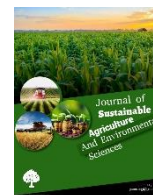




JOURNAL OF SUSTAINABLE AGRICULTURE AND ENVIRONMENTAL SCIENCES
(JSAES)

Journal homepage: <http://jsaes.org/index.php/jsaes/index>



BIOCHEMICAL SYNERGISM OF *Z. OFFICINALE*, *D. STRAMONIUM* EXTRACTS AND DELTAMETHRIN FOR CONTROLLING *TRIBOLIUM* *CASTANEUM* AND *RHYZOPERTHA DOMINICA*

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Article info	ABSTRACT
Article history: Received: 03 Sep 2023 Accepted: 20 Sep 2023	Research conducted at the Grain Research, Training, and Management Cell of the Department of Entomology, University of Agriculture in Faisalabad aimed to address insect pests that infest stored grain products. <i>Rhyzopertha dominica</i> and <i>T. castaneum</i> , which feed on grains that have been kept, were the main pests to be concerned about. The study made use of acetone-prepared extracts from the plants <i>Datura stramonium</i> and <i>Zingiber officinale</i> . A chemical insecticide called deltamethrin was also used. Various concentrations of the plant extracts (0.01%, 0.02%, 0.03%, 0.04%, and 0.05%) were created along with a controlled concentration of Deltamethrin. The concentrations were applied using a syringe, and both the individual and combined treatments were evaluated for their lethal effects on <i>T. castaneum</i> and <i>R. dominica</i> . Mortality data was collected at 24, 48, and 72-hour intervals and analyzed using statistical methods. The mortality rates for <i>Tribolium castaneum</i> exposed to Deltamethrin were 47.588%, 58.932%, and 74.637% at each time interval, while for <i>Rhyzopertha dominica</i> , the rates were 50.347%, 58.294%, and 74.221%. The mortality rates caused by <i>Datura stramonium</i> were 18.279%, 25.362%, and 36.730% for <i>T. castaneum</i> , and 24.211%, 40.183%, and 51.485% for <i>R. dominica</i> . For <i>T. castaneum</i> , <i>Zingiber officinale</i> induced mortality rates of 8.421%, 12.506%, and 22.548%, and for <i>R. dominica</i> , 11.727%, 18.577%, and 30.362%. According to the findings, <i>Datura stramonium</i> is more potent than <i>Zingiber officinale</i> , and Deltamethrin is more potent than plant extracts.
Keywords: <i>D. stramonium</i> , Deltamethrin, <i>Rhyzopertha dominica</i> , <i>Tribolium castaneum</i> , <i>Z. officinale</i> Arshad et al., (2023). Biochemical synergism of <i>z. officinale</i> , <i>d. stramonium</i> extracts and deltamethrin for controlling <i>Tribolium castaneum</i> and <i>Rhyzopertha dominica</i> : <i>J. S. Agri. Enviro. Sci</i> , 1(1), 19-34. https://doi.org/10.5281/zenodo.8360964 https://orcid.org/0009-0006-5636-4593 Copyright©2023 JCSC *Corresponding author Muhammad Nabeel Arshad Email: nabeelarshad@outlook.com.au Conflict of Interest: The authors declare no conflict of interest.	



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1. INTRODUCTION

Grain crops are a fundamental food source for humans (Padín *et al.*, 2002; Pérez Mendoza *et al.*, 2004). Insects pose a major problem for the grain industry and its sectors, causing significant losses in weight for grain stocks globally (Hill, 1990; Talukder *et al.*, 2004). Stored grain products suffer damage due to insect pests, resulting in losses ranging from 5% to 16% in advanced countries and 11% to 40% in underdeveloped countries (Padín *et al.*, 2002). In Pakistan, annual losses due to insect damage to stored products range from 4% to 26%, with additional losses of 10% to 20% during post-harvest conditions (Irshad and Balouch, 1988; Khan *et al.*, 2010). The pests *Tribolium castaneum* and *Rhyzopertha dominica* are particularly problematic for stored grains (Ashfaq *et al.*, 2001).

