

## **Efficacy of leaf extracts of Neem (*Azadirachta indica*), Ak (*Calotropis procera*) and Bitter Apple (*Citrullus colocynthis*) for the control of Khapra Beetle (*Trogoderma granarium*).**

**Rehana Bibi<sup>1\*</sup>, Muntazir Mehdi<sup>1</sup>, Muhammad Amjad Bashir<sup>1</sup>  
Muhammad Ibrahim<sup>1</sup> & Ghayoor Fatima<sup>2</sup>**

<sup>1</sup>University of Agriculture Faisalabad, Sub-campus Dera Ghazi Khan, Pakistan

<sup>2</sup>Organic Plant Production and Agro-ecosystems Research in Tropics and Sub Tropics,  
University of Kassel Germany

\*Corresponding Author's Email: [rehanacadgk@gmail.com](mailto:rehanacadgk@gmail.com)

### **Abstract**

Neem (*Azadirachta indica*), Ak (*Calotropis procera*) and Bitter Apple (*Citrullus colocynthis*) aqueous leaf extracts were evaluated against damaging effect of *Trogoderma granarium* on stored wheat. The experiment was conducted in Entomological laboratory, College of Agriculture, Dera Ghazi Khan. Four different concentrations viz., control, 5%, 10%, and 15% of aqueous leaf extracts of Neem, Ak and Bitter Apple were tested to protect wheat store grain against *Trogoderma granarium*. Experiment was carried out in Completely Randomized Design (CRD) with factorial arrangement having three replications. At the end of trial completion, data regarding different parameters (insect count, mortality, and repellency studies) were collected according to standard procedures and analyzed statistically on a computer by using MSTATC, statistical software. Treatment means were compared by applying Least Significant Difference (LSD) test at 1% probability level. Data was recorded at each 15 days interval for insect count, mortality. In case of repellency studies data was recorded at 1, 5, 24, 48 and 72 hours intervals. The most effective treatment was 15% concentration of aqueous leaf extracts of Neem, Ak and Bitter Apple while least effective treatment was 5% concentration for insect count, mortality and repellency studies. Maximum repellency was observed at 15% concentration of Bitter Apple and minimum repellency was observed at 5% concentration of Ak.

**Keywords:** Entomology, Leaf Extracts, Repellency, Concentration, Efficacy

## 1. Introduction

Wheat (*Triticumaestivum*) is the most important cereal grain and staple food for people of Pakistan and contributed 14.4 percent to value added in agriculture and 3.1 percent to GDP during 2009-2010. It was grown on 9.045 million hectares with the production of 25 million tones (Govt. of Pakistan, 2010). Farmers preserve most of the wheat grain for their domestic consumption and as seed purpose. In Pakistan production is lower as compared to other developed countries due to improper storage condition as well as main problem of storage pests such as *Triboliumcastaneum*, *Sitophilusoryzae*, *Rhizoperthadominica* and *Trogodermagranarium*.

The Khapra beetle (*Trogodermagranarium*) particularly in its larval stage of development is the world's most destructive pest of cereals, oilseeds, dry fruits, copra and other stored products in Indo-Pakistan. (Khattak *et al.* 1996). Its vast economic importance is due to its potential to cause huge loss in stored grains through rapacious feeding and heating of grains. The larvae are able to withstand starvation for up to three years and live on food with very low moisture content. The young larvae feed on damaged seed while older larvae are able to feed on whole grains. Larvae typically attack the embryo point or a weak place in the pericarp of seed.

The infestations of Khapra beetle most likely to be held to food processing plants, grain storage facilities, warehouses, or other buildings containing suitable host material. In case of severe infestations infested grains are filled with excreta, frass and cast skins, which badly deteriorate quality of the grains. In sorghum, wheat and maize grains infestation level of 75% significantly decreased crude fat, sugars, total carbohydrates and true protein contents while it increases the crude fiber, moisture and total protein contents. Besides, substantial loss of vitamins e.g., riboflavin, niacin and thiamin occurs due to the infestation. Due to depletion of specific nutrients the infested grains become unpalatable and unmarketable and also produce harmful effects to the human health. The barbed hairs of the larvae that rub off and remain in the grain may prove a severe hazard to human health if swallowed. Besides, cast skins may cause dermatitis in people handling heavily infested grains.

Synthetic insecticides have been described to provide quick, effective and popular method of pests control but associated with residual effects causing acute and chronic poisoning in man and other non-target animals. Phosphine fumigation is a promising control measure against stored product insect pests, but in Pakistan large amount of wheat is stored in gunnies where fumigation is not successful due to leakage of gas. It is also very difficult to maintain the recommended lethal concentration over the required exposure period due to leaky storage structures. Moreover, *Trogodermagranarium* has been observed to have gone resistant to phosphine due to sub-standard techniques of fumigation. Therefore, there is an urgent need to describe environment friendly alternatives with the potentials to replace the highly toxic chemicals.

The new trend is towards the use of botanical having insecticidal properties throughout the world. Botanical are considered to be non-pollutant, less toxic and easily bio-degradable. Some botanical are extremely efficient against insect pests, safe for human beings, environment friendly, convenient and economical for protection of stored grains. Although certain botanical have already been reported to possess repellent action against stored grain pests. Repellents are the substances which act as stimulants arouse avoiding reactions, non-poisonous and cause insects to change their movement away from the food source. These are normally volatile chemicals and show their activity in volatile phase. The insects are very susceptible to repellents substances even from a few centimeters distance causing them to fly or crawl away.

Many biologically active compounds have been isolated from Neem, azadirachtin which possess antifeedant, ovicidal, growth inhibiting and insecticidal effects against many insect pests. Neem is usually used as a powder from crushed seeds for storage protection of grain. It gives protection of many insect pests including Lesser grain borer, *Rhizoperthadominica* and Khapra beetles, *Trogodermagranarium*. Abundance of latex in the green parts of *Calotropisprocera* produced and accumulated as a defense strategy against organisms such as fungi, virus, and insects. Exude of latex secretion of *Calotropisprocera* from injured leaves immobilize the insects. It was also found that the latex of *Calotropisprocera* is a suitable source of active compounds exhibiting larvicidal activity. Botanicals are biodegradable, less expensive, environmentally suitable, safe for the human beings and favorable for protection of stored grains. *Citrulluscolocynthis* (*Cucurbitaceae*), commonly known as Bitter Apple has gained increasing attention as a natural insecticide and its activity has been evaluated against many economically important insect species. *Citrulluscolocynthis* has antifeedant, growth-regulating, deterrent, and fertility reducing properties on

insects (Prabuseenivasan *et al.*, 2004).

## 2. Materials and Methods

The experiment was conducted to evaluate the efficacy of aqueous leaf extracts of Neem, Ak and Bitter Apple against Khapra Beetle (*Trogoderma granarium*), a stored grain pest of wheat on basis of insect count, mortality, loss in larval weight, loss in grain weight and repellency studies. The research was conducted in the Entomological Laboratory, College of Agriculture, Dera Ghazi Khan by using Completely Randomized Design (CRD) with factorial arrangement having three replications. The experiment was conducted for a period of 4 months.

The material used in experiment comprised of *Trogoderma granarium*, petri dishes, jars, cotton, filter paper, butter paper, muslin clothes, rubber bands, infested wheat grains, wheat flour, botanical extracts of Neem, Ak and Bitter Apple, sieves mesh, camel hair brush, beakers, bowls, distilled water, incubator, electrical shaker and electrical balance.

