Pak. J. Sci. Ind. Res. 2005 **48**(4) 252-256

Laboratory Evaluation of Plant Extracts as Antifeedant Against the Lesser Mealworm, *Alphitobius diaperinus* and Rice Weevil, *Sitophilus oryzae*

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(received November 19, 2003; revised January 11, 2005; accepted April 27, 2005)

Abstract. Studies were conducted on leaf, seed and bark extracts (acetone, ethanol and water) of *Ipomoea fistulosa, Datura fastuosa, Eucalyptus citridora, Helitropium indicum, Hedyotis corymbosa* and *Sapium indicum* for their antifeedant effects against the lesser mealworm, *Alphitobius diaperinus* and rice weevil, *Sitophilus oryzae*. The results showed that all the extracts of test plants had antifeedant effect on both the insects. Among the six plant extracts tested, *Sapium indicum* extracts had the highest antifeedant effect on the lesser mealworm and rice weevil. The ethanol extracts of leaf and seed were more effective than those obtained in the other two solvents. The coefficient of deterrency increased proportionally with increase in doses. The seed extract was more effective than leaf extract.

Keywords: plant extracts, antifeedant, lesser mealworm, rice weevil, *Alphitobius diaperinus, Sitophilus oryzae*

Introduction

Insect infestation in stored grains and their products is a serious problem throughout the world. Approximately, 200 species of insects and mites attack stored grains and stored products (Maniruzzaman, 1981). Among these species, the lesser mealworm *(Alphitobius diaperinus)* and rice weevil *(Sitophilus oryzae)* are the most common and destructive pests. Chemical control of insects during storage has been in practice for a long time, but it has serious drawbacks (Sharaby, 1988). Indiscriminate use of chemical insecticides has given rise to many serious problems, including genetic resistance in pest species, toxic residues, increasing costs of application, environmental pollution, and hazards to human beings and animals during its handling and afterwards (Khanam *et al.*, 1990; Ahmed *et al.*, 1981). This situation is indicative of the need for safe, locally available and less expensive materials for pest control during storage. Locally available plants and minerals have been widely used in the past to protect stored products against insect infestations (Golob and Webley, 1980). The advantages of botanical products for this purpose are that they are less expensive, non-hazardous and can be easily produced by farmers. In the rural areas of South-Asia, including Bangladesh, farmers traditionally mix leaves, barks, seeds, roots or oils of certain plants with stored grains to protect them from insect attacks. The use of antifeedants obtained from indigenous plants in plant protection is still in the experimental stages in Bangladesh. Very little work has been reported on their efficacy against insect pest (Shahjahan and Amin, 2000; Akhtar *et al.*, 1998). The present study was undertaken with some locally grown plants, such as *Ipomea fistulosa* (vern. dholkalmi), *Datura fastuosa* (vern. datura), *Eucalyptus citridora* (eucalyptus), *Helitropium indicum* (vern. hatisur), *Hedyotis corymbosa* (vern. khetpapri) and *Sapium indicum* (vern. urmoi) to investigate their compatibility with the pest management programme by determining their antifeedant effects against *Alphitobius diaperinus* and *Sitophilus oryzae.*

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Materials and Methods

The present studies were conducted on the evaluation of some plants for their antifeedant effects against the lesser mealworm, *Alphitobius diaperinus* and rice weevil, *Sitophilus oryzae* in the laboratory of the Department of Entomology, Bangladesh Agricultural University, Mymensingh during the period from July 1999 to June 2000. The test insects were reared separately in plastic jars (12.0 x 23.0 x 6.5 cm). The lesser mealworms were fed on wheat grains and rice weevils on rice grains. The jars were kept in laboratory at 18.70-28.9 °C temperature and 73.34-87.90% relative humidity.

