Journal of Medicinal Plants Research Vol. 5(2), pp. 259-265, 18 January, 2011
Available online at http://www.academicjournals.org/JMPR
ISSN 1996-0875 ©2011 Academic Journals

Full Length Research Paper

Tropical medicinal plant extracts against rice weevil, *Sitophilus oryzae* L.

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Accepted 22 November, 2010

Rice weevil, *Sitophilus oryzae* L. is one of the major pests of stored commodities, the adult weevils feed on rice and the females lay eggs inside rice kernels. In the study chemical composition of extracts from black pepper, *Piper nigrum* L. and physic nut, *Jatropha curcas* L. were tested against this pest, under laboratory conditions. The chemical compositions of the extracts were identified by gas chromatography (GC) and gas chromatography-mass spectroscopy (GC-MS). The major extracted components of *P. nigrum* were piperine (74.34%) and caryophyllene (18.53%), and for *J. curcas* were oleic acid (40.67%), linoleic acid (34.17%) and palmitic acid (18.03%). The mortality of adults increased with increasing concentration of extracts from 2 to 10 µl/g of rice and exposure time from 24 to 72 h. The petroleum ether (LC_{50}=1.61 µl/g) and chloroform extracts (LC_{50}=1.70 µl/g) of *P. nigrum* showed higher mortality rate compared to petroleum ether extracts (LC_{50}=6.82 µl/g) of *J. curcas* with 99.56, 93.56 and 66.00% mortality, respectively. The *P. nigrum* extracts (92.0%) were significantly repelled *S. oryzae* compared to *J. curcas* extracts (69.6%). Petroleum ether and chloroform extracts of *P. nigrum* and petroleum ether extract of *J. curcas* extracts also showed strong antifeedant and opposed to progeny production. Furthermore, F1 adults were suppressed at the lowest concentration (2 µl/g) and no F1 was produced in all treatments. The results of this study show that *P. nigrum* and *J. curcas* extracts were able to protect stored grain.

Key words: *Piper nigrum*, *Jatropha curcas*, black pepper, physic nut, contact toxicity.

INTRODUCTION

Stored agricultural and animal origin products are attacked by more than 600 species of beetle pests, 70 species of moths and about 355 species of mites, which cause quantitative and qualitative losses (Sarker et al., 2006; Rajendran and Sriranjini, 2008). This damage may loss about 5 to 10% in temperate zone and 20-30% in tropical zone (Haque et al., 2000). One of the major pests of stored commodities in tropics is "rice weevil", *Sitophilus oryzae* L. (Col: Curculionidae) (Lucas and Riudavets, 2002). Adult weevils feed on rice and lay their eggs inside rice kernels, where the larva can develops to the adult stage (Lee et al., 2001; Lucas and Riudavets, 2002). To control of pests in storages methyl bromide (MeBr) and phosphine (PH3) are used, that may several problems on stored products (Negahban et al., 2006). Therefore, alternatives pests control methods, need to be developed. For example, a lot of natural pesticides can be diverted from higher plants (Huang and Ho, 1998). These products do not leave harmful residue to the

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environment and have medicinal properties for human, with lower toxicity to mammals (Negahban et al., 2006). Black pepper (*Piper nigrum* L.) and physic nut (*Jatropha curcas* L.) are examples of such plants, which can possess medicinal, insecticidal, repellent or antifeedant property (Salimon and Abdullah, 2008; Scott et al., 2008). *P. nigrum* is a perennial vine found in tropical regions and native to the Indo-Malaysian region, whereas *J. curcas* is a perennial tree found in tropical regions such as India. *J. curcas* extracts were reported to be toxic toward leaf cutting larvae (Prakash and Rao, 1997). In this study, we evaluated the insecticidal effects those medicinal plant extracts to control rice weevil.

MATERIALS AND METHODS

Insect rearing

Colonies of rice weevil, *S. oryzae* were obtained from an entomology laboratory stock culture of University Putra Malaysia (UPM) and reared on whole rice grains initially 13 to 14% moisture content (Chen, 2003) in plastic container under the laboratory conditions at 28 ± 2°C, 75 ± 5% R.H. and L12:D12 (Rahman and Talukder, 2006). The subcultures and the tests were carried out under the same conditions. 7 to 14 days old adult of *S. oryzae* were used to the experiments.