### 2.1. Rearing and Collection of Insect

Adult insects were collected from Godowns of Punjab Food Department located in D.G. Khan District. Insect collection was done by taking the most infested grains samples. These samples of infested grains were containing Khapra beetle (*Trogoderma granarium*) eggs, larvae, pupae, and adult. They were taken in laboratory for rearing in order to get offsprings of same age for further study.

Insect were reared in already damaged grains of local wheat variety Seher 2006 under controlled conditions of  $30 \pm 2^\circ\text{C}$  temperature and 70-80% relative humidity in an incubator. Glass jars of 1kg capacity were used for rearing of insects. Each glass jar was covered with muslin cloth, tied with rubber bands, to avoid entry of ants and escape of beetle. The insects were reared in laboratory for 2 months. After completion of rearing, the infested grains containing eggs, larvae, pupa and adults were screened through mesh to separate the adults of *Trogoderma granarium* of same size and age. The adult insects of *Trogoderma granarium* were shifted to experimental jars for data recording.

### 2.2. Preparation and application of extracts

Fresh leaves of *Azadirachta indica*, *Calotropis procera* and *Citrullus colocynthis* were collected from different areas of Dera Ghazi Khan and brought in Entomological laboratory, College of Agriculture, Dera Ghazi Khan. These plants leaves were washed under tap water, dried in shade having proper ventilation. The fine powders of these plant materials were prepared by grinder. One hundred gram of each plant powder was extracted in 200 ml of distilled water 1:2 (w/v) for 24 hours. These materials were shaken under electric shaker for 12 hours and filtered it with filter paper (Whatman No. 42). This procedure was repeated three times to obtain maximum extraction. The extracts were dried in glass bowl to obtain crude extract after the evaporation of water and used for making different concentrations of each NeemAk and Bitter Apple. The grains were treated with concentration i.e. 0%, 5%, 10% and 15% formed in 10 ml water. The jars were open for few hours for allowing the moisture to evaporate. The insects were released in jars @ 16 insects /100 grams wheat grains per jar (Collins, 1998).

### 2.3. Treatments of each Neem, Ak and Bitter Apple

#### 2.3.1. Plant extracts

- i. Control
- ii. 5%
- iii. 10%

iv. 15%

Wheat grains having weight 100 gm. of local variety Seher 2006 were used for each treatment and total volume required for pasting for each 100 gm. wheat grains was 10 ml.

### 2.3.2. Preparation of different concentrations of each Neem, Ak and Bitter Apple

From the crude extracts, different concentrations (5%, 10% and 15%) of Neem, Ak and Bitter Apple were prepared. These concentrations of Neem, Ak and Bitter Apple were prepared by using the beaker flask method. For the preparations of 5% concentration 5gm crude extract was put in graduated flask and added distilled water up to 10 ml, similarly remaining concentration of 10% and 15% were prepared by using this method.

These concentrations were made from Neem, Ak and Bitter Apple crude extract. Each concentration was replicated thrice in experimental jars for insect count, loss in grain weight, mortality and loss in larval weight. For repellency studied, these concentrations were applied to a filter paper in the petri dishes for repellency studies; data was obtained at 1, 5, 24, 48 and 72 hours intervals and subjected to statistical analysis to determine the difference among different concentrations of plants extracts.

## 2.4. Parameters

The effect of treatments and their different concentrations was observed on following parameter and explained one by one according to standard procedures.

### 2.4.1. Insect count

Insect count was done at each 15 days interval for two months. Before releasing the insects, each jar was treated with different concentrations (0%, 5%, 10% and 15%) of Neem, Ak and Bitter Apple leaf extracts. The no. of insect alive in the control and no. of insect alive in the each treated wheat grains jar were observed. For insect count in each jar, grains were removed out from jars on a paper and insect were separated from infested grains with help camel hair brush. This practice was repeated in each jar and alive insect were counted.

### 2.4.2. Mortality (%)

The jars of wheat grains were treated with Neem, Ak and Bitter Apple at different concentrations 0%, 5%, 10% and 15% of leaf extracts before releasing the specific no. of insects in each jar. Three replications were done of each concentration and 16 insects of same size were added in each jar. At the end of trial completion, jars were opened and grains in treated and untreated jars were removed on a paper and alive insects in each treated and untreated jars were counted separately. Data was recorded and percentage mortality of *Trogodermagranarium* was calculated by using the given formula and also compared with control samples.

$$\text{Percent Mortality} = \frac{\text{No. of Insects alive in test}}{\text{No. of insects alive in control}} \times 100$$

### 2.4.3. Repellency Studies

Repellency studies were carried out by using filter paper strip method. Filter paper (Whatman No. 1) was cut into strips of 8×10 cm dimensions. Half filter paper strips was treated with 1 ml of extract and allowed to air dry for 10 minutes. Each treated half strip of filter paper was then attached lengthwise, edge to edge to a control half strip with adhesive tape and placed in a petri dish. Twenty adult insects were released in the middle of each filter paper circle in petri dish. Insect that settled on each of the filter paper strip was counted at 1, 5, 24, 48 and 72 hours intervals. Repellency was studied against *Trogodermagranarium* on basis of time interval (1, 5, 24, 48 and 72 hours) at different concentrations (0%, 5%, 10% and 15%) of Neem, Ak and Bitter Apple.

## 3. Results and Discussion

The present research work was conducted in the laboratory condition at College of Agriculture, Dera Ghazi Khan Sub-Campus University of Agriculture, Faisalabad. The mean values regarding the effect of Bitter Apple, Ak and Neem aqueous leaf extracts on the protection of wheat stored grains against *Trogodermagranarium* with statistical interpretation are demonstrated and discussed in the following pages.

### 3.1. Insect Count

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the insect count. Neem aqueous leaf extracts were found inhibitorier to *Trogodermagranarium* as compared to Ak and Bitter Apple. Different concentrations of each Neem, Ak and Bitter Apple aqueous leaf extracts significantly effect on *Trogodermagranarium*. As the concentration of aqueous leaf extracts increased the insect count was decreased.

### 3.2. Insect count at 15 days interval

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the insect count at 15 days interval (Table 4.1.1 A). Neem aqueous leaf extracts were found inhibitorier to *Trogodermagranarium* as compared to Ak and Bitter Apple. Different concentrations of each Neem, Ak and Bitter Apple aqueous leaf extracts significantly effect on *Trogodermagranarium*.

Table No. 4.1.1 A shows the Effect of different concentrations of Neem,Ak and Bitter Apple leaf extracts on insect count of *Trogodermagranarium* at 15 days interval.

**Table 4.1.1 A: Analysis of Variance**

S. O. V	df	TSS	MS	F-Value	P-Value
<b>Concentration</b>	3	3613.64	1204.35	1667.83	0.00 ***
<b>Plant Extracts</b>	2	42.89	21.44	29.69	0.00 ***
<b>Concentration * Plant Extracts</b>	6	25.11	4.19	5.79	0.00 ***
<b>Error</b>	24	17.33	0.72		
<b>Total</b>	35	3698.97			

The interactive effect of plant extracts and concentrations was also found significant (Table 4.1.1 B). The highest insect count was recorded at 5% concentration of Bitter Apple and minimum insect count was observed at 15% concentration of Neem. The effect of 10% concentration of Ak and 15% concentration of Bitter Apple were statistically similar from each other. As the concentration of aqueous leaf extracts increased the insect count was decreased. Concentrations of 15% of each Neem, Ak and Bitter Apple leaf aqueous extracts was found the most effective against *Trogodermagranarium*. While the concentration of 5% of each Neem, Ak and Bitter Apple aqueous leaf extracts was found the least effective against *Trogodermagranarium*.

