EFFICACY OF SELECTED PLANT PRODUCTS ON THE CONTROL OF *Tribolium castaneum*(Herbst.) (Coleoptera: Tenebrionidae)

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DEDICATION

To my family with great pleasure,

To my father and mother and

To my wife with sincere love.

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ABSTRACT

The effect of powder and aqueous extracts of leaves and seeds of Ushar. Neem and Hargel plant as natural products have been tested against the 4th larval and adult stages of the red flour beetle T*ribolium. castaneum* (Herbst.) under the laboratory conditions. Mortality and repellency effects were evaluated.

Rsults of Ushar plant indicated its highest mortality effect, (88.8%) using 10% concentration against the adult stages. Mortality effects were significantly higher in leaves than seeds and powder than aqueous extracts. The 4th larval stage had lesser effect than the adult stage.

Neem seeds aqueous extract (10% concentration) gave higher mortality than the powder on the larval instar (42.5%) compared to the adult stage (21.21%). On the other hand neem seeds showed higher mortality than neem leaves.

Results of Hargel plant indicated that leaves and seeds powder give highest effects than aqueous extracts on the adult stage, 12.38% and 13.66% were the highest mortality effect using 10% concentration of

leaves and seed extracts on the adult stage. In 4th larval instar stage, 12.19% was reported to be the highest mortality when the Hargel applied was aqueous extract using 10% concentration.

Results in general indicated that Ushar plant extracts were most the effective followed by neem, while the Hargel extracts were the least one. In all treatments, the higher concentration of the plant extracts, the more the mortality of the insect stage.

With respect to the repellency effect, neem seeds powder showed 100% repellency when using 10% concentration. Hargel plant extracts came the next and gave 92.0% repellency. As for Ushar plant extract results showed that this plant came the third, as it gave 50% repellency. In general, repellency effects increased with the increase in concentration. On other hand the repellency effect showed higher in adult stage than the 4th larval instar.

ملخص الأطروحـة

أجريت هذه الدراسة لمعرفة تأثير المساحيق والمستخلصات المائية لأوراق وبذور نباتات العشر، النيم والحرجل كعناصر مكافحة نباتية طبيعية من حيث الأثر القاتل والطارد على خنفساء الدقيق الحمراء *Tribolium costaneum* في طورها البالغ وطورها اليرقي الرابع وذلك تحت ظروف المعمل .

دراسة الأثر القاتل وضحت أن استخدام أوراق العشر في شكل مسحوق وبتركيز 10% أعطى أعلى نسبة موت بلغت 88.8% للطور البالغ. نسب الموت التي تم الحصول عليها كانت معنوياً أعلى باستخدام الأوراق منها في البذور وباستخدام المسحوق أكثر منه باستخدام المستخلص المائي. المعاملات المختلفة لنبات العشر كانت أكثر فاعلية على الطور البالغ منها على الطور اليرقي الرابع.

المستخلص المائي لبذور النيم كان الأكثر فاعلية في تأثيره القاتل على حشرات الاختبار مقارنة بالمسحوق وعلى الطور اليرقي الرابع بصورة أكبر (42.5%) من الطور البالغ (21.21%) باستخدام التركيز 10%. عموماً، مستخلصات بذور النيم أعطت نسب موت أعلى مقارنة بالأوراق.

أوضحت الدراسة إن استخدام نبات الحرجل في صورة مسحوق بذور ومسحوق أوراق على الطور البالغ قد أعطى نسب موت أعلى مقارنة بالمستخلصات المائية. وتعتبر 13.66% و12.38% هي نسب الموت الأعلى التي تحققت باستخدام مسحوق البذور والأوراق بالتركيز 10% على التوالي، بينما 12.19% كانت هي أعلى نسبة موت في الطور اليرقي الرابع تم الحصول عليها باستخدام المستخلص المائي لبذرة الحرجل باستخدام التركيز 10%.

في هذه الدراسة، اتضح أن نبات العشر هو الأعلى في تأثيره القاتل على حشرات الاختبار يليه النيم، ثم الحرجل كأقل تأثير.. وقد تلاحظ زيادة الأثر القاتل بزيادة التركيز المستخدم.

أما فيما يختص بدراسة الأثر الطارد، فقد أثبتت التجارب أن جميع نباتات الاختبار كانت ذات تأثيرات طاردة لحشرة الاختبار حيث كان التأثير أكثر وضوحاً في البالغات منه في الأطوار اليرقية. ويعتبر مسحوق بذور أوراق النيم كأفضل المعاملات فعالية محققاً أعلى

نسبة طرد بلغت 100% باستخدام التركيز 10%. كما تلاحظ أيضاً أن نسبة الطرد تزيد بزيادة التركيز المستخدم. حقق النيم أعلى نسبة طرد يليه الحرجل 92%.. والعشر يأتي في المرتبة الثالثة محققاً نسبة طرد بلغت 50%.

CHAPTER ONE

INTRODUCTION

Problems of synthetic insecticides currently used in agriculture, household and disease vectors control, are steadily increasing in spite of the serious hazards encountered by man and animals, destruction of beneficial insects, resistance to insecticides and high cost.

The cost of synthetic pesticides has reached a fairly high level and still increasing. Consequently, farmers in many parts of Africa and other parts of the tropics can not afford to buy such products to control pests attacking their crops, (Dreyer, 1983).

Such problems of synthetic insecticides warranted the search for safer agents among the cheap naturally occurring substances. These agents have shown insecticidal activities, repellents or antifeedants. Novozhilor, (1978), suggested, in addition to the existing control measures, the use of physiologically active substances produced by plants which may have less hazardous effects can easily be incorporated into pest management programmes.

The red flour beetle *Tribolium castaneum*, (Herbst.) is one of the known species of stored product pests. The two closely related species, the red flour *T. castaneum* and the confused flour beetle *Tribolium confusum* occur on many varieties of stored grains and are major pests of flourmills. Howe (1956), concluded that the multiplication rate of

Tribolium castaneum, even in sub-optimal conditions, was very high. In Sudan *Tribolium castaneum* is more common than *Tribolium confusum* (Rodwan, 1970).

There are many organic compounds of plant origin that have been identified to affect insect pest population in different ways. Some of these natural substances are used as poisons such as pyrethrum, nicotine, rotenone, orabsine, (Metcalf, 1962). In the Sudan, work has been carried out on some plant parts to investigate their potentialities as insecticides e.g. Neem extracts, (Siddig, 1991).

This work, however, is intended to contribute in finding ways and means for controlling stored product insects using natural products to avoid poisonous effects for both humans and environment with the following objectives.

To explore the potentialities of three plants (Ushar, Neem, Hargel) as biocides against two stages adult and 4^{th} larval stages of the red flour beetle (*Tribolium castaneum*) to investigate:

1. The mortality rate of the pest.
2. The repellent activity of the biocides.

CHAPTER TWO
LITERATURE REVIEW

2.1 Ushar plant *Calotropis procera* (Ait),

2.1.1 Characteristics and distribution of Ushar

Calotropis procera (Ait), locally known as Ushar, belongs to the family Asclepeadaceae. Andrews (1952) reported it as one species (*Procera*) under the genus *Calotropis*.

According to Erdman (1983), the Ushar plant has a large ever green broad leaves. It grows abundantly in arid and semi-arid regions of the world without irrigation, fertilizer, pesticides or other agronomic practices.

Andrews (1952) described the Ushar plant as a soft wooded shrub or small tree up to 18 feet high with a clean pole 6-8 feet long. Bark is yellow brown, thick and corky. Young parts are covered by a white to mentum, leaves are pale green, fleshy, sessile or shortly petiolated

2.1.2 Chemical Constituents of *Calotropis procera* (Ait)

The chemical constituents present in the aerial parts of the plant include alkaloids, cardiac glycosides, flavonoides, tannius, saponins, sterols and triterpens (Hesse and Reicheneder, 1936; Sebier, *et al.*, 1982).

Rajapopalan, *et al.* (1955), isolated and analyzed the glycosides from the seeds of *Calotropis procera.* The presence of alkaloids has been reported by Gary, *et al*., (1980).

Atal and Sethi (1962) reported the isolation of a protease from the latex. Shukla and Krishnamurty (1961), reported the presence of a bacteriolytic enzyme in the latex. Polysacchride from the leaves has been isolated by Quadrate *et al*, (1969). Sulfur containing heat poisons was reported in the latex (Hesse and Ludwing, 1960).