Extraction of plant extracts

Plant extracts were prepared by the percolation method described by Sarker et al. (2006) with some modifications. Dry seeds of *P. nigrum* and *J. curcas* were grounded to powder using a grinder prior to oil extraction (Salimon and Abdullah, 2008). The powder (3 kg) were soaked with 95% methanol for 48 h, filtered and the residues were extracted afterwards. All filtrates were combined and concentrated by rotary evaporator. An equal volume of water added to the crude extract, and extraction were done by petroleum ether. The residues were followed by chloroform and were collected as chloroform fraction and residues (Aqueous extract), and finally were concentrated by rotary evaporator (40°C) and put at 4°C.

Gas chromatographic (GC) analysis was performed extractions to determine the fatty acids, using a 30m × 0.25 mm ID (0.20 µm film thickness) (Agilent 7890N) and Supelco SP-2330 capillary column (Supelco, Inc., Bellefonte, PA, USA).

One micro liter was injected by an auto sampler into the chromatograph, equipped with a split injector and a Flame Ionization Detector (FID). The split ratio was 1:20 after injection of 1 µl of the Fatty Acid Methyl Esters (FAME). The injector temperature was programmed at 250°C and the detector temperature was programmed at 300°C. The column temperature program initiated runs at 100°C, for 2 min, warmed up to 170°C at 10°C /min, hold for 2 min, warmed up to 200°C at 7.5°C /min, and then hold for 20 min to facilitate optimal separation. The GC mass analysis was carried out to determine the major components of the extractions on a Shimadzu GCMS-QP2010 Plus equipped with a BPX-5 column (30 m × 0.25 mm × 0.25 µm), helium as carrier gas at a flow rate of 1 ml min^{-1}, in electronic impact mode (70 eV) and split injection ratio (1:20). The injector and GC/MS interface were kept at 320°C. The column temperature program was as follows: 50°C, heating at 10°C min^{-1} until 320°C and remaining at this temperature for 15 min. The components of the oils were identified by comparison of the mass spectra with the NIST08 library information.

Toxicity tests

Toxicity effects of plant extracts on *S. oryzae* were carried out in thelaboratory according to the methods of Talukder and Howse (1994) with some modifications. Five gram rice were soaked in a 1 ml of 1, 2, 3, 4 and 5% extractions of *P. nigrum* (3 fractions) and *J. curcas* (3 fractions) sequentially. Where, the control rice was treated with solvent only and air dried for 30 min to evaporate the solvent. Then, each sample were placed in a vial and ten adult of *S. oryzae* were released on each of them. The experiments were done with five replicates. The adult mortality was recorded after 24, 48 and 72 h. The LC_{50} and LC_{95} values of six extracts were calculated by probit analysis (Finney, 1971) using Polo-Plus Software (LeOra, 2003). The original data were corrected by Abbott's (1925) formula, transformed into percentage and square root values and then variance analysis (ANOVA) were done, by SAS program. In the end mean values were adjusted by Tukey's Multiple Comparison Test.

Evaluation repellency activities

The area preference test described by McDonald et al. (1970) was used to evaluate repellent action of *S. oryzae*. Test areas consisted of 9 cm Whatman No. 1 filter papers that were cut two parts. In first part one ml (1, 2, 3, 4 and 5%) of petroleum ether and chloroform extracts of *P. nigrum* or petroleum ether extractions of *J. curcas* were applied as possible as uniformly with a micropipette. The other part (control) was only treated with 1 ml of acetone. Both the treated part and the control part were air dried to evaporate the solvent completely. A full disc was carefully remade by attaching the treated part to the control part with adhesive paper tape. Each filter paper was placed in a Petri dish and 10 adult of *S. oryzae* were released in the center of each filter paper disc and covered. Each treatment was replicated five times. The number of insects present on control (NC) and treated (NT) strips were recorded after 1, 2, 3, 4 and 24 h. Percent repellency (PR) values for test was computed as PR=[(NC-NT)/(NC+NT)]×100 (Obeng-Ofori and Reichmuth, 1997).