**Table 4.1.1 B: Comparisons of Means Treatment**

Concentrations	Plant Extract			Means
	Neem	Ak	Bitter Apple	
Control	28 a	28.33 a	27.33 a	27.89 a
5%	9 d	11.33 c	13 b	11.11 b
10%	3.333 fg	4.33 f	6.33 e	4.67 c
15%	0 h	2.33 g	4.33 f	2.22 d
Total	10.08 c	11.58 b	12.75 a	

LSD value for Plant Extracts ( $p > 0.01$ ) = 0.97

LSD value for Concentration ( $p > 0.01$ ) = 1.12

LSD value for Plant Extracts\* Concentrations ( $p>0.01$ ) = 3.36  
 Treatment means sharing a letter in column did not differ significantly at  $p>0.01$

**4.1.2. Insect count at 30 days interval**

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the insect count at 30 days interval (Table 4.1.2 A). Neem aqueous leaf extracts were found more inhibitory to *Trogodermagranarium* as compared to Ak and Bitter Apple. Different concentrations of each Neem, Ak and Bitter Apple aqueous leaf extracts significantly effect on *Trogodermagranarium*. The insect count was decreased significantly with increased the concentration of aqueous leaf extracts.

**Table No. 4.1.2** Effect of different concentrations of Neem, Ak and Bitter Apple leaf extracts on insect count of *Trogodermagranarium* at 30 days interval.

**Table 4.1.2 A: Analysis of Variance**

S. O. V	df	TSS	MS	F	P
Concentrations	3	17015.64	5671.88	1334.36	0.00 ***
Plant Extracts	2	222.17	111.08	26.14	0.00 ***
Concentrations * Plant Extracts	6	134.94	22.49	5.29	0.00 ***
Error	24	102	4.25		
Total	35	114.37			

The interactive effect of plant extracts and concentrations was also found significant (Table 4.1.2 B). The highest insect count was recorded 5% concentration of Bitter Apple and minimum insect count was observed at 15% concentration of Neem. The effect of 10% concentration of Neem and 10% concentration of Ak were statistically similar from each other. As the concentration of aqueous leaf extracts increased the insect count was decreased. Concentrations of 15% of each Neem, Ak and Bitter Apple leaf aqueous extracts was found the most effective against *Trogodermagranarium*. While the 5% concentration of each Neem, Ak and Bitter Apple aqueous leaf extracts was found the least effective against *Trogodermagranarium*.

**Table 4.1.2 B: Comparisons of Means Treatment**

Concentrations	Plant Extract			Means
	Neem	Ak	Bitter Apple	
Control	59.33 a	59 a	58.33 a	58.89 a
5%	18 d	24 c	30 b	24 b
10%	5 g	6.67 fg	10.33 e	7.44 c
15%	0 h	4 g	8 ef	4 d
Total	20.58 c	23.5 b	26.67 a	

LSD value for Plant Extract ( $p>0.01$ ) =2.35

LSD value for Concentration ( $p>0.01$ ) =2.72

LSD value for Plant Extract\* Concentration ( $p>0.01$ ) = 8.15

Treatment means sharing a letter in column did not differ significantly at  $p>0.01$

**4.1.3 Insect count at 45 days interval**

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the insect count at 45 days interval (Table 4.1.3 A). Neem aqueous leaf extracts were found more inhibitory to *Trogodermagranarium* as compared to Ak and Bitter Apple. Different concentrations of each Neem, Ak and Bitter Apple aqueous leaf extracts significantly effect on *Trogodermagranarium*.

Table No. 4.1.3 Effect of different concentrations of Neem,Ak and Bitter Apple leaf extracts on insect count of *Trogodermagranarium* at 45 days interval.

**Table 4.1.3 A: Analysis of Variance**

S. O. V	df	TSS	MS	F-Value	P-value
Concentration	3	83326.31	27775.44	685.34	0.00 ***
Plant Extract	2	1122.06	561.03	13.84	0.00 ***
Concentration * Plant Extract	6	601.28	100.21	2.47	0.05 ns
Error	24	972.67	40.52		
Total	35	86022.31			

The interactive effect of plant extracts and concentrations was also found significant (Table 4.1.3 B). The highest insect count was recorded 5% concentration of Bitter Apple and minimum insect count was observed at 15% concentration of Neem which was statistically not similar to 5% and 10% concentration of each Neem, Ak and Bitter Apple. It was also statistically not similar to 15% concentration of Ak and 15% concentration of Bitter Apple. The effect of 10% concentration of Ak and 15% concentration of Bitter Apple were statistically similar from each other. As the concentration of aqueous leaf extracts increased the insect count was decreased. Concentrations of 15% of each Neem, Ak and Bitter Apple leaf aqueous extracts was found the most effective against *Trogodermagranarium*. While the concentration of 5% of each Neem, Ak and Bitter Apple aqueous leaf extracts was found the least effective against *Trogodermagranarium*.

**Table 4.1.3 B: Comparisons of Means Treatment**

Concentration	Plant Extract			Means
	Neem	Ak	Bitter Apple	
Control	128.33 a	128 a	129.67 a	128.67 a
5%	40 d	54.67 c	69 b	54.36 b
10%	10.33 f	14.33 ef	20.67 e	15.11 c
15%	0 g	7.33 fg	14 ef	7.11 c
Total	44.67 b	51.08 ab	58.33 a	

LSD value for Plant Extract ( $p > 0.01$ ) = 7.27

LSD value for Concentration ( $p > 0.01$ ) = 8.39

LSD value for Plant Extract\* Concentration ( $p > 0.01$ ) = 25.18

Treatment means sharing a letter in column did not differ significantly at  $p > 0.01$

#### 4.1.4 Insect count at 60 days interval

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the insect count at 60 days interval (Table 4.1.4 A). Neem aqueous leaf extracts were found more inhibitory to *Trogodermagranarium* as compared to Ak and Bitter Apple. Different concentrations of each Neem, Ak and Bitter Apple aqueous leaf extracts significantly effect on *Trogodermagranarium*. The insect count was decreased significantly with increased the concentration of aqueous leaf extracts.

Table No. 4.1.4 Effect of different concentrations of Neem,Ak and Bitter Apple leaf extracts on insect count of *Trogodermagranarium* at 60 days interval.

**Table 4.1.4 A: Analysis of Variance**

S. O. V	df	TSS	MS	F-value	P-value
Concentration	3	300469.89	100156.63	1141.39	0.00***
Plant Extract	2	5255.06	2627.53	29.94	0.00***
Concentration * Plant Extract	6	2947.61	491.27	5.59	0.00***
Error	24	2106	87.75		
Total	35	310778.56			

The interactive effect of plant extracts and concentrations was also found significant (Table 4.1.4 B). The highest insect count was recorded 5% concentration of Bitter Apple and minimum insect count was observed at 15% concentration of Neem. The effect of 10% concentration of Ak and 15% concentration of Bitter Apple were statistically similar from each other. The effect of 5% and 10% concentration of Neem were also statistically similar from each other. As the concentration of aqueous leaf extracts increased the insect count was decreased. Concentrations of 15% of each Neem, Ak and Bitter Apple leaf aqueous extracts was found the most effective against *Trogodermagranarium*. While the concentration of 5% of each Neem, Ak and Bitter Apple aqueous leaf extracts was found the least effective against *Trogodermagranarium*.

