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(RESEARCH ARTICLE)

Toxic and repellent potentials of different plant oils and new chemistry insecticides against *Tribolium castaneum*

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Abstract

Stored grains commodities are attacked by a variety of beetles and larvae of lepidopteron insect pest of them, *Tribolium castaneum* (Herbst) is a severe insect pest of stored commodities throughout the world. This insect is widely spreading various climatic regions throughout the world. Results of bioassay with Spinetoram exposed that maximum larval mortality was detected 88.87% and 44.04% after "48 hr" and "72 hr". Exposure time period after 0.03% concentration, correspondingly. Minimum mortality 14.17% after "24 hr" at same concentration. At lower concentration 0.02%, maximum mortality 61.96% after "72 hr", 31.65% after "48 hr" of exposure time period. Minimum mortality of 15.02% was observed after "24 hr". At lowest concentration 0.01%, maximum mortality 60.38% was recorded at "72 hr", 28.22% after "48 hr". Whereas, minimum mortality 8.41% was detected after "24 hr". The mortality was increased by increased the concentration of spinetoram and exposure time. Repellent activities of acetone based plant extracts of *Eruca sativa*, *Azadirachta indica* and *Ricinus communis* against the insect pest of stored grain commodities, *Tribolium castaneum*. Various concentrations (5, 10 and 15%) of the plant extracts were applied on the filter papers in the bioassay experiments and after the release of 15d old beetles, repellency was evaluated after fixed intervals (12, 24). Increased repellency was found at increased concentrations of plants. The concentration interaction and plant extracts findings for the treatments remained momentous. The generally findings exposed raised death rate with raise the doses and time period.

Keywords: *Eruca sativa; Azadirachta indica; Ricinus communis; T. castaneum*

1. Introduction

Stored grains commodities are attacked by a variety of beetles and larvae of lepidopteron insect pets. Of them, *Tribolium castaneum* (Herbst) is a severe insect pest of stored commodities throughout the world. The larvae and adults feed actively on extensive range of long term commodities such as cereals, spices, beans etc. Mainly attack the germ part of seed leading to its poor germination [1]. Huge infestation occurs in favorable conditions (hot and humid conditions). Moreover, *T. castaneum* attacks in enormous number, leave behind shredded skins, secrete quinines and other toxic substances [2]. This insect is widely spreading various climatic regions throughout the world [3]. Total annual post-harvest deficits of stored cereals credited to various natural factors in the storages range between 10-20% of overall development [4]. Traditional insecticides (fumigants and other synthetic insecticides) have been in practice for the stored grains insect pest management. But excess, repeated and injudicious use of these pesticides poses a lot of problems to humans and natural environment [5]. Use of these fumigants has results in soil contamination, resistance development in the insects (Phosphine resistance) in insects [6]. Indiscriminate use of organophosphates produces

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resistance in a number of stored grain insect pests. After that, the use of these organophosphates was decreased [7]. Therefore, there is need to develop and use those pesticides which are environment friendly, less toxic to humans and can control store grain insect pest efficiently. Due to toxic and harsh nature of the fumigants, adverse effects have occurred on human beings and natural enemies such as predator, parasites and parasitoids [8]. All plant derived substances have repellent as well as feeding deterrence properties [8]. The insecticidal action of wide-ranging plant extracts plus more generally of some plant based products chemicals established fact and their utilize was looked after for a large number of previous time throughout all the farming parts of the planet [9]. Plant extracts can be potential and reliable sources for the effective management of stored products insect pests [10]. Many plants have been used in past a now a day against different insect pests' species. Plant materials have repellent effects against stored products insect pests [11]. Plants belong have many toxic substance and volatile compounds which can be explored for the efficient management of insect pests [12]. Scented oils from aromatic plants have been reported to have feeding deterrence [13] and toxic effects can be applied as potential and sustainable alternatives to synthetic insecticides in IPM program for efficient management of stored grains insect pests [14]. Besides these many other researchers have also documented the repellent and toxic effects of different plant materials against insects. The discovery of new chemistry insecticides has opened new horizons in insect pest management. New chemistry insecticides are the microorganisms derived insecticides and have been applied for the management of stored grain insect pests as well as filed insect pests [15]. These insecticides are eco-friendly, have comparatively less toxic effects and have low mammal toxicity compared to other synthetic insecticides [16].