Over 1700 species of insect pests pose a threat to post-harvest agricultural products at various stages, including transportation, handling, selling, and storage (Hagstrum and Subramanyam, 2009). Approximately 31% of losses in agricultural products occur during storage as a result of these pests. Among them, the red flour beetle is recognized as a significant and destructive pest that causes damage to stored grain products on a global scale (Danahaye *et al.*, 2007). In Pakistan's food production industry, these pests contribute to a loss of 3-5% during the storage process (Avesi, 1983).

Tribolium castaneum, commonly known as the red flour beetle, is a polyphagous insect found worldwide (Lu *et al.*, 2010). It poses a secondary contamination risk due to substandard feeding or mechanical damage, and its excreted toxic quinones can lead to allergic diseases (Rodwan, 1970; Velki *et al.*, 2014). *T. castaneum* is destructive to legumes, cereals, and stored products,

causing significant losses (Mondal *et al.*, 1994). Researchers use it as an animal model in toxicology and population ecology studies (Abu Osman *et al.*, 2011). In contrast to the major invader, the lesser grain borer, *T. castaneum* primarily infests damaged grain kernels (Vayias *et al.*, 2010; Rees, 2004). Plant-based insecticides are commonly used as safer alternatives to synthetic ones (Belmain *et al.*, 2001). Effective grain storage practices and insecticides are crucial in preventing infestations (Arian *et al.*, 2004; Athanassiou and Palyvos, 2006). Residues found in synthetic insecticides have led to a decrease in customer acceptance, as there is a growing demand for residue-free food. Additionally, the extensive use of insecticides has resulted in pest resistance, posing risks to both human health and the environment. Consequently, there is a need to manage pests that destroy stored grains by exploring new substances (Irshad and Gillani, 1992). Researchers have been investigating innovative molecules within existing insecticidal groups for this purpose (Kavallieratos *et al.*, 2011). One common strategy to protect stored products from insect pests involves treating grains and seeds with insecticide residues (Arthur, 1996). Among various options, organophosphates and pyrethroids residual insecticides have demonstrated the highest safety and reliability for long-term grain and seed preservation (Nighat *et al.*, 2007).

Chemicals are commonly used to control insect pests, but their continuous use can have negative effects on natural control systems and lead to the development of resistance in insects. This can also pose risks to human health, other organisms, and the environment (Irshad and Iqbal, 1994). Deltamethrin is a synthetic pyrethroid widely employed worldwide to manage pests in stored products (Kljajic and Peric 2009). It is a registered pesticide in the United States, specifically used to

protect stored grains, and has been approved for use in many other regions (Dotson *et al.*, 2010; Vayias *et al.*, 2010). Deltamethrin is derived from pyrethrin, which is extracted from dried chrysanthemum flowers in the form of pyrethrum (Bhanu *et al.*, 2011). Compared to other insecticides, deltamethrin has low toxicity to vertebrates and poses minimal hazards. It does not accumulate in organs and can be absorbed by plants and animals (Anonymous, 1990; Dotson *et al.*, 2010). The mode of action of deltamethrin involves paralyzing the nervous system of insects, resulting in rapid knockdown and eventual death due to loss of coordination (Velki *et al.*, 2014). Insecticides have several disadvantages, including the development of resistance and the reappearance of pests, their toxic effects on other organisms, the potential for infection to users, and their contribution to environmental pollution (Tapondjou *et al.*, 2002). In underdeveloped countries, traditional farmers lack proper storage facilities and knowledge of protecting themselves from the toxic effects of chemicals, which limits the effectiveness of chemical control methods for preserving grains (Fields *et al.*, 2001; Tapondjou *et al.*, 2002). Stored grains possess physical, chemical, and biochemical characteristics that provide resistance against insect attacks. Factors such as hardness, color, size, moisture content, shape, protein, sugar, and phenol content contribute to the grains' natural defense against pests (Tongjura *et al.*, 2010). However, protecting stored grains and seeds from insect pests remains a significant challenge in agricultural development. One effective approach is the utilization of plant extracts, which have shown success as insect anti-feedants, repellents, and insecticides (Mordue *et al.*, 1998). Numerous plants have been discovered to possess insecticidal and damaging properties, offering potential alternatives to synthetic

insecticides (Hedin and Hollingworth, 1997). Many of these plants are tropical and contain secondary metabolites with insecticidal properties (Hiiesaar *et al.*, 2001).