**Table 4.1.4 B: Comparisons of Means Treatment**

Concentration	Plant Extract			Means
	Neem	Ak	Bitter Apple	
Control	249.33 a	249.33 a	248 a	248.89 a
5%	88.33 d	121.33 c	148.33 b	119.33 b
10%	77 d	33.67 f	51 e	36.78 c
15%	0 h	15.33 g	31.33 f	16.56 d
Total	90.83 c	104.92 b	120.42 a	

LSD value for Plant Extract ( $p > 0.01$ ) = 10.69

LSD value for Concentration ( $p > 0.01$ ) = 12.35

LSD value for Plant Extract\* Concentration ( $p > 0.01$ ) = 37.05

Treatment means sharing a letter in column did not differ significantly at  $p > 0.05$

My results are similar to Shanthi and Logiswaran (1996) they studied petroleum-ether extract of rhizomes of *Acoruscalamus* with different concentrations to evaluate their effect on the biology of *Sitotrogacerealella*. They concluded that the percent adult-emergence of *Sitotrogacerealella* was the lowest in the grains, treated with 0.15% and 0.20% of the *Acoruscalamus*.

My results are similar to Kumari and Verma (1999) they tested the effect of leaf powder of *Acoruscalamusto* control *Callosobruchschinensis*. The mortality of beetles was observed for 240 hours, at 24 hour intervals. The effect of low doses of *A. calamus* leaf powder on the mortality of adult beetles had a longer duration, while that of the high doses resulted in a higher mortality for shorter durations.

My results are similar to Muda and Cribb (1999) they tested the effects of Neem-extract having enriched azadirachtin against the feeding behavior and reproduction of *Rhizoperthadominica* in wheat grains. Treating 10% of the grains observed the same level of protection, as in treating 100% of the grains. The antifeedant effect of azadirachtin on the *Rhizoperthadominica*, also remained unaffected when 50% of the grains were treated.

My results are similar to Dwivedi and Venugopalan (2001) they tested the ovicidal action of acetone extracts of seven plant species *Murrayakoenigii*, *Ficusreligiosa*, *Ficusindica*, *Tamarindusindica*, *Tabernaemontanalivaricate*, *Chenopodium album*, *Syzygiumcumini* to control *Callosobruchschinensis*. They concluded that *Chenopodium*, *Murraya* and *Tabernaemontana* showed higher ovicidal action than *Ficusreligiosa*, *Ficusindica*, *Tamarindusindica* and *Syzygiumcumini* at the same dose level.



My results are similar to Islam and Talukder (2005) they studied the extracts of seed and leaf powders of the *Tagetes erecta*, *Cynodondactylon* and *Azadirachtaindica* along with two insecticides, malathion and carbaryl to control *Tribolium castaneum*. They concluded that *Azadirachtaindica* seed extract showed higher toxicity than *Tagetes erecta* and *Cynodondactylon* seed extracts. They also concluded that 5 % of *Tagetes erecta* leaf powder showed a higher residual toxicity than *Azadirachtaindica* and *Cynodondactylon* leaf powder.

My results are similar to Das *et al.* (2006) they studied the effect of Nimbecidine against the eggs of *Tribolium castaneum*. Nimbecidine was highly suppressed hatching, pupation and adult emergence of *Tribolium castaneum*. They concluded that in the growth of larvae, pupation and adult emergence significant reductions showed on the next generation of *Tribolium castaneum*.

My results are similar to Kudachi and Balikai (2009) they tested efficacy of *Acorus calamus* rhizomes for the management of *Rhizopertha dominica* in sorghum during storage. They concluded that *Acorus calamus* was found to be significantly superior to control *Rhizopertha dominica* and protected sorghum grains up to 180 days after treatment followed by *Acorus squamosa* seed powder, malathion dust and *Azadirachtaindica* seed powder with higher germination percentage, minimum seed damage, maximum adult mortality and minimum weight loss.

## 4.2. Mortality Percentage

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the mortality percentage of insect. Neem aqueous leaf extracts were found more toxic to *Trogoderma granarium* as compared to Ak and Bitter Apple. Different concentrations of each Neem, Ak and Bitter Apple aqueous leaf extracts significantly effect on *Trogoderma granarium*. As the concentration of aqueous leaf extracts increased the mortality of *Trogoderma granarium* was also increased.

### 4.2.1 Mortality percentage at 15 days interval

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the mortality percentage of insect at 15 days interval (Table 4.2.1 A). Neem aqueous leaf extracts were found more toxic to *Trogoderma granarium* as compared to Ak and Bitter Apple. Different concentrations of each Neem, Ak and Bitter Apple aqueous leaf extracts were significantly effect on mortality of *Trogoderma granarium*.

Table No. 4.2.1 Effect of different concentrations of Neem, Ak and Bitter Apple leaf extracts on mortality of *Trogoderma granarium* at 15 days interval.

**Table 4.2.1 A: Analysis of Variance**

S. O. V	df	TSS	MS	F-Value	P-value
Concentration	3	124.06	41.35	3721.93	0.00 ***
Plant Extract	2	3.37	1.68	151.6	0.00 ***
Concentration * Plant Extract	6	1.42	0.24	21.23	0.00 ***
Error	24	0.27	0.01		
Total	35	129.12			

The interactive effect of plant extracts and concentrations was found also significant (Table 4.2.1 B). The highest mortality was recorded at 15% concentration of Neem and minimum mortality was observed at 5% concentration of Bitter Apple. The effect of 10% concentration of Ak and 15% concentration of Bitter Apple were statistically similar from each other. As the concentration of aqueous leaf extracts increased the mortality percentage of insect was increased. Concentrations of 15% of each Neem, Ak and Bitter Apple leaf aqueous extracts was found the most effective against *Trogoderma granarium* while the concentration of 5% of each Neem, Ak and Bitter Apple aqueous leaf extracts was found the least effective against *Trogoderma granarium*.

### Table 4.2.1 B: Comparisons of Means Treatment

Concentration	Plant Extract			Means
	Neem	Ak	Bitter Apple	
Control	17.24 i	17.53 i	17.7 i	17.48 d
5%	67.73 f	59.37 g	53.39 h	60.16 c
10%	88.05 c	84.46 d	71.16 e	83.27 b
15%	100 a	91.63 b	84.46 d	92.03 a
Total	68.26 a	63.24 b	58.21 c	

LSD value for Plant Extract (p>0.01) = 0.12

LSD value for Concentration (p>0.01) = 0.14

LSD value for Plant Extract\* Concentration (p>0.01) = 6.76

Treatment means sharing a letter in column did not differ significantly at p>0.01

#### 4.2.2 Mortality percentage at 30 days interval

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the mortality percentage of insect at 30 days interval (Table 4.2.2 A). Neem aqueous leaf extracts were found more toxic to *Trogodermagranarium* as compared to Ak and Bitter Apple. Different concentrations of each Neem, Ak and Bitter Apple aqueous leaf extracts were significantly effect on mortality of *Trogodermagranarium*.

Table No. 4.2.2 Effect of different concentrations of Neem,Ak and Bitter Apple leaf extracts on mortality of *Trogodermagranarium* at 30 days interval.