Evaluation antifeedant activities

Antifeedant activities were study as the methods of Keita et al. (2001) and Mahdi and Rahman (2008) with some modifications. So five gram impregnated rice with plant extracts were placed in 27 ml vials and 10 adult *S. oryzae* were allowed to feed for 7 days. After the feeding period, grains were weighed, and weight loss was measure by this formula:

$$\%WL = (IW-FW) \times 100/IW,$$

where the IW is the initial weight and FW is the final weight.

Plant extracts efficacy on *S. oryzae* progeny production

Twenty five gram disinfected rice was soaked in 125 ml conical flax contain 5 ml of different appropriate concentrations of plant extractions as the method of Huang et al. (2000) and Jbilou et al. (2006) with some modifications. After thorough mixing and evaporation of the solvent, the treated rice was divided into 5 vial (five gram each). Then ten adult of *S. oryzae* were added to each vial (five replications).

The control was set up using the appropriate solvent without any extractions. The adults in each vial had chance to lay eggs in the rice for one week. Afterward, the mortality was recorded before being removed and the developmental stages were monitored until

Table 1. Chemical constituents of *P. nigrum* and *J. curcas* (Analysis by GC).

%	Name constituents	*P. nigrum* extracts (AVG ± SE)	*J. curcas* extracts (AVG ± SE)
12:0	Lauric acid methyl ester	1.74 ± 0.35	ND [1]
14:0	Myristic acid methyl ester	2.00 ± 0.35	ND
15:0	Pentadecanoic acid methyl ester	4.55 ± 0.65	ND
15:1	Cis-10 Pentadecenoic acid methyl ester	1.78 ± 0.41	0.12 ± 0.02
16:0	Palmitic acid methyl ester	17.94 ± 1.81	18.03 ± 0.47
16:1	Palmitoleic acid methyl ester (cis-9)	3.76 ± 0.55	0.66 ± 0.07
17:0	Heptadecanoic acid methyl ester	4.21 ± 0.60	0.35 ± 0.13
18:0	Stearic acid methyl ester	6.08 ± 0.65	5.27 ± 0.84
18:1	Oleic acid methyl ester (cis-9)	28.58 ± 2.43	40.67 ± 0.53
18:2 n-6	Linoleic acid methyl ester	26.78 ± 1.95	34.17 ± 1.73
18:3 n-3	Linolenic acid methyl ester	2.58 ± 0.68	ND
20:5 n-3	Cis-5, 8, 11, 17 – Eicosapentaenoic acid methyl ester	ND	0.72 ± 0.12
Total saturated		36.52 ± 0.54	23.66 ± 1.38
Total unsaturated		63.48 ± 0.54	76.34 ± 1.38
Total monoenes		34.12 ± 1.60	41.45 ± 0.53
Total PUFA[3] n-3		2.58 ± 0.68	0.72 ± 0.12
Total PUFA n-6		26.78 ± 1.95	34.17 ± 1.73
n-6 : n-3 Ratio		12.18 ± 3.80	50.12 ± 8.23
Unsat:Sat[2]		1.74 ± 0.04	3.26 ± 0.25
Poly:Sat Ratio		0.81 ± 0.07	1.49 ± 0.16

1- Not detected, 2- Unsat = Unsaturated; Sat = Saturated, 3- polyunsaturated fatty acids (PUFA).

Table 2. Major constituents of *P. nigrum* and *J. curcas* (analysis by GC-MS).

Plant extracts	Compound	%
Petroleum ether extracts of *P. nigrum*	Caryophyllene	18.53
	Piperine	74.34
	Cinnamic acid	5.20
Petroleum ether extracts of *J. curcas*	Piperine	5.17

all adults had been emerged. Data were analyzed by using analysis of variance (ANOVA) and Tukey's test was used for comparison of means.

