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BIOEFFICACY OF SOME INDIGENOUS PLANT EXTRACTS AGAINST RICE WEEVIL (*Sitophilus oryzae* L.)

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ABSTRACT

An investigation was carried out to study the bioefficacy of five indigenous plant extracts against rice weevil, *Sitophilus oryzae* L. in the laboratory condition (temp. 28±3ºC and R.H. 70-75%). The petrolium ether extracts of seed of Bullock's heart (*Annona reticulata*) and Castor (*Ricinus communis*), leaf of Oleander (*Nerium olender*), Marigold (*Tagetes erecta*) and Chinese chaste tree (*Vitex negundo* L.) at 0.5, 1.0 and 1.5 % concentration were evaluated for their repellent, direct toxic and residual effects against *S. oryzae* L. The results showed that extracts of all tested plants had different toxic, residual and repellent effects on *S. oryzae*. In the toxicity test among the tested plant extracts, Bullock's heart seed extract showed the highest toxic effect (mortality, 61.67 %) and lowest number of F_1 adult emergence whereas castor seed extract showed the lowest toxic effect (21.66 %) and highest number of F_1 adult emergence. Mortality percentages of all the plant extracts were directly proportional to the level of concentration and hours after treatment. Bullock's heart seed extract also showed the highest repellency (82.20%) while concentration was (1.5%). Residual effect of Bullock's heart seed extract was higher than that of all other plant extracts. Considering the different level of concentration the bioefficacy of tested extracts, the gradual order of toxicity was found as Bullock's heart › Oleander › Marigold › Chinese chaste tree › Castor.

Key words: Bioefficacy, mortality, plant extracts, petrolium ether, rice weevil

INTRODUCTION

Bangladesh is an agro-based country and almost 90% of the population depends on rice as their major food (DAE 2011). The people of Bangladesh store rice, wheat, maize, different kinds of pulses and oil seed both for the seed and food purposes. Millions of tons of food grains are either damaged or lost for lack of proper knowledge of storage methods. Losses due to insect infestation are the most serious problem in grain storage, particularly in village and towns of developing countries. Stored product insect caused post harvest losses up to 9% in developed countries to 20% over more in developing countries every year (Phillips and Throne 2010).

More than 600 species of Coleopteran pests attack stored products which cause quantitative and qualitative losses (Sarker *et al.* 2006, Rajendran and Sriranjini 2008). The estimated damage caused by these pests measured about 5 to 10 % in temperate zone and 20 to 30 % in tropical zone (Haque *et al.* 2000). Among the Coleopteran pests, Rice weevil (*Sitophilus oryzae* L.) has been reported as one of the severe pests of cereal grains and their products (Baloch 1992). Both the adult and larva (grub) feed voraciously on a variety of stored cereal grains and causing serious losses, particularly in the monsoon (Lee *et al.* 2001). Although rice weevil causes substantial losses to stored grain in Bangladesh but the information of loss estimates are scanty.

Currently different kinds of preventive and curative control measures are practiced to get protection from this pest. Various synthetic insecticides like the fumigants, methyl bromide and phosphine have been used to control this pest for a long time, but have serious drawbacks (Sharaby 1988) such as direct toxicity to beneficial insects, fishes and human health hazard (Bhaduri *et al.* 1989) and increased environmental pollution and social costs (Negahban *et al.* 2006 and Cosimi *et al.* 2009). Moreover, *Sitophilus oryzae* has been reported to develop resistance to synthetic insecticide (Benhalima *et al.* 2004). Therefore, the development of safer alternatives to conventional synthetic insecticides and fumigants is highly desirable.

