



EFFICIENCY OF ORGANIC AND INORGANIC PESTICIDES AGAINST STORED GRAIN INSECT PESTS

J. Zaib¹, S. A. Memon^{2*}, A. Ali², G. A. Bugti² and G. Khaliq³

¹Department of Plant Protection, Quarantine Sea Port Section, Karachi, Pakistan

²Department of Entomology, ³Department of Horticulture, Lasbela University of Agriculture,
Water and Marine Sciences, Uthal, Balochistan, Pakistan

ABSTRACT

The insect pests cause substantial loss of grains in the field and during storage of food grains that worth millions of rupees. Hence, in order to manage stored grain insect pests a combination of organic and inorganic pesticide control materials was selected to check the efficiency against red flour beetle (*Tribolium castaneum*) and pulse beetle (*Callosobruchus chinensis*). Total 10 treatments were used, eight different organic bio-pesticides (neem seed, neem leaves, naswar, tobacco, eucalyptus, citrus, dhatura and mint) and one inorganic (naphthalene balls) and control used at $32 \pm 2^\circ\text{C}$ and $70 \pm 5\%$ RH. The results indicated that three doses of all treatments were used as 5, 10 and 20gm in 50gm grains. Overall, maximum ($4.33 \pm 1.00\%$) mortality of red flour beetle was observed using neem seed powder and no ($0.0 \pm 0.00\%$) mortality was observed in mint leaves powder. In case of pulse beetle, the maximum ($5.07 \pm 0.87\%$) mortality was observed using neem seed powder and minimum ($0.66 \pm 0.22\%$) using citrus leaves powder. Maximum (16.26 ± 0.03) antifeedant efficiency of red flour beetle was observed in control group and minimum (6.46 ± 0.65) antifeedant efficiency of red flour beetle was found in dhatura leaves powder at all tested concentrations. Maximum (14.23 ± 0.13) antifeedant efficiency of pulse beetle was determined in control group and minimum (1.00 ± 0.04) was observed for naphthalene balls at all tested concentrations. Maximum (94.67%) repellency against red flour beetle was observed using neem seed powder and minimum (62.00%) was found in naphthalene balls as compared with their controls. Maximum (81.32%) repellency against pulse beetle was observed using naswar powder and minimum (63.34%) repellency was determined using neem leaves powder as compared with their control group. We concluded that 20% of neem seed powder concentration proved effective to suppress the population of both red flour beetle and pulse beetle.

Keywords: antifeedant, *Callosobruchus chinensis*, mortality %, repellency, *Tribolium castaneum*

INTRODUCTION

The demand of food is increasing rapidly for mankind due to the increasing population globally. It is expected that world's population will increase up to 9.1 billion till the year 2050 for which 70% extra food will be required to feed them (FAO, 2019). Furthermore, it is expected that most of the increase in population is attributed to the developing countries, despite that several countries are already facing the issues of food protection and hunger. The concerns of increasing food demands increased because of climatic change, increase urbanization and land used for industrialization. Owing to these threats most of countries have focused on the improvement of their agricultural production, land use and population control as their policies to cope with the increasing food

demand (FAO, 2019). In Pakistan almost 65% land of agriculture was used for the cultivation of wheat crop. During 2020 the wheat produced in the country about 27.293 million tons from 9.118 million hectares (GoP, 2021).

The insect pests cause substantial loss of grains in the field and during storage of food grains that worth millions of rupees. According to an estimate about 10 to 20% of the wheat is damaged during storage by insect pests. (GoP, 2020). The reason behind these losses are untrained staff, misuse of phosphine and other chemicals to control insect pests procurement of substandard wheat, very old and unmaintained warehouses etc (Hagstrum and Subramanyam, 2009). Around 1660 species of insects is estimated that attacked products of agriculture in various storage, marketing, processing and transportation phases (Hagstrum and Subramanyam, 2009). This loss increases up to

*Corresponding author: ahmedshafique89@yahoo.com



30 percent during storage. According to (Mondal, 1994) *T. castaneum* is one of the most damaging and disruptive pest species of stored products all over the world. In Pakistan, approximately 2-6% of food grains production is lost annually by the insect species.

