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Antifeedant Effect of Plant Extracts for Management of Rice Weevil, *Sitophilous oryzae* L.

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Abstract: Rice weevil (*Sitophilus oryzae* L.) is one of the major pest of stored connodities. In this study the extracts from n-Hexane, dichloromethane (DCM) and methanol leaf and seed/fruit of Karanja, *Pongamia pinnata* (L.); Mahogany, *Swietenia mahogani* Jacq.; Neem, *Azadirachta indica* A. Juss and Urmoi, *Sapium indicum* Willd. at 2.0, 4.0, 6.0, 8.0 and 10.0% (w/v) concentrations were evaluated for their antifeedant effect against rice weevil, *Sitophilus oryzae*. The experiment was conducted with Completely Randomized Design with three replications at the Entomology Division, Bangladesh Institute of Nuclear Agriculture (BINA). All the extracts had moderate inhibitory effects on the feeding activities of rice weevil. Among the four plant extracts tested, urmoi possessed the highest feeding deterrent effect (126.52) whereas neem possessed the least deterrent effect (89.20). Mahogany and urmoi had the same and high level of efficacy (+++), whereas karanja and neem had same but low level of efficacy (++). The fruit extract had the highest total feeding deterrent effect (110.44) and the leaf extract had the least total feeding deterrent effect (98.68). The results showed that the fruit extracts were better than leaf extracts. Among the three solvents, the highest total coefficient of deterrency was observed in methanol extract (116.83). The coefficient of deterrency increased proportionally with the increase of doses. The results of this study shows that 10% urmoi plant extracts able to protect rice weevil in storage condition for their strong antifeedant effect.

Keywords: Plant leaf extract; Seed extract; Antifeedant effect; Rice weevil.

INTRODUCTION

Rice is grown in most of the countries of the world and also in Bangladesh as a staple food. According to Alam (1971), 5- 8% of the food grains, seeds and different stored products are lost annually due to storage pests and if the losses incurred on farms were included, it would be around 10%. Insect pests cause considerable losses to stored rice, which may affect the food availability of a large number of people, particularly in the developing countries like Bangladesh.

The rice weevil, *Sitophilus oryzae* (Linnaeus) (Coleoptera: Curculionidae), is one of the most widespread and destructive major insect pests of stored product throughout the world (Plague *et al.*, 2010; Khani *et al.*, 2011). Both the adults and larvae feed on different stored cereal grains viz. rice, wheat, maize and sorghum products causing serious losses, particularly in the monsoon. It also causes damage to oats, barley, cotton seed, linseed and cocoa. Bhuiyan *et al.* (1992) reported 11-16% weight loss of husked rice during 4 months of storage in the laboratory. Such damage may reach up to 40%, in countries where modern storage technologies have not been introduced (Shaaya *et al.*, 1997).

Now-a-days different kinds of preventive and curative control measures are practised (such as phostoxin pellet, methyl bromide, phosphine etc.) to manage this pest. Among the practices, chemical control measures have been used for a long time which has got many limitations and undesirable side effects like development of pesticide resistance in pests, pest resurgence, and lethal effects on non target organisms, health hazards, ecological imbalance, and toxic residue in food, feed and environment (Benhalima *et al.,* 2004; Negahban *et al.,* 2006).

The poor storage facilities of the farmers in developing countries, which are unsuitable for effective conventional chemical control (Tapondjou *et al.*, 2002), emphasize the necessity of new and effective methods for insect pest control of stored products. Thus, there is an urgent need to develop safe alternatives to conventional insecticides and fumigants for the protection of grain products against insect infestations.

There are increasing efforts to understand indigenous pest control strategies, with a view to reviving and modernizing their use (Shaaya *et al.*, 1997; Belmain *et al.*, 2001). Higher plants are a rich source of novel insecticides. Plant materials with insecticidal properties have been used traditionally for generations throughout the world (Belmain *et al.*, 2001). Botanical insecticides compared to synthetic ones may be safer for the environment and human beings, are generally less expensive, safe to apply, easily processed and used by farmers and small industries (Belmain *et al.*, 2001; Talukder, 2006; Isman, 2006). Since these insecticides are often active against a limited number of species and biodegradable to nontoxic products and are potentially suitable for use in integrated pest management, they could lead to the development of new classes of safer insect control agents (Kim *et al.*, 2003).