RESULTS AND DISCUSSION

Results revealed that the major components of *P. nigrum* and *J. curcas* extracts contained piperine (74.34%), oleic acid (40.67%), linoleic acid (34.17%), caryophyllene (18.53%) and palmitic acid (18.03%) (Tables 1 and 2). The alkaloids piperine is a major component of black pepper (Bhardwaj et al., 2002) and it is found naturally in plants belonging to piperaceae family, such as *P. nigrum* and *P. longum*. Piperine is the trans stereoisomer of 1-piperoylpiperidine (Reshmi et al., 2010). The pungency of the black pepper and long pepper are due to the presence of piperine in the fruit that might have killed the beetle earlier (Lale, 1992; Mahdi and Rahman, 2008; Reshmi et al., 2010). It has also been used in some forms of traditional medicine as well as pesticide (Su, 1977; Lee et al., 2001; Scott et al., 2008; Reshmi et al., 2010). Oleic acid has insecticidal effective which enhances the efficacy of the microbial insecticides such as *Bacillus thuringiensis* (B. T.) Berliner (Gaudet and Puritch, 1989). It also appeared that effective fatty acid that pesticide effectiveness against *Zabrotes subfasciatus* (Boheman) that stored beans (Hill and Schoonhoven, 1981). Oleic acid and linoleic acid were reported with insecticide effect against fourth instar *Aedes aegyptii* larvae and exhibited potent feeding deterrent activity against larvae of *Helicoverpa zea*, *Lymantria dispar*, *Orgyia leucostigma* and *Malacosoma disstria* (Ramsewak et al., 2001). It is also appeared that effective fatty acid has insecticidal effectiveness against *Zabrotes subfasciatus* (Boheman) in contamination

Table 3. Probit analysis for toxicities of *P. nigrum* and *J. curcas* extracts to *S. oryzae*.

Plant	Extracts	LC_{50}[1] (Min – Max)	LC_{95} (Min – Max)	Slope ± SEM	X^2(df)
P. nigrum	Petroleum ether	1.61 (0.50 – 2.26)	4.47 (3.29 – 11.02)	3.70 ± 0.70	3.40 (3)
	Chloroform	1.70 (0.88 – 2.36)	11.24 (8.10 – 21.76)	1.93 ± 0.39	2.57 (3)
	Aqueous	-	-	-	-
J. curcas	Petroleum ether	6.82 (5.30 – 9.63)	23.77 (14.29 – 105.96)	3.03 ± 0.42	4.00 (3)
	Chloroform	-	-	-	-
	Aqueous	-	-	-	-

Units LC_{50} and LC_{95}= µl/g, applied for 72 h at 28 ± 2°C and 75 ± 5 r.h. Values were based on 5 concentrations, 5 replications of 10 insects each. Chi-square values for goodness of fit of data to the Probit model was not significant (P < 0.05). (2) Did not show any effect on *S. oryzae*.

