.14	32.71	38.63	34.07	27.50	21.94	-
Dose effect	Dose 1 (7.07)	56.67 a	65.00 a	63.33 a	70.00 a	81.67 a	67.33 a	IV
	Dose 2 (3.53)	46.67 a	63.33 a	58.33 a	78.33 a	76.67 a	64.67 a	IV
	Dose 3 (1.76)	28.33 b	65.00 a	65.00 a	63.33 a	71.67 a	58.67 a	III
	LSD	14.00	13.15	14.99	14.99	13.15	8.695	-
	CV (%)	51.14	32.71	38.63	34.07	27.50	21.94	-
Interaction effect	CA Dose 1 (7.07)	66.67ab	66.67abc	66.67abc	73.33abc	93.33 a	73.33ab	IV
	CA Dose 2 (3.53)	26.67cde	86.67 a	46.67 bc	93.33 a	66.67ab	64.00abc	IV
	CA Dose 3 (1.76)	13.33de	66.67 abc	66.67 abc	66.67abc	80.00ab	58.67bc	III
	TA Dose 1 (7.07)	73.33a	66.67 abc	60.00 abc	86.67 ab	86.67 a	74.67ab	IV
	TA Dose 2 (3.53)	40.00bcd	40.00c	60.00 abc	66.67abc	86.67 a	58.67 bc	III
	TA Dose 3 (1.76)	20.00 de	53.33bc	40.00c	73.33abc	73.33ab	52.00c	III
	Tobacco Dose 1 (7.07)	26.67cde	46.67 c	40.00c	53.33 bc	66.67ab	46.67c	III
	Tobacco Dose 2 (3.53)	40.00bcd	46.67c	46.67 bc	66.67abc	66.67ab	53.33c	III
	Tobacco Dose 3 (1.76)	26.67cde	53.33bc	73.33abc	46.67 c	53.33 b	50.67c	III
	Neem Dose 1 (7.07)	60.00ab	80.00ab	86.67a	66.67abc	80.00ab	74.67ab	IV
	Neem Dose 2 (3.53)	80.00a	80.00ab	80.00ab	86.67ab	86.67 a	82.67a	V
	Neem Dose 3 (1.76)	53.33abc	86.67a	80.00 ab	66.67abc	80.00ab	73.33ab	IV
	LSD	27.99	26.30	29.98	29.98	26.30	17.39	
	CV (%)	51.14	32.71	38.63	34.07	27.50	21.94	

However, these differences of per cent average repellency were statistically significant ($p< 0.05$). In some cases, repellency rate decreased which depends on with the progress of time. The rate of repellency always differed with the extract type. The highest mean repellency (67.33 %) was found with 7.07% dose extract while the lowest (58.67 %) was found with 1.76% doses of plant extract.

It was clear from the results that the tested four plant extracts would be effective to control rice weevil but neem was the most effective. The results of the present study are agreed by the observation of Isman (2006). In controlling rice weevil, neem plant extract is most active as a feeding deterrent, repellent, growth regulator, oviposition (egg deposition) suppressant, sterilant, or toxin (Isman 2006, Rembold 1989).

CONCLUSION

It is concluded that custard apple, thorn apple, neem and tobacco had direct toxicityand repellent effect against rice weevil. Among the four botanical extracts neem showed the highest toxic and repellent effects against rice weevil. So, neem plant extracts may recommend as botanical insecticides against the the adult of *Sitophilus oryzae*for safe grain protection in storage.

REFERENCES

Abbott WS. 1987. A method of computing the effectiveness of an insecticide. Journal of the American Mosquito Control Association. 3: 302-303.

Akunne CE, Obiefuna OI and Ononye BU. 2014. Lethal effects of *Anarcadium occidentale, Carica papaya* and *Azadirachta indica* leaf powders on *Sitophilus oryzae* in rice grains. Journal of Entomology andZoology Studies. 2(6): 144-146.

Ali A, Ahmad F, Biondi A, Wang Y and Desneux N. 2012. Potential for using *Datura alba* leaf extracts against two major stored grain pests, the khapra beetle *Trogoderma granarium* and the rice weevil *Sitophillus oryzae*. Journal of PestScience. 85(3): 359.

Arya M and Tiwari R.2013. Efficacy of some indigenous bioproducts against rice weevil, *Sitophilus oryzae* on wheat. Indian Journal of Applied Research. 3(6): 2249.