Many synthetic chemicals like phosphine tablets, phenyl tablets are used to protect the stocks. While some are using eucalyptus, neem and tobacco leaves or seeds and other materials as sand, debris, and salts for the protection of grains from pests (Chomchalow, 2003). It has been reported that plants have shown an insecticidal property against several insect pests of stored grains. Various plant substances demonstrated high physiological properties against insect pests as antifeedant, harmful and repellent impacts. Turmeric oil and its powder have shown repellent impacts against numerous grains insects. Mostly sweet-smelling plants have been seen rich in insecticidal properties which could be used as insect's sprays. Some flowering plants have been assessed as antifeedant, anti-agents and toxicants against Coleopteran species that show tremendous impacts against grains. Many plants have been reported as repellent effects against several insect pests associated with stored grains. Mostly people use synthetic insecticide like, naphthalene phenyl tablets mostly to protect *T. castaneum* capacity to control population (Latif *et al.*, 2004).

Numerous factors are responsible for the low yield of store grain products like a-biotic factors such temperature, humidity, light, wind, rain and biotic factors such as weeds, disease agents and various insect pests. Among insect pests, red flour beetle (*Tribolium castaneum*), Pulse beetle (*Callosobruchus chinensis*) are serious insect pests of wheat grains. Both quality and quantity of commodity in stored foods affects directly by presence of these insect pests (Mondal, 1994).

Pests can be controlled by using insecticides (FAO, 1983). Although, commonly used chemicals are not recommended to be used for stored grains due to their health hazardous properties potentially for human. Botanical pesticide control materials play a crucial role in controlling various insect pests from grains (Hochachka and Somero, 1984; Cossins and Bowler, 1987). According to estimation 10-40% of the grain food is damaged in storerooms solely by insect pests. Therefore, present study was conducted to find essential botanical pest control materials for the

management of stored grain insect pests such as red flour beetle (*T. castaneum*) and pulse beetle (*C. chinensis*) in vitro conditions. Moreover, insufficient work has been done in this country to study the storage problems which include storage methods, loss assessment, and varietal susceptibility of grains to stored product pests, biology, and ecology of pests. Keeping in view, the store grain products and losses caused by various stored grain insect pests; present study was carried out to evaluate in vitro research on organic and inorganic pesticide control materials against stored grain pests.

MATERIALS AND METHODS

Insect culture

The studies were carried out in the Department of Entomology, Faculty of Agriculture, Lasbela University of Agriculture, Water and Marine Science (LUAWMS), Uthal, Balochistan. The initial culture of stored grain pests i.e., pulse beetle (*Callosobruchus chinensis*) and red flour beetle (*Tribolium castaneum*) was obtained from Pakistan Agriculture Research Council (PARC), Karachi and Agriculture Research Center (ARI), Tandojam. The culture of these insects was further augmented on wheat grain flour and legumes seeds under laboratory conditions at $32\pm 2^{\circ}\text{C}$ and $70\pm 5\%$ RH.

Preparation of organic pesticides powder

Ten treatments were used in present research and eight different organic botanical pest control materials (neem seed, neem leaves, naswar, tobacco, eucalyptus, citrus, datura and mint leave powders) and one inorganic (naphthalene balls) were tested against pulse beetle and red flour beetle used in powder form and control. The leaves of botanical pest control materials were collected from surroundings of LUAWMS, Uthal, Balochistan. The leaves were dried under shade and which were ground to fine powder form with the help of an electric blender while naphthalene balls were purchased from local market. Ten treatments were used in present experiments and each treatment was replicated three times.

Plan of work

Neem seed powder 5gm, 10gm, 20gm and 50gm wheat/ pluses bean.