Preparation of plant extracts. The plant samples (leaf, seed, bark) of "dholkalmi", "datura", eucalyptus, "hatisur", "khetpapri" and "urmoi" were collected from different areas of Bangladesh. Fresh leaves, seeds and barks of these plants were washed with water, air-dried, and followed by drying in oven at 60 °C. The dried plant samples were ground manually and passed through a 25-mesh sieve to obtain fine powder of each plant part. The powders were preserved in airtight containers. Thirty grams of the fine powder of each plant sample was taken in a 600 ml beaker to which were separately added 300 ml of different solvents (acetone, ethanol and water). The mixtures were then stirred for 30 min with a magnetic stirrer (at 6000 rpm) and left to stand for 24 h. The mixture was then filtered through a fine cloth and then filter paper. The filtered extracts were concentrated by evaporation of solvents in a waterbath at the temperature of 45 °C, 55 °C and 80 °C for acetone, ethanol, and water, respectively. The extracts were preserved in tightly-corked, labelled bottles and stored in refrigerator until their use for insect bioassays. Different concentrations (7.5, 10.0, 12.5 and 15.0% for the lesser mealworm, and 2.5, 5.0, 7.5 and 10.0% for rice weevil) of each category of plant extracts were prepared by dissolving them in water, prior to insect bioassay.

Antifeedant test. The potency of antifeedant effects of the plant extracts, against the lesser mealworm and rice weevil, were determined by the method originally described by Nawrot *et al.* (1986), later modified by Talukder and Howse (1995). Six wheat wafer disks (15 mm dia) were used in each case as the test food. The disks were oven-dried and saturated by dipping either in solvents (control: C) or diluted extracts (treated disk: T). They were dried in air through the night and their individual weight was taken before feeding them to 10 insects as the sole feed for 10 days. Two blank disks in each case (treated with solvent only, but not fed to insects) were also prepared. The feeding of insects was recorded under the following three condition: (i) on pure food, composed of two untreated disks (control: cc), (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). Each treatment was replicated thrice. After ten days, all the disks were reweighed. The disks were observed for 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 amount of food consumed (FC), was calculated by the following formula given by Serit *et al.* (1992).

$$FC = IW-[(FW_s \times IW_b)/FW_b]$$

where:

IW = initial weight of the disk after being treated with extract or solvent
FW = final weight of the wafer disk
b = weight of the blank disk (treated with solvent only and where no insects were released)
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 test (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):

$$A = (CC - TT/CC + TT) \times 100$$

(ii) Relative coefficient of deterrency (choice test):

$$R = (C - T/C + T) \times 100$$

(iii) Total coefficient of deterrency:

$$T = A + R$$

where:

T = total coefficient of deterrency
A = absolute coefficient of deterrency
R = relative coefficient of deterrency

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 the index for 200 for a compound with maximum activity. Indices were expressed as 151-200, + + + + ; 101-150, + + + ; 51-100,+ +; and 0-50, +. All the experimental data were analysed by analysis of variance (ANOVA).

Results and Discussion

The results of antifeedant effects of "dholkalmi", "datura", eucalyptus, "hatisur", "khetpapri" and "urmoi" plant extracts on the lesser mealworm and rice weevil are presented in Tables 1-4. For both the insects, the differences of coefficient deterrent values between plant, plant part, solvent and dose were found to be significant at 1% level of probability.

The lesser mealworm. It may be noted from Table 1 that among the six tested plant extracts, "urmoi" *(Sapium indicum)* had the highest antifeedant effect (120.99), whereas eucalyptus had the least antifeedant effect (98.79). The seed extracts of "urmoi" showed the highest total feeding deterrent effect (123.60), while the leaf extract of eucalyptus possessed the least total feeding deterrent effect (92.22), as may be noted from Table 2. The results also showed that the seed extracts were more effective than leaf extracts. Considering the effect of solvents (Table 3), ethanol extract showed the highest total antifeedant effect (123.65), which was significantly different from water extract (105.13) and acetone extract (103.24). The coefficient of deterrent values increased proportionally with the increase of doses (Table 4).

Rice weevil. All the plant extracts had moderate inhibitory effects on the feeding activities of rice weevil. Among the six tested plant extracts, "urmoi" had the highest feeding deterrent effect (115.47), whereas eucalyptus possessed the least

Table 1. Antifeedant effect of different plant extracts on *Alphitobius diaperinus* and *Sitophilus oryzae*