#### Table 4.2.2 A: Analysis of Variance

S. O. V	df	TSS	MS	F-value	P-value
Concentration	3	110.46	36.82	3898.71	0.00 ***
Plant Extract	2	2.87	1.43	151.79	0.00 ***
Concentration * Plant Extract	6	1.01	0.17	17.91	0.00 ***
Error	24	0.23	0.01		
Total	35	114.37			

The interactive effect of plant extracts and concentrations was found also significant (Table 4.2.2 B). The highest mortality was recorded at 15% concentration of Neem and minimum mortality was observed at 5% concentration of Bitter Apple. The effect of 10% concentration of Ak and 15% concentration of Bitter Apple were statistically similar from each other. The effect of 10% concentration of Neem and 10 concentration of Ak were also statistically similar. As the concentration of aqueous leaf extracts increased the mortality percentage of insect was increased. Concentrations of 15% of each Neem, Ak and Bitter Apple leaf aqueous extracts was found the most effective against *Trogodermagranarium* while the concentration of 5% of each Neem, Ak and Bitter Apple aqueous leaf extracts was found least effective against *Trogodermagranarium*.

#### Table 4.2.2 B: Comparisons of Means Treatment

Concentration	Plant Extract			Means
	Neem	Ak	Bitter Apple	
Control	8.44 h	8.27 h	8.37 h	8.36 d
5%	69.42 e	59.25 f	49.06 g	59.24 c
10%	91.5 b	88.11 c	82.45 d	87.36 b
15%	100 a	93.21 b	86.42 c	93.21 a
Total	67.34 a	62.21 b	56.58 c	

LSD value for Plant Extract (p>0.01) = 0.93

LSD value for Concentration (p>0.01) = 1.99

LSD value for Plant Extract\* Concentration (p>0.01) = 5.98

Treatment means sharing a letter in column did not differ significantly at p>0.01

### 4.2.3 Mortality Percentage at 45 Days Interval.

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the mortality percentage of insect at 45 days interval (Table 4.2.3 A). Neem aqueous leaf extracts were found more toxic to *Trogodermagranarium* as compared to Ak and Bitter Apple. Different concentrations of each Neem, Ak and Bitter Apple aqueous leaf extracts were significantly effect on mortality of *Trogodermagranarium*.

**Table No. 4.2.3** Effect of different concentrations of Neem,Ak and Bitter Apple leaf extracts on mortality of *Trogodermagranarium* at 45 days interval.

**Table 4.2.3 A: Analysis of Variance**

S. O. V	df	TSS	MS	F-value	P-value
Concentration	3	42948.06	14316.02	5075.61	0.00 ***
Plant Extract	2	646.45	323.22	114.39	0.00 ***
Concentration * Plant Extract	6	393.72	65.62	23.26	0.00 ***
Error	24	67.69	2.82		
Total	35	44055.92			

The interactive effect of plant extracts and concentrations was found also significant (Table 4.2.3 B). The highest mortality was recorded at 15% concentration of Neem and minimum mortality was observed at 5% concentration of Bitter Apple. The effect of 10% concentration of Ak and 15% concentration of Bitter Apple were statistically similar from each other. As the concentration of aqueous leaf extracts increased the mortality percentage of insect was increased. Concentrations of 15% of each Neem, Ak and Bitter Apple leaf aqueous extracts was found the most effective against *Trogodermagranarium* while the concentration of 5% of each Neem, Ak and Bitter Apple aqueous leaf extracts was found least effective against *Trogodermagranarium*.

**Table 4.2.3 B: Comparisons of Means Treatment**

Concentration	Plant Extract			Means
	Neem	Ak	Bitter Apple	
Control	7.49 i	6.52 i	7.43 i	7.15 d
5%	68.91 f	57.51 g	46.37 h	57.59 c
10%	91.97 c	88.86 d	83.94 e	88.24 b
15%	100 a	94.3 b	89.12 d	94.47 a
Total	67.09 a	61.80 b	56.72 c	

LSD value for Plant Extract ( $p > 0.01$ ) = 1.92

LSD value for Concentration ( $p > 0.01$ ) = 2.21

LSD value for Plant Extract\* Concentration ( $p > 0.01$ ) = 6.64

Treatment means sharing a letter in column did not differ significantly at  $p > 0.01$

### 4.2.4 Mortality Percentage at 60 Days Interval.

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the mortality percentage of insect at 60 days interval (Table 4.2.4 A). Neem aqueous leaf extracts were found more toxic to *Trogodermagranarium* as compared to Ak and Bitter Apple. Different concentrations of each Neem, Ak and Bitter Apple aqueous leaf extracts were significantly effect on mortality of *Trogodermagranarium*.

**Table No. 4.2.4** Effect of different concentrations of Neem,Ak and Bitter Apple leaf extracts on mortality of *Trogodermagranarium* at 60 days interval.

**Table 4.2.4 A: Analysis of Variance**

S. O. V	df	TSS	MS	F-value	P-value
Concentration	3	32006.81	10668.94	1617.25	0.00 ***
Plant Extract	2	835.23	417.62	63.30	0.00 ***
Concentration * Plant Extract	6	429.62	71.60	10.85	0.00 ***
Error	24	158.33	6.59		
Total	35	33429.99			

The interactive effect of plant extracts and concentrations was found also significant (Table 4.2.4 B). The highest mortality was recorded at 15% concentration of Neem and minimum mortality was observed at 5% concentration of Bitter Apple. The effect of 10% concentration of Neem, 15% concentration of Ak and 15% concentration of Bitter Apple were statistically similar from each other. As the concentration of aqueous leaf extracts increased the mortality percentage of insect was increased. Concentrations of 15% of each Neem, Ak and Bitter Apple leaf aqueous extracts was found the most effective against *Trogodermagranarium* while the concentration of 5% of each Neem, Ak and Bitter Apple aqueous leaf extracts was found least effective against *Trogodermagranarium*.

**Table 4.2.4 B: Comparisons of Means Treatment**

Concentration	Plant Extract			Means
	Neem	Ak	Bitter Apple	
Control	18.72 h	18.62 h	18.1 h	18.47 d
5%	64.31 e	51.25 f	40.4 g	52.05 c
10%	90.02 c	86.47 c	79.51 d	85.33 b
15%	100 a	93.84 b	87.95 c	93.93 a
Total	68.28 a	62.57 b	56.49 c	

LSD value for Plant Extract ( $p > 0.01$ ) = 2.93

LSD value for Concentration ( $p > 0.01$ ) = 3.39

LSD value for Plant Extract\* Concentration ( $p > 0.01$ ) = 10.16

Treatment means sharing a letter in column did not differ significantly at  $p > 0.01$

Results are similar to Su (1991) tested contact toxicity of essential oil of *Acoruscalamus* against the adults of *Callosobruchuschinensis*, *Sitophilusoryzae*, *Lasiodermaserricorne* and *Triboliumconfusum*. The oil, when topically applied was highly toxic to the *L. serricorne*, with 100% mortality. When applied at a dosage of 1000 ppm to the wheat or cow peas (*Vignaunguiculata*), the oil gave 100% protection from the infestation of *S. oryzae* and *C. maculatus*, respectively.

Results are similar to Okonkwo and Okoye (1992) they tested dried ground leaves of *Ricinuscommunis* against *Callosobruchusmaculatus*, in stored cowpeas. They concluded that the application of dried ground leaves of *Ricinuscommunis* controlled effectively *Callosobruchusmaculatus*.

Results are matched to Maleket *al.* (1996) who reported *Triboliumcastaneum* adults were exposed to seed oil extracts of *Ricinuscommunis*, *Aracchishypogaea*, *Thevetiameriifolia* and *Carissacarands*. Adult mortality was recorded at 24, 48, 72 and 96 hour after treatment. The most effective treatment against the pest in which mortality was 50% when adults were exposed to seed oil extracts of *Thevetiameriifolia*.

