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Research Article

Repellent Potential of Three Medicinal Plant Extracts against *Tribolium castaneum* (Coleoptera: Tenebrionidae)

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HR and SM perceived idea and elaborated it. HR, MH and QA expand experimental set up. HR, QA and MY performed experiment, collected and arranged data. HR and SM wrote manuscript. MH and SM made final editing. All authors read and agreed for submission of current form of manuscript.

Keywords
Tribolium castaneum, Ricinus communis, Methanol, Petroleum ether, Repellency, Synthetic pesticides.

Abstract | The present study was aimed to evaluate the repellent potential of *Ricinus communis* (L.), *Jatropha curcas* (L.) and *Citrus paradise* (MACF.) against *Tribolium castaneum* (Herbst). Plant materials (50 g powders of each of the plant was extracted on rotary shaker using four solvents *viz.*; methanol, chloroform, petroleum ether and n-hexane separately. Periodic analysis for the repellent effects was carried by impregnating each filter paper (half-disc of filter papers) with micropipette at three concentrations (5, 10 and15%) of each of the plant extract. The repellence was recorded after 24, 48 and 72 h of the treatments application. The findings of experimental trials presented significant mean repellency 79.15% of *T. castaneum* (with methanolic extract of *C. paradise*) followed by 76.21% (with *R. communis* extract) and 63.36% (in *J.curcus* extract) at 15% concentration, after exposure period of 24 h. Comparatively low mean repellency 58.45, 54.24 and 42.57% was observed at same concentration after exposure period of 72 h. Least repellency (11.23%) was recorded at 5% concentration of n-hexane based extract of *J. curcus* after exposure period of 72 h. Repellency was found significantly influenced by concentrations of plant extracts and the exposure time. Overall results showed that methanolic extracts were more effective than other three solvents and extract of *C.* paradise was found comparatively more effective and *R. communis* was found effective than *C. paradise*. Repellency varied inversely with increase of exposure time. Hence, these findings underlined the potential repellent effects of both plant extracts and highlighted their efficient use as ecofriendly stored food protectants instead of hazardous synthetic pesticides.

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Introduction

Stored products insect pests are accountable for substantial economic losses to stored commodities. *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae) and *Tribolium castaneum* (L.) (Coleoptera: Silvanidae) are key pests of stored grains products (Talukdar *et al.*, 2004). Use of phosphine fumigant, pyrethroids and organophosphates are the main streams for controlling insects in stored grain stuff (Muntaha *et al.*, 2017; Sousa *et al.*, 2008). However, development of resistance to these traditionally used insecticides has prompted the researchers to explore safe alternatives to synthetic insecticides for the effective control of stored grains pest insects (Ribeiro *et al.*, 2003; Guedes *et al.*, 2006; Pimentel *et al.*, 2010). Plant derived chemi-

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cals can be perfect candidates in controlling grain pests in worldwide (Talukdar *et al*., 2004; Hanif *et al*., 2016; Iqbal *et al*., 2015). They can be easily cultivated, are generally used as oils, powders or extracts and many are safe for both applicators and consumers (Oliveira *et al*., 1999). Numerous extracts of the plant extracts have been described to have insecticidal activities on vectors of veterinary interest or medical on pests of non-agricultural concerns, repellent and antifeedant effect against insect pests (Huang *et al*., 1998; Brahim *et al*., 2006; Obeng-Ofori and Freeman, 2001; Hasan *et al*., 2014). More than 100,000 secondary metabolites with insecticidal properties have already been identified, such as alkaloids, terpenoids, flavonoids and quinones, in approximately 200,000 species of plants worldwide (Ali *et al*., 2017; Potenza *et al*., 2004). These compounds present several modes of action on insects, mainly acute toxicity, repellency and the inhibition of feeding, growth, development and reproduction (Coats, 1994). So for are the *J. curcas*, *R. communis* and *C. paradise*. The miracle plant, *J. curcas* belongs to Euphorbiaceae, has been considered as potential source of ricin, a bio-pesticide for the management of insect pests of stored commodities, characterized by rusticity, resistance to drought and low susceptibility to pest attack (Nunes *et al*., 2009; Sapetaa *et al*., 2013). The latter characteristic can be attributed to the presence of compounds toxic to animals, such as lectins, saponins, phytates, trypsin inhibitors and phorbol esters (Adebowale and Adedire, 2006; Makkar *et al*., 1998; Silva *et al*., 2012). These compounds can be found in the whole *J. curcas* plant, but are more abundant in its seeds (Wakandigara *et al*., 2013). Studies report that seeds of *J. curcas* present insecticidal (Mahfuz and Khanam, 2007; Nabil and Yasser, 2012) and fungicide (Rana *et al*., 2012) activity. Many researchers have reported its repellent against stored grain insect pests like *Callosobruchus maculates* (F.) and *Callosobruchus chinensis* (L.) (Sabbour, 2013), *T. castaneum* with dichloromethane extract of *J. curcas* (Iqbal *et al*., 2010; Kalita and Bhola, 2014), *Lasioderma serricorne* (Salem *et al*., 2017). Castor bean, *Ricinus communis* has been selected for the management of insect pests due to presence of ricin, ricinine, N-demethylricinine, and flavonoids (Rossi *et al*., 2012). Ricin is the most toxic bioactive component present in seeds but ricinine which is an effective insecticide is located in all parts of the plant (Rana *et al*., 2012; Singh and Kaur, 2016; Openshaw, 2000). Oil of *R. communis* was found repellent against *T. castaneum* and *L. serricorne* (Salem *et al*., 2017). Oil of *C. paradise* was used against *Trogoerma granarium* and proved very effective (Sagheer *et al*., 2013). Leaf extracts of *C. paradisi* and *C. reticulata* proved very effective against *Rhyzopertha dominica*. Besides these three plant extracts many other plants such as *Allium sativum* (Ho *et al*., 1996), *Azadirachta indica* (Sagheer *et al*., 2014), *Nicotiana tabacum* (Hanif *et al*., 2016) and Talukdar *et al*. (2004) have found plant extracts very effective for the control of *T. castaneum*. Keeping in view the above scenario, current experiment was designed to check the repellent action of three plant extracts against *T. castaneum.*