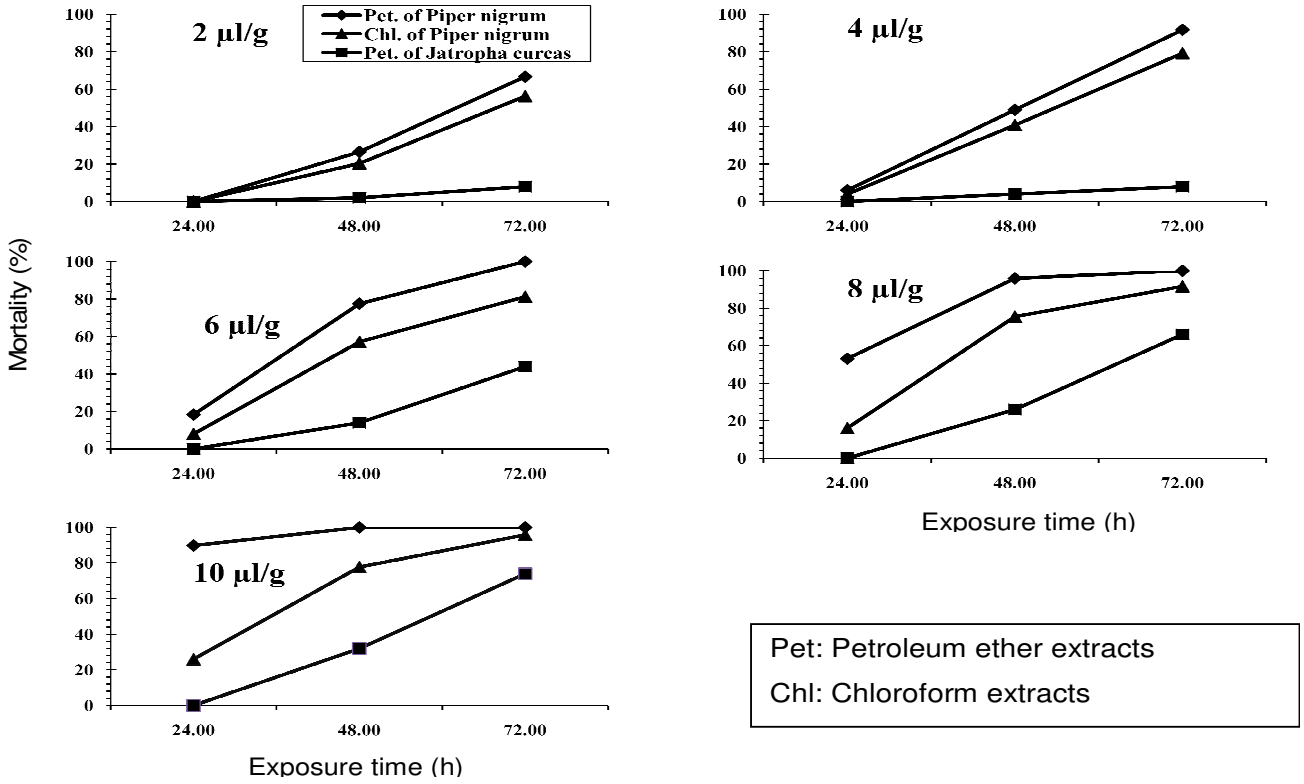

Figure 1. Percentage mortality of *S. oryzae* exposed to various periods of time to plant extracts from *P. nigrum* and *J. curcas* impregnated with rice and held at 28 ± 2°C and 75 ± 5% r.h.

stored beans (Hill and Schoonhoven, 1981). Oleic acid and linoleic acid were reported with insecticide effect against fourth instar *Aedes aegyptii* larvae and exhibited potent feeding deterrent activity against larvae of *Helicoverpa zea*, *Lymantria dispar*, *Orgyia leucostigma* and *Malacosoma disstria* (Ramsewak et al., 2001).

Petroleum ether and chloroform extracts of *P. nigrum* and petroleum ether extracts of *J. curcas* caused highest mortality rates for rice weevil based on LC_{50}. The order of LC_{50} of the plant extracts on *S. oryzae* after 72 h was petroleum ether extracts of *P. nigrum* (1.61 µl/g), followed by chloroform extract of *P. nigrum* (1.70 µl/g) and petroleum ether extract of *J. curcas* (6.82 µl/g). Aqueous extracts of *P. nigrum*, chloroform and aqueous extracts of *J. curcas* showed no toxicity action against adults of *S. oryzae* (Table 3). Petroleum ether and chloroform extracts of *P. nigrum* L. were more toxic than petroleum ether extract of *J. curcas* with 99.56, 93.56 and 66.00% mortality rates, respectively (Figure 1). Rice grains treated with 6 µl/g or more of petroleum ether extracts of *P. nigrum* caused 100% mortality within 72 h. Therefore, the insecticidal activities of those plant extracts may be

Table 4. Mean percent repellency (PR) values for different concentrations of *P. nigrum* and *J. curcas* extracts against *S. oryzae*.