Plant species	*Alphitobius diaperinus*				*Sitophilus oryzae*			
	Coefficient of deterrency*				Coefficient of deterrency*			
	Absolute	Relative	Total	Efficacy**	Absolute	Relative	Total	Efficacy**
Ipomea fistulosa ("dholkalmi")	58.15^{a}	61.82^{a}	119.97^{a}	+++	51.09^{b}	55.26^{b}	106.35^{b}	+++
Datura fastuosa ("dutura")	54.25^{b}	58.45^{b}	112.70^{b}	+++	43.28^{c}	46.06^{c}	89.34^{c}	++
Eucalyptus citridora (eucalyptus)	48.01^{d}	50.78^{e}	98.79^{e}	++	33.44^{e}	38.15^{e}	71.59^{e}	++
Helitropium indicum ("hatisur")	53.10^{b}	57.00^{c}	110.10^{c}	+++	40.28^{d}	43.47^{d}	83.75^{d}	++
Hedyotis corymbosa ("khetpapri")	49.64^{c}	53.65^{d}	103.29^{d}	+++	41.02^{d}	44.20^{d}	85.22^{d}	++
Sapium indicum ("urmoi")	58.22^{a}	62.77^{a}	120.99^{a}	+++	55.64^{a}	59.83^{a}	115.47^{a}	+++
$S_{\bar{x}}$	0.43	0.31	0.60		0.29	0.40	0.53	

*probability level = 0.01; different letters in the same column denote significant differences by DMRT; ** on a scale of 0 - 200 index (inactive - highly active), + + + = 101 - 150 index, + + 51 - 100 index

Table 2. Antifeedant effect of extracts of different plant parts on *Alphitobius diaperinus* and *Sitophilus oryzae*

Plant species	Plant parts	*Alphitobius diaperinus*				*Sitophilus oryzae*			
		Coefficient of deterrency*				Coefficient of deterrency*			
		Absolute	Relative	Total	Efficacy**	Absolute	Relative	Total	Efficacy**
Ipomea fistulosa	Leaf	56.69^{b}	60.64^{cd}	117.33^{bc}	+++	47.58^{d}	50.03^{d}	97.61^{d}	++
("dholkalmi")	Bark	59.61^{a}	63.00^{ab}	122.61^{a}	+++	54.60^{b}	60.49^{b}	115.09^{b}	+++
Datura fastuosa	Leaf	52.28^{de}	58.32^{e}	110.60^{d}	+++	41.67^{f}	44.77^{f}	86.44^{f}	++
("datura")	Seed	56.22^{bc}	58.59^{e}	114.81^{c}	+++	44.88^{e}	47.35^{e}	92.23^{e}	++
Eucalyptus citriodora	Leaf	45.21^{f}	47.01^{h}	92.22^{h}	++	28.14^{i}	32.16^{i}	60.30^{i}	++
("eucalyptus")	Seed	50.21^{e}	54.55^{f}	104.76^{f}	+++	38.73^{g}	44.15^{f}	82.88^{g}	++
Helitropium indicum	Leaf	51.56^{de}	54.43^{f}	105.99^{ef}	+++	38.35^{g}	42.08^{g}	80.43^{g}	++
("hatisur")	Seed	54.64^{c}	59.97^{de}	114.61^{c}	+++	42.21^{f}	44.86^{f}	87.07^{f}	++
Hedyotis corymbosa	Leaf	46.62^{f}	51.35^{g}	97.97^{g}	++	34.73^{h}	38.00^{h}	72.73^{h}	++
("khetpapri")	Seed	52.67^{d}	55.94^{f}	108.61^{de}	+++	47.31^{d}	50.40^{d}	97.71^{d}	++
Sapium indicum	Leaf	56.99^{b}	61.39^{bc}	118.38^{b}	+++	52.08^{c}	55.69^{c}	107.77^{c}	+++
("urmoi")	Seed	59.46^{a}	64.14^{a}	123.60^{a}	+++	59.20^{a}	63.96^{a}	123.16^{a}	+++
$S_{\bar{x}}$		0.61	0.44	0.84		0.40	0.56	0.75	

* probability level = 0.01; different letters in the same column denote significant differences by DMRT; ** on a scale of 0 - 200 index (inactive - highly active), + + + = 101 - 150 index, + + = 51 - 100 index

Table 3. Antifeedant effect of different solvents, used for obtaining plant extracts, on *Alphitobius diaperinus* and *Sitophilus oryzae*