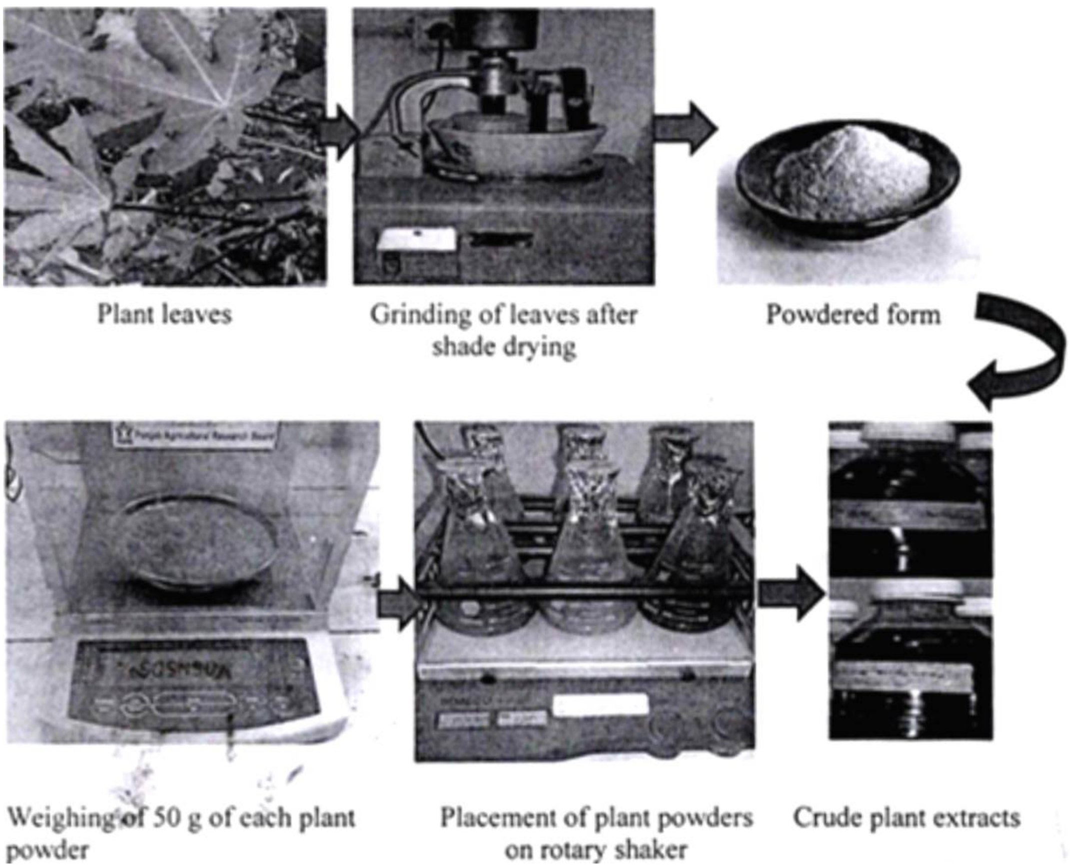

Figure 1: Schematic layout of plant material extraction for toxicity bioassay.