Neem, *Azadirachta indica* from Meliaceae family, is the most important source of botanical insecticide presently in use throughout the world. However, many other indigenous plant species have the potential to be used as botanical insecticide or as a source of bioactive compounds (Talukder, 2006).

Therefore, the present research work was conducted with four indigenous plants to evaluate their antifeedant effect to serve as basis for developing botanical insecticides.

MATERIALS AND METHODS

Collection and rearing of rice weevil

The rice weevil was collected from the stock culture of the Department of Entomology, Bangladesh Agricultural University, Mymensingh. The rice weevil was reared in round plastic jars (12 x 23 x 6.5cm in size) with rice grains (13 to 14% moisture) in growth chamber at 28±5°C temperature and R.H. 75±5% in the Entomology laboratory of BINA.

Photo 1: Rearing of rice weevil

Collection and preparation of plant materials

Fresh leaves and fruits of Karanja, *P. pinnata* (L.); Mahogany, *S. mahogani* Jacq. and Neem, *A. indica* A. Juss were collected from Bangladesh Agricultural University campus, Mymensingh. Leaves and fruits of urmoi, *S. indicum* Willd. were collected from Chalna under the District of Khulna.

Photo 2: Urmoi plant

Photo 3: Urmoi fruits

After collection, all fresh leaves of the test plants were washed with water and kept in the shade up to 15 days for air-drying. Mature seed(s) were collected from fresh fruits of Karanja, Mahogany, Neem and mature fruits were collected from Urmoi. The dried plant materials were then ground separately with electrical grinder and sieving through 60 micron diameter sieve to obtain fine powder. The powder were preserved into plastic pot at low temperature (4˚C) till their use in extract preparation.

Preparation of plant extracts

Previously prepared leaf, seed and fruit powder were used for preparation of plant extract following the method of Tikum *et al.* (2008). The dried plant powders (50 g) were taken into a 400 ml beaker. The powder of leaves, seeds and fruits were extracted with n-hexane, dichloromethane and methanol. The extract was collected after 24 hours, filtered by fine cloth and concentrated by a rotary vacuum evaporator. The residual solvent was removed by high vacuum pump. Each of the extract was stored in a freezer until use.

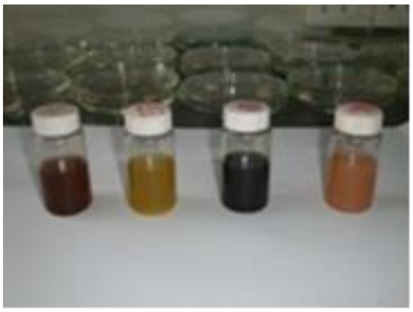

Photo 4: Preparation of stock solution

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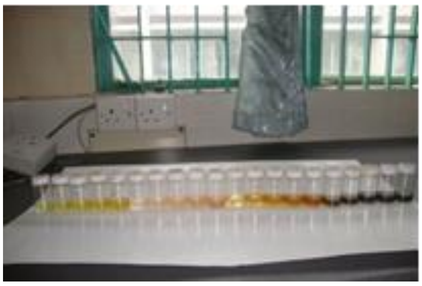

Photo 5: Preparation of different concentrations

Stock solutions (20% w/v) of plant extracts were prepared by diluting the condensed extracts with respective solvent. Different concentrations (2.0, 4.0, 6.0, 8.0 and 10.0% w/v) of each category of plant extracts were prepared by dissolving them in the same solvent prior to insect bioassay.