Results are similar to Paneru *et al.* (1997a) they tested the powdered Sweet flag rhizomes, with the wheat, against *Sitophilusoryzae* and *Sitophilusgranarius* adults. An admixture of rhizome-powder, with the wheat @ 2%, gave a complete kill of the adults of *Sitophilusoryzae* and *Sitophilusgranarius*, with an exposure of 7 days, while a concentration of 1% either killed them rapidly or prevented the emergence of adults.

Results are similar to Lale and Mustapha (2000) they tested the insecticidal efficacy of Neem seed oil, applied on cowpea seeds, for reducing the reproductive potential of *Callosobruchusmaculatus*, in three storage devices, over a period of three month.

Results are similar to Ahmed (2000) they tested the efficacy of Castor-seed extract, as an insecticide, against *Sitophilusoryzae*. He concluded it to be inhibiting cholinesterase and peroxidase enzymes in the insect body and the enzyme-inhibition levels varied differently in adult insects, at different exposure times.

Results are similar to Umoetok (2000) tested the toxicity of the powdered *Acoruscalamus* against *Rhizoperthadominica*, *Sitophilusoryzae* and *Triboliumcastaneum*. They concluded that only *Sitophilusoryzae* and *Rhizoperthadominica* were susceptible to test products and 100% of *Sitophilusoryzae* and 90% of *Rhizoperthadominica* died, within 16 days. In the case of *Triboliumcastaneum* no mortality was observed

My results are similar to Nath et al. (2002) they tested Neem-based formulations against the population of insect pests of sesame. They resulted that NSKE was the most effective in reducing the pest populations among the Neem-based formulations. They also resulted that Nimbicidin was the most effective Neem-based commercial formulation in controlling, capsule borer, leaf webber, Bihar hairy caterpillar, and sesame hawk moth and Neemta-2100 was the most effective for controlling sesame gall fly.

Results are also similar to Egwurube et al. (2010) they tested the efficacy Neem seed powder and Neem leaf powder. They conclude that Neem seed powder treatment gave 100% mortality only at 10% w/w level with about 6.5% and 6.7% seed damage and progeny emergence respectively.

### 4.3 Repellency Studies

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the repellency percentage of insect. The highest repellency was found in 15% concentration of Bitter Apple leaf aqueous extract as compared to Ak and Neem leaf aqueous extracts. The low concentrations of Neem, Ak and Bitter Apple aqueous leaf extracts were highly significantly repelled *Trogodermagranarium*, and the efficacy of aqueous leaf extracts to repel *Trogodermagranarium* was increased significantly as concentrations increased.

#### 4.3.1 Repellency studies at one hour interval

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the repellency percentage (Table 4.3.1 A). Bitter apple aqueous extracts was more efficient to repel *Trogodermagranarium* as compared to Neem and Ak. The concentrations of Neem, Ak and Bitter Apple aqueous leaf extracts significantly repelled *Trogodermagranarium*.

**Table No. 4.3.1** Effect of different concentrations of Neem, Ak and Bitter Apple leaf extracts on repellency percentage against *Trogodermagranarium* at time interval of one hour.

**Table 4.3.1 A: Analysis of Variance**

S. O. V	df	TSS	MS	F. Value	P
Concentration	3	40283.33	13427.78	19336	0.00 ***
Plant Extract	2	1088.89	544.44	784	0.00 ***
Interaction Concentration * Plant Extract	6	416.67	69.44	100	0.00 ***
Error	24	16.67	0.69		
Total	35	41805.56			

The interactive effect of aqueous leaf extracts and concentration was observed significant (Table 4.3.1 B). The 10% concentration of Neem and 15% concentration of Ak were not statistically differ from each other. The repellency at 10% concentration of Ak and 5% concentration of Bitter Apple were also not statistically differ from each other. The concentrations of Neem, Ak and Bitter Apple aqueous leaf extracts significantly repelled *Trogodermagranarium*. The minimum repellency was noted at 5% concentration of Ak. The maximum repellency was observed at 15% concentrations of Bitter Apple. The increased in concentration the repellency of *Trogodermagranarium* was increased.

**Table 4.3.1 B: Comparisons of Means Treatment**

Concentration	Plant Extract			Means
	Neem	Ak	Bitter Apple	
Control	0 h	0 h	0 h	0 d
5%	60 f	55 g	70 e	61.66 c
10%	75 d	70 e	90 b	78.33 b
15%	85 c	75 d	93.33 a	84.44 a
Total	55 b	50 c	63.33 a	

LSD value for Plant Extract (p>0.01) = 0.95

LSD value for Concentration (p>0.01) = 1.1

LSD value for Plant Extract \*Concentration (p>0.01) = 3.3

Treatment means sharing a letter in column did not differ significantly at p>0.01

**4.3.2 Repellency studies at five hours interval**

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the repellency percentage (Table 4.3.2 A). Bitter apple aqueous extracts was more efficient to repel *Trogodermagranarium* as compared to Neem and Ak.

**Table No. 4.3.2** Effect of different concentrations of Neem, Ak and Bitter Apple leaf extracts on repellency percentage against *Trogodermagranarium* at time interval of five hours.

**Table 4.3.2 A: Analysis of Variance**

S. O. V	df	TSS	MS	F. Value	P
Concentration	3	45583.33	15194.44	7293.33	0.00 ***
Plant Extract	2	1276.39	638.19	306.33	0.00 ***
Interaction Concentration * Plant Extract	6	429.17	71.53	34.33	.0000 ***
Error	24	50	2.08		
Total	35	47338.89			

The interactive effect of aqueous leaf extracts and concentration was observed significant (Table 4.3.2 B). The repellency at 10 and 15% concentration of Bitter Apple were non- significantly different with each other but these concentrations were significantly different with 5% concentration of Bitter Apple and these were also significantly different with 5%, 10% and 15% concentration of each Neem and Ak. Bitter Apple. The repellency at 10% and 15% concentration of Ak were also not statistically differ from each other. The concentrations of Neem, Ak and Bitter Apple aqueous leaf extracts significantly repelled *Trogodermagranarium*. The maximum repellency was observed at 15% concentrations of aqueous leaf extracts of Bitter Apple while minimum repellency was noted at 5% concentration of Ak. The increased in concentration the repellency of *Trogodermagranarium* was increased significantly.

**Table 4.3.2 B: Comparisons of Means Treatment**

Concentration	Plant Extract			Means
	Neem	Ak	Bitter Apple	
Control	0 g	0 g	0 g	0 d
5%	70 e	60 f	80 c	70 c
10%	85 b	75 d	95 a	85 b
15%	86.67 b	78.33 cd	96.67 a	87.22 a
Total	60.42 b	53.33 c	67.92 a	

LSD value for Plant Extracts (p>0.01) = 1.65

LSD value for Concentration (p>0.01) = 1.9

LSD value for Plant Extracts \*Concentration (p>0.01) = 5.71

Treatment means sharing a letter in column did not differ significantly at  $p>0.01$

#### 4.3.3 Repellency studies at 24 hours interval

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the repellency percentage (Table 4.3.3 A). Bitter apple aqueous extracts was more efficient to repel *Trogodermagranarium* as compared to Neem and Ak.

**Table No. 4.3.3** Effect of different concentrations of Neem, Ak and Bitter Apple leaf extracts on repellency percentage against *Trogodermagranarium* at time interval of 24 hours.