The problems of insecticide resistance and the harmful effects they pose have led to the need for evaluating the bioactivities of *Datura stramonium* extract as a potential alternative to combat the Red flour beetle (*Tribolium castaneum*). Researchers have been exploring various alternatives, and plant extracts have emerged as promising candidates (Wang *et al.*, 2006). These extracts have shown diverse biological activities that can effectively control pests in stored grains (Rajendran and Sriranjini, 2008). Numerous higher plants provide a valuable source of natural pesticides, anti-feedants, repellents, and antifungal agents (Tunaz *et al.*, 2009). Among the various plant-derived substances studied, plant extracts have demonstrated significant effects against insect pests in stored grains (Shaaya *et al.*, 1991). Botanical insecticides have been found to have fewer negative effects on the environment compared to synthetic pesticides. They have been successfully used as substitutes for various insect pests, demonstrating different levels of effectiveness (Kuusik *et al.*, 1995). In an effort to reduce the use of pesticides and prevent environmental pollution, researchers have explored natural repellents, deterrents, and anti-feedants (Govindachari *et al.*, 2000). The development of new chemical pesticides has helped address the problem of resistance in stored grains and reduced the selection pressure on insects. Recent studies have highlighted the efficacy of bio-based pesticides, which act as contact poisons, providing effective pest control (Wakil *et al.*, 2013).

Bio-pesticides are considered a viable and environmentally friendly alternative to chemical pesticides for pest control. They have various effects on insects that infest stored products, such as repelling them, acting as toxins, and reducing their feeding (Isman, 2006). Throughout history, plant extracts and botanicals derived from plants have been known for their insecticidal properties and have been used in agriculture for thousands of years (Regnault-Roger *et al.*, 2012). Plant-based insecticides are quickly broken down and do not accumulate in the bodies of non-targeted species, making them less harmful to the environment. They also help prevent the development of pest resistance (Saroukolai *et al.*, 2010). In the regions of India and Pakistan, farmers have traditionally used various plant materials, such as walls, leaves, seeds, oils, and roots, to protect stored grains from insect pests (Saxena *et al.*, 1988). The essential oil found in ginger (*Zingiber officinale*) is toxic to insects but harmless to mammals (Andrea, 2011). Derivatives of *Zingiber officinale* have been found to be harmful to pests that infest stored products (Owolabi *et al.*, 2009). *Datura* plants have been widely used in traditional medicine for a long time, particularly in India (Priya *et al.*, 2002). These plants contain high levels of scopolamine, which has negative effects on various insects (Krug and Proksch, 1993).

Jimson weed (*Datura stramonium*) is a globally distributed plant used in traditional medicine for conditions like epilepsy and burns. It contains toxic compounds and should not be used for homeopathic purposes (Mateeva *et al.*, 2003). Certain extracts from Jimson weed have shown promise in pest management, particularly against *T. castaneum* and *R. dominica* (Kamruzaman *et al.*, 2005). In developing nations, these plant extracts represent an affordable and secure alternative to treating grain products that have been stored for

insect management (Regnault-Roger *et al.*, 2012). Approximately 75 plant species have been tested and confirmed as insecticides for pests in stored grain products (Rajendran and Sriranjini, 2008).

This study aims to evaluate the insecticidal properties of two plant extracts, *Datura stramonium* and *Zingiber officinale*, against two types of pests, *T. castaneum* and *R. dominica*. Additionally, the study aims to compare the toxicity of these plant extracts with a commonly used insecticide called Deltamethrin. The research focuses on determining the effectiveness of these natural plant extracts as potential alternatives to synthetic insecticides.

2. MATERIALS AND METHODS

A research study took place at the Grain Research, Training, and Storage Management Cell Department of Entomology at the University of Agriculture Faisalabad between 2018 and 2019. The study involved the use of various materials and substances, such as the insecticide Deltamethrin, extracts from *datura* plants, ginger (*zingiber officinale*), treated wheat and flour, sieves, an incubator, rubber bands, an electric grinder, muslin cloth, and fine hair brushes. Additionally, the study utilized samples of the lesser grain borer (*Rhyzopertha dominica*) and the red flour beetle (*Tribolium castaneum*).