The objectives of study is to investigate the toxic and repellent potentials of three plant oils (*Azadirachta indica*, *Ricinus communis* and *Eruca sativa*) and new chemistry insecticide against *Tribolium castaneum*.

2. Material and methods

2.1. Collection and mass rearing of the bioassay insects

Adults of *Tribolium castaneum* were collected from different grains handlings and storage localities (grain markets) and brought back for mass reared in the laboratory to get homogenous insect culture of the test insect pest. Sterilized plastic jars (having 1.0 kg capacity) were used for mass rearing insect culture. To confined (avoid the escape) the population of the tested insect, plastic jars were covered with muslin cloth, tightened with rubber bands. The insects were reared on wheat grains flour (as diet). Counted number of adults (100 adults) was released in the plastic jars and place under optimal growth conditions (30+2 ºC and 65+5 % R.H) of the insect. After 3 days, the released beetles were shifted to other jars. The sieved flour containing eggs was again placed into the plastic jars for rearing of the insect till achievement of same age adults, to be used for bioassays.

2.2. Collection of plants parts for oil extraction

Seeds of *Eruca sativa*, *Azadirachta* indica and Ricinus communis were gathers from different experimental fields in UAF, Faisalabad. The seeds were washing by fresh water and shade dried in the laboratory. Then ground into powders with the help of electrical grinder. Plant oils were extracted against acetone in Soxhlet apparatus in 1:5 ratios of each plant powder (g) and acetone (dipping 50 gram of plant powder in 250 ml acetone). Extracted oils of the selected plants were poured into small cleaned reagent bottles, air tightened and then stored in refrigerator at 4 ºC for further experimentations. New chemistry insecticides were purchased from spray market, located in Faisalabad.

2.3. Mortality Bioassays

Different concentrations (5, 10 and 15 %) of each of the plant oil and 0.01, 0.02 and 0.03% new chemistry insecticide were prepared in acetone and applied on filter papers, separately. Thirty adults of *T. castaneum* (from homogenous population) were bio-assayed. After treatments application, all the experimental units (petri-dish) were placed in cool incubators and data regarding mortality of the test insect pest were recorded after 24, 48, and "72 hr" of the post treatment application.

2.4. Repellency bioassay

Surface area preference method was followed in evaluating the repellent potential of the plant extracts and new chemistry insecticides. Half of each filter paper was treated whilst leaving untreated the second half of each filter paper by different concentrations (as mentioned earlier). Both half of each filter paper was clipped at central point and placed in petri-dishes and data regarding repellency were recorded after 12 and "24 hr".

2.5. Statistical analysis

Outcomes of the bioassays (especially mortality data) were corrected by Abbott's formula and then subjected to static software 8.1 for analysis. Comparison of treatments means was done by Tukey's-HSD test (at α 5%).

3. Results and discussion

3.1. Mortality findings after "24 hr"

Table 1 Comparison per cent mean mortality values of *Tribolium castaneum* after application of altered concentrations of plant oils

Concentrations (%)	Per cent Mean mortality ± SE
5	5.13 ± 1.30 c
10	2.21 b
15	15.90 a

Data in Table (1) displayed lowest mean per cent mortality 5.13 % at 5% concentration and 15.90 % mortality was recorded at 15% concentration of the plant oils, used. From findings of the bioassay we can conclude that per cent mean per cent mortality of *T. castaneum* was found significantly affected by plant oil concentrations.