Plant extracts (Concentration %)	PR (Mean % ± SEM)[1] hours after insect release[2]					Overall (Mean %)[3]
	1	2	3	4	24	
Petroleum ether extract of *P. nigrum* (5)	84 ± 9.8^{a}	88 ± 8.0^{a}	100 ± 0.0^{a}	100 ± 0.0^{a}	88 ± 4.9^{c}	92.0 ± 2.8^{a}
Chloroform extract of *P. nigrum* (5)	60 ± 6.3^{b}	68 ± 4.9^{b}	88 ± 4.9^{b}	100 ± 0.0^{a}	60 ± 0.0^{g}	75.2 ± 3.7^{b}
Petroleum ether extract of *P. nigrum* (4)	52 ± 13.6^{c}	56 ± 7.5^{d}	84 ± 7.5^{c}	84 ± 9.8^{d}	92 ± 4.9^{b}	73.6 ± 4.9^{b}
Petroleum ether extract of *J. curcas* (5)	48 ± 8.0^{d}	60 ± 6.3^{c}	64 ± 4.0^{f}	80 ± 6.3^{e}	96 ± 4.0^{a}	69.6 ± 4.2^{c}
Petroleum ether extract of *P. nigrum* (3)	60 ± 8.9^{b}	60 ± 10.9^{c}	64 ± 7.5^{f}	88 ± 8.0^{c}	68 ± 4.9^{e}	68.0 ± 4.0^{cd}
Chloroform extract of *P. nigrum* (4)	32 ± 8.0^{f}	60 ± 8.9^{c}	80 ± 8.9^{d}	92 ± 4.9^{b}	64 ± 11.7^{f}	65.6 ± 5.5^{d}
Petroleum ether extract of *P. nigrum* (2)	40 ± 6.3^{e}	60 ± 6.3^{c}	80 ± 8.9^{d}	76 ± 7.5^{f}	68 ± 8.0^{e}	64.8 ± 4.2^{d}
Chloroform extract of *P. nigrum* (3)	24 ± 4.0^{h}	56 ± 4.0^{d}	68 ± 8.0^{e}	72 ± 4.9^{g}	56 ± 14.7^{h}	55.2 ± 4.8^{e}
Petroleum ether extract of *J. curcas* (4)	40 ± 6.3^{e}	52 ± 4.9^{e}	68 ± 4.9^{e}	64 ± 7.5^{i}	48 ± 4.9^{i}	54.4 ± 3.2^{e}
Petroleum ether extract of *J. curcas* (3)	32 ± 8.0^{f}	40 ± 8.9^{g}	48 ± 4.9^{j}	60 ± 6.3^{j}	68 ± 13.6^{e}	49.6 ± 4.5^{f}
Petroleum ether extract of *P. nigrum* (1)	16 ± 4.0^{i}	32 ± 8.0^{h}	56 ± 4.0^{h}	68 ± 4.9^{h}	72 ± 10.2^{d}	48.8 ± 5.2^{f}
Petroleum ether extract of *J. curcas* (2)	28 ± 4.9^{g}	44 ± 4.0^{f}	60 ± 0.0^{g}	56 ± 7.5^{k}	36 ± 11.7^{j}	44.8 ± 3.7^{g}
Chloroform extract of *P. nigrum* (2)	24 ± 4.0^{h}	40 ± 8.9^{g}	52 ± 10.2^{i}	56 ± 11.7^{k}	28 ± 8.0^{k}	40.0 ± 4.7^{h}
Chloroform extract of *P. nigrum* (1)	4 ± 4.0^{j}	24 ± 4.0^{i}	36 ± 7.5^{k}	32 ± 4.9^{l}	28 ± 13.6^{k}	24.8 ± 3.9^{i}
Petroleum ether extract of *J. curcas* (1)	4 ± 4.0^{j}	8 ± 4.9^{j}	20 ± 6.3^{l}	24 ± 7.5^{m}	20 ± 6.3^{l}	15.2 ± 2.9^{j}

Values were based on 5 levels of content (1, 2, 3, 4 and 5%), five replicates of 10 insects in each replication.2- Values were based on 5 levels of content (1, 2, 3, 4 and 5%), over the 5 time duration (at 1, 2, 3, 4 and 24 h after insects were released). 3- Means with the same letter are not significantly different by Tukey's multiple range test ($P < 0.05$).