The industrial method for the manufacture of cardioactive preparation from *Calotropis procera* was proposed by Williams (1949). Sharma (1984) reported many active materials from the different parts of Ushar. The latex contains calation, calotropin, calotoxin, uscharin, uscharidin, voruscharin, and calotropagenin. The seeds contain

coroglaucigenin, corotoxigenin, calotropin and frugoside. The leaves and stems contain calotropin, calotropagenin, calactin and calotoxin.

2.1.3 Insecticidal Properties of Ushar:

According to Wat, *et al.* (1962), the plant contains insecticidal ingredients and the leaf is useful for destroying fuel lice in Senegal. The root extracts showed strong positive antibiotic activity. Sharma (1983) reported that flower extract of *Calotropis procera* has an antifeedant action against adult of the lesser grain borer *Rhizopertha dominica*. Two years later (1985) he reported antifeedant action against larvae of this insects. Extracts of the flowers of Ushar when mixed with wheat flour and provided to 1^{st}, 2^{nd}, 3^{rd}, and 4^{th} instar larval of *R.. dominica* in the laboratory, the mortality of the larvae increased and adult emergence decreased as the concentration of the extract was increased from 0.1 to 1000 ppm. The younger larvae were more susceptible than the older ones (Sharma, 1985).

Calotropis procera latex has toxic effect on the larvae of *Anopheles stephensi, Culex fatigans, C. quinquefasciatus and Ades aeaqyptii*, giving 100% mortality to eggs and larvae under laboratory conditions (Girdhar, *et al.*, 1984).

Ahmed (1993) found that *Calotropis procera* has antifeedant, repellent and insecticidal action against the larvae of *Trogoderma granarium*. Two fifth grams of powder of flower, roots and leaves when mixed with 20 grams of wheat seeds and provided to the 1^{st}, 2^{nd} 3^{rd} and 4^{th} instar larvae retarded the larval development. Also he found the aqueous solution of the roots, leaves and flower at 1.25, 2.5 and 5% concentration failed to protect the seed after three month and the larval development was retarded compared to the control. Aqueous and ethanolic extract of the flower, roots and leafs showed antifeedant effects against the insect. The leaves ethanolic extracts were the more effective in retarding larval development.

In laboratory experiments, powdered leaves of *Calotropis procera* incorporated into flour-yeast medium at concentration ranging from 15000 to 75000 ppm were toxic to larvae of *Tribolium confusum*, (Jahan, *et al*, 1991).

Leaf powder of *Calotropis procera* was evaluated at 2.5% and 5% for the control of *R. dominica* on rice grains in the laboratory at 28°C. All treatments significantly reduced the number of adults emerging from grains, treated with the powder at 5% (Jacob and Sheila, 1993).

Maheshwari and Dwivedi (1996) reported that leaves powders of *Calotropis procera* at 5 and 10% w/w significantly reduced the adult emergence of *Tribolium castaneum*. Oviposition and development were also affected.

Osman (1999) reported that Ushar leave extract had repelling, antifeedant and insecticidal action against *Bruchidius incarnatus* (Boh).

2.2 Neem plant (*Azadirachta indica* A. Juss):

2.2.1 Origin and Characteristics of Neem:

According to Jain (1983) neem (*Azadirachta indica* A. Juss; *Melia azadirachta Linn*) tree a native of India, is commonly known as morgosa tree. Neem leaves are imporipinnately compound, alternate, estipulate and 20 – 38 Cm long. Each leaf has a swollen base and bears 8 to 19 opposite or alternate leaf lets on a slender petiole (Randhawa and Parmar, 1993).

The fruit is a smooth, ellipsoidal drupe, up to almost 2 cm long. When ripe, it is yellow or greenish yellow and comprises a sweet pulp enclosing a seed. The seed is composed of a shell and a kernel (sometimes two or three kernels), each about half of the seeds weight (Ruskin, 1991).

2.2.2 Chemical Constituents of Neem tree

All parts of Neem tree (*A. indica*) were examined by chemists and the following compounds were identified: Azadirachtin (Az), Lenotranortriterpenoids, Salannin, Salannol, Salannolacetate, 3- deacetyl salaninn, 4- eopxy-azaradion, nimbinen and deacetyl nimbinen, (Jones *et al*, 1989).

Azadirachtin is one of the first ingredients isolated from neem tree. It is apparently responsible of about 90 percent of the effect on insect pests. It does not kill most insects immediately but instead it repels and disrupts their growth. It also act as feeding deterrent for insects and nematodes. Neem seed kernel contain between 2 an 4 mg of azadirachtin per gram of kernel, (Ruskin, 1991).

Although studies indicated a strong potency of salanin in inhibition of insect feeding, yet no report about the influences on insect moults (Ruskin, 1991). More information about the chemical structure and properties of substances, such as azadirachtin, nimbin, meliatin or meliantroil of the tripenoid or limonoid group, and about the mode of

action of their repellent, phagodeterrent, growth regulatory (Post-embryonic metamorphosis retarding) and reproduction inhibitory effects on wide range of insect pest, has been reported (Adhikary, 1980).

2.2.3 Insecticidal activity

In recent years, neem has been widely investigated as a source of natural insecticides (Schmutterer, *et al*, 1981; Schmutterer and Aschar, 1984 and 1987). Jotwani and Sircar (1965) stated that a mixture of neem seed powder at the rate of 1 to 2 parts (W/W) of wheat seed gave satisfactory protection to the seed against *Sitophilus oryzae* (col.), *Rhizopertha dominica* (F.) and *Trogdema granarium* Everst for at least about 270, 320 and 380 days respectively. Pruthi (1937) reported the efficacy of neem leaves and neem cakes as effective repellents of wheat stored pests. Neem derivatives were found effective against 123 species of insect pests, including those infesting stored-products (Jacobson, 1986). Islam (1986) stated that neem leaves and seed extracts showed ovipositional deterrency and caused inhibition of adult emergence in rice hispa. *Discladispa amigera* (Oliver) and the pulse beetle, *Callosobruchus chinensis*.

In the Sudan, Siddig (1991) reported that neem seed water-extracts gave good results against the flea beetle *Podagrica* spp, *Madurasia observrella* Jacoby, white fly, *Bemisia tabaci* (Genn.), Jassid *Jacobiasca lybica* (Pruthi), aphids *Aphids* spp. and Egyptian ball worm *Earias insulana* Bosid on okra. The toxicity of neem kernel oil to eggs, larvae and adults of the stored products pest *Callosobruchus chinensis* was examined in the laboratory on chick peas (*Cicer arietinum*). Results indicated a significant increase in egg, larval and adult mortalities. Effects were dose dependent (Das, 1986).

Adhikary (1980) reported the efficiency of different preparations of neem leaf and seed powder in controlling the major pests of stored corn, namely *Sitophilus zeamais*, *Tribolium* spp. and *Rhyzopertha dominica*.

Radwanski (1977) found that, neem seed extracts, tested against three species of stored grain insect: *Tribolium castaneum*, *Trogoderma granarium* and *Rhyzopertha dominica*, caused inhibitory effect on the feeding beside repulsion. The test also indicated that seed extracts can be used for protecting stored grains from insect attacks if applied to the bags or earthen pots used by farmers in Pakistan.

Extracts of various plants reputed to be immune to insect attacks have been tested for their repellency and toxicity to various insect pests. The neem plants possessed the maximum repellent property and the best repellency was caused seed compared to leaves, flower and fruits (Ghulain and Malik, 1973).

Parmar (1986), according to Jhansi (1984) stated that the larval development of *Corcyra cephalonica* (Staint) and *Tribolim castaneum* (Herbst) was completely inhibited when the insects were released in wheat flour containing 2 parts of kernel per 100 parts of flour. Lower concentrations caused high larval mortality, significant reduction in insect size and weight, delay in development of larval-pupal an pupal-adult intermediates, deformed adult and poor adult emergence.

Ivbijaro (1986) found that neem was very effective in suppressing development of *Tribolium castaneum*. At dosage rates of 2.5 g/20g of flour, neem applies as powder or ethanolic extract caused up to 55% mortality in larvae of *T. castareum*.

Neem (*Azadirachta indica*) seed kernel powder (NSKP) at low dose (2% w/w) was effective against *Sitophilus oryzae* and protected maize seed for 2 weeks. However, 6 weeks the dose (NSKP) could not

protect the grain from the attack of *Rhyzopertha dominica*, *Tribolium castaneum* and *Trogoderma granarium*. A higher concentration of NSKP (10% w/w) was effective against all the test insects over longer periods of time. However, even at high concentration, (NSKP) could not provide complete protection of maize from the attack of *Tribolium castaneum* over a short period (Sharma, 1995).