2.1. Insects' collection

Adult *T. castenium* and *R. dominica* insects were gathered from warehouses, homes, and grain markets in Layyah district for our current study.

2.2. Rearing of insects

Adult *T. castaneum* and *R. dominica* insects were gathered for this investigation from a number of sites in District Layyah. The insects were put in jars and sterilised for 70

minutes at a high temperature of 500 °C. *R. dominica* was raised using wheat, while *T. castaneum* was raised using flour as the media. To stop viruses from escaping or entering, the jars were labelled and wrapped with muslin cloth. Then, they were housed in a growth chamber with a 29.62 °C temperature and a 695% relative humidity. Before being moved to another jar to create a new generation, the adults were given five days to reproduce. The F1 generation, which consists of insects of the same age, was produced from the eggs laid by the adult insects in the flour and wheat. The flour and wheat storage containers were kept in a good environment. The insects' transformation into adults took place over the course of 40 days.

2.3. Plant extracts Bioassay

Datura and ginger plants (*Zingiber officinale*) were gathered from several areas around the University of Agriculture Faisalabad. The plants were prepared by washing them in distilled water, allowing them to dry in the shade, and then powdering them in an electric grinder. Prior to grinding, the drying process required a maximum of fifteen days. The powdered plants were combined with a solvent to extract the plants. The solvent of choice was acetone, and 49.9g of the powder from each plant was added to 250 ml of acetone. Conical flasks were used for the extraction process, and to stop acetone evaporation, cotton plugs and aluminium caps were placed on top of the flasks. For 24 hours, the flasks were shaken on a rotating platform at 215 rpm. The mixture was then passed through Activat Whitman filter paper. To determine the impact of plant extracts and a common insecticide named Deltamethrin on the test insect, the contact toxicity bioassay was carried out.

In this investigation, an acetone solution with four distinct plant extract concentrations was created. Each treatment

was repeated three times in the experiment, which used a Complete Randomized Design. A control treatment without the plant extracts was also included, and the concentrations were administered on filter paper using a pipette. On the filter paper, the plant extracts were uniformly dispersed. Twenty unsexed adults of *Rhyzopertha dominica* and *Tribolium castaneum* were inserted in each jar after the acetone had evaporated. Rubber bands were used to cover the jars to stop the insects from escaping. At 24, 48, and 72 hours, the insects' mortality was noted.

2.4. Insecticide Bioassay

In this investigation, distilled water was used to create five distinct quantities of the chemical substance deltamethrin (0.01%, 0.02%, 0.03%, 0.04%, and 0.05%). The regulated concentration was created by mixing 99.9ml of pure water with Deltamethrin. A syringe was used to apply the concentrations at a ratio of 0.3ml. After filtering the liquids, the filter sheets underwent an overnight drying process.

Two different insect species *R. dominica* and *T. castaneum* with a total of 20 insects per dish were added to the treated filter papers in separate dishes. All concentrations were duplicated three times, and the experimental design was entirely random. Insect mortality statistics were logged every 24 hours, 48 hours, and 72 hours. The 1925 Abbott formula was used to determine the percentage of adjusted mortality.

$$\% \text{ Corrected Mortality: } M (\%) - (M_c \%) / (100 - (M_c \%) \times 100$$

Where, Mo= Observed mortality and Mc- Mortality in control unit

2.5. Bioassay study about mutual influence of insecticide and plant extracts

A combination of the effective insecticide Deltamethrin and plant extracts was used in sufficient amounts following the prescribed procedure.

2.6. Experimental analysis:

Complete Randomized Design will be used to plan the experiment. Data will be statistically analysed using analysis of variance (ANOVA), and Tuckey's honestly significant difference (THSD) test will be used to compare treatment means.

3. RESULTS

3.1: Effects of Deltamethrin Concentrations on Adult *T. castaneum* Population:

The results concerning effect of Deltamethrin on *Tribolium castaneum* with different concentrations (0.01%-0.05%) along with one control group treatment and causing mortality at time exposure 24, 48 and 72 hours.