Neem leaves powder 5gm, 10gm, 20gm and 50gm wheat/ pluses bean.

Tabacco leaves powder 5gm, 10gm, 20gm and 50gm wheat/ pluses bean.

Naswar powder 5gm, 10gm, 20gm and 50gm wheat/ pluses bean.

Eucalyptus leaves powder 5gm, 10gm, 20gm and 50gm wheat/ pluses bean.

Citrus leaves powder 5gm,10gm, 20gm and 50gm wheat/ pluses bean.

Mint leaves powder 5gm,10gm, 20gm and 50gm wheat/ pluses bean.

Datura 5gm, 10gm, 20gm and 50gm wheat/ pluses bean.

Naphthalene balls 5gm,10gm, 20gm and 50gm wheat/ pluses bean.

In control no organic and inorganic pesticides were used 50 gm wheat/ pluses bean.

Different concentrations of each treatment were used in 5, 10, 20gm and 50gm of wheat and bean grain were mixed in each concentration of treatments. Total ten adults of both beetle species, i.e., red flour beetle and pulse beetle were exposed on treated wheat and bean grain to check the effect of organic and inorganic pesticide concentrations on the mortality % of red flour beetle and pulse beetle. The data on mortality of both insects was recorded after 10 days later.

Similarly, fifty adult insects of both beetles were exposed on 500 treated grains as antifeedant to check the damage % of both insects. Data was observed after 10 days later.

To used formula for damage grain: $\frac{DG \times 100}{500}$

Ten adult insects of both beetles were taken from already established culture and released in 10 cm glass Petri dish. Half filter paper was cut and placed in the center of Petri dish and remaining half of Petri dish was treated with both organic and inorganic. Ten adults of both beetles were released in the Petri dishes for 24 hours to find the repellence percentage of both adult insects.

Statistical analysis

The collected data was statistically analyzed using software SPSS (SPSS Inc. Chicago, L, US). One way annova was used and entire means were compared with Tukey test at ($P<0.05$) probability.

RESULTS

Mortality (%) of red flour beetle under different organic and inorganic insecticides

A significant ($P<0.05$) increased mean mortality was observed by neem seed powder ($4.33\pm1.00\%$), followed by naswar powder ($2.81\pm0.26\%$), naphthalene balls ($1.77\pm0.67\%$)

and tobacco leaves powder ($1.29\pm0.42\%$) as compared to dhatura leaves powder ($0.63 \pm 0.53\%$), neem leaves powder ($0.66\pm0.30\%$), eucalyptus leaves powder ($0.37\pm0.17\%$), citrus leaves powder ($0.04\pm0.06\%$) and mint leaves powder ($0.00\pm0.00\%$) as presented in (Table 1).

Mortality (%) of pulse beetle with different organic and inorganic insecticides

A significant ($P<0.05$) increased mean mortality was observed by neem seed powder ($5.07\pm0.87\%$), naphthalene balls ($3.29\pm0.06\%$), naswar powder ($3.26\pm0.06\%$), mint leaves powder ($2.62\pm1.22\%$) as compared to eucalyptus leaves powder ($2.55\pm0.34\%$), neem leaves powder ($2.18\pm0.06\%$), tobacco leaves powder ($1.55 \pm 0.48\%$), dhatura leaves powder ($1.21\pm0.49\%$) and citrus leaves powder ($0.66\pm0.22\%$) as indicated in (Table 2).