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In recent years, many scientists have focused on the search for natural products derived from indigenous terrestrial plants as natural insecticides. These plants are known to contain a rich source of bioactive metabolites which show antifeedant, repellent and toxic effects in a wide range of insects (Ukeh *et al*. 2009). About 2000 plants have been reported to possess pest control properties (Ahmed *et al*. 1984). The utilization of botanical insecticides against stored grains pest control demonstrates to be very promising, mainly due to the possibility of controlling environmental conditions inside the stores units, maximizing the insecticidal effect. Many research reports have documented the potential of several plant-based products as candidate bio-pesticides (Pavela 2007). So far, the present study evaluated the toxicity potentialities and repellency effect of some native plant extracts against *S. oryzae.*

MATERIALS AND METHODS

Study on bioefficacy of five indigenous plant extracts namely, Oleander (*Nerium olender*), Marigold (*Tagetes erecta*), Chinese chaste tree (*Vitex negundo* L.), Bullock's heart (*Annona squamosa*), and Castor (*Ricinus communis*) against Rice weevil, *Sitophilus oryzae* (L.) was conducted in the laboratory of the Department of Entomology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from March 2012 to October 2012.

Preparation of plant extracts

The fresh leaves and seeds were collected from the HSTU campus and neighboring areas. After collection, they were kept in the laboratory for 7 days for the purpose of air drying followed by one day sun drying before making powder. After dried they were made powder separately by an electric grinder. For making extracts, 100 g of different plant powders were dissolved in 300 ml of petroleum 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. Finally, hard different coloured extracts were obtained. The extracts were preserved in tightly corked vials and stored in a refrigerator for experimental use.

Collection of wheat grains

Wheat grains were used as test materials. Healthy wheat grains *Triticum aestivum* L. were purchased from the local market of Dinajpur town. The grains were thoroughly cleaned, sun dried and cooled at 8-10% moisture level. Before setting up the experiment, the wheat grains were stored at room temperature in big air tight plastic bags for further use.

Mass rearing of rice weevil

Rice weevil **(***Sitophilus oryzae* L.) adults were collected from naturally infested wheat grains from the local market of Dinajpur and was mass reared in the laboratory at ambient room temperature (28±3ºC) in glass jars (47 cm height×4 cm dia). Approximately 200 adults of the collected Rice weevils were released in each glass jar containing 500 g of wheat seeds and the mouth was closed with nylon organza. After oviposition, the beetles were separated from the seeds by sieving and seeds along with eggs were left in the container for emergence of next generation. After emergence, the newly emerged adults were collected and again allowed for oviposition with new seeds in different containers to maintain a stock culture of the test insect. The stock culture of the test insect was maintained throughout the study period. Only 1 to 7 days old adult beetles were used for the subsequent experiments.

Evaluation of toxicity of different plant extracts

Toxicity test were conducted according to the Film residue method describe by Busvine (1971) with minor modifications. The extracted materials were weighed and dissolved in petroleum solvent for making different concentration (1.5%, 1.0%, and 0.5% along with control). Pilot experiments were done to obtain the appropriate dose. Then 1 ml liquid of each concentration was dropped separately on petridishes (90 mm) with the help of pipette, covering uniformly the whole area of the petridish. The petridishes were then kept in air for drying for a few minutes. When the solvent was fully evaporated, 10 adults (2-4 days old) were released in each petridish. Three replications were made for each concentration. Equal number of insect with petrolium solvent only was treated as control. Insect mortality was recorded at 24, 48 and 72 hours after treatment (HAT). The percentage of mortality was corrected using by Abbott's (1987) formula before analysis.

Determination of residual effect

For the residual effect of plant extracts against insect mortality, the extracts were mixed with wheat grains separately (1 mL/50 g seed) followed by air dried for 10 minutes. 10 adults (2-4 days old) were released into the bottle containing plant extracts treated wheat grain and bottle was covered with perforated lid. Three replications were maintained for each of the concentration of the individual plant extracts. Only petroleum solvent treated same amount of grain and equal number of insect released were treated as control. All treated and untreated bottles were kept at ambient room temperature (28±3ºC) in the laboratory for oviposition and development of *S. oryzae.* After 7 days, dead and alive beetles were removed from each container and the efficacy of plant extracts as protectant against *S. oryzae* was assessed. For the determination of oviposition, 100 seeds were collected randomly from each bottle of each treatment and examined under magnifying glass (10x). The total number of eggs deposited, number of hole and number of F_1 adult emerged per 100 seeds were counted up to 35 days.