Table 1: Effects of Deltamethrin Concentrations on *Tribolium castaneum*: Analysis of Variance during 24, 48, and 72-Hour Exposure Periods

Conc.	Mean mortality S. E at 24 hr	Mean mortality S. E at 48 hr	Mean mortality S. E at 72 hr
0.01%	31.03± 2.1808 e	37.57± 2.1127 d	52.72± 2.2998d
0.02%	39.65± 2.3789 c	48.21± 2.1587 c	60.01± 2.4689cd
0.03%	50.01± 2.4529 b	60.71± 2.2365 b	69.09± 2.7468c
0.04%	51.72± 3.0012 b	69.65± 2.5764 ab	80.01± 3.0123b
0.05%	65.51 ± 3.0841 a	78.50±2.9879 a	90.90± 3.2523a

The study examined the effects of different concentrations of the insecticide Deltamethrin on the mortality of *Tribolium castaneum* beetles. The concentrations ranged from 0.01% to 0.05%. The beetles were exposed to the insecticide for 24, 48, and 72 hours. The results showed (Table 1) that increasing the concentration of Deltamethrin led to higher mortality rates in the beetles. At

the 24-hour exposure period, the highest mortality rate (65.51%) was observed with the 0.05% concentration, while the lowest rate (31.03%) was seen with the 0.01% concentration. Similar trends were observed at the 48-hour exposure period, with the highest mortality rate (78.50%) occurring at the 0.05% concentration and the lowest rate (37.57%) at the 0.01% concentration. At

the 72-hour exposure period, the highest mortality rate (90.90%) was observed (Table 1) with the 0.05% concentration, and the lowest rate (52.72%) was seen with the 0.01% concentration.

3.2. Assessment of Deltamethrin's Efficacy on Adult Lesser Grain Borer (*R. dominica*):

The present study aimed to investigate the effectiveness of the new chemistry insecticide Deltamethrin against the adult population of the lesser grain borer (*Rhyzopertha dominica*) in the Layyah district. Different concentrations of Deltamethrin (ranging from 0.01% to 0.05%) were tested, along with a control group, to assess the mortality rate after exposure periods of 24, 48, and 72 hours.

Table 2: Effects of Deltamethrin Concentrations on *Rhyzopertha dominica*: Analysis of Variance across 24-72 Hour Exposure

Conc.	Mean mortality S. E at 24 hr	Mean mortality S. E at 48 hr	Mean mortality S. E at 72 hr
0.01%	31.03±2.0400c	37.50±1.7856e	51.78±2.3956c
0.02%	39.34±2.2810c	50.04±1.9823d	66.07±2.4535b
0.03%	51.72±2.3415b	60.71±2.0012c	73.21±2.7589b
0.04%	60.34±2.6712ab	60.64±2.3043b	85.71±3.0034a
0.05%	68.96±2.8849a	80.35±2.5252a	92.85±3.3879a

The results revealed a concentration-dependent effect of Deltamethrin on *R. dominica*. At the 24-hour exposure period, the mortality rate increased with higher concentrations of Deltamethrin. The highest mean mortality rate of 68.97% (± 2.8849 standard error) was observed at a concentration of 0.05%, while the minimum mortality rate of 31.03% was recorded at a concentration of 0.01%. Similarly, at the 48-hour exposure period, the mortality rate increased with increasing concentrations of Deltamethrin. The highest mean mortality rate of 80.35% (± 2.5252 standard error) was observed at a concentration of 0.05%, while the lowest mortality rate of 37.50% was recorded at a concentration of 0.01%. Furthermore, the mortality rate of *R. dominica* was assessed at the 72-hour exposure period using

analysis of variance (ANOVA). The results indicated that mortality increased with higher concentrations of Deltamethrin. The highest mean mortality rate of 92.85% (± 3.3879 standard error) was observed at a concentration of 0.05%, while the lowest mortality rate of 51.78% was recorded at a concentration of 0.01% during the 72-hour exposure period. In conclusion, the study demonstrated that Deltamethrin showed significant efficacy against the adult population of *R. dominica*, with higher concentrations leading to increased mortality rates. These findings highlight the potential of Deltamethrin as an effective insecticide for controlling the lesser grain borer in the Layyah district.

