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POTENTIAL OF THREE INDIGENOUS PLANTS EXTRACTS FOR THE CONTROL OF *TRIBOLIUM CASTANEUM* (HERBST) AND *RHYZOPERTHA DOMINICA* (FAB.)

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ABSTRACT

The present investigation was done to evaluate the toxicity of leaf extracts of *Ricinus communis* (Linnaeus), *Citrus paradise* (Macfad) and *Jatropha curcus* (Linnaeus) against *Tribolium castaneum* and *Rhyzopertha dominica*. Plant extracts were prepared in four different solvents (methanol, chloroform, petroleum ether and n-hexane) and were applied at 5, 10 and 15% concentrations on wheat flour placed in small plastic jars. The data for mortality was recorded after 24, 48 and 72 hours. The highest mortality (65.06%) of *T. castaneum* was observed in methanol extract of *R. communis* while comparatively the least (39.21%) mortality was observed in n-hexane extract of *R. communis* at 15% concentration after an exposure period of 72 hours. In case of *J. curcus*, highest mortality (37.32%) was recorded in methanol extract while the lowest mortality (21.07%) was observed after 72 hours of treatment at 15% concentration. While in methanol extract of *C. paradise* the highest mortality (24.69%) was recorded at 15% concentration after 72 hours exposure period. The n-hexane based extract of *J. curcus* gave comparatively low mortality of the *T. castaneum* with values 4.24% at 15% and 1.03 % at lowest concentrations (5%) after 24 hrs. In case of mortality bioassay against *R. dominica*, highest mortality 59.51% was observed at 15% concentration of methanolic extract of *R. communis* after 72 hours while least 1.01 % at 5% concentration (of n-hexane extract of *J. curcus*) after 24 hours. The outcomes of current bioassays revealed that the mortality response of the tested insects was influenced by dose, exposure time and nature of solvent, used. The order of effectiveness of plant extracts was *R. communis* > *J. curcus* > *C. sinensis* and that of solvents was methanol > chloroform > petroleum ether > n-hexane. From results we conclude that methanolic extract of *R. communis* gave comparatively highest mortality of both insects after exposure of 72 hrs and lowest was recorded in n-hexane extract of *J. curcus* (after 24 hr).

Keywords: Solvent, Mortality, exposure period, concentrations, mortality, exposure period

INTRODUCTION

Stored grains and their products are attacked by different insect pests (Ahmedani *et al*., 2007). Around 10-25% postharvest losses have been assessed throughout the world due to the infestation of insect pests, microbial deterioration and other factors (Mathews, 1993). The red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) is a pervasive pest of stored commodities like wheat flour and crushed cereals (Lu *et al*., 2010). Larvae and adults of this insect feed on damaged grains (Boxall, 2001), resulting up to 1-10% losses in different stored varieties of sorghum (Majeed *et al*., 2016). *Rhyzopertha dominica* (Fabricius) (Coleoptera: Bostrichidae) is also a severe insect pest of stored grain items as their larvae are internal feeders (Toews *et al*., 2000).

The *T. castaneum* and *R. dominica* are primarily controlled by fumigant insecticides (Fields and White, 2002), but use of fumigants has become limited due to development of resistance and environmental hazards because of their reckless and injudicious use against these insect pests (Wright

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et al., 1993; Zettler *et al*., 2000). Other chemicals like pyrethroids are being used for the management of stored grains insect pests, but consistent use of theses insecticides may lead to serious problems related to biochemical and hematological changes in the human beings (Khan *et al*., 2012). Conventional insecticides also pose hazardous effect on non-target organisms including beneficial insects (Desneux *et al*., 2007; Miller, 2004). Unfortunately, these synthetic insecticides are not easily degradable and get accumulated in the environment, resulting in polluted surrounding (Fields and White, 2002). This alarming situation has prompted the researchers to explore biodegradable and ecofriendly insecticides (Hasan *et al*., 2016) which are crucial needs of the contemporary scenario. Botanicals can be the possible alternative for the control of insect pest due to their potential insecticidal properties (Sharma *et al*., 1998; Sukontason *et al*., 2004). The effect of plant products showed insecticidal, repellent and anti-feedant effects against insect pests (Ali *et al*., 2017).