Detection of repellency

The repellent activities were evaluated according to the method described by Talukder and Howse (1994) with minor modifications. First of all, Petridishes (90 mm dia.) were divided into two parts: treated and untreated. With the help of pipette, 1ml solution of each doses of plant extracts was applied to one half (10 g) of the wheat grain then air dried. Ten adults were released at the centre of the petridish and a cover was placed on the petridish. Each treatment was replicated thrice and the number of insects on each portion was counted at hourly intervals upto the 6^{th} hour. 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 expressed repellency and negative values attractancy. The average values were categorized according to the following scale (McDonald *et al*. 1970) (Table 1)

Table 1. Relationship between repellency classes for the repellency test

Class		Class	Repellency (%)
0	0 > 0.01 to 0.1	III	40.1 to 60
I	0.1 to 20	IV	60.1 to 80
II	20.1 to 40	V	80.1 to 100

Statistical analysis

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

RESULTS AND DISCUSSION

Direct toxicity effects

Mortality of rice weevil was differed statistically among all the plant extracts and the concentration level at different time interval. Average Mortality percentage at 24, 48 and 72 hours after treatment (HAT) indicated that Bullock heart seed extract possessed the highest (mortality, 61.67%) toxic effect and Castor seed extract possessed the lowest (mortality, 24.73%) toxic effect (Table 2). Mortality percentages were directly proportional to the time after treatment. The orders of the toxicity of five plant extracts were: Bullock's heart > Oleander > Marigold > Chinese chaste tree >Castor. The highest mortality (79.11%) was observed at the maximum concentration (1.5%) of plant extracts and it was also found that the mortality percentage directly proportional to the level of concentration of different plant extracts (Table 3). The interaction effects of plant extracts, dose and time also indicated that the percent mortality was found in Bullock's heart plant extracts at utmost dose (1.5%) which is statistically different from all other plant extracts of different concentration levels (df-12, F-5.064, P- 0.00001) (Table 4). From the above finding, it was observed that the tested five plant extracts possessed toxicity effect on rice weevil but Bullock's heart can be most effective against rice weevil and castor plant extracts can be less effective. The seeds of *A. squamosa* were reported to have insecticidal and abortifacient properties (Babu *et al.* 1998). The mortality per cent recorded by Ali *et al*. (1981) also supports the present findings.

Probit analysis for direct toxic effect

The results of the probit analysis for the estimation of LC_{50} values and their 95 % fiducial limits at different HAT for the mortality are presented in Table 5. The LC_{50} values at 24 HAT indicated that Bullock's heart (0.45 mg) was the most toxic followed by Oleander (0.50 mg) while Castor (2.16 mg) was the least toxic. Bullock's heart was also maintained its highest toxicity when the LC_{50} values were compared at 48 HAT (0.41 mg) and 72 HAT (0.36 mg). Similar trend of results was showed at 48 HAT and 72 HAT in all other plant extracts. The chi-square values of different plant extracts at different HAT were insignificant at 5% level of probability and did not show any heterogenity of the mortality data. From the probit results it is clear that all the tested plants would be more or less effective for controlling rice weevil but Bullock's heart and Oleander will be the most effective.

Probit regression lines

The probit regression lines of five tested plant extracts are presented in figures 1-3. The insect mortality rate showed positive correlation with the doses in all treatments.

The calculated regression equation lines at 24 HAT were $Y=4.065x+1.728$, $Y=3.750x+1.341$, $Y=3.0x+1.05$, $Y=2.868x+2.155$, and $Y=2.395x+2.336$ for Bullock's heart, Oleander, Castor, Marigold and Chinese chaste tree extracts, respectively (Figure 1). Among the five regression lines, Bullock's heart seed extract showed the highest probit mortality while Castor seed extract showed the lowest probit mortality. Bullock's heart was also maintained its highest probit mortality when the probit regression lines were compared at 48 HAT and 72 HAT (Figure 2 and 3). The regression lines showed a clear linear relationship between probit mortality and their log doses and the regression lines become sloper as doses increased, because the adult insects were treated with more toxins for the same period at higher doses.