**Table 4.3.3 A: Analysis of Variance**

S. O. V	df	TSS	MS	F-Value	P-value
Concentration	3	47813.89	15937.96	4590.13	0.00 ***
Plant Extracts	2	937.5	468.75	135	0.00 ***
Interaction Concentration * Plant Extracts	6	340.27	56.71	16.33	0.00 ***
Error	24	83.33	3.47		
Total	35	49175			

The interactive effect of aqueous leaf extracts and concentration was observed significant (Table 4.3.3 B). The repellency at 10% and 15% concentration of each Neem, Ak and Bitter Apple were non significantly different with each other, but repellency at 10% and 15% concentrations of Bitter Apple were significantly different with different concentration of each Neem, Ak and also with 5% concentration of Bitter Apple. The minimum repellency was noted at 5% concentration of Ak. The concentrations of Neem, Ak and Bitter Apple aqueous leaf extracts significantly repelled *Trogodermagranarium*. The maximum repellency was observed at 15% concentrations of aqueous leaf extracts. The increased in concentration the repellency of *Trogodermagranarium* was increased.

**Table 4.3.3 B: Comparisons of Means Treatment**

Concentration	Plant Extract			Means
	Neem	Ak	Bitter Apple	
Control	0 e	0 e	0 e	0 d
5%	75 c	65 d	85 b	75 b
10%	86.67 b	80 c	95 a	87.22 b
15%	88.33 b	80 c	95 a	87.77 a
Total	62.5 b	56.25 c	68.75 a	

LSD value for Plant Extracts ( $p>0.01$ ) = 2.13

LSD value for Concentration ( $p>0.01$ ) = 2.46

LSD value for Plant Extracts \* Concentration ( $p>0.01$ ) = 7.37

Treatment means sharing a letter in column did not differ significantly at  $p>0.01$

#### 4.3.4 Repellency studies at 48 hours interval

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the repellency percentage (Table 4.3.4 A). Bitter apple and Neem aqueous extracts were efficient to repel *Trogodermagranarium* as compared and Ak.

**Table No. 4.3.4** Effect of different concentrations of Neem, Ak and Bitter Apple leaf extracts on repellency against *Trogodermagranarium* at time interval of 48 hours.

**Table 4.3.4A: Analysis of Variance**

S. O. V	df	TSS	MS	F-Value	P-value
Concentration	3	50094.44	16698.15	6011.33	0.00 ***

Plant Extract	2	401.39	200.69	72.25	.000 ***
Interaction Concentration * Plant Extracts	6	193.06	32.18	11.58	0.00 ***
Error	24	66.67	2.78		
Total	35	50755.56			

The interactive effect of aqueous leaf extracts and concentration was observed significant (Table 4.3.4 B). The repellency at 15% concentration of Bitter apple was significantly different with different concentrations of each Neem, Ak and Bitter Apple and 10% and 15% concentrations of Neem were not statistically differ from each other. The concentration of Neem at 5% also not statistically differs from 15% concentration of Ak. The minimum repellency was noted at 5% concentration of Ak. The concentrations of Neem, Ak and Bitter Apple aqueous leaf extracts significantly repelled *Trogodermagranarium*. The maximum repellency was observed at 15% concentrations of Bitter Apple. The increased in concentration the repellency of *Trogodermagranarium* was increased significantly.

**Table 4.3.4B: Comparisons of Means Treatment**

Concentration	Plant Extract			Means
	Neem	Ak	Bitter Apple	
Control	0 f	0 f	0 f	0 c
5%	80 cd	68.33 e	80 d	76.11 b
10%	93.33 ab	85 c	90 b	89.44 a
15%	91.33 ab	83.33 cd	95 a	90 a
Total	66.25 a	59.17 b	66.25 a	

LSD value for Plant Extracts (p>0.01) = 1.9

LSD value for Concentration (p>0.01) = 2.19

LSD value for Plant Extracts\* Concentration (p>0.01) = 6.59

Treatment means sharing a letter in column did not differ significantly at p>0.01

**4.3.5. Repellency studies at 72 hours interval**

Neem, Ak and Bitter Apple aqueous leaf extracts significantly affected the repellency percentage (Table 4.3.5 A). Bitter apple and Neem aqueous extracts were more efficient to repel *Trogodermagranarium* as compared Ak. The minimum repellency was noted at 5% concentration of Ak. The concentrations of Neem, Ak and Bitter Apple aqueous leaf extracts significantly repelled *Trogodermagranarium*. The maximum repellency was observed at 15% concentrations of aqueous leaf extracts. The increased in concentration the repellency of *Trogodermagranarium* was increased.

**Table No. 4.3.5** Effect of different concentrations of Neem, Ak and Bitter Apple leaf extracts on repellency percentage against *Trogodermagranarium* at time interval of 72 hours.

**Table 4.3.5A: Analysis of Variance**

S. O. V	df	TSS	MS	F. Value	P-value
Concentration	3	51808.33	17269.44	24868	0.00 ***
Plant Extracts	2	518.06	259.03	373	0.00 ***
Interaction Concentration * Plant Extracts	6	254.17	42.36	61	0.00 ***
Error	24	16.67	0.69		
Total	35	52597.22			

The interactive effect of aqueous leaf extracts and concentration was observed significant (Table 4.3.5 B). The repellency at 10% and 15% concentration of each Neem, Ak and Bitter Apple were non significantly different with each other, but repellency at 10% and 15% concentrations of Bitter Apple were significantly different with different



concentration of each Neem, Ak and also with 5% concentration of Bitter Apple. The repellency was minimum at 5% concentration of Ak and maximum repellency at 15% concentrations of and Neem.

**Table 4.3.5B: Comparisons of Means Treatment**

Concentration	Plant Extract			Means
	Neem	Ak	Bitter Apple	
Control	0 e	0 e	0 e	0 d
5%	85 c	70 d	85 c	80 c
10%	95 a	85 c	90 a	90 b
15%	95 a	85 c	93.33 a	91.11 a
Total	68.75 a	60 c	67.08 b	

LSD value for Plant Extracts ( $p>0.01$ ) = 0.95

LSD value for Concentration ( $p>0.01$ ) = 1.1

LSD value for Plant Extracts\* Concentration ( $p>0.01$ ) = 3.3

Treatment means sharing a letter in column did not differ significantly at  $p>0.01$

Results are similar to Mohiuddinet *al.* (1993) they tested plant oils for their toxicity and repellency against *T. castaneum* and *R. dominica*. Botanical oils showed repellence in an order of, *A. indica*>*T. foenumgraecum*>*M. fragrans*>*Piper nigrum*>*Nigella sativa* >*C. longa*. Oils of *M. fragrans*, *A. indica* and *P. nigrum* produced the highest toxicity with a dose of 0.25% (w/w) as a surface treatment of the wheat grains.

Results are similar to Chanderet *al.* (1999) they tested the repellent activity of acetone extracts of the *Acoruscalamus* and *Curcuma longa*, on the jute fabric, to control *Triboliumcastaneum*. Extracts of the *Acoruscalamus* and *Curcuma longa* rhizomes were highly effective at the lowest concentrations of jute fabric.

My results are also dissimilar to Elhag (2000) who reported some extracts of plant materials as oviposition deterrents against *Callosobruchusmaculatus* on chickpea. They resulted that the repellency in citrus peels was 58.6% and *Heliotropiumbacciferum* aerial parts was 59.2%.

Results are similar to Khan and Marwat (2003) they tested the powders made from leaves, seeds and bark of *Azadirachtaindica* and *Nerium oleander* for their deterrent effects against *Rhizoperthadominica* and got its repellency upto 96 %, from Neem-leaves and seeds.

Results are similar to Nazli *et al.* (2003) they appraised the 'Neem' seed oil, in the laboratory studies, as an insect repellent against red flour beetle. 'Neem' seeds were collected from different localities of Pakistan. They observed repellence of the beetles up to 52.25%, in response to the Neem-seed oil, obtained from Hyderabad.