Bioassay

The experiment was conducted according to the method originally described by Nawrot *et al.* (1986) and later modified by Talukder and Howse (1995). Wheat wafer disks (15 mm diameter) which were made from wheat flour were used as the test food. The disks were saturated by dipping into solvents (control disk "C") or into different concentrations (2.0, 4.0, 6.0, 8.0 and 10.0% w/v) of different extracts (treated disk "T"). Then the disks were air-dried over-night and their individual weight was taken before being offered them to 10 weevils (5 ♂ + 5 ♀) insects (1-2 weeks old) over the next 10 days as the sole food source. Some blank disks (treated with solvent only but not offered to insects) were also prepared. The feeding of insects was recorded under the following three conditions, i.e. (i) on pure food, composed of two untreated disks "CC" (control), (ii) on food with a possibility of choice between one treated "T" and the other untreated "C" disks (choice test), and (iii) on food with two treated "TT" disks (no choice test).

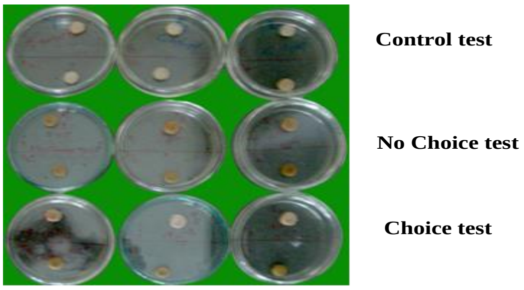

Photo 7: Antifeedant test

After ten days, all the disks were reweighed. The disks were observed to increase in weight because of the absorption of moisture from the surrounding air, which was provided for the normal growth and development of the insects. Therefore, a correction procedure was applied. Disk weight loss, which was the estimate of the amount of food consumed (FC) and was calculated by the following formula given by of Serit *et al.* (1992): FC=IWs-[(FWs X IWb /FWb] where, IW = initial weight of the disk after treatment with extract or solvent, FW = final weight of the wafer disk, b =weight of blank disk (treated with solvent only and no insects were released on this disk) and s = weight of treated or control (treated with solvent only) disks which were given to insects as food.

Therefore, according to the amount of the food consumed by the insects in the control (CC), choice test (CT) and no choice tests (TT), three feeding deterrent activity coefficients were calculated using the following formulae as described by Nawrot *et al.* (1986): (i) absolute coefficient of deterrency (control and no-choice test), A=(CC –TT/CC+TT) X 100, (ii) relative coefficient of deterrency (choice test), R = C-T/C+T) X 100, and (iii) total coefficient of deterrency, T = A + R

The total coefficient values served as an index of antifeedant activity expressed on a scale between 0 and 200 (index values between 200 and <0 might be considered as insect phagostimulants). The index zero (0) designated an inactive compound and 200, a compound with maximum activity. Indices were expressed as 151-200, ++++; 101-150, +++; 51-100, + +; and 0-50, +. All experimental data were analysed by ANOVA

RESULTS

Interaction of plant extracts on feeding deterent effect

The results of antifeedant effects of karanja, mahogany, neem and urmoi plant extracts on rice weevil are given in Tables 1-4 and Figures 1-3. All the extracts had moderate inhibitory effects on the feeding activities of rice weevil.

Among the four plant extracts tested, urmoi had the highest absolute deterrency (63.19) and neem had the lowest effect (42.10). In case of relative deterrency, urmoi also showed the highest effect (63.33) followed by mahogany (58.95). Considering as the total effects, the urmoi possessed the highest feeding deterrent effect (126.52) whereas neem possessed the least deterrent effect (89.20) (Table 1).

Interaction of plant parts extracts on antifeedant effect

The results of antifeedant effects of different plant parts on rice weevil are given in Figure 1.

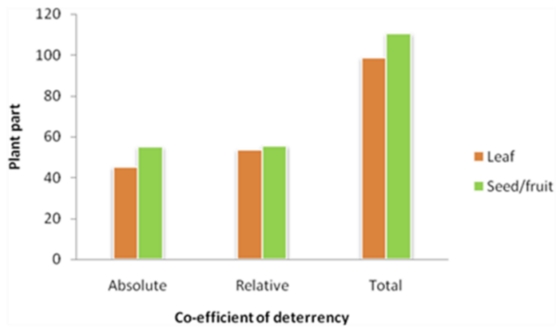

Figure 1. Antifeedant effects of leaf and seed/fruit extracts on rice weevil, *S. oryzae.*

The fruit extract had the highest total feeding deterrent effect (110.44) and the leaf extract had the least total feeding deterrent effect (98.68). The results showed that the fruit

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extracts were better than leaf extracts. The results of the antifeedant interaction effects of different plant and plant parts on rice weevil are given in Table 2.