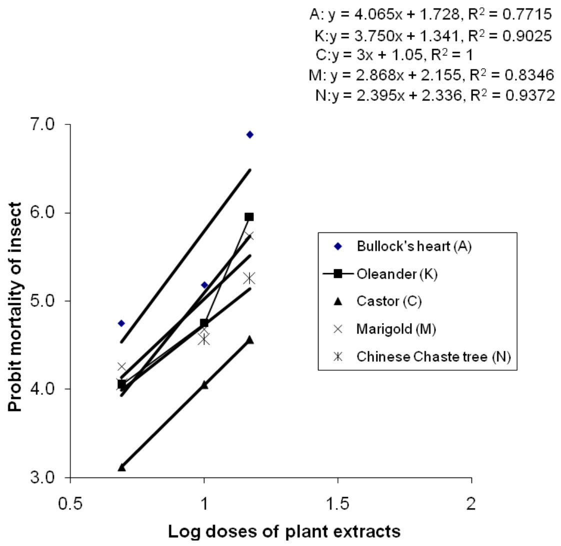

Figure 1. Relationship between probit mortality and log doses of different plant extracts on rice weevil at 24 HAT

Residual toxicity effects

The grain protectant effect of five plant extracts were evaluated and presented in Table 6. The number of eggs, number of holes and the number of F_1 adults were showed significant differences among the plant extracts in all doses and the residual toxicity was directly proportional to the doses. The lowest number of eggs, number of holes and the number of F_1 adult (6.00, 3.33 and 0.67) were found in Bullock's heart followed by Oleander (8.00, 3.67 and 1.33) in highest concentration (1.5%). On the contrary, the highest number of eggs, number of holes and the number of F_1 adult (18.00, 12.00 and 10.67) were found in Castor in highest concentration (1.5%). It was observed that all the tested plant extracts possessed residual toxicity effect on rice weevil. The present study agreed with the previous finding of Mishra *et al*. (1992). They found that wheat grains can be protected from the attack of *S. oryzae* by mixing custard apple seed powder at 5% for 75 days.

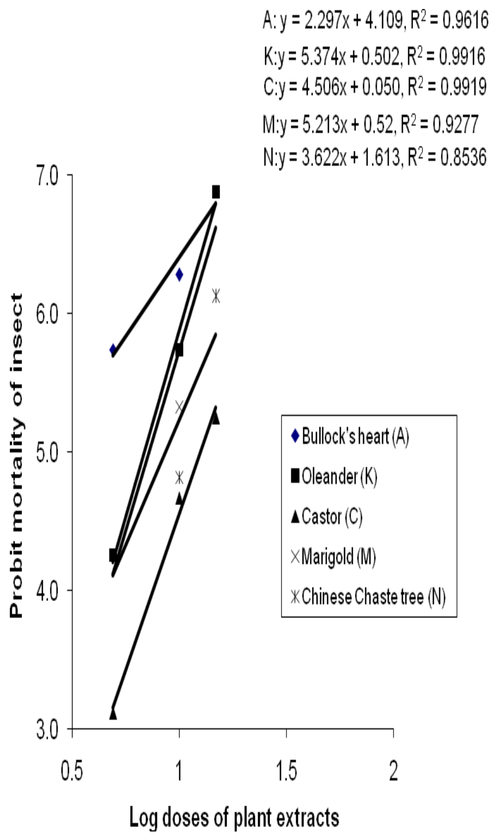

Figure 2. Relationship between probit mortality and log doses of different plant extracts on rice weevil at 48 HAT