3.3. Impact of *Datura stramonium* concentrations on *Tribolium castaneum*:

The effects of various concentrations (0.01%, 0.02%, 0.03%, 0.04%, 0.05%) of *Datura stramonium* plant extract on the mortality of *Tribolium castaneum* (red flour

beetle) were studied at different time intervals (24, 48, and 72 hours). A control group without treatment was also included.

Table 3. Comparative Analysis of % Mortality in Layyah Population of *T. castaneum* Exposed to Various Concentrations of *Datura stramonium* Extract at 24 to 72 Hours

Conc.	Mean mortality S. E at 24 hr	Mean mortality S. E at 48 hr	Mean mortality S. E at 72 hr
0.01%	3.45± 1.7241c	10.72±2.1127 c	21.82±2.667c
0.02%	8.64±1.9854c	17.86±2.1634 bc	30.91±2.7862 bc
0.03%	18.96±2.1121c	23.22±2.35435b	36.36±3.2213 b
0.04%	25.86±2.3214c	33.93±2.6645 a	41.803.4565 ab
0.05%	34.48±2.4382 c	41.07±2.9879 a	52.72±3.8137a

Analysis of variance (ANOVA) was used to determine the percentage of *Tribolium castaneum* mortality for the various doses of *Datura stramonium* extract (0.01%–0.05%) after a 24-hour exposure period. In (table 3), the mortality rates of the red flour beetle throughout the 24-hour exposure period are shown. During the 24-hour exposure period, the highest mean death rate was 34.48% at a dose of 0.05% and the lowest was 3.45% at a concentration of 0.01%. ANOVA was used to analysis the death rates of *Tribolium castaneum* for the various doses of *Datura stramonium* extract (0.01%–0.05%) during a 48-hour exposure period. (Table 3) displays the fatality rates at the 48-hour exposure period. The findings showed that mortality rose as concentration rose. During the 48-hour exposure period, the highest mean death rate was 41.07% at a dose of 0.05% and the lowest was 10.72% at a concentration of 0.01%. ANOVA was used to analysis the death rates of *Tribolium castaneum* for the various doses of *Datura stramonium* extract

(0.01%–0.05%) during a 72-hour exposure period. In (table 3), the mortality percentages for the 72-hour exposure period are shown. The findings showed that mortality rose as concentration increased. During the 72-hour exposure period, the highest mean death rate was 52.72% at a dose of 0.05% and the lowest was 21.82% at a concentration of 0.01%.

3.4. *Datura stramonium* extract's impact on *Rhyzopertha dominica* population:

The study investigated the response of *Rhyzopertha dominica*, a type of lesser grain borer, to different concentrations of *Datura stramonium* plant extract. The concentrations tested were 0.01%, 0.02%, 0.03%, 0.04%, and 0.05%, along with a control group. The exposure periods were 24, 48, and 72 hours.

Table 4. Comparative Analysis of % Mortality in *Rhyzopertha dominica* Exposed to Various Concentrations of Datura stramonium Extract at 24, 48, and 72 hours

Conc.	Mean mortality S. E at 24 hr	Mean mortality S. E at 48 hr	Mean mortality S. E at 72 hr
0.01%	7.01+1.7544 c	16.07 1.7856 d	21.82+2.667c
0.02%	19.29 1.9832 b	26.79 1.9192 c	30.91+2.7862 bc
0.03%	22.80+2.0212 b	39.29+2.0012 b	36.36+3.2213 b
0.04%	33.33+2.3214 a	48.21+2.3431 a	41.803.4565 ab
0.05%	38.59+2.4811 a	55.36+2.5252 a	52.72+3.8137a

After being exposed for 24 hours, the mortality rate of *R. dominica*, a type of insect, varied depending on the concentration of Datura stramonium plant extract. The highest average mortality rate observed was 38.59% when the concentration was 0.05%, whereas the lowest rate was 7.01% at a concentration of 0.01%. Similarly, when the exposure period was extended to 48 hours, the mortality rate of *R. dominica* increased as the concentration of the plant extract increased. The highest average mortality rate recorded was 55.36% at a concentration of 0.05%, while the lowest was 16.07% at a concentration of 0.01%. Finally, after 72 hours of exposure, the mortality rate of *R. dominica* continued to rise with higher concentrations of the plant extract. The highest average mortality rate reached 70.91% at a concentration of 0.05%, and the lowest was 27.27% at a concentration of

0.01%. These findings indicate a positive correlation between the mortality of *R. dominica* and both the concentration of Datura stramonium plant extract and the duration of exposure. Higher concentrations and longer exposure periods resulted in higher mortality rates for *R. dominica*.