Plant extracts are environment friendly insect pest management tools and can be effectively applied against stored grain insects (Tapondjou *et al*., 2002). Many plant extracts have been screened for the toxic effects such extracts of *Jatropha curcus* having insecticidal properties against *Sitophilus granarius* (Nabil and Yasser, 2012; Rana *et al*., 2012), *T. castaneum* and *T. confusum* (Silva *et al*., 2012). Extract of *Moringa oleifera* and *Nicotiana tabacum* were found effective against *T. castaneum* (Ali *et al*., 2013). Use of garlic extract was proved effective for the control of *S. zeamais* and *T. castaneum* (Ho *et al*., 1996). Extract of *Azadirachta indica* and *N. tabacum* proved effective against *T. castaneum* (Hanif *et al*., 2016). Several indigenous plant extracts were recorded as repellent against *Trogoderma granarium* (Al-Moajel and Al-Fuhaid 2003; Ali *et al.,* 2012). Crushed seeds and leaves of plants have been found effective against *R. dominica* and *T. castaneum* (Talukdar *et al*., 2004). *Azadirachta indica* was found very effective against *T. castaneum* (Iqbal *et al*., 2015). Different varieties of citrus species including *Citrus paradise* have been used for the control of *R. dominica* and *T. granarium* (Abbas *et al*., 2012; Sagheer *et al*., 2013). Castor bean, *Ricinus communis* (Linnaeus) was selected for the management of insect pests due to presence of ricin, ricinine, N-demethylricinine, and flavonoids. 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 (Singh and Kaur, 2016). These compounds have shown remarkable insecticidal, antifeedent and repellent activities. Studies have reported toxic effects of *R. communis* extract against arthropod vectors like ticks, mites and mosquitoes. Obeng-Ofori and Freeman (2001) used extracts of *R. communis* and *Solanum nigrum* against *T. castaneum* and *S. oryzae* and proved very effective against both beetles. Aqueous extract of this plant was also found effective against many other insects like larvae of *Culex pipiens*, *Aedes caspius*, *Culiseta longiareolata, Anopheles maculipennis* (Diptera: Culicidae) (Brahim *et al.*, 2006). The leaf extract of *R. communis* has been shown to possess insecticidal properties against insect pests like *Spodoptera frugiperda* (Rossi *el al*., 2012), *Callosobruchus chinensis* (Upsani *et. al*., 2003) and *Cosmopolites sordidus* (Coleoptera: Curculionidae) (Tinzarra *et al*., 2006). Leaf extract of *R. communis* was proved very effective for the control *M. domestica* population (Singh and Kaur, 2016). So, keeping in view the above experimentally proved desirable properties, the current research work was carried out to evaluate the insecticidal potential of three plant extracts (*Ricinus communis*, *Jatropha curcus* and *Citrus paradise*) against *T. castaneum and R. dominica*. The findings of this study will be helpful for eco-friendly management of insect pests in our storage structures with no residual effects in grains. It will open new horizons for upcoming researchers to explore the potential of botanicals for efficient control of insect pests and purification of crude extracts, finally commercialize these bio-based insecticides to cut down the un-judicial use of traditionally used hazardous fumigants.

MATERIALS AND METHODS

The present study was carried at Entomology Laboratory, Punjab Bioenergy Institute, Post Graduate Agricultural Research Station (PARS), University of Agriculture Faisalabad.

Collection and rearing of test insects

Mixed age population of *T. castaneum* and *R. dominica* was collected from grain markets located in Faisalabad. The population for each of the two insects was acclimatized to laboratory in plastic jars of 1.5 kg capacity having commodity (sterilized wheat grains for *R. dominica* and wheat flour for *T. castaneum*), sterilized for 30 min at 70 ºC 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. and 30±2 ºC) to get the F_1 population that was considered as homogenous.

Plant materials

Leaves of *R. communis*, *Jatropha curcus* and *Citrus paradise* were collected from different localities in Faisalabad, cleaned with sterilized water and shade dried. Dried leaves were ground into powder using electrical grinder (Pascal engineering Co. ltd., Gatwick road crawley sussex, England) 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 (Sagheer *et al*., 2013). After evaporation, the extracts obtained were considered as stock solution and were put in clean and air tight lid bottles, labeled and stored at 4.0°C in refrigerator.