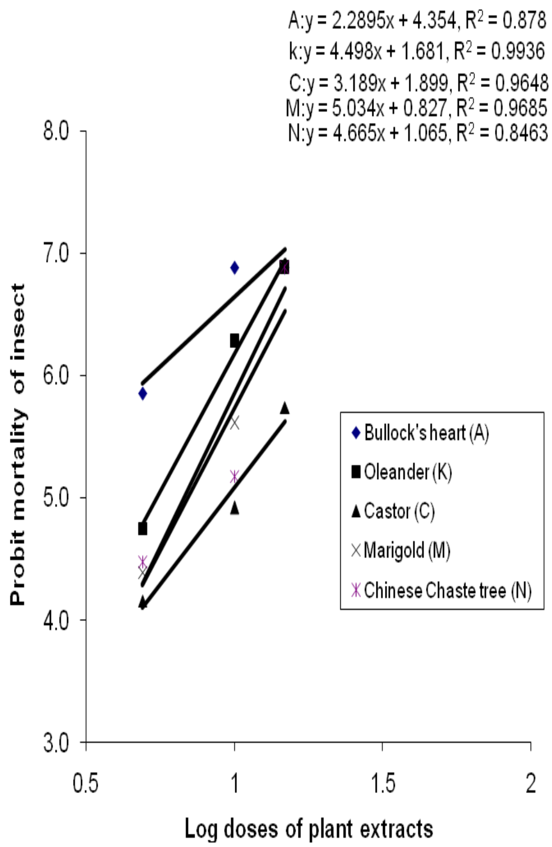

Figure 3. Relationship between probit mortality and log doses of different plant extracts on rice weevil at 72 HAT

Table 2. Direct toxic effect of different plant extracts against Rice weevil at different HAT (Interaction of plant extracts and time)

Name of the plant extracts	Mortality percentage at different time intervals			
	24 HAT	48 HAT	72 HAT	Mean mortality
Bullock's heart	48.33a	66.67a	70.00a	61.67a
Oleander	35.00	50.0b	57.5b	47.50b
Castor	13.3d	25.0d	35.8d	24.73d
Marigold	34.2b	45.8b	50.0c	43.33bc
Chinese chaste tree	27.5c	38.3c	47.5c	37.78c
P- value	0.0001	0.0001	0.0001	0.0001
LSD	6.61	7.48	5.99	5.67
CV (%)	4.29	4.06	3.90	3.98
SE	2.31	2.61	2.09	1.98

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

Table 3. Direct toxic effect of plant extracts of different doses against Rice weevil at different HAT (Interaction of dose and time)

Dose (%)	Mortality percentage at different time intervals			
	24 HAT	48 HAT	72 HAT	Mean mortality
0.0	0.00d	0.0d	0.00d	0.00d
0.5	20.c	30.0c	40.0c	30.00c
1.0	36.67b	62.0b	73.3b	57.35b
1.5	70.0a	88.67a	95.3a	84.65a
P- value	0.0001	0.0001	0.0001	0.0001
LSD	5.91	6.69	5.35	5.07
CV (%)	4.29	4.06	3.90	3.98
SE	2.06	2.34	1.87	1.77

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

Table 4. Direct toxic effect of different plant extracts of different doses on Rice weevil at different HAT (Interaction of plant, dose and time)

Name of the plant extracts	Doses (%)	Percentage of insect mortality at different time intervals			
		24 HAT	48 HAT	72 HAT	Mean mortality
Bullock's heart	0.0	0.00h	0.00g	0.00i	0.00f
	0.5	40.d	76.7bc	80.0bc	65.57c
	1.0	56.7c	90.0ab	100.0a	82.23b
	1.5	96.67a	100.0a	100.0a	98.90a
Oleander	0.0	0.00h	0.00g	0.00i	0.00f
	0.5	16.7fg	23.33f	40.0ef	26.67e
	1.0	40.00d	76.7bc	90.0ab	68.90c
	1.5	83.33b	100.0a	100.0a	94.43a
Castor	0.0	0.00h	0.00g	0.00i	0.00f
	0.5	3.33gh	3.33g	20.00h	8.90f
	1.0	16.67fg	36.67ef	46.67de	33.37de
	1.5	33.33de	60.00d	76.67c	56.63c
Marigold	0.0	0.00h	0.00g	0.00i	0.00f
	0.5	23.33ef	23.33f	26.67gh	24.43e
	1.0	36.7de	63.3cd	73.33c	57.77c
	1.5	76.67b	96.67a	100.0a	91.10ab
Chinese chaste tree	0.0	0.0h	0.0g	0.00i	0.00f
	0.5	16.7fg	23.3f	33.3fg	24.43e
	1.0	33.3de	43.33e	56.67d	44.47d
	1.5	60.00c	86.7ab	100.0a	82.20b
	P- value	0.0001	0.0001	0.0001	0.0001
	LSD	13.24	14.98	11.98	11.36
	CV (%)	4.29	4.06	3.90	3.98
	SE	4.62	5.23	4.18	3.96

HAT= Hour after treatment

Within column values followed by different letter(s) are significantly different by DMRT at 5 % level of probability.