Sahayaraj and paulraj (2000) reported that the leaf extract of *Azadriachta indica* was found to be the most effective repellent against *Tribolium castaneum* on groundnut seed.

2.3 Hargel *Solanostemma argel* (Del) Hayne

2.3.1 Description

It is an erect perennial shrubby plant reaching up to 1.5 – 2 feet in height with smaller branches carrying opposite decussate leaves. The leaves are lanceolate to a belong-ovate, with acute or sub-acute apex and cuneate base. The leaf petiole is about 1-1.5 long and ¼ - ¾ in. broad. Fruits are solitary follicles, thick, and ovoid lanceolate, acuminate at the apex and they are very hard with dark purple colour. Seeds are turgid, ovoid and they are channel down at one face; they are minutely

tuberculate bearing an apical tuft hair, (Andrews, 1952, El-Kamali, 1991).

2.3.2 Distribution

Hargel grows naturally in the northern part of Sudan it is also widely distributed through out North Africa (Egypt, Libya and Algeria) and in Saudi Arabia. However, among these above mentioned countries the Sudan is regarded as the richest source of this plant. The principle production area in the Sudan is northern region that extends from Barber to Abu-Hamed, especially Rubatab area. In the Sudan and in other Arabic countries the plant is known as “Hargel” (El. Kamali, 1991).

2.3.3 Chemical Constituent of Hargel

El-Kamali (1991) concluded a phytochemical screening of Hargel (*Solanostemma argel*) constituents the looked at leaves, stems and roots for the possible presence of certain active constituents with relation to spacing (25, 50, 75 and 100 cm.) at the plant pre-flowering and flowering stages. Results of phytochemical screening showed the presence of a number of chemical groups (flavonoides, tannins, sterols, triterpens and saponins), the most important of them are the saponins.

2.3.4 Insecticidal activity of Hargel plant

In the Northern State of Sudan at shaygia area in Eshishi land and Elbalel region in the south of Nouri town, farmers used Hargel as traditional method to control insect pests on okra specially the ballworms. The farmers put the vegetative parts of Hargel plants in main irrigation canals. The extract of Hargel in this case is transformed with water to okra field where it is sucked through the roots and later by the larvae while feeding (Personal communications).

A crude aqueous extract of dried fruit pericarp, flower, root and stem of the plant were tested for larvicidal activity on the third instar larvae of the mosquito *Culex quinquefasiatus* (Say). Extract of the fruit pericarp was found most effective with Lc_{50} of 0.49g/ml at 24 h. (El-Kamali, 2001).

2.4 The Red Flour Beetle *Tribolium castaneum* (Herbst.) (Coleoptera: Tenebrionidae)

2.4.1 Description

The flour beetles adult is 3 to 4 mm in length parallel sided and reddish brown in colour. The antennae are composed of eleven segments

with the last three comprising the club. The compound eyes are partly divided horizontally by a back word projection of the head (Anon. 1986).

Tribolium castaneum is confused with *Tribolium confusum* due to their similarity in appearance, behaviour and life cycle. According to Robert and Pfadt (1985), the two species could be distinguished by the following characters:

Confused flouer beetle	Red flour beetle
1. Larger	1. Smaller
2. Antennae gradually enlarged toward the tip	2. Antennae with the last three segments abruptly enlarged
3. Eyes smaller	3. Eyes larger
4. On under side of head the width of each eye is about $^1/_3$ the distance separating them.	4. On under side of head the width of each eye is equal to the distance separating them.
5. Wings not functional	5. Wings functional

The eggs are small and white in colour. Each egg when laid is covered with a fluid to which food particle stick, making the egg difficult to see. Eggs hatch into yellowish white larvae that bear small, dark, forked processes on the tip of the abdomen (Robert and Pfadt, 1985).

At the pupal stages sexing can be done on the basis of the external characters. The appearance of the ventral surface of the terminal abdominal segment of the pupa differs greatly in the males and females.

The chief characteristic feature of this segment in the male is a flat disc-like depression where as in the female they are two cone-like appendages, but much and shorter and relatively thicker (Good, 1936). The pupae are pale in colour and immobile, except for the ability to flex the body between the thorax and abdomen rendering the sexing of the living pupa more convenient.

2.4.2 Distribution

Tribolium castaneum occurs all over the world wherever stored cereal products are found. It lives inside the buildings and may easily be carried from place to place in small quantities of food stuffs, this beetle is likely to be recorded from practically any part of the world. It is essentially an insect of warm climates (Good, 1936). It is best characterized as a sub-tropical species due to the utilization of heated grainaries and other storage places (Kranz, *et al*., 1977).

The vertical and horizontal distribution of *T. castaneum* in a rice warehouse was studied using light traps hung around selected cracks of bagged rice. Traps hung at 4 m or higher from the floor caught more *Tribolium castaneum* than other insect species in the warehouse. At 6 m height, the traps caught mainly this species. The horizontal distribution

pattern of *Tribolium castaneum* sampled at 6m was not homogenous. The factors influencing distribution are numerous including the height, the temperature, the moisture content …etc, (Boon, and Ho, 1995).

2.4.3 Biology

Each female may deposit from 400 to 500 white eggs among the food particles, frequently eggs are pushed through the mesh of sacks containing cereal products. A 5 xx-mesh bolting cloth will remove all flour beetle eggs from flour. When the food media becomes over populated, the populations become self-limiting by cannibalism; the larvae eat the eggs and adults eat eggs and pupae. The number of larval instar varies between 5 and 12. On a suitable food the number of instars may reach seven to eight instars in more than half of the hatched eggs. The time required to develop from egg to adult depends upon the moisture and temperature.

As with most grain damaging insects within the limits required by the species, when the humidity and temperature are higher, the development period is shorter. Under optimum conditions of environment and food, the development period is approximately 30 days.

As they mature, the larvae come to the surface of their food media and transform into naked pupae (Robert and Pfadt, 1985).

The biology of *Tribolium Castaneum* was studied on wheat, gram (chickpea, bajra (*Pennistum glaucum*) and maize flours in the laboratory at 15 – 36°C and 25 – 71% RH. The beetles aggregated at the surface of the flour from dusk to 1.00 h. and then tunneled into the flour. The pre-oviposition and oviposition period lasted 8 days on all the flours, except on bajra where it lasted 10 days. There were 10 larval instars and the larval period lasted 159.5, 162.0, 153.5 and 163.5days on wheat, chickpea, bajra and maize flours, respectively. The pupal period lasted 8.5, 8.0, 6.0 and 6.2 days on these same media, respectively. Adult emergence was 94%, 88%, 94% and 88% on wheat, chickpea, bajra and maize flours respectively, with corresponding male to female ratios of 1:1.7, 1:1.1, 1:1.5 and 1:1.1, respectively (Singh *et al*., 1992).

The biology of *Tribolium Castaneum* on rice, wheat, maize and sorghum flour was studed in the laboratory at 24-29°C and 70% R.H. wheat flour was the most suitable with regard to development and fecundity, while rice flour was the least suitable, (Lingappa, *et al.* 1995).

2.4.4 Damage

This species was found attacking primarily milled grain products. In whole grain they feed only on grain dust and broken kernels (Leonard and Ralph, 1941). *Tribolium castaneum* is unable to feed on or attack sound grain, but cause considerable losses and serious damage to grain previously attacked by internal feeders such as *Sitotroga cerealella* or *Sitophilus oryzae* (Primary pest). In Sudan, sorghum grain after harvest always has some broken and damaged kernels due to the threshing process, and damage is even greater when sorghum is threshed manually. About 20% of the kernels are recorded to be damaged (Saad, 1978). Damaged grain is always more attractive to the beetles (McGregor, 1964). Thus the so-called secondary pests might not need the help of primary feeders.

2.4.5 Environmental Requirement and Control

A great deal of information has been gathered on the population dynamics of *Tribolium castaneum* under controlled conditions. Both temperature and humidity are very important factors in determine rates of natality and mortality. In addition, both the adults and larvae of *Tribolium castaneum* cannibalize eggs and pupae. This cannibalism is the major factor limiting population growth under laboratory conditions

(Kranz, *et al,* 1977). Howe (1956) concluded that the multiplication rate of *Tribolium castaneum*, even in sub-optimal conditions was very high.