Table 2 Comparative mean percentage mortality values of *Tribolium castaneum* at different concentrations

Plant oils x Concentrations (%)	(%) Mean Mortality ± SE
Ricinus communis x 5	3.15±1.06 e
Ricinus communis x 10	7.36±1.92d
Ricinus communis x 15	13.52±1.64cd
Eruca sativa x 5	8.16±2.19 d
Eruca sativa x 10	15.67±1.96 cd
Eruca sativa x 15	22.42±1.25 b
Azadirachta indica x 5	9.62±2.57 d
Azadirachta indica x 10	18.71±2.03 c
Azadirachta indica x 15	38.16±2.03 a

Table 2 displayed that relatively highest mortality 38.16% was recorded at 15% concentration of *Azadirachta indica* with exposure period of "24 hr". Followed 22.42 % with extract of *Eruca sativa* and 13.52% by extract of *Ricinus communis* at same concentrations. At 10% concentration, mean percentage mortality values were 18.71, 15.67 and 7.36% respectively. Comparatively low mortality values 9.62, 8.16 and 3.15% were examined at 5 % concentrations of *A. indica*, *E. sativa* and *R. communis* correspondingly. From the outcomes we can determined that there was a slowly increase in mortality values with rise in plant extract concentrations, used.

3.2. Mortality data after exposure of "48 hr"

Table 3 Comparison of the mean percentage mortality of *Tribolium castaneum* after exposure to different concentrations of plant oils

Concentrations (%)	Mean percentage mortality ± SE
5	8.34±2.04
10	20.16±1.86
15	32.13±3.07

Tabulated data (3) represents the lethal effects of different concentrations of three different oil against *Tribolium castaneum*. Highest mortality (32.13%) at 15% was noticed. The mortality was 8.34 and 20.16 % at 5 and 10 % concentration, respectively. From the outcomes it is concluded that mortality only increased with increase in concentrations of the three plant oils and also displayed that concentration has notice-worthy effect on % mean per cent mortality of T. castaneum.

Table 4 Interaction effect (Plant oils x Concentrations) for mean percentage mortality of *Tribolium castaneum*

Plant oils x Concentrations (%)	(%) Mean Mortality ± SE
Ricinus communis x 5	6.34±1.52g
Ricinus communis x 10	13.15±1.52def
Ricinus communis x 15	18.17±1.52efg
Eruca sativa x 5	9.67±0.34fg
Eruca sativa x 10	21.34±1.34de
Eruca sativa x 15	29.01±1.27bc
Azadirachta indica x 5	12.12±1.54cd
Azadirachta indica x 10	31.98±1.87b
Azadirachta indica x 15	49.11±2.42a

Table 4 showed the interaction between different concentrations (5, 10 and 15%) and different exposure time period. Mean comparison of percentage mortality values of *T. castaneum* at different concentrations of selected plant extract were highest at maximum concentration. Findings of the mortality bioassay indicated that maximum mortality (49.11%) at 15% was recorded by *Azadirachta indica*. The mean mortality was 31.98% at 10% concentration and 12.12% mortality was observed at 5% concentration of the plant oil. Oil of *Eruca sativa* gave mean per cent mortality (27.01%) at 15% was recorded. The mean mortality was 21.34% at 10% concentration and 9.67% mortality was observed at 5% concentration of the *E. sativa*. Plant oil of *Ricinus communis* gave relatively mean mortality (18.17%) at 15% was recorded whilst least mortality 6.34% was observed at 5% concentration of the plant extracts. The given outcome showed that interaction of exposure time and concentration was significant. From results we concluded that there was a gradually increase in mortality values with increase in concentration of plant oils.

3.3. Mortality data after exposure of "72 hr"

Table 5 Comparison of the mean percentage mortality of *Tribolium castaneum* after exposure to different plant oil concentrations

Concentrations (%)	Mean % mortality ± SE
5	21.61 ± 2.36 c
10	30.97 ± 3.24 b
15	44.86 ± 2.56 a

Data Table 5 showed that mortality 21.71% mean percentage mortality was recorded at 5% concentration and 44.86% mortality was observed at 15% concentration of the plant oils. From results we can conclude that concentration has significant effect on per cent mean per cent mortality of *T. castaneum*.