Solvent	*Alphitobius diaperinus*				*Sitophilus oryzae*			
	Coefficient of deterrency*				Coefficient of deterrency*			
	Absolute	Relative	Total	Efficacy**	Absolute	Relative	Total	Efficacy**
Acetone	49.71 [b]	53.53 [c]	103.24 [c]	+ + +	41.64 [b]	45.32 [b]	86.96 [b]	+ +
Ethanol	59.98 [a]	63.67 [a]	123.65 [a]	+ + +	53.02 [a]	56.24 [a]	109.26 [a]	+ + +
Water	50.10 [b]	55.03 [b]	105.13 [b]	+ + +	37.71 [c]	41.91 [c]	79.62 [c]	+ +
$S\bar{x}$	0.304	0.220	0.421		0.202	0.281	0.375	

* probability level = 0.01; ** on a scale of 0 - 200 index (inactive - highly active), + + + = 101 - 150 index, + + = 50 - 100 index; different letters in the same column denote significant difference by DMRT

Table 4. Mean antifeedant effect of different plant extracts in different dose levels on *Alphitobius diaperinus* and *Sitophilus oryzae*

Alphitobius diaperinus					*Sitophilus oryzae*				
Doses	Coefficient of deterrency*				Doses	Coefficient of deterrency*			
(%)	Absolute	Relative	Total	Efficacy**	(%)	Absolute	Relative	Total	Efficacy**
7.5	33.91 [d]	37.28 [d]	71.19 [d]	+ +	2.5	26.06 [d]	29.00 [d]	55.06 [d]	+ +
10.0	48.28 [c]	51.72 [c]	100.00 [c]	+ +	5.0	37.54 [c]	41.00 [c]	78.54 [c]	+ +
12.5	60.56 [b]	64.83 [b]	125.39 [b]	+ + +	7.5	50.77 [b]	55.06 [b]	105.83 [b]	+ + +
15.0	71.50 [a]	75.82 [a]	147.32 [a]	+ + +	10.0	62.12 [a]	66.24 [a]	128.36 [a]	+ + +
$S\bar{x}$	0.351	0.254	0.486			0.233	0.325	0.433	

* probability level = 0.01; ** on a scale of 0 - 200 index (inactive - highly active), + + + = 101 - 150 index, + + = 50 - 100 index; different letters in the same column denote significant difference by DMRT

deterrent effect (71.59) on rice weevil (Table 1). The absolute and relative coefficient of deterrency represented the no choice and choice tests, respectively. When the insects had no opportunity to choose between the treated and the 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 coefficient values. However, when they had the opportunity to choose between the treated and the control disks (choice test), the adults directed their feeding activity to the control disks, which produced high relative coefficient values. The results showed that the seed extracts were better than leaf extracts (Table 2). The seed extracts of *S. indicum* ("urmoi") had the highest feeding deterrent effect (123.16), while the leaf of *E. citridora* (eucalyptus) had the least feeding deterrent effect (60.30). Among the three solvents, the highest total coefficient of deterrency was observed with ethanol extract (109.26), which was significantly different from water (79.26) and acetone (86.96) extracts (Table 3). The coefficient of deterrency increased proportionally with the increase of doses (Table 4). Similar feeding deterrent effects of different plant extracts, like *Aphanamixis polystachya* (vern. pithraj) on *Tribolium castaneum* (Talukder and Howse, 1995; 1993), *Polygonum hydropiper* (vern. bishkatali), *Vitex negundu* (vern. nishinda) and *Aphanamixis polystachya* on *Rhizopertha domonika* (Akhter *et al*., 1998); *Asclepias calotropis* (vern. akanda), *Polygonum hydropiper* (vern. bishkatal), *Azadirachta indicum* (vern. neem) on *Sitophilus oryzae* (Shahjahan and Amin, 2000); castor (*Ricinus communis*), *Azadirachta indicum*, *Aphanamixis polystachya* on *Alphitobius diaperinus* (Rahman *et al*., 2001); and *Melia azedarach* and eucalyptus *(E. citridora)* plant extracts on *Plecopetra reflexa* (Meshram, 2000) have been also reported. The results obtained suggest that *Sapium indicum* (vern. urmor) leaf and seed extracts are useful for inhibition of feeding by the lesser mealworm and rice weevil during storage, as the extracts have shown strong antifeedant characteristics.

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