3.5. Impact of Zingiber officinale extract concentrations on *Rhyzopertha dominica* Population:

This study investigates the impact of Zingiber officinale plant extract on the response of the lesser grain borer (*R. dominica*) at different concentrations (0.01%, 0.02%, 0.03%, 0.04%, and 0.05%) and time intervals (24, 48, and 72 hours) of exposure. The experiment includes a control group for comparison.

Table 5. Mean % Mortality of Lesser Grain Borer (*R. dominica*) with Zingiber officinale Extract at 24-72 hours

Conc.	Mean mortality S. E at 24 hr	Mean mortality S. E at 48 hr	Mean mortality S. E at 72 hr
0.01%	0.003±2.0400 d	5.36±1.7856 c	16.07+2.8792 c
0.02%	3.45±2.0551 cd	10.72±1.9912bc	23.22+2.9992 bc

0.03%	12.07±2.2543 bc	16.07± 2.1134 b	25.05±3.0245 bc
0.04%	18.96±2.6457 ab	26.70±2.3671 a	33.93±3.6634 b
0.05%	24.14±2.8849 a	33.93±2.5252 a	53.57±4.0718 a

The mortality rate of *Rhyzopertha dominica* (lesser grain borer) was analyzed using Analysis of Variance (ANOVA) after exposure to five different concentrations (ranging from 0.01% to 0.05%) of Zingiber officinale (ginger) for 24, 48, and 72 hours. A control group was also included in the study. The results are presented in Table 5. At the 24-hour exposure period, the highest mean mortality rate observed was 24.14% at a concentration of 0.05%, while the lowest mortality rate was 0.003% at a concentration of 0.01%. For the 48-hour exposure period, the highest mean mortality rate recorded was 33.93% at a concentration of 0.05%, whereas the lowest mortality rate was 5.36% at a concentration of 0.01%. Lastly, at the 72-hour exposure period, the highest mean mortality rate observed was 53.57% at a concentration of 0.05%, while the lowest mortality rate was 16.07% at a concentration of 0.01%. These

results show how varied Zingiber officinale concentrations and exposure times affect the mortality of *R. dominica*.

3.6. Zingiber officinale Extract: Combatting Tribolium castaneum:

This study investigates the reaction of *Tribolium castaneum*, a species of beetle, to the plant extract derived from Zingiber officinale (commonly known as ginger). The experiment involves testing different concentrations of the extract, namely 0.01%, 0.02%, 0.03%, 0.04%, and 0.05%, along with a control group. The exposure period for the beetles is set at three time intervals: 24 hours, 48 hours, and 72 hours. The aim is to assess the response of *Tribolium castaneum* to the various concentrations of Zingiber officinale extract over these specified time periods.

Table 6. Comparison of % Mortality of *T. castaneum* in Layyah Population with Different Concentrations of Zingiber officinale Plant Extract at 24-72 Hours

Conc.	Mean mortality S. E at 24 hr	Mean mortality S. E at 48 hr	Mean mortality S. E at 72 hr
0.01%	0.001± 1.7544 d	0.007± 1.7856 c	5.45± 2.1512 d
0.02%	1.74± 1.8365 cd	5.36± 1.8832 bc	14.54± 2.3357 cd
0.03%	7.01± 2.1145 bc	12.06± 2.0021 b	21.82± 2.7172 bc
0.04%	14.03± 2.3910 b	21.34± 2.2956 a	29.03± 2.9913 b
0.05%	22.80± 2.4811 a	23.20± 2.5252 a	41.82± 3.0423 a