Table 6 Comparative mean percentage mortality of T. castaneum after exposure to various concentrations of plant oils after

Plant oils x Concentrations (%)	(%) Mean Mortality ± SE
Ricinus communis x 5	15.32±2.88
Ricinus communis x 10	25.82±1.66
Ricinus communis x 15	28.67±2.64
Eruca sativa x 5	22.46±2.88
Eruca sativa x 10	42.56±2.92
Eruca sativa x 15	49.38±2.89
Azadirachta indica x 5	30.87±1.66 bc
Azadirachta indica x 10	35.02±3.38 ab
Azadirachta indica x 15	57.81±3.40ab

Table 6. Exposed that, highest mortality 57.81% was recorded with 15% concentration of *Azadirachta indica* after exposure of "48 hr" followed 49.38 % with extract of *Eruca sativa*, *whilst Ricinus communis* gave 28.67% at 15% concentrations. Mean percentage mortality of 30.87 % was recorded at 5% concentration of *Azadirachta indica*, followed by *Eruca sativa* 22.46%. Mean mortality of 17.40 % was given by *Ricinus communis* at 5% concentration. The lowest mean mortality was found 25.82 at 10% concentration of *R. communis*. In case of *Azadirachta indica* and *Eruca sativa* 35.02 and 42.56% mean percentage mortality were observed at 10% concentration of plant extract. From results we concluded that, there was a gradually increase in mortality values with increase in concentration of plant extracts

3.4. Mortality data with Spinetoram

Table 7 Comparison of the mean percentage mortality of *Tribolium castaneum* after exposure to different concentrations of Spinetoram

Concentrations (%)	Larval Emergence ± SE
0.01	32.08 ± 3.36 b
0.02	36.54 ± 2.98 b
0.03	3.24 a

Data Table 7 showed that mortality 32.08 % mean percentage mortality was observed at 0.01% concentration and 49.96% mortality was observed at 0.03% concentration of the plant extracts. From results we can conclude that concentration has significant effect on per cent mean per cent mortality of *T. castaneum*.

Table 8 Comparative mean percentage mortality of *Tribolium castaneum* after exposure to different concentrations of Spinetoram

Time x Concentrations (%)	(%) Mean Mortality ± SE
24 x0.01	8.42±2.88 f
24x 0.02	15.02±1.66de
24x 0.03	15.27±2.64 de
48 x0.01	28.32 ±3.13cd
48x 0.02	31.65±1.65 cd
48x 0.03	45.02±3.32 bc
72 x 0.01	59.48±2.88 ab
72x 0.02	62.96±2.92 b
72x 0.03	89.88±2.89 a

Table 8 showed that maximum mortality 89.88% was observed with 0.03% concentration of spinetoram after exposure of "72 hr". Mortality was 62.96% followed by 31.65% and 15.02 was observed with 0.02% concentration of the

spinetoram. Mortality was 59.48 was observed after "72 hr" at 0.01% concentration, followed by 28.32 % after "48 hr" and 15.27 % after "24 hr" of the exposure period of the spinetoram. The 0.02 % and 0.03 % concentrations of the spinetoram showed almost equal mortality results. After "48 hr", mortality was 45.02 at 0.03% concentrations of spinetoram. From results we concluded that almost all concentration and exposure time intervals were significant there was a gradually increase in mortality values with increase in concentration of spinetoram.

3.5. Combined mortality data of plant extracts and spinetoram

Table 9 Combined effects of plant oils and Spinetoram for mean percentage mortality of *Tribolium castaneum*

Combined effects	% Mortality ± SE
Ricinus communis (15%)+*Spinetoram*(0.03%)	34.28 ± 2.36 b
Eruca sativa (15%)+*Spinetoram*(0.03%)	36.53 ± 2.38 b
Azadirachta indica (15%)+*Spinetoram*(0.03%)	3.05 a

Data Table 9 showed that mortality 34.28% mean percentage mortality was observed with *Ricinus communis* (15%)+*Spinetoram* (0.03%). Mortality of 36.53 % was observed for *Eruca sativa* (15%)+*Spinetoram* (0.03%). Mortality of 52.47 % was observed by *Azadirachta indica* (15%)+*Spinetoram* (0.03%). From results we can conclude that combine action of *Azadirachta indica* + *Spinetoram* has significant effect on per cent mean per cent mortality of *T. castaneum*.