Toxicity bioassay

Three concentrations (5, 10 and 15 %) of the plant extracts were diluted from the stock solution using the four solvents. The concentrations were applied on 20 g crushed grains, shaken for even distribution of concentrations, allowed to air dried and placed in small plastic jars. Thirty adults of both the insects were released in treated diet containing jars. The treated units were placed in incubator until the completion of

mortality bioassay and data regarding mortality was recorded after 24, 48 and 72 hours of the treatment.

Statistical analysis

Recorded data was subjected to Abott's formula for the calculation of percent corrected values (i.e. mortality), and statistical analysis (ANOVA) was performed using statistica-8.1 software. Treatments means were compared by using Tukey-HSD test at 5% significant level.

RESULTS

Results in Table-1 shows that the highest mortality (65.06%) of *T. castaneum* was achieved at higher concentrations (15%) of methanol base extract of *R. communis* whilst the lowest mortality (1.11%) was recorded in n-hexane based extract of *R. communis* at lowest treatment application rate (5%) after 24 hours of exposure time. All plants concentrations (5, 10 and 15%) were found significant ($p<0.001$, F (cal) = 14.231) and there was a significant difference between different plants at various concentrations ($p<0.041$, F (cal) = 6.145). Mortality response was also influenced by nature of the solvent.

Table 1

Toxicity of leaf extracts of *Ricinus communis* against *Tribolium castaneum*

Solvent	Concentrations (%)	Mortality (%) ± SE		
		24 hours	48 hours	72 hours
Methanol	5	10.54±1.09	27.54±2.22	49.10±1.09
	10	34.43±1.11	43.10±1.11	59.43±2.87
	15	46.21±1.09	59.76±1.21	65.06±2.08
Chloroform	5	5.21±1.11	19.34±1.07	32.10±1.11
	10	10.23±1.11	31.55±1.10	41.10±1.59
	15	26.12±2.93	35.52±1.11	52.32±1.09
Petroleum ether	5	2.21±1.11	5.32±1.11	5.32±1.10
	10	4.43±1.11	9.43±2.21	25.43±2.11
	15	12.23±2.93	27.76±2.93	46.12±2.83
n-Hexane	5	1.11±1.09	3.32±1.11	8.87±1.11
	10	4.43±1.11	6.65±1.11	20.00±1.92
	15	10.21±2.93	24.23±2.93	39.21±2.93

Table 2

Toxicity of leaf extracts of *Jatropha curcus* against *Tribolium castaneum.*

Solvent	Concentrations (%)	Mortality (%) ± SE		
		24 hours	48 hours	72 hours
Methanol	5	1.11±1.09	3.36±2.27	7.36±2.27
	10	2.21±1.10	6.64±1.92	13.10±1.92
	15	9.27±1.92	21.27±1.12	37.32±1.92
Chloroform	5	1.11±1.07	5.31±2.11	6.35±2.17
	10	5.11±1.12	8.12±1.72	11.10±1.92
	15	6.29±1.82	20.23±1.82	33.42±1.72
Petroleum ether	5	1.05±1.00	2.25±1.13	5.72±1.94
	10	2.27±1.12	4.47±1.19	8.21±1.12
	15	5.24±1.32	18.43±1.42	31.65±1.94
n-Hexane	5	1.03±1.09	3.36±1.12	6.73±1.94
	10	1.27±1.11	4.48±1.12	10.21±1.12
	15	4.24±1.12	18.24±1.12	25.07±1.13

Data in Table 2 elaborates that highest mortality 37.32% was recorded at concentrations 15% of methanolic extract of *Jatropha curcus*. Comparatively lowest mortality 1.03% was achieved at 5% concentration in n-Hexane based extract. Methanolic extract was found comparatively more effective than the other three solvents and mortality response was influenced by exposure time and concentration of the plant extract.