The urmoi leaf extract had the highest total feeding deterrent effect (127.81) and the neem leaf extract had the least total feeding deterrent effect (85.41). Considering all plants, the results showed that the seed extracts were better than leaf extracts**.** Mahogany seed and urmoi leaf and seed had the same and high level of efficacy (+++), whereas karanja and neem leaf and seed and mahogany leaf had same but low level of efficacy (++).

Among the three solvents, the highest total coefficient of deterrency was observed in methanol extract (116.83) and it was significantly different from n-hexane (91.78) and dichloromethane (105.07) extracts (Figure 2).

Table 1. Antifeedant effect of different plant extracts on rice weevil, *S. oryzae.*

Name of the plant extracts	Co-efficient of deterrency			Efficacy of extracts
	Absolute	Relative	Total	
Karanja	45.37 b	48.63 b	94.00 c	++
Mahogany	49.47 b	58.95 a	108.42 b	+++
Neem	42.10 b	47.20 b	89.20 c	++
Urmoi	63.19 a	63.33 a	126.52 a	+++
$S\bar{x}$	2.2279	1.6558	2.8484	
Probability level	0.01	0.01	0.01	

Within column values followed by different letter(s) are significantly different by DMRT. Indices were expressed as 151-200, ++++; 101-150, +++; 51-100, + +; and 0-50, +.

Table 2. Antifeedant effect of different plant part extracts on rice weevil, *S. oryzae* (Interaction of plant and plant part extracts).

Name of the plant extracts	Name of the plant part	Co-efficient of deterrency values			Efficacy of extracts
		Absolute	Relative	Total	
Karanja	Leaf	40.57 cd	48.83	89.40 b	++
	Seed	50.16 bc	48.43	98.59 b	++
Mahogany	Leaf	37.00 d	55.10	92.10 b	++
	Seed	61.94a b	62.81	124.75 a	+++
Neem	Leaf	37.49 d	47.92	85.41 b	++
	Seed	46.72 cd	46.48	93.20 b	++
Urmoi	Leaf	65.34 a	62.47	127.81 a	+++
	Fruit	61.04 ab	64.19	125.23 a	+++
$S\bar{x}$		3.1507	2.3134	4.0282	
Probability level		0.01	NS	0.01	

Table 3. Antifeedant effect of different plant extracts of different solvents on rice weevil, *S. oryzae* (Interaction of plant extract and solvent).

Name of the plant extracts	Name of the solvents	Co-efficient of deterrency			Efficacy of extracts
		Absolute	Relative	Total	
Karanja	n-Hexane	47.67	48.30 d	95.97 cd	++
	DCM	46.92	45.65 de	92.57 cd	++
	Methanol	41.52	51.95 cd	93.47 cd	++
Mahogany	n-Hexane	47.10	49.91 cd	97.01 cd	++
	DCM	48.61	60.07 bc	108.68 bc	+++
	Methanol	52.70	66.89 ab	119.59 ab	+++
Neem	n-Hexane	35.00	35.32 e	70.32 e	++
	DCM	40.11	41.31 de	81.42 de	++
	Methanol	51.20	64.97 ab	116.17 b	+++
Urmoi	n-Hexane	53.35	50.48 cd	103.83 bc	+++
	DCM	69.74	67.91 ab	137.65 a	+++
	Methanol	66.49	71.59 a	138.08 a	+++
$S\bar{x}$		3.8588	2.8333	4.9335	
Probability level		NS	0.01	0.01	

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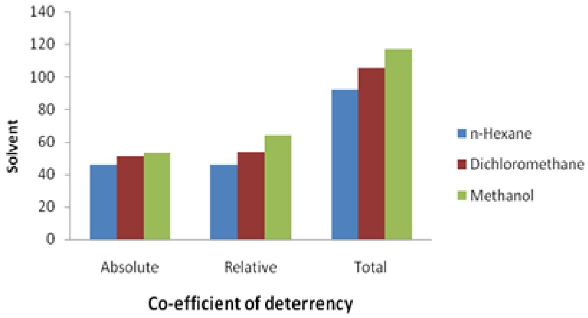