Table 5. Relative toxicity (by probit analysis) of different plant extracts treated against Rice weevil after 24, 48 and 72 HAT

Name of the plant extracts	No. of insect used	LC 50 values (mg)	95 % fiducially limits	γ^2 values
		24 HAT		
Bullock's heart	90	0.67	0.385 – 1.162	6.092045
Oleander	90	0.98	0.821 – 1.161	2.691956
Castor	90	2.12	1.264 – 3.570	0.003238
Marigold	90	1.01	0.808 – 1.270	2.946346
Chinese chaste tree	90	1.31	0.956 – 1.792	0.708652
		48 HAT		
Bullock's heart	90	0.24	0.090 – 0.648	0.276800
Oleander	90	0.70	0.067 – 0.818	0.356201
Castor	90	1.27	1.065 – 1.522	0.368782
Marigold	90	0.75	0.644 – 0.880	2.643044
Chinese chaste tree	90	0.89	0.741 – 1.080	3.424729
		72 HAT		
Bullock's heart	90	0.21	0.068 – 0.646	0.420368
Oleander	90	0.56	0.463 – 0.680	0.233553
Castor	90	0.95	0.781 – 1.164	0.612812
Marigold	90	0.69	0.586 – 0.814	0.651228
Chinese chaste tree	90	0.74	0.501 – 1.088	4.50445

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

Table 6. Residual toxicity of different plant extracts at different concentrations on Rice weevil after grain treatment (interaction effect)

Name of the plant extracts	Doses (%)	No. of eggs / 100 seeds	No. of holes / 100 seeds	No. of F1 adults / 100 seeds
Bullock's heart	0.0	29.33 a	28.67 a	27.00 a
	0.5	11.00 ghi	9.67 ij	2.33 hij
	1.0	7.67 ij	6.67 jk	1.67 hij
	1.5	6.00 f	3.33 l	0.67 j
Oleander	0.0	29.33 a	26.00 abc	23.67 b
	0.5	15.67 ef	7.33 jk	3.67 h
	1.0	12.00 gh	5.33 kl	2.33 hij
	1.5	8.00 ij	3.67 l	1.33 ij
Castor	0.0	28.67 a	27.00 ab	27.00 a
	0.5	24.67 bc	20.33 d	18.67 c
	1.0	21.33 cd	18.33 de	16.00 d
	1.5	18.00 de	12.00 hi	10.67 f
Marigold	0.0	27.67 ab	25.00 bc	25.00 ab
	0.5	18.00 de	15.00 fg	13.00 e
	1.0	14.67 efg	12.67 gh	10.00 f
	1.5	11.67 gh	8.00 jk	3.33 hi
Chinese chaste tree	0.0	27.67 ab	24.00 c	25.00 ab
	0.5	18.00 de	15.67 ef	11.67 ef
	1.0	14.00 fgh	12.33 ghi	7.67 g
	1.5	10.67 hi	9.00 j	3.33 hi
	LSD value	3.341	2.712	1.929
	$S\bar{x}$	1.169	0.948	0.675

Within column values followed by different letter(s) are significantly different by DMRT at 5 % level of probability.

Repellency effect

The repellency effects of plant extracts with different doses are presented in Table 7. The repellency effect of five plant extracts influenced by different doses of plant extracts at different HAT and had significant differences. Among different plant extracts, Bullock's heart showed the highest repellency rate (82.20 %) in maximum concentration (1.5%) level. The repellency class of different plant extracts at different doses varied between II to V. From the above result it was found that Bullock's heart seed extracts showed strong repellent effect against rice weevil than other plant extracts. The plants of *A. squamosa* is reported to contain glycoside, alkaloids, saponins, flavonoids, tannins, carbohydrates, proteins, phenolic compounds, phytosterols, amino acids and about 30 acetogenins are isolated from the seeds of *A. squamosa* Linn. These compounds show remarkable antimicrobial and cytotoxic activities (Rakesh and Mahendra 2009). These findings indicate that such active compounds may play a role in the repellent activity against *S. oryzae*. The present study partially agreed with the previous finding of Quadri (1973) who concluded that custard apple seed extract possess more olfactory repellency against normal susceptible strain of *S. oryzae* and *T. castaeum.*