Table 3
Toxicity of leaf extracts of *Citrus paradise* against *Tribolium castaneum.*

Solvent	Concentrations (%)	Mortality (%) ± SE		
		24 hours	48 hours	72 hours
Methanol	5	2.12±1.00	5.54±1.12	7.85±1.12
	10	4.67±1.11	6.12±1.92	15.71±1.82
	15	5.32±1.12	14.43±1.12	24.69±2.24
Chloroform	5	1.12±1.11	4.97±1.12	7.76±1.11
	10	2.10±1.11	6.89±1.92	12.92±2.23
	15	4.12±1.12	12.32±2.12	20.21±2.54
Petroleum ether	5	1.10±1.11	5.52±1.12	6.84±2.12
	10	1.27±1.11	5.89±1.92	9.89±1.52
	15	3.57±1.12	11.32±2.12	17.32±2.11
Hexane	5	1.12±1.00	3.29±1.11	3.29±1.11
	10	2.01±1.11	4.48±1.12	4.48±1.12
	15	5.17±1.12	10.17±1.12	13.17±1.12

Data presented in Table-3 showed that highest mortality (24.69%) was recorded in methanolic extract of *C. paradise* at 15% after time interval of 72 hours and least 1.12% was noticed after 24 hr at 5% concentration (in case of n-Hexane extract). Methanolic extract was found comparatively more effective than others.

Data in Table-4 disclosed that all plants concentrations (5, 10 and 15%) were found significant ($p<0.001$, F (cal) = 10.157) and there was a significant difference between different plants at various concentrations ($p<0.046$, F (cal) = 4.971). Highest mortality 59.51% of *R. dominica* was achieved at higher concentrations (15%) of methanol base extract of *R. communis*. Lowest mortality (1.00%) was given by n-hexane based extract at lowest treatment application rate, after 24 hours of exposure time. Mortality response was found time, concentration and solvent nature dependent.

Table 4
Toxicity of leaf extracts of *Ricinus communis* against *Rhyzopertha dominica.*

Solvent	Concentrations (%)	Mortality (%) ± SE		
		24 hours	48 hours	72 hours
Methanol	5	9.57±1.11	17.57±1.11	32.02±1.24
	10	15.25±1.24	28.21±1.84	42.96±2.12
	15	24.44±2.54	40.41±2.92	59.51±3.12
Chloroform	5	5.07±1.10	8.87±1.11	17.76±1.24
	10	6.56±1.11	16.15±1.84	32.23±1.12
	15	14.23±2.54	28.81±2.52	51.54±1.12
Petroleum ether	5	2.12±1.10	6.43±1.11	11.26±2.24
	10	6.27±1.11	10.13±1.84	22.23±1.12
	15	13.14±1.54	20.11±1.92	44.52±1.12
n-Hexane	5	1.05±1.10	6.43±1.34	10.26±3.24
	10	4.27±1.23	9.43±1.84	19.13±1.12
	15	9.14±2.54	15.11±2.82	39.34±3.34

Data in Table-5 elaborated that highest mortality 49.17% was examined at 15% concentration of methanolic extract of *R. communis*. Comparatively lowest mortality 1.05 % was achieved at 5% concentration of n-Hexane based extract. Methanolic extract was found comparatively more effective than the other three solvents and mortality response was influenced by exposure time and concentration of the plant extract.

Table 5
Toxicity of leaf extracts of *Jatropha curcus* against *Rhyzopertha dominica.*

Solvent	Concentrations (%)	Mortality (%) ± SE		
		24 hours	48 hours	72 hours
Methanol	5	8.12±1.12	13.12±1.18	21.32±2.28
	10	24.92±1.27	32.52±1.66	39.12±2.66
	15	30.27±2.64	37.27±2.64	49.17±2.74
Chloroform	5	6.12±1.12	11.12±2.39	15.32±1.88
	10	17.42±1.66	26.42±1.66	31.52±2.67
	15	23.07±2.64	29.27±2.32	38.27±3.17
Petroleum ether	5	3.05±1.00	7.15±1.13	12.72±1.94
	10	9.27±1.12	17.47±1.19	24.21±1.07
	15	14.24±1.42	22.23±2.23	29.65±2.18
n-Hexane	5	1.01±1.03	5.36±1.12	9.73±1.14
	10	3.05±1.11	11.48±1.92	21.11±3.12
	15	8.14±2.12	15.14±1.12	19.07±2.13