related to their components of plant extracts are mainly sesquiterpenes, alkaloids and fatty acids (Su, 1977; Lee et al., 2001; Adebowale and Adedire, 2006). *P. nigrum* extract could also be used as an insecticidal for adult boll weevil, *Anthonomus grandis* and both the dried seed powder of *P. nigrum* (Scott and McKibben, 1978). Its extracts were found to be effective grain products against rice weevil, *S. oryzae* and cowpea weevil, *Callosobruchus maculatus* (Su, 1977). Sighamony et al. (1986) showed that *P. nigrum* seed oil protected stored wheat effectively from two stored grain pests, *S. oryzae* (L.) and *Rhyzopertha dominica* (F.) at concentrations above 100 mg/l for up to 30 days. Su (1977) also showed that the ground black pepper and its crude extract were generally toxic for adult rice weevil at the lowest dose (3.13 µg/insect) and toxicity of *P. nigrum* extracts against *S. oryzae* showed 33 ± 3.3% mortality after 4 days (Kim et al., 2003). Dry black pepper, *P. nigrum* also has been reported to be toxic for housefly, *Musca domestics* L., rice weevil, *S. oryzae* L. and cowpea weevils, *C. maculatus* F. (Su, 1977; Scott and McKibben, 1978; Su and Horvat, 1981). Boateng and Kusi (2008) showed that *J. curcas* seed oil was highly toxic toward *C. maculatus* (100%) and *Dinarmus basalis* (78.7%) at the lowest dose (0.5 ml). This study shows that *P. nigrum* L. and *J. curcas* extracts were toxic to adult rice weevil. Additionally, our data also showed that insecticidal activities varied with the concentrations of the extracts used and exposure time.

Results shown in Table 4 revealed that plant extracts of *P. nigrum* and *J. curcas* repelled adults of *S. oryzae*. Where, the repellency activities were dependent to the extractions dosage. A five percent concentration of petroleum ether and chloroform extracts of *P. nigrum* and petroleum ether extracts of *J. curcas* showed 100, 100 and 80% repellency, after 4 h against adult of *S. oryzae*, respectively. However, after 24 h, only the petroleum ether extractions of *J. curcas* strongly repelled the adults of *S. oryzae* (96%). In overall, the repellent activities were more pronounced for petroleum ether and chloroform extracts of *P. nigrum* with 92 and 75.2% compared with petroleum ether extract of *J. curcas* with 69.6% (Table 4). As this result Prakash and Rao (1997) reported the dried seed powder of black pepper has an effective repellent against corn earworm, *Heliothis zea*. The results also supported by Boateng and Kusi (2008) who showed that *J. curcas* seed oil could repel 47.5% of the *Chalosobruchus maculatus* and *D. basalis* at the lowest dose (0.5 ml), whereas the highest dose (2 ml) repelled 95.0%. Yoon et al. (2007) showed that caraway and grapefruit oils at a dose of 1 µl repelled 77.8 and 61.1% of *S. oryzae*, respectively. Iqbal and Poswal (1995) reported that cloves and black peppers gave equal result in controlling *C. maculatus*. Furthermore, this study demonstrated that the plant extracts tested are effective as repellent for adults of *S. oryzae*.

There was also a significant weight loss on rice treated with plant extracts and control that treated with acetone only. The weight loss in rice is higher, where both larval and adult rice weevil feeding of them and larvae developing inside kernel. So this study showed the weight loss (%) on rice treated with petroleum ether and

Table 5. Antifeedant activity of extracts of *P. nigrum* and *J. curcas* and effect on emergence of F1 adult of *S. oryzae*[1].