Antifeedant efficiency (%) of red flour beetle with different organic and inorganic insecticides

Results on organic and inorganic insecticides indicated that a maximum significant ($P<0.05$) antifeedant efficiency (%) of red flour beetle was recorded in control ($16.10 \pm 1.11\%$), following by naswar powder ($14.66 \pm 0.16\%$), naphthalene balls ($12.93 \pm 0.29\%$), neem seed powder ($11.73 \pm 0.14\%$), tobacco leaves powder ($10.33 \pm 0.21\%$), citrus leaves powder ($8.86 \pm 0.35\%$), eucalyptus leaves powder ($8.53 \pm 0.17\%$), mints leaves powder ($8.26 \pm 0.25\%$), neem leaves powder ($7.20 \pm 0.13\%$), respectively. Whereas, the minimum antifeedant efficiency of red flour beetle was observed on dhatura leaves powder ($6.46 \pm 0.65\%$) at all tested concentrations as given in (Table 3).

Antifeedant efficiency (%) of pulse beetle with different organic and inorganic insecticides

The results organic and inorganic insecticides indicate that a maximum significant ($P<0.05$) antifeedant efficiency of pulse beetle were recorded ($14.23 \pm 0.13\%$) under control followed by neem leaves powder ($9.4 \pm 0.13\%$), Citrus leaves powder ($2.80 \pm 0.29\%$), Mint leaves powder, ($2.73 \pm 0.31\%$), Eucalyptus leaves powder, ($2.73 \pm 0.17\%$), Tobacco leaves powder ($2.46 \pm 0.20\%$), Neem seed powder ($1.93 \pm 0.11\%$) Dhatura leaves powder ($1.26 \pm 0.07\%$), respectively. While, the minimum antifeedant efficiency of pulse beetle was observed for naphthalene balls (1.00 ± 0.04) at all tested concentrations as given in (Table 4).

Repellency (%) of red flour beetles with different organic and inorganic insecticides

A maximum repellency (%) of red flour beetles were observed using neem seed powder (94.67%) followed by mint leaves powder (80%), neem leaves powder (76.66%), tobacco leaves powder (76.67%), eucalyptus leaves powder (73.33%), citrus leaves powder (73.34%), naswar powder (70%), dhatura leaves powder (66.67%), respectively and the minimum repellency against red flour beetles were observed for naphthalene balls (62%) (Figure 1).

Repellency (%) of pulse beetles with different organic and inorganic insecticides

A maximum repellency (%) of pulse beetles were observed using naswar powder (81.34%) followed by neem seed powder (76.67%), naphthalene balls (76.67%), dhatura leaves powder (73.34%), tobacco leaves powder (71.67%), eucalyptus leaves powder (70%), mint leaves powder (66.67%), citrus leaves powder (66.34%), respectively and the minimum repellency against pulse beetles were observed for neem leaves powder (63.34%) (Figure 2).

Table 1. Mortality (%) of red flour beetle (*Tribolium castaneum*) with different organic and inorganic insecticides

Treatments	5%	10%	20%	Mean
Neem seed powder	3.33±0.66ab	4.33±0.66a	5.33±0.66a	4.33±1.00a
Neem leaves powder	0.44±0.22ab	0.55±0.11ab	1.00±0.38a	0.66±0.30d
Tobacco leaves powder	0.99±0.80a	1.11±0.58a	1.77±0.88a	1.29±0.42c
Naswar powder	2.67±0.57a	2.66±0.19a	3.11±0.78a	2.81±0.26b
Eucalyptus leaves powder	0.22±0.11a	0.33±0.33a	0.55±0.29a	0.37±0.17d
Citrus leaves powder	0.00±0.00a	0.11±0.11a	0.00±0.00a	0.04±0.06d
Mint leaves powder	0.00±0.00a	0.00±0.00a	0.00±0.00a	0.00±0.00e
Dhatura leaves powder	0.22±0.11ab	0.44±0.22ab	1.22±0.58ab	0.63±0.53e
Naphthalene balls	1.33±0.69a	1.44±0.77a	2.55±1.25a	1.77±0.67c

Note: The mean values followed by different letters in the same column are significantly different by Tukeytest ($P < 0.05$)

Table 2. Mortality (%) of pulse beetle (*Callosobruchus chinensis*) with different organic and inorganic insecticides