Table 6
Toxicity of leaf extracts of *Citrus paradise* against *Rhyzopertha dominica.*

Solvent	Concentrations (%)	Mortality (%) ± SE		
		24 hours	48 hours	72 hours
Methanol	5	7.42±1.88	16.24±1.12	23.15±1.12
	10	13.02±1.67	19.13±1.92	29.81±2.42
	15	17.27±2.23	28.32±2.12	36.69±3.21
Chloroform	5	3.12±1.12	8.97±1.12	17.32±2.11
	10	8.76±1.11	16.19±1.72	20.92±2.23
	15	12.12±2.12	19.02±2.92	25.46±2.94
Petroleum ether	5	1.10±1.11	5.52±1.12	12.14±2.12
	10	1.27±1.11	4.29±1.92	9.89±1.52
	15	7.57±1.12	9.52±2.12	19.12±2.17
n-Hexane	5	1.12±1.00	3.29±1.11	3.29±1.11
	10	4.47±1.11	7.41±1.59	11.48±1.12
	15	5.17±1.12	10.17±1.12	14.31±1.12

Data presented in Table-6 showed that highest mortality 36.69% (in methanolic extract) at 15% after time interval of 72 hours and comparatively 1.10 % (as in case of petroleum ether extract) of the tested plant extract (*C. paradise*). Methanolic extract was found comparatively more effective than other.

DISCUSSION

Leaf extracts of three plant *R. communis*, *J. curcus* and *C. paradise* were used to check their possible toxic effects against *T. castaneum*. Extract of methanol was proved comparatively more effective and caused 70.06% of *T. castaneum* at 15% concentration of *R. communis*. The finding of current study was close to Hanif *et al*. (2016) who found 68% and 69 % mortalities with extract of *A. indica* after 72 hours of treatment application. Our findings were similar to Singh and Kaur (2016) who found 72% mortality against *Musca domestica* with methanol extract of *R. communis*. Slight difference may be due to different insect species. Our result of 32.65% mortality of *T. castaneum* with petroleum ether extract of *R. communis* was close to findings of Iqbal *et al*. (2015) who used similar solvent extract of *A. indica* against *T. castaneum*. Mortality results of current study with *C. paradise* were in confirmation with the Sagheer *et al*. (2013) who used citrus species against *T. granarium*. Slight difference may be due to different insect spp. and treatment (plant oils) than current study (plant extracts). The findings were close to Talukdar *et al*. (2004) who use plant extracts against *T. castaneum* and found increased mortality with increased concentrations of extracts. The results of petroleum ether of our study were close to Singh and Kaur (2016). Rossi *et al*. (2012) used *R. communis* extract against *Spodoptera frugiperda* and found increased mortality at highest concentration similar to our results. Obeng-Ofori and Freeman (2001) found increased mortality values at higher concentrations in confirmation with our study. The mortality results of current study were in accordance with Silva *et al*. (2012) carried toxicity bioassay against two stored grain insect pests (*S. zeamais* and *R. dominica*) and found increased mortality at highest concentration of *J. curcus* and after longest exposure period. The findings of mortality in current

study against *R. dominica* (1.10, 1.12 and 7.42% after 24) are close to Toews *et al*. (2000) who found mortality values 1.67, 2.92 and 5.46% against same insect species. A slight difference may be due to different plant extracts were used compared to our study. Our results of mortality bioassays coincide with Ho *et al*. (1996) used *Allium sativum* against *T. castaneum* and found increased mortality at higher concentrations. Keita *et al*. (2000) checked the efficacy of some plant oils against *Callosobruchus maculatus* (F.) and found increased mortality at highest concentration, confirms our results.

Overall extracts of methanol extracts were found comparatively more effective than others. This might be due to the fact that more polar is the solvent the greater will be the extraction ability to polar compounds. Hence methanol has relatively greater polarity index so methanolic extract gave comparatively better results than other solvents ("like dissolve like" rule)**.** The order of effectiveness of plants was *R. communis*>*J.* curcus>C. *paradise*. Hence, Plant extracts are effective tools and can be efficiently used in integrated way with other controlling tactics for the ecofriendly management of stored product insect pests.

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