Figure 2. Antifeedant effects of different solvents used in preparing different plant extracts on rice weevil, *S. oryzae.*

Interaction of solvent and plant extracts on antifeedant effect

The antifeedant effects of different plant extracts as influenced by the different solvents are presented in Table 3. Among the three solvents the highest total feeding deterrent effect (138.08) was observed in methanol extracts and hexane extract of neem possessed lowest total feeding deterrent effect (70.32)**.**

The interaction of relative and total co-efficient of deterrency of different plant extracts and solvents were significant at 1% level of probability. The efficacy level of different plant extracts influenced by different solvents varied between ++ to +++. The interaction effect of coefficients of deterrency and different dose level on rice weevil is presented in Figure 3.

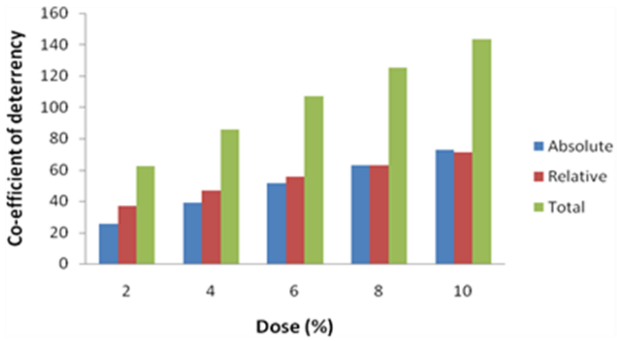

Figure 3. Mean antifeedant effect of different plant extracts at different dose level on rice weevil, *S. oryzae.*

The antifeedant effects of different plant extracts at different dose level on rice weevil is shown in Table 4. The highest total coefficient of deterrency occurred in 10% concentration of urmoi extract (158.90) and the lowest in 2.0% of karanja extract (44.04). The coefficients of deterrency values of different doses of plant extracts were statistically insignificant. The efficacy levels of different plant extracts at different dose level varied between + to ++++.

Table 4. Antifeedant effect of different plant extracts at different dose levels on rice weevil, *S. oryzae* (Interaction of plant extract and solvent).

Name of the plant extracts	Doses (%)	Co-efficient of deterrency			Efficacy of extracts
		Absolute	Relative	Total	
Karanja	2.0	16.83	27.21	44.04	+
	4.0	30.64	42.16	72.80	++
	6.0	46.41	51.91	98.32	++
	8.0	59.34	58.85	118.19	+++
	10.0	73.61	63.04	136.65	+++
	2.0	23.99	38.45	62.44	++
Mahogany	4.0	38.10	51.09	89.19	++
	6.0	48.11	61.15	109.26	+++
	8.0	65.40	67.98	133.38	+++
	10.0	71.73	76.10	147.83	+++
Neem	2.0	19.39	32.05	51.44	++
	4.0	30.13	38.19	68.32	++
	6.0	43.00	45.54	88.54	++
	8.0	52.85	54.55	107.4	+++
	10.0	65.15	65.66	130.81	+++
Urmoi	2.0	41.29	49.19	90.48	++
	4.0	54.61	55.34	109.95	+++
	6.0	67.45	63.22	130.67	+++
	8.0	73.03	69.55	142.58	+++
	10.0	79.57	79.33	158.90	++++
$S\bar{x}$		4.9817	3.6578	6.3691	
Probability level		NS	NS	NS	

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DISCUSSION

All the extracts had moderate inhibitory effects on the feeding activities of rice weevil. Among the four plant extracts tested, urmoi had the highest absolute deterrency (63.19) and neem had the lowest effect (42.10). In case of relative deterrency, urmoi also showed the highest effect (63.33) followed by mahogany (58.95). Considering the total effects, the urmoi possessed the highest feeding deterrent effect (126.52) whereas neem possessed the least deterrent effect (89.20).