Table 6 presents the results of an analysis examining the mortality rates of *Tribolium castaneum*, commonly known as the red flour beetle. The study investigated the effects of different concentrations (ranging from 0.01% to 0.05%) of *Zingiber officinale*, also known as ginger, on the mortality of *T. castaneum* over three different exposure periods: 24 hours, 48 hours, and 72 hours. Additionally, a control group was included for comparison purposes. At the 24-hour exposure period, the analysis revealed that the highest average mortality rate observed was 22.80% when using a concentration of 0.05% *Zingiber officinale*. Conversely, the lowest mortality rate recorded was 0.001% when utilizing a concentration of 0.01% *Zingiber officinale*. Moving to the 48-hour exposure period, the results indicated that the highest average mortality rate increased slightly to 23.22% at the 0.05% concentration of *Zingiber officinale*. Similarly, the lowest mortality rate also increased slightly to 0.007% when employing the 0.01% concentration of *Zingiber officinale*. Finally, at the 72-hour exposure period, it was observed that the mortality rates of *T. castaneum* continued to rise as the concentration of *Zingiber officinale* increased. The highest average mortality rate observed was 41.82% when using the 0.05% concentration, while the lowest mortality rate recorded was 5.45% when employing the 0.01% concentration.

4. DISCUSSION

The present research was conducted at the Grain Research, Training and Storage Management Cell, Department of Entomology, University of Agriculture Faisalabad, during the period of 2018-2019. The study's goal was to determine the effects of plant extracts from *Datura stramonium* and *Zingiber officinale*, a brand-new insecticide called Deltamethrin, and a control group on the mortality of *T.*

castaneum herbst and *R. dominica*. The concentrations used in the study were 0.01%, 0.02%, 0.03%, 0.04%, and 0.05%. The findings of the study indicated that the highest mortality rate of the adult population of *T. castaneum*, collected from Layyah district, was observed after 72 hours of exposure to the five treatments of Deltamethrin, with mortality reaching 74.63%. The lowest mortality rate was recorded after 24 hours, with a value of 47.58%. These results align with the findings reported by Collins (1990).

Similarly, the population of *R. dominica* exhibited an average mortality rate at different time intervals (24, 48, and 72 hours) after exposure to the five treatments of Deltamethrin. The highest mortality rate was observed after 72 hours, reaching 74.22%, while the minimum mortality rate was recorded after 24 hours, with a value of 50.34%. These results are consistent with the research conducted by Arthur (1994) and Athanassiou et al. (2004). The study also demonstrated the average death rate of the adult population of *Tribolium castaneum* from Layyah after exposure to five treatments with *D. stramonium* extract at varying doses (0.01% - 0.05%), along with a control group. The highest mortality rate was observed after 72 hours, reaching 36.73%, while the lowest mortality rate occurred after 24 hours, with a value of 18.27%. These results are consistent with the findings reported by Farkhanda et al. (2011).

The agriculture sector in Pakistan has a significant impact on the country's economy, with wheat being a major staple crop (Talukder et al., 2004). Insect pests cause substantial damage to stored grain products, leading to significant losses in both advanced and underdeveloped countries (Padin et al., 2002). In Pakistan, annual losses from insect damage to stored

products range from 4-26% (Irshad and Balouch, 1988), with 10-20% losses during post-harvesting (Khan et al., 2010). *Tribolium castaneum* and *Rhyzopertha dominica* are particularly problematic insect pests in stored grains (Ashfaq et al., 2001). Flour and grain already infected by major invaders (Vayias et al., 2010). *T. castaneum* is highly destructive, causing significant losses and secreting allergenic substances (Lu et al., 2010). Larvae and adult species of *T. castaneum* are severe economic pests in tropical and subtropical regions (Rees, 2004).

5. CONCLUSION

The study demonstrated that Deltamethrin exhibits significant toxicity towards the red flour beetle and lesser grain boarer, resulting in maximum mortality when exposed to this insecticide. Moreover, plant extracts were found to have effective insecticidal properties as well. Among the plant extracts tested, jimson weed (*Datura stramonium*) exhibited the highest mortality rate within a 72-hour timeframe. The insecticidal effect of *Zingiber officinale* (ginger) was comparatively lower than that of jimson weed. Overall, the strains collected from the Layyah region displayed elevated mortality rates when exposed to both the new chemical insecticide and the plant extracts.

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