Materials and Methods

The present study was carried at entomology lab of Punjab Bioenergy Institute, PARS, UAF during 2017.

Collection and rearing of test insects

Mixed population of *T. castaneum* was collected from grain markets located in Faisalabad. The population of each of the two insects was acclimatized to laboratory in plastic jars of 1.5 kg capacity having commodity sterilized wheat flour for *T. castaneum*) sterilized for 30 min at 70ºC using oven (Lab Line Instruments Inc., Model No 3512-1) and covered with the muslin cloths. The adults of both insects were sieved out after three days from commodity. Sieved commodities containing eggs of target insects were placed in jars and placed under optimum conditions (65±5% R.H, 30±2ºC) to get the F_1 population that was considered as homogenous.

Plant materials

Leaves of *R. communis*, *J. curcas* and *C. paradise* were collected from different localities in University of Agriculture Faisalabad (UAF), cleaned by washing with sterilized water and shade dried in Entomology Lab of Punjab Bioenergy Institute, UAF. Dried leaves were ground into powder form using electrical grinder and sieved through a mesh (40 mm) to get a fine powder. Plant materials were extracted by mixing 50 g powder of each plant separately in 100 ml of the methanol, chloroform, petroleum ether and n-hexane by using Rotary Shaker (IRMECO, OS-10) at 220 rpm. After filtration, the solvent from the filtrate was evaporated by placing the filtrate in the rotary evaporator (Hasan *et al*., 2012; Sagheer *et al*., 2014). Complete process of plant material extraction is shown in Figure 1. After evaporation, the extracts obtained were considered as stock solution and were put in clean and air tight lid bottles and stored at 4.0°C in refrigerator.

Repellency bioassay

Three concentrations (5, 10 and 15 %) of the plant extracts were diluted from the stock solution using the four solvents. Dilutions were applied on filter papers and each filter paper was cut into two halves, first half of paper was treated with the dilution while remaining half was treated only with acetone as control unit (Area preference method). Thirty larvae of both insects were release in treated half of each petri-dish. Triplicates of each treatment level and control unit were used. The experiment units were placed in incubator until the completion of repellency bioassay and data regarding percentage repellency was recorded after 24, 48 and 72 h of the treatments application (Sagheer *et al*., 2014).

Statistical analysis

Recorded data was subjected to completely randomized design (Factorial under CRD) and Statistical Software version 7.0 was used for statistical analysis.

Table I: Repellent effect of leaf extract of *Ricinus communis, Jatropha curcas* and *Citrus paradise* against *Tribolium castaneum.*

Solvent	Concent. (%)	Repellency (%) ± SE 24 h	48 h	72 h
Ricinus communis				
Methanol	5	42.11±2.67	38.17±1.65	35.23±1.15
	10	64.01±2.87	56.02±2.87	50.42±2.37
	15	76.21±2.92	68.11±2.98	54.24±2.98
Chloroform	5	36.03±1.81	29.31±1.81	25.41±1.21
	10	45.41±2.66	39.21±2.35	33.21±2.25
	15	61.12±3.16	52.92±3.05	48.82±2.99
Petroleum ether	5	20.61±1.66	20.61±1.56	17.39±1.06
	10	43.32±2.77	37.27±1.87	27.27±1.87
	15	51.34±2.11	46.54±2.11	36.54±2.11
n-Hexane	5	20.23±1.21	16.25±2.17	14.43±1.11
	10	40.76±1.77	34.26±1.77	24.21±1.77
	15	48.76±2.47	35.10±1.87	29.37±1.92
Jatropha curcas				
Methanol	5	45.07±2.77	41.26±2.77	36.16±1.77
	10	51.17±3.23	43.00±3.03	39.12±3.03
	15	63.36±3.43	46.67±3.43	42.57±3.13
Chloroform	5	41.63±2.66	26.63±2.66	21.43±1.27
	10	47.02±2.77	37.52±1.77	28.86±1.77
	15	56.82±3.33	34.92±3.04	25.28±2.24
Petroleum ether	5	33.65±1.64	23.15±1.24	19.14±1.04
	10	39.06±2.52	30.02±1.52	22.39±1.48
	15	40.82±2.67	31.00±2.32	25.19±2.62
n-Hexane	5	26.65±1.64	20.14±1.24	11.23±1.64
	10	32.27±1.22	23.84±1.12	18.33±1.22
	15	36.98±2.77	28.18±1.87	20.68±1.42
Citrus paradise				
Methanol	5	57.35±3.03	50.05±2.03	41.35±1.87
	10	70.51±2.98	61.14±2.38	54.39±2.58
	15	79.15±3.03	68.95±2.89	58.45±3.33
Chloroform	5	47.64±1.45	38.87±1.45b	31.97±1.45
	10	49.10±2.33	30.10±1.33	23.62±1.13
	15	67.52±1.66	53.92±2.66	43.92±2.88
Petroleum ether	5	41.03±1.97	30.42±1.27	22.42±1.27
	10	47.16±2.11	34.63±1.81	25.63±1.81
	15	52.42±2.21	39.68±2.11	30.68±2.11
Hexane	5	20.84±2.27	19.24±2.27	12.84±1.17
	10	31.21±2.17	20.51±2.17	14.91±1.27
	15	35.93±2.67	24.93±2.67	16.83±2.07