Results are similar to Zaidi *et al.* (2003) they compared extracts of 'Neem', turmeric and Sweet flag as insect repellents against *Sitotrogacereallega*, under laboratory conditions and found that the acetone-extract of Neem was the most effective botanical insecticide.

Results are similar to Dwivedi and Shekhawat (2004) they reported the repellency of six indigenous plant species against *Trogodermagranarium*. Repellent property has been maintained in plant species by using olfactometer. Repellency was maximum in acetone extract of *Emblicaofficinalis* and minimum in *Ziziphus jujube* ether extract.

Results are similar to Satti *et al.* (2010) they tested the insecticidal activities of *Azadirachtaindica* seeds under laboratory and field conditions as affected by different storage durations. They concluded that Neem seeds were better which stored at two, three and four years than the seeds stored at one or five years, in controlling the storage pest. The older seeds seemed to be less repellent than newest seeds.

## References

- Ahmedani, I., T. Ahsan, R. Tabassum, A. Azam and S. N. H. Naqvi. 2011. Effects of *Acoruscalamus* extract and cypermethrin on enzymatic activities in *Sitophilusoryzae*. J. Zool. India, 3(2): 169-173.

- Chander, H., A. Nagender, D. K. Ahuja and S. K. Berry. 1999. Laboratory evaluation of plant extracts as repellents to the rust red flour beetle, *Tribolium castaneum* (Herbst.) on jute fabric. *Int. Pest Control*, 41(1): 18-20.
- Das, D. R., S. Parween and S. I. Faruki. 2006. Efficacy of commercial neem based insecticide, Nimbecidine against eggs of the red flour beetle *Tribolium castaneum* (Herbst). *Univ. J. Zool., Rajshahi Univ.*, 25: 51-55.
- Dwivedi, S. C. and N. B. Shekhawat. 2004. Repellent effect of some indigenous plant extracts against *Trogoderma granarium* (Everts). *Asian J. Exp. Sci.*, 18(2): 47-51.
- Dwivedi, S. C. and S. Venugopalan. 2001. Evaluation of leaf extracts for their ovicidal action against *Callosobruchus chinensis* (L.). *Asian J. Exp. Sci.*, 16(1-2): 29-34.
- Egwurube, E., B. T. Magaji and Z. Lawal. 2010. Laboratory evaluation of Neem (*Azadirachta indica*) seed and leaf powders for the control of Khaprabeetle (*Trogoderma granarium*) (Coleoptera: Dermestidae) infesting groundnut. *Int. Agric. Biol.*, 12: 638-640.
- Elhag, E. A. 2000. Deterrent effects of some botanical products on oviposition of the cowpea bruchid, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). *Int. J. Pest Manag.*, 46(2): 109-113.
- Govt. of Pakistan. 2010. Economic survey of Pakistan, Government of Pakistan, Ministry of Food, Agriculture and Livestock (Economic Wing) Islamabad pp. 19.
- Islam, M. S. and F. A. Talukder. 2005. Toxic and residual effects of *Azadirachta indica*, *Tagetes erecta* and *Cynodon dactylon* seed extracts and leaf powders towards *Tribolium castaneum*. *J. Pl. Dis. and Protect.*, 112(6): 594-601.
- Khan, S. M. and A. A. Marwat. 2003. Deterrent / Repellent effects of different plant parts of neem and kanair against lesser grain borer (*Rhizopertha dominica* F.). *Pak. Entomol.*, 25(2): 131-136.
- Khattak, S. U., M. Hamed, A. Sattar and A. U. Khan. 1996. Screening of new wheat genotypes against khapra beetle, *Trogoderma granarium* (Everts). *Proc. Pak. Congr. Zool.*, 15: 87-93.
- Kudachi, D. C. and R. A. Balakai. 2009. Efficacy of botanicals for the management of lesser grain borer, *Rhizopertha dominica* in sorghum during storage. *Karnataka J. Agri. Sci.*, 22: 487-490.
- Kumari, P. and M. K. Verma. 1999. Effect of *Acorus calamus* sasa grain protectant against *Callosobruchus chinensis*. *J. Appl. Biol.*, 9(2): 188-189.
- L. Prasuna. 1993. Laboratory evaluation of some vegetable oils as protectants of stored products. *Pak. J. Scient. Industr. Res.*, 36(9): 377-379.
- Lale, N.E. S. and A. Mustapha. 2000. Efficacy and acceptability of Neem (*Azadirachta indica*) seed oil and primiphos-methyl, applied in three storage devices for the control of *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). *J. Plant Dis. Protect.*, 107(4): 399-405.
- Malek, M. A., B. Perveen and D. Talukder. 1996. Insecticidal properties of four indigenous plant extracts against adult of CR-I strain of *Tribolium castaneum* (Herbst). *Bangladesh. J. Entomol.*, 6(1-2): 7-11.
- Mohiuddin, S., R. A. Qureshi, Z. Ahmed, S. A. Qureshi, K. Jamil, K. N. Jyothi and A.
- Muda, R. and B.W. Cribb. 1999. Effect of uneven application of azadirachtin on reproductive and anti-feedant behaviour of *Rhizopertha dominica* (Coleoptera: Bostrichidae). *Pestic. Sci.*, 55(10): 1007-1026.
- Nath, P., S. Bhushan and A. K. Singh. 2002. Evaluation of neem based formulations and neem seed kernel extract against the insect pests of sesamum. *Ann. Plant Protect. Sci.*, 10(2): 207-211.
- Nazli, R., G. Jilani, F. Ibrahim, A.R. Kazmi and A. H. Solangi. 2003. Repellency of neem seed oil obtained from different localities of Pakistan against red flour beetle. *Pak. Entomol.*, 25(2): 201-206.
- Okonkwo, E. U. and W. I. Okoye. 1992. The control of *Callosobruchus maculatus* (F.) in stored cowpeas with dried ground *Ricinus communis* (L.) leaves in Nigeria. *Trop. Pest Manag.*, 38(3): 237-238.
- Paneru, R. B., G. N. J. Le-Patourel and S. H. Kennedy. 1997a. Toxicity of *Acorus calamus* rhizome powder, from Eastern Nepal, to *Sitophilus granaries* (L.) and *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae). *Crop Protect.*, 16(8): 759-763.
- Prabuseenivasan, S., M. Jayakumar, N. Raja and S. Ignacimuthu. 2004. Effect of Bitter Apple, *Citrullus colocynthis* (L.) Schrad seed extracts against pulse beetle, *Callosobruchus maculatus*. (Coleoptera: Bruchidae). *Entomol.*, 29: 81-84.
- Satti, A. A., M. E. Ellaithy and A. E. Mohamed. 2010. Insecticidal activities of Neem (*Azadirachta indica* A.

- Juss) seeds under laboratory and field conditions as affected by different storage durations. *Agric. Biol.*, 1(5): 1001-1008.
- Shanthi, M. and G. Logiswaran. 1996. Efficacy of petroleum-ether extract of plant parts on the biology of *Sitotroga cerealella*. *Madras Agric. J.*, 83(1): 53-56.
- Su, H.C. F. 1991. Laboratory evaluation of toxicity of *Acorus calamus* oil against four species of stored product insects. *J. Entomol. Sci.*, 26 (1): 76-80.
- Zaidi, S. R., G. Jilani, J. Iqbal, M. Ashfaq and U. Rafique. 2003. Settling response of Angoumois moth, *Sitotrogacerealella* (Oliv) to plant derivatives. *Pak. Entomol.*, 25(1): 107-112.