Table 10 Comparison of the mean percentage mortality of *Tribolium castaneum* by combine action of different plant oils at different time periods

Plant x Time	(%) Mean Mortality ± SE
Ricinus communis (15%)+*Spinetoram*(0.03%) x 24	15.24±2.88 d
Ricinus communis (15%)+*Spinetoram*(0.03%) x 48	25.17±2.66cd
Ricinus communis (15%)+*Spinetoram*(0.03%) x 72	39.38±1.71 bcd
Eruca sativa (15%)+*Spinetoram*(0.03%)x 24	16.65 ±3.40d
Eruca sativa (15%)+*Spinetoram*(0.03%)x 48	33.35±3.26 bcd
Eruca sativa (15%)+*Spinetoram*(0.03%) x 72	52.86±3.37 b
Azadirachta indica (15%)+*Spinetoram* (0.03%) x24	24.23±2.91 cd
Azadirachta indica (15%)+Spinetoram (0.03%)x 48	48.33±2.18 bc
Azadirachta indica (15%)+Spinetoram (0.03%)x 72	78.83±2.91 a

Table 10 showed that maximum mortality 78.83% was observed after exposure of "72 hr". by Azadirachta indica (15%)+*Spinetoram* (0.03%) followed by 52.86% by *Eruca sativa* (15%)+*Spinetoram* (0.03%) and 39.38 was observed by Ricinus communis (15%)+Spinetoram (0.03%), respectively. Mortality was 48.33 was observed after "48 hr". exposure period, followed by 33.35 % and 25.17%, respectively. While least percentage mean mortality 15.24 % was observed by application of Ricinus communis (15%)+*Spinetoram* (0.03%) after "24 hr" of the exposure period. From results we concluded that combined action of A. indica after "72 hr"s. was most effective than other exposure periods and there was almost a significant increase in mortality values with increase in exposure period.

3.6. Repellency data after "12 hrs"

The outcome of the repellency bioassays in Table 11 revealed that repellency was found increased with increase in concentration for all extract of plants. Maximum repellency 71.24 % was recorded at 15% concentration while minimum 40.60% was recorded at 5% concentration.

Table 11 Comparison of the mean percentage repellency of T. castaneum after exposure to various concentrations of plant oils

Concentration (%)	% Repellency ± SE
5	40.60 ± 2.98 c
10	63.45 ± 2.54 b
15	3.11a

Table 12 Comparative Plants x Concentrations for mean percentage repellency against *Tribolium castaneum*

Plants x Concentrations (%)	%Repellency ± SE
Eruca sativa x 5	28.34±1.13
Eruca sativa x 10	46.23±2.10
Eruca sativa x 15	53.56±2.91
Ricinus communis x 5	35.42±2.61
Ricinus communis x 10	57.13±2.76
Ricinus communis x 15	65.89±3.05
Azadirachta indica x 5	46.56±2.60
Azadirachta indica x 10	60.31±1.89
Azadirachta indica x 15	69.16±3.03a

Data in Table 12 showed that all extract of plants were significantly different from each other. Repellency was increased with rise in concentration for all extracts of plant. Extracts of *Azadirachta indica* and *Ricinus communis* gave highest repellency results with values 69.16 and 65.89 % followed while *Eruca sativa* gave 53.56% at 15% concentration. At 10% concentrations of the plant extracts gave relatively lower values but comparatively greater values of mean per cent repellency at 5 % concentrations of the test plant extracts.

3.7. Repellency data after "24 hr"

The outcomes of the repellency bioassays in Table 13 revealed that repellency was found increased with rise in concentration for all plant extracts. Maximum repellency (76.36%) was observed at 5% concentrations while minimum 40.60 % was recorded in untreated unit (control treatment).

Table 13 Comparative mean percentage repellency of *Tribolium castaneum* after exposure to different concentrations of plant oils

Concentrations (%)	% Repellency ± SE
5	40.60 ± 2.98 c
10	71.21 ± 2.49 b
15	76.36± 2.33 a

Data in Table 14 showed that all plant extracts were significantly different from each other. Repellency was increased with rise in concentration for all plant extracts. Extracts of lemongrass and basil gave similar and maximum repellency results with values 90.00% followed by Datura 86.56% and garlic 85.67% at 15% concentration. Extracts of marigold gave 80.00% at similar concentration. Repellency value of 73.32% was recorded in case of monocarps at 15% concentration while minimum repellency was recorded in control treatment. Repellency of 43.32% was recorded in Petunia after "24 hr". exposure period. Extracts of mint, basil and petunia, and gave relatively low repellency with values 26.65%, 21.66% and 20.03%, respectively.