Storage bins should be thoroughly cleaned prior to use by removing all old grains and sweeping ceiling, walls and floors. After cleaning and about one week before filling bins, treat the interior with Malathion, methoxychlor or pyrethrin sprays. Clean up all grain spills out side storage facility and spray outside area. Store only dry, clean grain containing less than 12 percent of moisture and free from weed seeds, broken kernels and dirt. Infestation can usually be prevented for up to a year by adding a protectant (Malathion, Piperonyl, butoxide or pyrethrins) to the grain as it enters the bin. Infestation in bulk grain is best controlled by fumigation (Kranz, *et al.*, 1977).

Ciobanu (2001) reported the efficacy of Dobol (cyphenothrin) 7.2% and pestoxin (phosphine) 56% in for controlling *Tribolium castaneum.* Yang-longde, *et al.* (2003) stated that phostoxin fumigation has positive result on the red flour beetle *Tribolium castaneum*.

Two neem compounds, a crude methanolic extract of neem kernels and a neem formulation compared with coopex (permethrin and bioallethrin) as standard synthetic pyrethroid, were tested against

Tribolium castaneum adults. The LD_{50} were found to be 12.0, 320 and 0.41 μg/cm^3 respectively. The crude methanolic extract was much more toxic than the neem formulation, (Khan, *et al*., 1994).

2.4.6 Repellent Activity

Fifteen volatile compounds found in bay leaves (*Laurus nobilis* L.) and crushed bay leaves were tested as repellents against adult of *T. castaneum* when added to wheat flour, give positive result (Norasaim, *et al.*, 1986).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Ushar plants

3.1.1 Collection of leaves and preparation of powder of Ushar Plants

Leaves of Ushar plants were collected randomly from the area of the Faculty of Agriculture, University of Khartoum during April 2003. Collected leaves were washed and left to dry at room temperature for 3 to 4 days (Plate 3-1). The dried leaves were first crushed by hand and then powdered by an electric blender Type (Braun: Mx 32). The powder (Plate 3-2), was stored in glass jars with tight cover until needed for preparation of extracts.

3.1.2 Collection of seeds and preparation of powder of Ushar Plants

Seed of Ushar plants were collected from matured fruits at the same time and place of collection of Ushar leaves. The seeds were then easily separated by hand from their hairs (Plate 3-3) and left to dry at room temperature and later was powdered using the same above method (Plate 3-4).

Plate (3-1) : leaves
1- Usher 2- Neem 3- Hargel

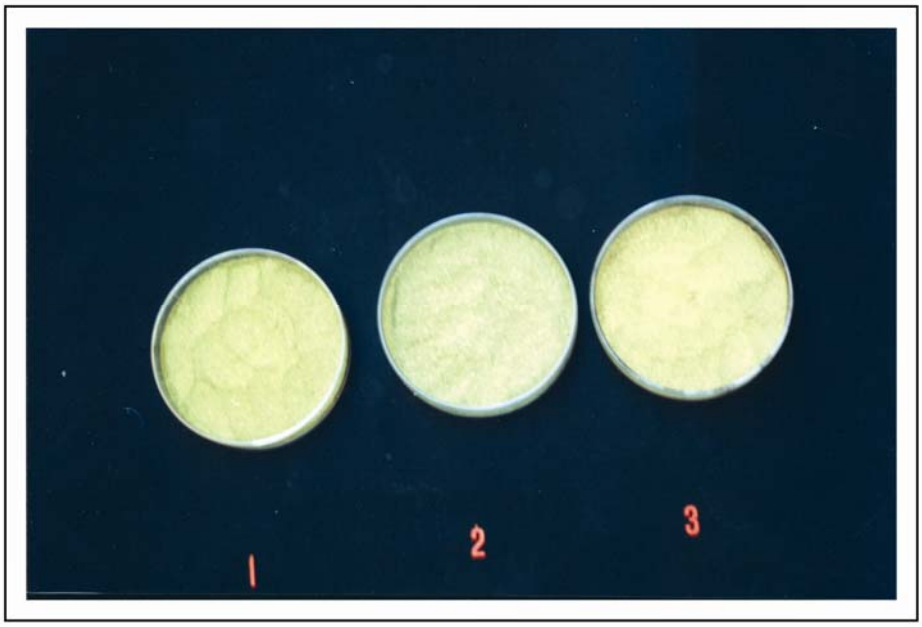

Plate (3-2) : leaves powder.
1- Usher 2- Neem 3- Hargel

Plate (3-3) : Seeds
1- Usher 2- Neem 3- Hargel

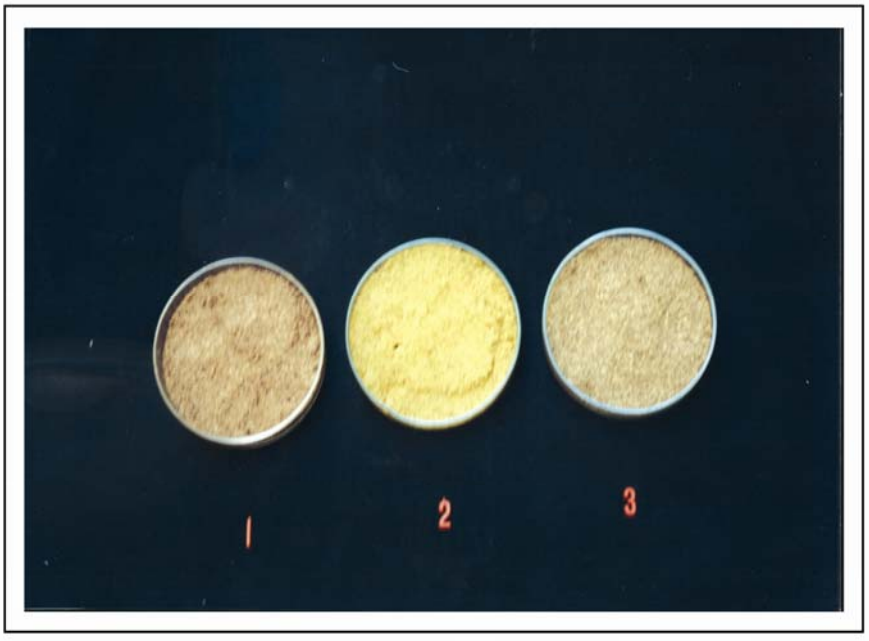

Plate (3-4) : Seeds powder.
1- Usher 2- Neem 3- Hargel

3.1.3 Preparation of water extracts of leaves and seeds of Usahr Plants

Aqueous solutions of leaves and seeds of Ushar plants were prepared by mixing 20 grams powder of each with 180 ml distilled water in a conical flask. The mixture was left to stand for 24 hours at room temperature while thoroughly shaken by hand for 5 minutes every 8 hours for 24 hours. The mixture was then strained through a light cloth and then filtered through a Whatman filter paper No 1. The stock solution (10% w/v) was kept in the refrigerator at 4°C for further work. This preparation method based on the method was adopted by Ascher (1981).

3.2 Neem Plants

3.2.1 Collection of leaves and preparation of powder of Neem plants

Neem leaves were collected from Shambat area, cleaned and powdered following the same method used for Ushar.

3.2.2 Collection of seed and preparation of powder of Neem plants

Following the technique initiated by Siddig (1991), yellow ripen fruits were collected from the ground under Neem trees in July 2003 in the area of the Faculty of Agriculture, University of Khartoum. The skin

of the fruits was removed by pressing them inside a bucket full of water and the slimy tissue covering the seeds rubbed out between the hands inside water. Seeds were then placed on a paper and left to dry under room temperature for a week period. Dried seeds were crushed using pestle and mortar to break the seed coat which was separated from the broken kernels by winnowing (Plate 3-3). The broken seed kernels were then powdered using an electric blander.. The powder (Plate 3-4) was stored in glass jars with tight cover until needed for preparation of solution extracts.

3.2.3 Preparation of water extracts of leaves and seeds of Neem plants

Aqueous solution of leaves and seeds of Neem plants were prepared using the same described in section 3.1.3.

3.3 Hargel Plants:

3.3.1 Collection of leaves and seeds and preparation of powder of Hargel Plants

The leaves and seeds samples of Hargel plants were collected from Robatab area (Alshereig) in the northern Sudan in June 2003. The

parts of Hargel plants were cleaned using a quick wash by water and spread to dry at room temperature (Plate 3-1 and 3-3). The dried leaves and seeds were powdered using the same method for Ushar.

3.3.2 Preparation of water extracts of leaves and seeds of Hargel Plants

Aqueous solutions of leaves and seeds Hargel plants were prepared the method used for Ushar plants.