Treatments	5%	10%	20%	Means
Neem seed powder	4.10±0.98a	5.33±1.07a	5.77±1.44a	5.07±0.87a
Neem leaves powder	2.22±0.29a	2.11±0.44a	2.22±0.44a	2.18±0.06c
Tobacco leaves powder	1.22±0.67ab	1.32±0.33ab	2.10±0.55a	1.55±0.48d
Naswar powder	3.22±1.47a	3.22±1.31a	3.33±1.38a	3.26±0.06b
Eucalyptus leaves powder	2.21±0.29a	2.88±0.22a	2.55±0.39a	2.55±0.34c
Citrus leaves powder	0.44±0.22a	0.66±0.33a	0.88±0.39a	0.66±0.22
Mint leaves powder	1.44±0.29a	2.55±0.29a s	3.88±0.67a	2.62±1.22c
Dhatura leaves powder	0.99±0.50a	0.88±0.44a	1.77±0.72a	1.21±0.49d
Naphthalene balls	3.22±2.05a	3.33±1.85a	3.33±2.83a	3.29±0.06b

Note: The mean values followed by different letters in the same column are significantly different by Tukey test ($P < 0.05$)

Table 3. Antifeedant efficiency of red flour beetle (*Tribolium castaneum*) with different organic and inorganic insecticides

Treatments	5%	10%	20%	Means
Neem seed powder	13.60±0.21c	11.60±0.13c	10.00±0.23c	11.73±0.14bc
Neem leaves powder	8.40±0.24g	7.20±0.11g	6.00±0.21f	7.20±0.13d
Tobacco leaves powder	11.60±0.20d	10.40±0.23d	9.00±0.28d	10.33±0.21c
Naswar powder	16.00±0.28a	14.60±0.20a	13.40±0.25a	14.66±0.16ab
Eucalyptus leaves powder	10.00±0.24e	8.60±0.28f	7.00±0.23e	8.53±0.17d
Citrus leaves powder	10.40±0.21e	9.20±0.24e	7.00±0.20e	8.86±0.35d
Mint leaves powder	9.20±0.26f	8.60±0.20f	7.00±0.29e	8.26±0.25d
Dhatura leaves powder	8.00±0.21g	6.80±0.21h	4.60±0.24g	6.46±0.65d
Naphthalene balls	14.40±0.28b	13.00±0.20b	11.40±0.23b	12.93±0.29b
Control	16.20±1.41a	16.48±1.44a	16.10±1.11a	16.26±0.03a

Note: The mean values followed by different letters in the same column are significantly different by Tukey test ($P < 0.05$)

Table 4. Antifeedant behaviour of pulse beetle (*Callosobruchus chinensis*) with different organic and inorganic insecticides

Treatments	5%	10%	20%	Means
Neem seed powder	3.00±0.23c	2.00±0.26b	0.80±0.26b	1.93±0.11d
Neem leaves powder	14.00±0.20a	13.00±0.20a	1.20±0.21a	9.4±0.13b
Tobacco leaves powder	3.60±0.24c	2.40±0.10b	1.40±0.20a	2.46±0.20c
Naswar powder	3.00±0.21c	2.00±0.82b	1.40±0.23a	2.13±0.07c
Eucalyptus leaves powder	3.80±0.11c	2.80±0.23b	1.60±0.16a	2.73±0.17c
Csitrus leaves powder	4.20±0.19b	2.40±0.41b	1.80±0.41a	2.80±0.29c
Mint leaves powder	3.60±0.20c	2.80±0.28b	1.80±0.41a	2.73±0.31c
Dhatura leaves powder	2.40±0.26d	1.40±0.25c	0.00±0.00c	1.26±0.07d
Naphthalene balls	2.00±0.28d	1.00±0.19c	0.00±0.23c	1.00±0.04d
Control	14.20±0.14d	14.24±0.21b	14.26±0.25a	14.23±0.13a