Table 14 Comparative mean percentage repellency of *Tribolium castaneum* after exposure to different concentrations of plant oils

Plants x Concentrations (%)	% Repellency ± SE
Eruca sativa x 5	50.01±2.77
Eruca sativa x 10	76.67±3.33
Eruca sativa x 15	86.56±3.33
Ricinus communis x 5	40.11±2.67
Ricinus communis x 10	63.01±2.77
Ricinus communis x 15	70.00±2.81
Azadirachta indica x 5	56.00±2.66
Azadirachta indica x 10	83.31±3.33ab
Azadirachta indica x 15	85.67±2.88a

4. Discussion

Results of bioassay with spinetoram exposed that maximum larval mortality was detected 88.87% and 44.04% after "48 hr". and "72 hr". exposure time period after 0.03% concentration, correspondingly. Minimum mortality 14.17% after "24 hr". at same concentration. At lower concentration 0.02%, maximum mortality 61.96% after "72 hr"., 31.65% after "48 hr". of exposure time period. Minimum mortality of 15.02% was observed after "24 hr". At lowest concentration 0.01%, maximum mortality 60.38% was recorded at "72 hr"., 28.22% after "48 hr". whereas, minimum mortality 8.41% was detected after "24 hr". The mortality was increased by increased the concentration of spinetoram and exposure time. Furthermore, interactions of different concentrations and exposure time periods were found highly significant. [1] evaluate the 3 important oils like a *E. cardamomum, C. aromaticum* and *S. aromaticum* Merr and Petry alongside the *T. castaneum* at its different life stages. The findings exhibited that, *C. aromaticum* and *E. cardamomum* provide more effective for the young once and adults whereas, *S. aromaticum* has lower impact alongside the *T. castaneum* young once and adults. In make contact with fumigation lethal impact on mature and other developmental stages of red flour beetle was additional resilient to clove compared to cinnamon and cardamom oil. After described the efficacy of *Azadirachta indica*, the [17] assessed the impact of *Teminalia chebula*, *Azadirachta indica, Murraya exotica, Eucalyptus comeldulensis* and *Trachspermum ammi* were evaluated at the rate of 5, 10 and 15 % concentrations against the *T. castaneum*. The death rate of tested insects was increased by increased concentration. The mortality trend was found similar to our study.

4.1. Repellent effects of different plant material for alongside the (*T. castaneum*) red flour beetle at different exposure time and at different concentration levels

Our results of repellency against *T. castaneum* are in accordance with [18] who evaluated the laboratory experimentations were conducted for the evaluation of contact and repellent activities of acetone based plant extracts of *Eruca sativa, Azadirachta indica* and *Ricinus communis* against the insect pest of stored grain commodities, *Tribolium castaneum*. Various concentrations (5, 10 and 15%) of the plant extracts were applied on the filter papers in the bioassay experiments and after the release of 15d old beetles, mortality was evaluated after fixed intervals (12, 24). Increased mortality was found at increased concentrations of plants. The concentration interaction and plant extracts findings for the treatments remained momentous. The generally findings exposed raised death rate with raise the doses and time period.

5. Conclusion

The mortality was increased by increased the concentration of spinetoram and exposure time. Repellent activities of acetone based plant extracts of *Eruca sativa*, *Azadirachta indica* and *Ricinus communis* against the insect pest of stored grain commodities, *Tribolium castaneum*. Various concentrations (5, 10 and 15%) of the plant extracts were applied on the filter papers in the bioassay experiments and after the release of 15d old beetles, repellency was evaluated after fixed intervals (12, 24). Increased repellency was found at increased concentrations of plants. The concentration

interaction and plant extracts findings for the treatments remained momentous. The generally findings exposed raised death rate with raise the doses and time period.

Compliance with ethical standards

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Disclosure of conflict of interest

No observed conflict of interest among the authors.

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