3.4 Insect Rearing

The primary stock of *Tribolium castaneum* was obtained from the Department of Crop Protection, Faculty of Agriculture, University of Khartoum. The stock was reared in a plastic container (35x30x98cm) Plates (3-5) containing wheat flour and yeast (12:1 w/w). This culture was kept at room temperature. About 500 adults were collected from the stock cultures and reared in small containers (glass jars)(Plate 3-6). Each container was covered with muslin cloth. Paper balls were placed on the culture surface to enhance the mating rates and left for about 3 weeks under room temperature for oviposition. When cultures were just start to emerge they separated from the old adults and the newly emerged ones were collected over one-week period. Therefore, adults collected would

Plate (3-5) : plastic contenar

Plate (3 - 6) : glass jars.

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be 0-1 week. These adults were then transferred to fresh flour for another week. Hence, tested adults would be 1-2 weeks old. The 4^{th} larval instars were selected for studies

3.5 Bioassay

3.5.1 Testing the insecticidal activity of Ushar, Neem and Hargel parts

3.5.1.1 Powder

The crushed pre-cleaned wheat seeds were sub-divided into groups of 9 g, 9.5g and 9.75 g which were placed separately in Petri-dishes (9cm diameter). Those seeds were then treated by 1 g, 0.5 g and 0.25 g powder of each plant parts to obtained the concentrations of 10%, 5% and 2.5% (w/w) respectively.

Twenty adult insects of red flour beetle were introduced using a camel hair brush. Each treatment was replicated four times. A non-treated Petri-dishes of 10 g crushed wheat of each treatment were prepared as control for comparisons. The number of dead insects in each Petri-dishes was recorded every day for seven days.

With respect to the 4th larval instars, they were subjected to the same concentrations and replicates, with 10 larvae being tested in each Petri-dishes. The number of dead larval instars in each Petri-dishes was recorded every day for three days, (Plate 3-7).

3.5.1.2 Aqueous extracts

The crushed wheat seeds were sub-divided into groups of 10 g each which were placed separately in Petri-dishes (9 cm diameter). The concentrations of 10%, 5% and 2.5%of leaves and seeds of all tested plant parts were used. The control was treated with 2 ml distilled water. The treated crushed wheat seeds were allowed to dry. The same number of insects was placed in each Petri-dish with the same number of replicates and the intervals of data recording as mentioned above (section 3.5.1.1).

3.5.2 Repelling activity

3.5.2.1 Repelling activity of powder of Ushar, Neem and Hargel plant parts

Using a filter paper, the Petri-dishes (9 cm diameter) were divided into two equal sectors, treated and untreated. Crushed wheat

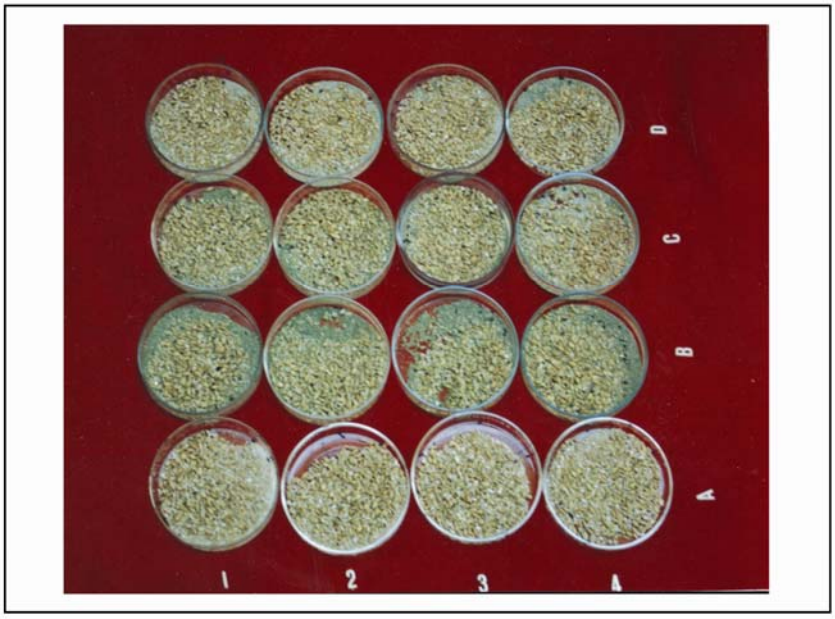

Plate (3-7) : Mortilty test

Plate (3-8) : Repellent test.

seeds treated or untreated were introduced separately into each sectors of each Petri-dishes, weights of crushed wheat sets were 4.5 g, 4.75 g and 4.875 g respectively, treated with 0.5 g, 0.25 g and 0.125 g powder of leaves and seeds of the different tested plants to obtained the concentration 10%, 5% and 2.5% (w/w) respectively.

Another sets of sectors with 5 g crushed wheat seeds each were left untreated as control. Five newly emerged adults of insects were introduced into each of the two sectors in each Petri-dish using a camel hair brush, and each treatment was replicated four times (Plate 3-8). The number of adults of each sector in each Petri-dish was recorded after 24 hrs for 3 days.

Repellency or attractancy effects were computed according to the formula of Leonard and Eherman (1970).

$$A = \frac{N_0 - N_b}{N_t}$$

Where:

A = repellency (-)/attractancy (+)

N_0 = Number of insects in the treat sectors.

N_b = Number of insects in the control.

N_t = Number of insects in both sectors.

To set the data the repellency factor was multiply by -1 prior to analysis.

The 4^{th} larval instars were subjected to the repellency test followed for adults.

3.5.2.2 Repelling activity of aqueous extracts of Ushar, Neem, Hargel plant parts

Sets of crushed wheat seeds (5 g) were soaked for one minute in the desired concentration (10%, 5%, 2.5%) and left to dry for one hour at room temperature. Untreated crushed seeds (5 g) were soaked in distilled water and left to dry as above. Petri-dishes (9 cm diameter) were divided into two equal sectors using filter paper.

Treated and untreated sets of crushed wheat seeds (5 g) were introduced separately each into one sector. Five newly emerged adult insects were introduced into each sector, using a hair camel brush. The control sets of both untreated seeds or seeds treated with distilled water were included. They were placed in both sectors, and each treatment was replicated four times. The number of adults of each sector in each Petri-

dish was recorded every 24 hrs. for 3 days. Repellency or attractancy effects were computed according to the formula of Leonard and Eherman (1970), mentioned above (section 3.5.2.1).

The 4^{th} larval instars were subjected to the same repellency test described for adults.

3.6 Analytical techniques

To achieve the objectives of the study complete randomized design was used. Data was subject to anova and means were separate by DMRT.

CHAPTER FOUR

RESULTS

4.1 The mortality effect

The result in general showed clearly that the mortality increased with the increase of the concentration and the period of exposure.

4.1.1 Toxicity of Ushar leaves powder and aqueous extract on the adult stage of *Tribolium castaneum*

Results in Table (1), showed mortality of 0.75% in the 2nd day in all concentrations of aqueous used as well as in powder using 2.5% concentration. In the last day (i.e. 7th day), 88.8% was the higher mortality percentage obtained with powder using 10% concentration. The mortality percentage of Ushar powder were significantly higher than Ushar aqueous extract all over the period beginning from the 2nd day. The mortality percentages 66.3%, 73.8% and 88.8% were achieved by Ushar powder versus 1.4%, 2.9% and 5% caused by Ushar aqueous extract using the concentrations 2.5%, 5% and 10%, respectively in the 7th day. However, the mortality percentages significantly increased with the increasing of the concentrations of Ushar leaves powder and aqueous extract.