Note: The mean values followed by different letters in the same column are significantly different by Tukey test ($P < 0.05$)

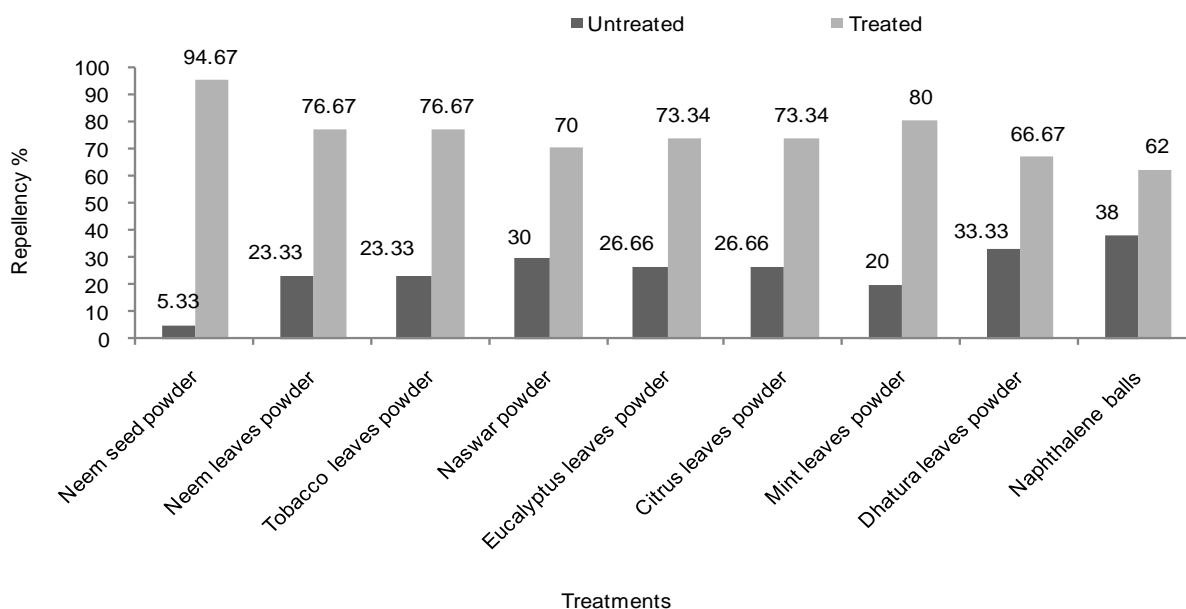


Figure 1. Repellency (%) of red flour beetles (*Tribolium castaneum*) with different organic and inorganic insecticides