Table 7. Repellent effect of different plant extracts at different dose level on Rice weevil using treated wheat grain at different HAT (Interaction of plant extracts, dose and time)

Name of the plant extracts	Repellency rate (%)								
	Dose (%)	1 HAT	2 HAT	3 HAT	4 HAT	5 HAT	6 HAT	% Mean repell.	Repel . lass
Bullock's heart	0.0	0.00f	0.00e	20.00de	0.00c	0.00f	0.00g	3.30h	I
	0.5	33.33abcdef	26.67bcde	20.00de	26.67bc	26.67cdef	26.67defg	26.67efg	II
	1.0	53.33abcd	26.67bcde	33.33cde	20.00c	33.33bcdef	13.33fg	30.03def	II
	1.5	66.67ab	53.33ab	100.0a	93.33a	86.67a	93.33a	82.20a	V
Oleander	0.0	20.00cdef	0.00e	0.00e	20.00c	0.00f	0.00g	6.700gh	I
	0.5	13.33def	20.00bcde	13.33de	33.33bc	20.00def	33.33cdefg	22.23efgh	II
	1.0	20.00cdef	6.66de	20.00de	6.66c	40.00bcde	66.67abcd	26.67efg	II
	1.5	46.67abcde	13.33cde	20.00de	33.33bc	20.00def	73.33abc	34.43def	II
Castor	0.0	0.00f	20.00bcde	20.00de	0.00c	0.00f	0.00g	6.70gh	I
	0.5	26.67bcdef	40.00abcd	40.00bcde	26.67bc	53.33abcd	66.67abcd	42.20cde	III
	1.0	60.00abc	40.00abcd	46.67bcd	73.33ab	80.00a	80.00ab	63.33b	IV
	1.5	53.33abcd	26.67bcde	13.33de	46.67bc	20.00def	33.3cdefg	32.23def	II
Marigold	0.0	0.00f	0.00e	80.00ab	0.00c	0.00f	20.00efg	16.70fgh	I
	0.5	46.67abcde	66.67a	46.67bcd	46.67bc	66.67ab	33.3cdefg	51.13bcd	III
	1.0	73.33a	33.3abcde	40.00bcde	40.00bc	13.33ef	60.0abcde	43.33cde	III
	1.5	33.3abcdef	60.00a	33.33cde	33.33bc	40.00bcde	40.bcdefg	40.00cde	II
Chinese chaste tree	0.0	0.00f	0.00e	0.00e	40.00bc	0.00f	0.00g	6.70gh	I
	0.5	26.67bcdef	66.67a	73.33abc	46.67bc	60.00abc	66.67abcd	56.67bc	III
	1.0	6.66ef	60.00a	46.67bcd	40.00bc	13.33ef	20.00efg	31.13def	II
	1.5	40.0abcdef	46.67abc	26.67de	26.67bc	60.00abc	53.3abcdef	42.20cde	III
P- value		0.0867	0.0439	0.0002	0.0071	0.0002	0.0021	0.0001	
LSD		36.33	28.70	36.95	39.76	33.25	38.76	18.19	
CV (%)		4.91	3.23	4.48	3.63	3.52	3.12	2.11	
SE		12.69	10.02	12.91	13.89	11.61	13.54	6.35	

HAT= Hour after treatment, Mean followed by the same letter(s) did not differ significantly at 5% level and ns indicate no significant by DMRT.

CONCLUSION

It has been observed that the tested all five plant extracts had repellent, direct and residual toxic effects on rice weevil, *S. oryzae*. Among the tested plant extracts, Bullock's heart seed extracts showed the most toxic, repellent and residual effects whereas Castor seed extract showed least effective against rice weevil. Therefore, the findings of the present study might be very useful to screen out effective botanical materials/extracts in controlling storage pest successfully.

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