Table No (1):-

Percent mortality of Usher leaves Powder and aqueous extract on the adult stage of *Tribolium castaneum*

	1st day		2nd day		3rd day		4th day		5th day		6th day		7th day	
Treatment	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous
control	0.00 (0.71)	0.00 (0.71)	0.00a (0.71)	0.00a (071)	0.00d (0.71)	0.00d (0.71)	0.00d (0.57)	0.00d (0.57)	0.32cd (3.23)	0.00d0 (0.57)	1.40c (6.75)	0.41c (3.66)	1.40c (6.75)	1.40c (6.75)
2.5%	0.00 (0.71)	0.00 (0.71)	0.75a (1.12)	0.75a (1.12)	8.60bc (3.02)	1.83d (1.53)	16.2c (23.73)	1.40d (6.75)	37.5b (37.75)	1.4cd (6.75)	38.7b (38.48)	1.40c (6.75)	66.3b (54.5)	1.40c (6.75)
5%	5.00 (2.35)	0.00 (0.71)	6.10a (2.57)	0.75a (1.12)	18.68a (4.38)	1.83d (1.53)	31.2b (33.98)	1.40d (6.75)	42.5ab (40.68)	1.4cd (6.75)	48.8b (44.28)	1.40c (6.75)	73.8b (59.20)	2.90c (9.83)
10%	0.00 (0.71)	0.00 (0.71)	3.24a (1.94)	0.75a (1.12)	10.0ab (3.24)	3.25cd (1.94)	45.0a (42.13)	2.90d (9.84)	56.3a (48.6)	5.00c (12.92)	71.3a (57.58)	5.00c (12.92)	88.8a (70.47)	5.00c (12.92)
SE_a±	0.00		0.17*		0.15**		1.07**		1.07**		1.26**		1.25**	
SE_c±	0.00		0.24*		0.21**		1.51**		1.52**		1.78**		1.77**	
CV%	000		51.35		27.51		27.46		21.80		22.75		17.63	

Number in parenthesis are transformed values

Means having the same letter were not significant at 5 % level according to Duncan's Multible Range Test (DMRT)

4.1.2 Toxicity of Ushar seeds powder and aqueous extract on the adult stage of *Tribolium castaneum*

Result in Table (2), showed maximum mortality of 10% of Ushar seed powder in the 5th day with the 5% concentration. The effect of Ushar seed powder was significantly higher than aqueous extract beginning from 2nd day and up to the last day, with significant differences between concentrations all over the test period.

4.1.3 Toxicity of Neem leaves powder and aqueous extract on the adult stage of *Tribolium castaneum*

Results in Table (3) and showed that neem leaves powder caused the highest percentage mortality on the adult stage compared to the neem leaves aqueous extract beginning from the 2nd day. The maximum mortality caused by neem leaves was 16.19% in the last day using powder of 10% concentration. However, the mortality percentages increased significantly with the increasing the concentration.

Table No (2):-

Percent mortality of Usher Seeds Powder and aqueous extract on the adult stage of *Tribolium castaneum*

	1st day		2nd day		3rd day		4th day		5th day		6th day		7th day	
Treatment	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous
control	0.00a (0.71)	0.75a (1.12)	0.00a (0.71)	0.75a (1.12)	1.83a (1.53)	0.75a (1.12)	1.83a (1.53)	0.75a (1.12)	1.83a (1.53)	0.75a (1.12)	3.25a (1.94)	0.75a (1.12)	3.25a (1.94)	0.75a (1.12)
2.5%	0.75a (1.12)	0.00a (0.71)	1.83a (1.53)	0.00a (0.71)	3.25a (1.94)	0.00a (0.71)	3.25a (1.94)	0.00a (0.71)	3.25a (1.94)	0.00a (0.71)	3.25a (1.94)	0.75a (1.12)	3.25a (1.94)	1.83a (1.53)
5%	1.83a (1.53)	0.75a (1.12)	6.10a (2.57)	3.25a (1.94)	7.30a (2.79)	3.25a (1.94)	8.60a (3.02)	3.25a (1.94)	10.0a (3.24)	3.25a (1.94)	10.0a (3.24)	3.25a (1.94)	10.0a (3.24)	6.26a (2.60)
10%	6.10a (2.57)	0.75a (1.12)	6.10a (2.57)	1.83a (1.53)	7.30a (2.79)	1.83a (1.53)	7.30a (2.79)	1.83a (1.53)	8.60a (3.02)	1.83a (1.53)	8.60a (3.02)	1.83a (1.53)	10.0a (3.24)	6.26a (2.60)
SE_a±	0.17		0.17*		0.18**		0.18**		0.18**		0.19**		0.15**	
SE_c±	0.24*		0.23*		0.26*		0.26**		0.25**		0.26*		0.21**	
CV%	55.07		42.05		41.12		40.13		37.62		37.66		27.27	

Number in parenthesis are transformed values

Means having the same letter were not significant at 5 % level according to Duncan's Multible Range Test (DMRT)

Table No (3):-

Percent mortality of Neem leaves Powder and aqueous extract on the adult stage of *Tribolium castaneum*

	1st day		2nd day		3rd day		4th day		5th day		6th day		7th day	
Treatment	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous
control	0.00 (0.71)	0.00 (0.71)	0.00a (0.71)	0.00a (0.71)	0.00a (0.71)	0.00a (0.71)	0.00a (0.71)	0.00a (0.71)	0.00d (0.71)	0.75cd (1.12)	0.75a (1.12)	0.75a (1.12)	0.75a (1.12)	1.83a (1.53)
2.5%	0.00 (0.71)	0.00 (0.71)	0.75a (1.12)	0.00a (0.71)	1.83a (1.53)	0.75a (1.12)	1.83a (1.53)	0.75a (1.12)	1.83bcd (1.53)	0.75cd (1.12)	5.00a (2.35)	1.83a (1.53)	5.00a (2.35)	1.83a (1.53)
5%	0.75 (1.12)	0.00 (0.71)	3.25a (1.94)	0.75a (1.12)	3.25a (1.94)	0.75a (1.12)	6.10a (2.57)	0.75a (1.12)	7.30ab (2.79)	0.75cd (1.12)	7.30a (2.79)	1.83a (1.53)	8.58a (3.01)	6.10a (2.57)
10%	0.75 (1.12)	0.00 (0.71)	3.25a (1.94)	0.75a (1.12)	6.10a (2.57)	0.75a (1.12)	6.10a (2.57)	1.83a (1.53)	11.16a (3.41)	3.25bc (1.94)	12.38a (3.59)	7.30a (2.79)	16.19a (4.09)	7.30a (2.79)
SE_a±	0.10		0.16*		0.17*		0.17**		0.18**		0.17**		0.16*	
SE_c±	0.14		0.23*		0.24**		0.23**		0.25**		0.24**		0.22**	
CV%	50.56		55.34		50.90		44.89		40.93		32.70		26.75	

Number in parenthesis are transformed values

Means having the same letter were not significant at 5 % level according to Duncan's Multible Range Test (DMRT)

4.1.4 Toxicity of neeem seeds powder and aqueous extract on the adult stage of *Tribolium castaneum*

Results in Table (4), showed the effect of aqueous extract and powder of neem seeds against adult stage of *T. castaneum* The aqueous extract was significant higher than the neem powder beginning from the 2nd day. The effect of concentration in all days were also significant except in the 1st day. Mortality percentages of 11.16%, 16.19% and 21.21% was caused by neem aqueous extract versus 6.1%, 7.3% and 5.83% scored by neem seeds powder using the concentration 2.5%, 5% and 10%, respectively, in the last day.

4.1.5 Toxicity of Hargel leaves powder and aqueous extract on the adult of *Tribolium castaneum*

Results in Table (5), showed the effect of Hargel leaves powder and aqueous extract on *T. castaneum*. The maximum mortality recorded by the last day was 12.38% caused by 10% concentration of Hargel leaves powder. However, significant differences were obtained between the concentrations in all days beginning from the 2nd day. Significant

Table No (4):-

Percent mortality of Neem Seeds Powder and aqueous extract on the adult stage of *Tribolium castaneum*

	1st day		2nd day		3rd day		4th day		5th day		6th day		7th day	
Treatment	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous
control	0.00 (0.71)	0.00 (0.71)	0.00a (0.71)	0.00a (0.71)	0.00a (0.71)	0.00a (0.71)	0.00d (0.71)	0.00d (0.71)	0.00d (0.71)	0.00d (0.71)	0.75a (1.12)	0.00a (0.71)	0.75a (1.12)	3.25a (1.94)
2.5%	0.00 (0.71)	0.00 (0.71)	0.00a (0.71)	0.75a (1.12)	1.83a (1.53)	3.25a (1.94)	1.83c (1.53)	8.58ab (3.01)	1.83c (1.53)	10.00b (3.24)	1.83a (1.53)	10.00a (3.24)	6.10a (2.57)	11.16a (3.41)
5%	0.00 (0.71)	0.75 (1.12)	0.75a (1.12)	5.00a (2.35)	1.83a (1.53)	7.30a (2.79)	5.00b (2.35)	11.16a (3.41)	7.30b (2.79)	12.38ab (3.59)	7.30a (2.79)	12.38a (3.59)	7.30a (2.79)	16.19a (4.09)
10%	0.00 (0.71)	0.75 (1.12)	0.75a (1.12)	1.83a (1.53)	1.83a (1.53)	7.30a (2.79)	6.10b (2.75)	12.38a (3.59)	8.58b (3.01)	17.42a (4.23)	8.58a (3.01)	17.42a (4.23)	5.83a (3.59)	21.21a (4.66)
$SE_a\pm$	0.00		0.15^{*}		0.17^{**}		0.11^{**}		0.11^{**}		0.17^{**}		0.13^{**}	
$SE_c\pm$	0.00		0.21^{*}		0.25^{**}		0.16^{**}		0.16^{**}		0.22^{**}		0.19^{**}	
CV%	0.00		51.53		41.25		19.92		18.26		22.70		17.55	