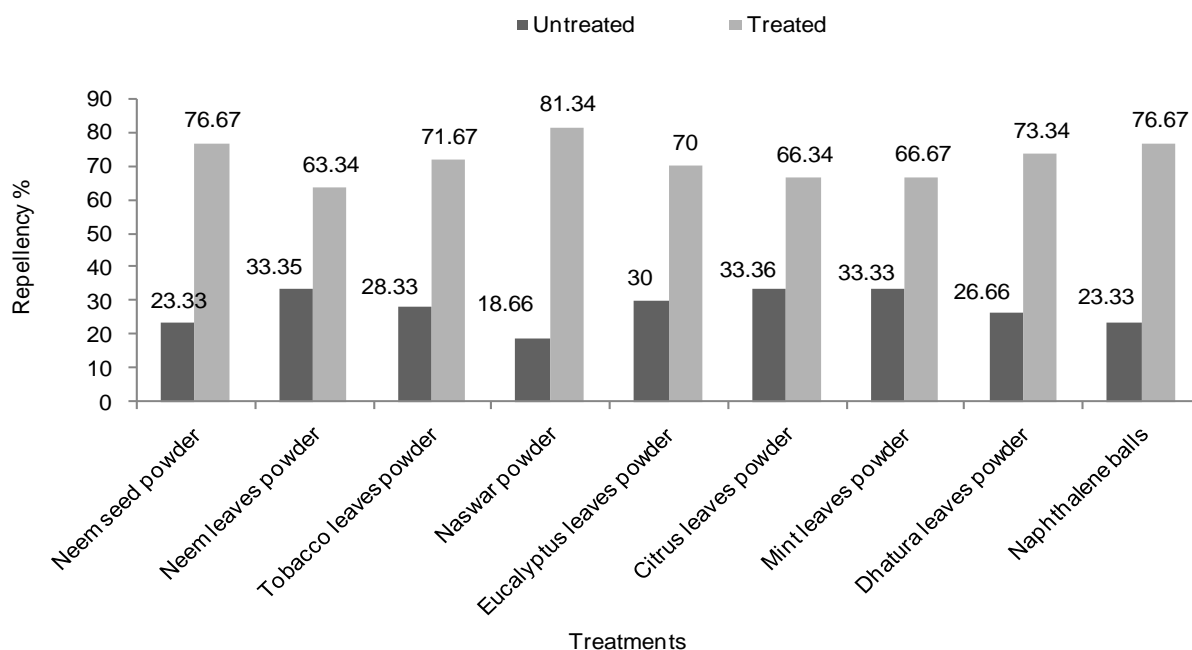


Figure 2. Repellency (%) of pulse beetles (*Callosobruchus chinensis*) with different organic and inorganic insecticides

DISCUSSION

Plant extracts have been used from old age to repel insects and preserve food grains. People used several herb and spices to control different insect pests. For instance, red and black chilies have been extensively used to repel insects. Several herbal products such as ginger, onion, garlic, turmeric, coriander, cumin, saffron etc. have been used against insect pests. Chemical

pesticides possess harmful effects and residual effects. The present research work was a trial to understand the efficacy of herbal pesticides against red flour and pulse beetles in order to establish a combating strategy to minimize qualitative as well as quantitative losses of stored wheat grain and setup a pattern of botanical management. Less frequent instances are available in the country as wheat grains are

concerned. Al-Moajel, (2004) used powders of eleven plant species for botanical management of stored grain pests.

In present study maximum mortality of red flour beetles was observed using neem seed powder at 20% concentrations. Maximum mortality of pulse beetles was observed on naswar powder at 20% concentrations. Moreover, maximum antifeedant efficiency of red flour beetle and pulse beetle was determined using naswar powder at 5%, 10% and 20% concentration and the minimum antifeedant efficiency of pulse beetle was observed for naphthalene balls at all tested concentrations. Similar kind of results were reported by Muhammad *et al.* (2018) where the highest concentration (6%) caused the highest mortality of adults and larvae by some plant species while lower concentrations had no significant effect. This study matched with present findings related to herbal pesticides which could be used for controlling khapra beetles. Rao *et al.* (2005) reported antifeedant losses by the use of some herbal pesticide showed that khapra beetle can be controlled by using plant extracts, including with present findings to some extent. Use of neem seed and leaf powder showed severe effects against khapra beetle as reported by (Egwurube *et al.*, 2010). They studied larval mortality, progeny emergence and seed damage and found that seed powder was more effective in causing mortality.

Another important study that matched present findings on mortality was conducted by Chayengia *et al.* (2010), who reported very high mortality (40%) of insect pests caused by plant extracts. They also reported antifeedant losses that are similar to present findings. Some studies reported lower value of mortality as compared to present findings. For instance Mansoor-ul-Hasan *et al.* (2012) reported that neem extract induced only 14.4% mortality in khapra beetle larvae while (*P. nigrum*) caused only 6.78% mortality. The causes of these contradictory findings might belong exposure time, which reduces its efficacy due to high volatility and lesser persistency. Diverse type of observations is reported in literature. Don Pedro, (1989) noted that plant extracts/ materials, mainly act against egg so rarely larval stages restrict their possible utilization in stored grains.