Results

Highest repellency of about 76.21% by *T. castaneum* was achieved at higher concentrations (15%) of methanolic extract of *R. communis* after 24 h of treatment application, followed by 61.12% (by chloroform based extract of *R. communis*), 51.34% (in case of petroleum ether based extract) and 48.76% with n-hexane based extract (Table I). Lowest repellency (11.23%) was given by n-hexane ex-

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traction of *R. communis* powder at lowest treatment application rate (5%) after time interval of 72 h. At 10% concentration, 40.76%-64.01% repellency was recorded. From the results we determined that repellency varied inversely with exposure period. Moreover, repellency was found both concentration as well as solvent nature dependent (Table I).

Results of present study (Table I) disclosed that highest repellency 63.36 % of *T. castaneum* was achieved at higher concentrations (15%) of methanolic extract of *J. curcas* after 24 h of treatment application, followed 56.82% (in chloroform based extract of *J. curcas*), 40.82% (in case of petroleum ether based extract) and 36.98% with n-hexane based extract. Lowest repellency (14.43%) was given by n-hexane extraction of *J. curcas* powder at lowest treatment application rate (5%) after time interval of 72 h. At 10% concentration, 32.27%-51.17% repellency was recorded. From the findings we concluded that repellency varied inversely with exposure period. Moreover, repellency was found both concentration as well as solvent nature dependent. Methanolic extract comparatively proved more effective than the other three solvents.

Table I shows the highest repellency (78.15%) in methanolic extract of *C. paradise* at 15% after shortest time interval (24 h). Whereas relatively low repellency 70.51% (in case of methanolic extract) followed by 49.10% (by chloroform based extract) and 45.03% (as in case of petroleum ether) and 31.21% (in n-hexane extracted plant material) at 10% concentrations of *C. paradise*. Therefore, methanolic extract was found comparatively more effective as compare to chloroform, petroleum ether and n-hexane.

Discussion

Leaf extracts of three plant *R. communis*, *J. curcas* and *C. paradise* were used to check their possible repellent effects against *T. castaneum*. Extraction of plant materials was done using four solvents *viz*., methanol, chloroform, petroleum ether and n-Hexane. Extract of methanol was proved comparatively more effective and caused 83.15% repellency of *T. castaneum* at 15% concentration of *C. paradise*. The finding of current study was close to Sagheer *et al*. (2013) who used *N. tobaccum*, *S. barysoma*, *P. hermala*, *S. costus* and recorded maximum mean repellency of 55.33, 52.33, 51.33 and 46.67, respectively. The findings were close to our repellency results (51.34, 56.82, 52.42 and 48.76%). A slight difference is may be due to different plant extracts and insect species. The findings of current study coincide with Sagheer *et al*. (2013) who used oil of *C. paradise* against *T. granarium* and found high repellency at increased concentration. Leaf extracts of *C. paradisi* and *C. reticulata* proved very effective against *R. dominica*. The repellency findings in current study (our study) are similar to Huang *et al*. (1998) who checked potential of nutmeg oil against *Tribolium castaneum* (Herbst) and *Sitophilus zeamais* and recorded increased repellency value confirming our result. A slight difference may be due to different plant extract. The repellency results of our study are close to Hasan *et al*. (2005) who evaluated the leaf extracts of two plant extracts *Amaranthud viridis* L., *Salsola baryosma* (Schultes) and a synthetic insecticide (Cypermethrin) against *Trogoderma granarium* and observed relatively high repellency at increased concentrations of plant extracts. Our results are agreed with Kalita and Bhola (2014) who recorded similar repellency trend as in our study (increases repellency at increased concentration of plant extracts. The similar findings have disclosed by many other researchers such as Nadi *et al*. (2001), Al-Moajel (2004), Dwivedi, (2004), Hasan *et al*. (2005), Anwar *et al*. (2005) and Dubey *et al*. (2008).

Conclusion

From this study it was concluded that plant extracts have strong repellent potential against stored commodities insect pests. So these should be an integral part of sustainable stored grain insect pest management program.

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Conflicts of interest

The authors declare no conflicts of interest.

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