Bachchu MAA, Ghani MO, Hossain MA and Ara R. 2013. Insecticidal and repellent effect of some indigenous plant extracts against rice weevil*, Sitophilus oryzae* (Coleoptera: Curculionidae). Bangladesh Journal of Entomology. 23(2): 97-114.

Bello DG, Padin S, Lopez LC and Fabrizio M. 2001. Laboratory evaluation of Chemical-biological control of the rice weevil (*Sitophilus oryzae*) in stored grain. Journal of Stored Product Research. 37: 77-84.

Benhalima H, Choudhary MQ, Millis KA and Price N. 2004. Phosphine resistance in stored product insect collected from various grain storage facilities. Journal of Stored Product Research. 40: 241-249.

Busvine JR. 1971. A critical review of the techniques for testing insecticides. Commonwealth Agricultural Bureau, London. pp. 345.

GhaniMO, Bachchu MAA, HossainMA and Ara R. 2014. Bioefficacy of some indigenous plant extracts against rice weevil, *Sitophilus oryzae*. Journal of Science and Technology. 12: 26-34.

Heyde JVD, Saxena RC and Schmutterer H. 1983. Neem oil and extracts as potential insecticides for control of Hemipterous, rice pests. *In*: Proceeding of second International Neem Conference, Rauischholzhausem, Germany, pp. 337-390.

Isman MB. 2006. Botanical insecticides, deterrents and repellents in modern agriculture and an increasingly regulated world. Annual Review of Entomology. 51: 45-66.

Khanam LAM, Talukder D, Khan AR and Rahman SM. 1990. Insecticidal properties of Royna, *Aphanamixis polystachya* wall. Against *Tribolium castaneum*. Journal of Asiatic Society of Bangladesh. 16: 71-74.

Mamta A and Ruchira T. 2013. Efficacy of some indigenous bioproducts against rice weevil, *Sitophilus Oryzae*on wheat. Indian Journal of Applied Research. 3(6): 2249.

Mcdonald LL, Guy RH and Speirs RD. 1970. Preliminary evaluation of new candidate materials as toxicants repellents and attractants against stored product insects. Marketing Research ReportNumber 882. Washington.

Morgan ED. 2009. Azadirachtin, a scientific gold mine, Bioorganic and Medicinal Chemistry. 17(12): 4096–4105.

Pandey N and Brave D. 2011. Phytochemical and Pharmacological Review on *Annona squamosa*. International Journal of Research in Pharmaceutical and Biomedical Sciences. 2(4): 1404 – 1412.

Perez MJ, Flinn PWW, Campbell JF, Hagstrum DW and Throne JE. 2004. Detection of stored grain insect infestation in wheat transported in railroad hopper-cars. Journal of Economic Entomology. 7: 1474-1483.

Rajendran S, Sriranjini V and Roy B. 2008. Plant products as fumigants for stored product insect control. Journal of Stored Products Research. 44(2): 126-135.

Rembold H. 1989. Azadirachtins: their structure and mode of action. *In:* insecticides of plant origin, J. T. Arnason, B. J. R. Philogene, and P. Morand, Eds., ACS Symposium series, American Chemical Society, Washington DC, USA, pp. 150–163.

Saxena J, Georg G, Orphae L and Paulin D. 2004. A study on the use of indigenous technological knowledge (ITK) for rice pest management in Assam. Department of Zoology, Gauhati University, Guwahati, India. Insect Environment. 8(1): 94-99.

Shukla R, Srivastava B, Kumar R and Dubey NK. 2007. Potential of some botanical powders in reducing infestation of chickpea by *Callosobruchus chinensis* (Coleoptera: Bruchidae). Journal of Agricultural Technology. 3(1): 11-19.

Srivastava C and Singh D. 2002. Study of phosphine resistence in *Rhyzopertha dominica* and

Callosobruchus maculatus. Indian Journal of Entomology. 64: 377-378.

Talukder FA and Howse PE. 1993. Deterrent and insecticidal effects of extracts of pithraj, *Aphanamixis polystachya* against *Tribolium castaneum*. Journal of Chemistry and Ecology. 19: 2463-2471.

Talukder FA and Howse PE. 1994. Laboratory evaluation of toxic and repellent properties of the pithraj tree, *Aphanamixis polystachya* Wall and Parker against *Sitophilus oryzae*. International Journal of Pest Manag