The coefficient of deterrency increased proportionally with the increase of doses. The interaction effects of coefficients of deterrency and different dose level were statistically significant at 1% level of probability. The antifeedant effects of different plant extracts at different dose level on rice weevil is shown in Table 4.

Among the three solvents the highest total feeding deterrent effect (138.08) was observed in methanol extracts and hexane extract of neem possessed lowest total feeding deterrent effect (70.32)**.** The interaction of relative and total co-efficient of deterrency of different plant extracts and solvents were significant at 1% level of probability. The efficacy level of different plant extracts influenced by different solvents varied between ++ to +++.

Talukder and Howse (1993, 1995) reported that the plant extracts had feeding deterrent effects on *Tribolium castaneum.* The absolute and relative coefficients represented the no choice and choice tests respectively. When the insects had no opportunity to choose between treated and control disks (no choice test), adults consumed either a small amount of the treated disks or a large amount of the control disks, which gave low absolute co-efficient values. But, when they had the opportunity to choose between treated and control disks (choice test), the adults directed their feeding activity to control ones, which produce high relative coefficient values. The differences of coefficient deterrent values among different plant extracts were found to be significant at 1% level of probability. Mahogany and urmoi had the same and high level of efficacy (+++), whereas karanja and neem had same but low level of efficacy (++).

The fruit extract had the highest total feeding deterrent effect (110.44) and the leaf extract had the least total feeding deterrent effect (98.68). The results showed that the fruit extracts were better than leaf extracts. The absolute and total coefficient of deterrent values of different leaf and seed extracts were significant at 1% level of probability. The results of present investigation on antifeedant effect were influenced by solvents. Among the three solvents, the highest total coefficient of deterrency was observed in methanol extract (116.83) and it was significantly different from n-hexane (91.78) and dichloromethane (105.07) extracts. The coefficient of deterrency increased proportionally with the increase of doses.

Kamruzzaman *et al.* (2005) reported that the urmoi plant extract had strong antifeedant effect on rice weevil. From the above results, it was found that urmoi extracts have strong antifeedant effects against rice weevil and agreed with the previous findings of Dadang and Ohsawa (2003), Sureshgouda and Singh (2004) and Chen-Bin (2010). According to Syahputra (2008) the antifeedant effect arises because of the presence of substances (active compounds) that are inhaled or touched taste organs, disrupting signals that stimulate appetite and then affecting eating activities. The stronger the aroma of the compounds absorbed by the insect's body, the stronger the ability to eat and ultimately the consumption of feed decreases. Again, Wicaksono *et al.* (2018) state that the antifeedant effect can obstruct the ability to eat, even stops eating activity in insects due to disorders of peripheral sensilla (taste organs). The present study has shown that urmoi extracts have strong antifeedant effects on adult rice weevils. This study also confirms the validity of traditional use of urmoi against stored grain pests.

CONCLUSION

The poor storage facilities of the farmers of Bangladesh, which are unsuitable for effective conventional chemical control, emphasize the necessity of new and effective methods for insect pest control of stored products. Thus, there is an urgent need to develop safe alternatives to conventional insecticides and fumigants for the protection of grain products against insect infestations. The natural products of plants come as an alternative and ecologically more compatible in substitution to the synthetic insecticides. In the context of agricultural pest management, botanical insecticides are best suited for use in organic food production in industrialized countries but can play a much greater role in the production and post harvest protection of food in developing countries like Bangladesh. The main advantages of botanical pesticides are that these are eco-friendly, easily biodegradable, nontoxic to non-target organisms. The compounds of urmoi plant could be exploited for the development of novel botanical antifeedants/protactant with highly precise targets for sustainable insect pest management. In summary, the results of this research clearly demonstrate the potent antifeedant effects of the urmoi plant extract against *S. oryzae*. As antifeedants are gaining importance as potential components of integrated pest management strategies. Besides the results demonostrate that urmoi seed extraction can be applied against rice weevil to protect stored grains.

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Conflict of Interest

The authors declare that there is no conflict of interest among authors regarding the submission and publication of this manuscript.

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