On the other hand (Pawal and Akpa, 1991) reported that plant material just hindered larval movement and reduced space between grains instead of some repellent effects. Rao *et al.*

(2005) reported that plant extracts were capable of introducing antifeedant and growth inhibitory effects against khapra beetles. Al-Moajel (2004) reported effects of plants insects on larval mortality of khapra beetle. Some plant extract caused powder of neem on mortality and emergence of Khapra beetle larvae was studied by Egwurube *et al.* (2010) and they reported significant effects of seed powders on these parameters. Many researchers have reported repellent, antifeedant or pesticide properties of neem seed and leaf powders against khapra beetle.

Lale, (2002) by comparing the results of this research to those of other studies, the results of this study are consistent with those of (Ileke and Ondo, 2012; Khaliq *et al.*, 2014; Ileke and Ondo, 2012) observed that the toxicity of certain plant powders to the maize weevil, (*Sitophilus zeamais*) Coleoptera: Curculionidae, and on stored wheat grains (*Triticum aestivum*) increased with concentration from 2.5 to 25%. Furthermore, (Khaliq *et al.*, 2014) discovered maize weevil mortality of 35.81 percent from (*Glycyrrhiza glabra*) at a concentration of 5% w/w and mortality of 35.55% owing to 24h exposure to the same plant at a concentration of 5% w/w. In the same research, (Khaliq *et al.*, 2014) discovered a 55.01% and 63.56% w/w mortality rate from (*Chicorium intybus*) and (*Terminalia chebula*), respectively, at a concentration of 5% w/w, and a mortality rate of 46.11 and 48.88 percent due to exposure for 24 hours for the same plants. However, the mortality rate in this research was lower than that observed in a study by (Yohannes *et al.*, 2018) found that after 10 days of exposure, maize seed treated with 10 g of (*Mentha arvensis*) and (*Schinustere binthifolia*) leaf powder had 96.6% mortality, accompanied by Melia (93.3%), and Phytolacca (93.3%) (90%).

The results of this analysis reveal that neem seed powder has the best repellency against red flour beetles. Naswar powder had the greatest repellency against red flour beetles. Our results are consistent with (Mishra and Tripathi's, 2012). They investigated the ability of (*C. reticulata*) and other plants to repel (*Sitophilus oryzae*). (*T. castaneum*) was not used, but essential oils were used. Mishra *et al.* (2012) investigated the repellent effectiveness of essential oils from (*Eucalyptus globules*) (Myrtaceae) and (*Ocimum basilicum*) (Lamiaceae) leaves against adults of (*T. castaneum*) and (*S. niger*). *Oryzae* is a form of *oryzae*. They discovered that (*E. coli*) has repellent properties. (*O. globules*) and

(*T. castaneum*) was greatly outperformed by (*Ocimum basilicum*), also at very low concentrations. When operating on four wild plants of Argentina, (Novo *et al.*, 1997) discovered that some rudimentary extracts had promising repellent action against (*T. castaneum*).

CONCLUSION

The results of present revealed different synthetic and botanical extracts differed significantly in mortality, antifeedant and repellency at different concentrations. Maximum mortality of red flour and pulse beetles were observed on neem seed powder at 20% concentrations. Maximum antifeedant efficiency of red flour beetle and pulse beetle was determined on naswar powder at 5%, 10% and 20% concentration. Maximum repellency against red flour beetles were observed using neem seed powder. Maximum repellency against pulse beetles were observed using naswar powder. Therefore, 20% of neem seed powder concentration proved effective to suppress the population of both red flour beetle and pulse beetle.

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AUTHOR'S CONTRIBUTION

J. Zaib: Conducted Research
A. Ali: Experimental designing
S. A. Memon: Paraphrasing
G. Khaliq: Manuscript reviewed
G. Ali: Manuscript Editing

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