Plant extract	Concentration (µl/g)	Number of F1 produced (Mean ± SEM[2])	Weight loss (Mean ± SEM[2])
Petroleum ether extract of *P. nigrum*	Control	19.09 ± 6.2 [a]	4.8 ± 1.5 [b]
	2	0	0.3 ± 0.0 [d]
	4	0	0.2 ± 0.0 [d]
	6	0	0.2 ± 0.0 [d]
	8	0	0.1 ± 0.0 [d]
	10	0	0.2 ± 0.0 [d]
Chloroform extract of *P. nigrum*	Control	19.76 ± 2.9 [a]	4.8 ± 1.5 [b]
	2	0	0.4 ± 0.1 [d]
	4	0	0.3 ± 0.0 [d]
	6	0	0.2 ± 0.0 [d]
	8	0	0.3 ± 0.0 [d]
	10	0	0.2 ± 0.0 [d]
Petroleum ether extract of *J. curcas*	Control	20.00 ± 3.1 [a]	8.6 ± 2.5 [a]
	2	0	8.1 ± 1.7 [a]
	4	0	7.6 ± 2.4 [a]
	6	0	3.3 ± 1.6 [c]
	8	0	0.8 ± 0.6 [d]
	10	0	0.2 ± 0.1 [d]

1- Each datum represents the mean of five replicates. 2- Mean within a column followed by the same letter is not significantly different (Tukey's Multiple Range test, $P < 0.05$).

chloroform extracts of *P. nigrum* and petroleum ether extracts of *J. curcas* were lower compared to the control ($F = 2.94$; $df = 10$; $P < 0.01$). Lower percentage of weight loss was observed at a concentration higher than 4 µl/g for petroleum ether extract of *J. curcas* (Table 5). Highest weight loss was recorded on sorghum by *S. oryzae*, too (Borikar and Tayde, 1979). This study also demonstrated that the plant extraction is effective, as antifeedant, against *S. oryzae* adults. Furthermore, the *S. oryzae* progeny was completely suppressed with petroleum ether and chloroform extracts of *P. nigrum* and petroleum ether extracts of *J. curcas* (Table 5). The adult of *S. oryzae* emerged from the treated rice was suppressed by the lowest concentration (2 µl/g) and no adult emerged was observed in all treatments as F1, except the control ($F = 12.13$; $df = 5$; $P < 0.0001$). Petroleum ether and chloroform extracts of *P. nigrum* and petroleum ether extracts of *J. curcas* caused complete inhibition of the eggs, larvae and pupae developments inside grain kernels (Table 5). These results find support by Agboka et al. (2009) who showed that the hatching of *Mussidia nigrivenella* eggs was adversely affected by "neem" and *Jatropha* oil, and decreased with increasing concentration of applied oils. Adebowale and Adedire (2006) reported that all tested *J. curcas* oil concentrations completely prevented adult emergence of *C. macullatus.* This study demonstrated that the tested plant extracts are effective as like as progeny production of adult *S. oryzae.* So, the findings of the present study indicated that using plant materials can be considered as alternative controls for *S. oryza*e.

Conclusion

The study was conducted to evaluate the toxicity and repellency of crude extract of *P. nigrum* and *J. curcas* on weight losses and progeny production of *S. oryza*e adults. The mortality increased with increasing concentration and exposure time. Meanwhile, petroleum ether and chloroform extracts of *P. nigrum* and petroleum ether extracts of *J. curcas* showed the highest toxicities compared to aqueous extracts of *P. nigrum* and chloroform and aqueous extracts of *J. curcas*. In addition the *P. nigrum* extractions showed a higher repellent effect on *S. oryzae* compared to *J. curcas* extractions. Moreover, petroleum ether and chloroform extracts of *P. nigrum* and petroleum ether extract of *J. curcas* extracts showed strong antifeedant and progeny production activities. F1 adults were suppressed at the lowest concentration and no F1 was produced in all treatments. The results demonstrate that *P. nigrum* and *J. curcas* extractions can be applied against rice weevil to protect stored grains.

ACKNOWLEDGEMENTS

The authors thank Dr. Ahmad Husni Mohd. Hanif (Department of Land Management, Faculty of Agriculture, University Putra Malaysia) for supplying of *J. curcas* seeds and Institute of Medicinal Plant (ACECR) Tehran, Iran for the assistance to supply the plant extracts.

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