Number in parenthesis are transformed values

Means having the same letter were not significant at 5 % level according to Duncan's Multible Range Test (DMRT)

Table No (5):-

Percent mortality of Hargel leaves Powder and aqueous extract on the adult stage of *Tribolium castaneum*

	1st day		2nd day		3rd day		4th day		5th day		6th day		7th day	
Treatment	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous
control	0.00a (0.71)	0.00a (0.71)	0.00c (0.71)	0.00c (0.71)	0.00c (0.71)	0.00c (0.71)	0.00a (0.71)	0.00a (0.71)	0.00d (0.71)	0.00d (0.71)	0.75a (1.12)	0.00a (0.71)	0.75a (1.12)	0.75a (1.12)
2.5%	0.75a (1.12)	0.00a (0.71)	0.75b (1.12)	0.00c (0.71)	1.83b (1.53)	0.00c (0.71)	1.83a (1.53)	0.00a (0.71)	3.25bc (1.94)	0.75c (1.12)	6.10a (2.57)	075a (1.12)	6.10a (2.57)	075a (1.12)
5%	1.83a (1.53)	0.00a (0.71)	1.83a (1.53)	1.83a (1.53)	1.83b (1.53)	3.25b (1.94)	1.83a (1.53)	3.25a (1.94)	3.25bc (1.94)	5.00b (2.35)	6.10a (2.57)	3.25a (1.94)	7.30a (2.79)	3.25a (1.94)
10%	1.83a (1.53)	0.00a (0.71)	6.10a (2.57)	0.00c (0.71)	8.58a (3.01)	1.83b (1.53)	8.58a (3.01)	3.25a (1.94)	10.00a (3.24)	3.25bc (1.94)	11.16a (3.41)	5.00a (2.35)	12.38a (3.59)	6.10a (2.57)
$SE_a\pm$	014*		0.14*		0.17		0.16		0.14*		0.14**		0.17**	
$SE_c\pm$	0.20		0.20*		0.24**		0.23**		0.20**		0.20**		0.23**	
CV%	57.76		48.05		45.65		42.73		33.28		28.57		31.55	

Number in parenthesis are transformed values

Means having the same letter were not significant at 5 % level according to Duncan's Multible Range Test (DMRT)

differences occurred between Hargel powder and aqueous in the 1st, 2nd and 5th days and between Hargel powder and aqueous extract in the last two days.

4.1.6 Toxicity of Hargel seeds powder and aqueous extract on the adult of *Tribolium castaneum*

The effect of different concentrations of Hargel seed powder and aqueous extract started from the 3rd day and continue to the 7th day where the values of mortality were significantly different. The percent mortalities of the adult exposed to 2.5%, 5% and 10% concentrations of Hargel seed powders were 1.83%, 0.75% and 6.1%, for the 3rd day respectively and 3.25%, 6.1% and 13.66%, for the 7th day respectively, 13.66% as a maximum mortality was recorded when Hargel seed powder was used with 10% concentration. No significant differences were obtained between applying Hargel powder and aqueous extract, Table (6).

4.1.7 Toxicity of Ushar leaves powder and aqueous extract on the 4th larval instar of *Tribolium castaneum*

Results in Table (7), showed low efficacy of Ushar leaves in controlling the 4th larval instars. The percent mortalities of the 4th larva

Table No (6):-

Percent mortality of Hargel Seeds Powder and aqueous extract on the adult stage of *Tribolium castaneum*

	1st day		2nd day		3rd day		4th day		5th day		6th day		7th day	
Treatment	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous	Powder	Aqueous
control	0.00a (0.71)	0.00a (0.71)	0.00a (0.71)	0.00a (0.71)	0.00a (0.71)	0.00a (0.71)	0.00a (0.71)	0.75a (1.12)	0.00a (0.71)	0.75a (1.12)	0.00a (0.71)	1.83a (1.53)	0.75a (1.12)	1.83a (1.53)
2.5%	0.00a (0.71)	0.00a (0.71)	1.83a (1.53)	0.75a (1.12)	1.83a (1.53)	0.75a (1.12)	3.25a (1.94)	3.25a (1.94)	3.25a (1.94)	3.25a (1.94)	3.25a (1.94)	3.25a (1.94)	3.25a (1.94)	3.35a (1.94)
5%	0.00a (0.71)	0.75a (1.12)	0.75a (1.12)	0.75a (1.12)	0.75a (1.12)	1.83a (1.53)	1.83a (1.53)	3.25a (1.94)	5.00a (2.35)	5.00a (2.35)	5.00a (2.35)	5.00a (2.35)	6.10a (2.57)	6.10a (2.57)
10%	1.83a (1.53)	0.75a (1.12)	4.16a (2.16)	1.83a (1.53)	6.10a (2.57)	3.25a (1.94)	8.58a (3.01)	3.25a (1.94)	11.16a (3.41)	6.10a (2.57)	12.38a (3.59)	7.30a (2.79)	13.66a (3.76)	7.30a (2.79)
SE_a±	0.13		0.20		0.18		0.17		0.15		0.14		0.17	
SE_c±	0.19		0.28		0.25**		0.26*		0.22**		0.20**		0.24**	
CV%	58.09		62.71		50.52		42.37		30.80		26.84		29.81	

Number in parenthesis are transformed values

Means having the same letter were not significant at 5 % level according to Duncan's Multible Range Test (DMR

Table 7: Percent mortality of4th larval instar of *Tribolium castaneum* exposed to Ushar leaves powder and aqueous extract.

	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
Control	0.00 c (0.71)	0.00 c (0.71)	1.296 a (1.34)	1.30 a (1.34)	1.30 a (1.34)	1.30 a (1.34)
2.5%	0.00 c (0.71)	1.30 bc (1.34)	6.30 a (2.61)	1.30 a (1.34)	12.19 a (3.56)	6.30 a (2.61)
5%	6.30 ab (2.61)	0.00 c (0.71)	12.19 a (2.61)	1.30 a (1.34)	17.19 a (4.26)	6.30 a (2.61)
10%	3.40 abc (1.97)	9.99 a (3.24)	20.00 a (4.53)	12.19a (3.56)	24.76 a (5.03)	20.00 a (4.53)
S.E a ±	0.20		0.26*		0.24 *	
S.E c ±	0.29**		0.37*		0.34**	
C.V%	54.50		42.93		30.89	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT).

instar exposed to 2.5%, 5% and 10% concentrations of Ushar leaves powder in the last day was 12.19%, 17.19% and 24.76%, respectively. These figures were higher than those of Ushar leaves aqueous extract at the same concentrations for the last day (6.3%, 6.3% and 20%) respectively. However, highly significant differences were obtained between the concentrations where as the Ushar powder was significantly higher than Ushar aqueous extract in the 2nd and 3rd days, with no significant differences in the 1st day. The mortality increased with the increase in concentrations and the exposure time.

4.1.8 Toxicity of Ushar seeds powder and aqueous extract on the 4th larval instar of *Tribolium castaneum*

Results in Table (8), showed that, the percent mortalities of the 4th larval instar exposed to (2.5%, 5% and 10% concentrations) of Ushar seeds powder in last day were 10%, 12.19% and 17.19% respectively, and Ushar seeds aqueous extract 3.4%, 10% and 27.32%, respectively. Highly significant differences were obtained between the different concentrations and no significant differences between powder and aqueous all over the test period.

Table 8: Percent mortality of4th larval instar of *Tribolium castaneum* exposed to Ushar seeds powder and aqueous extract.

	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
Control	1.30 b (1.34)	0.00 b (0.71)	3.40 a (1.97)	1.30 a (1.34)	3.40 a (1.97)	3.40 a (1.97)
2.5%	0.00 b (0.71)	1.30 b (1.34)	9.99 a (3.24)	3.40 a (1.974)	9.99 a (3.24)	3.40 a (1.97)
5%	1.30 b (1.34)	1.30 b (1.34)	9.99 a (3.24)	6.30 a (2.61)	12.19a (3.56)	9.99 a (3.24)
10%	12.19 a (3.56)	6.30 ab (2.61)	14.59 a (3.88)	14.59 a (3.88)	17.19 a (4.21)	27.32 a (5.27)
SE a ±	0.26		0.26		0.24	
SE c ±	0.36**		0.37**		0.34**	
CV%	6.38		37.41		30.43	

Numbers in parenthesis are transformed values.

Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT

4.1.9 Toxicity of Neem leaves powder and aqueous extract on the 4th larval instar of *Tribolium castaneum*

Results in Table (9), showed high significant differences between the different concentrations beginning from the 2nd day. The present mortalities recorded of the 4th larval instars exposed to neem leaves powder and aqueous extract were 17.19%, 14.59% and 27.92%, and 3.4%, 20% and 17.19% using 2.5%, 5% and 10% concentration respectively. No significant differences obtained between neem leaves powder and aqueous extract all over the test period.

4.1.10 Toxicity of neem seeds powder and aqueous extract on the 4th larval instar of *Tribolium castaneum*

Results in Table (10), showed a relatively higher effect on the mortality of the 4th larval instar than neem leaves especially when increasing of the concentrations used in each application. The percent mortalities of the 4th larval instars exposed to neem seed powder and aqueous extract were20%, 17.2% and 34.9% and 24.8%, 27.4% and 42.5% using 2.5%, 5% and 10% concentrations, respectively, in the last day. Highly significant differences were recorded between the

Table 9: Percent mortality of4th larval instar of *Tribolium castaneum* exposed to Neem leaves powder and aqueous extract.

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	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
Control	0.00 a	0.00 a	1.30 b	2.30 b	1.30 c	1.30 C
	(0.71)	(0.71)	(1.34)	(1.34)	(1.34)	(1.34)
2.5%	0.00 a	0.00 a	12.19 a	1.30 b	17.19 ab	3.40 C
	(0.71)	(0.71)	(3.56)	(1.34)	(4.21)	(1.97)
5%	0.00a	3.40 a	12.19 a	17.19 a	14.59 b	20.00 ab
	(0.71)	(1.97)	(3.56)	(4.21)	(3.88)	(4.53)
10%	1.30 a	3.40 a	14.59 a	9.99 a	27.92 a	17.19 ab
	(1.34)	(1.97)	(3.88)	(3.24)	(5.27)	(4.21)
S.E a ±	0.21		0.30		0.23	
S.E c ±	0.30		0.32 **		0.33**	
CV%	77.95		3235		27.96	

Numbers in parenthesis are transformed values.

Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT

Table 10 Percent mortality of4th larval instar of *Tribolium castaneum* exposed to Neem seeds powder and aqueous extract.

	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
Control	0.00 a	0.00 a	0.00 a	1.30 a	2.75 a	2.75 a
	(0.71)	(0.71)	(0.71)	(1.34)	(9.55)	(9.55)
2.5%	1.30 a	3.40 a	3.40 a	10.00 a	20.0 a	24.80 a
	(1.34)	(1.95)	(1.98)	(3.24)	(26.56)	(29.89)
5%	0.00 a	1.30 a	3.40a	14.86 a	17.20 a	27.40 a
	(0.71)	(1.34)	(1.97)	(3.88)	(24.53)	(31.55)
10%	6.30 a	10.00 a	17.19 a	17.19 a	34.90 a	42.51 a
	(2.61)	(3.24)	(4.21)	(4.21)	(36.22)	(40.67)
S.E a ±	0.23		0.24*		1.47	
S.E c ±	0.33 **		0.34**		2.08**	
CV%	58.99		35.42		22.53	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant according to Duncan's Multiple Range Test (DMRT).

different concentrations, whereas the differences were non-significant between the neem powder and aqueous extract in the 2nd day while aqueous extract scored significantly higher values than the powder.

4.1.11 Toxicity of Hargel leaves powder and aqueous extract on the 4th larval instar of *Tribolium castaneum*

All results in Table (11), showed no significant differences between powder and aqueous extract of Hargel leaves. Significant differences were obtained between the different concentrations in the 2nd and 3rd days. The percent mortality of Hargel leaves powder were 1.3%, 3.4% and 10% using 2.5, 5% and 10% concentrations, respectively, in the last day.

4.1.12 Toxicity of Hargel seeds powder and aqueous extract on the 4th larval instar of *Tribolium castaneum*

The effect of applying Hargel seeds aqueous was significantly higher than applying Hargel seed powder beginning from the 2nd day, with significant differences between the different concentrations.

Table 11: Percent mortality of4th larval instar of *Tribolium castaneum* exposed to Hargel leaves powder and aqueous extract.

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	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
Control	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a
	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)
2.5%	0.00 a	1.30 a	1.30 a	1.30 a	1.30 a	3.40 a
	(0.71)	(1.34)	(1.34)	(1.34)	(1.34)	(1.97)
5%	0.00 a	1.30 a	1.30 a	1.30 a	3.40 a	6.30a
	(0.71)	(1.34)	(1.34)	(1.34)	(1.97)	(2.61)
10%	1.30 a	3.40	6.30 a	10.00 a	10.00 a	10.00 a
	(1.34)	(1.97)	(2.61)	(3.24)	(3.24)	(3.24)
SE a ±	0.23		0.25		0.24	
SE c ±	0.33		0.35*		0.34**	
CV%	84.74		63.37		49.10	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT)

The percent mortalities of the 4th larval instar exposed to 2.5%, 5% and 10% concentrations of Hargel seed powder and aqueous extract in the last day were 1.3%, 1.3% and 10% and 3.4%, 10% and 12.19%, respectively, (Table 12).

4.2 The Repellency effect

All results indicated that the selected plant parts of Ushar, Neem, Hargel in powder or aqueous forms and in all concentrations showed repellency effects for both the larval and the adult stages of *T. castaneum*.

4.2.1 The repellency effect of Ushar leaves powder and aqueous extract on the adult stages of *T. castaneum*

Table (13) showed that the percent repellency of the adult stage exposed to 2.5%, 5% and 10% concentration of Ushar leaves powder and aqueous extract in the last day were 62%, 40% and 94.7% and 28.8%, 88.7% and 85.4% respectively. However, no significant differences were obtained between Ushar powder and aqueous extract in all test period.

Table 12: Percent mortality of4th larval instar of *Tribolium castaneum* exposed to Hargel seeds powder and aqueous extract.

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	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
Control	0.00	0.00	0.00 a	0.00 a	0.00 a	0.00 a
	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)
2.5%	0.00	0.00	0.00 a	1.30 a	1.30a	3.40 a
	(0.71)	(0.71)	(0.71)	(1.34)	(1.34)	(1.97)
5%	0.00	0.00	0.00 a	6.30 a	1.30 a	10.00 a
	(0.71)	(0.71)	(0.71)	(2.61)	(1.35)	(3.24)
10%	0.00	0.00	3.40 a	6.30 a	10.00a	12.19 a
	(0.71)	(0.71)	(1.97)	(2.61)	(3.25)	(3.56)
S.E a ±	0.00		0.23*		0.21*	
S.E c ±	0.00		0.33*		0.30**	
CV%	0.00		65.64		42.22	

Numbers in parenthesis are transformed values.

Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT)

Table 13: The repellency effect of Ushar leaves powder and aqueous extract to adult stage of *T. castaneum*.

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	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
2.5%	50.00 a (5.00)	34.70 a (6.06)	39.50 a (8.95)	39.50 a (8.95)	62.0 a (1.92)	28.8 a (2.45)
5%	24.60 a (9.73)	61.50 a (1.64)	44.50 a (1.83)	24.60 a (9.73)	40.00 a (9.23)	88.70 a (0.39)
10%	61.00 a (1.34)	76.30 a (0.86)	88.40 a (0.08)	61.50 a (1.64)	94.7 a (6.72)	85.40 a (7.50)
S.E a ±	4.93		4.24		5.98	
S.E c ±	6.04		5.20**		7.32*	
CV%	37.33		32.53		36.72	

Numbers in parenthesis are transformed values.

Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT

4.2.2 The repellency effect of Ushar seeds powder and aqueous extract on the adult stages of *T. castaneum*

The aqueous of Ushar seeds resulted in maximum repellant effect (98.6%) with the 10% concentration in the 1st day. The effect of Ushar seed aqueous extractwas significantly higher that the effect of Ushar seed powder in all days and 19.4% was a minimum repellent effect with 2.5% concentration of Ushar seed powder. The repellency effect of powder and aqueous were significantly different allover the test period (Table 14).

4.2.3 The repellency effect of neem leaves powder and aqueous extract on the adult stages of *T. castaneum*

Table (15), showed that the repellency effect of neem leaves powder was significantly higher than neem leaves aqueous extract in the 2nd day. In the 3rd day, highly significant differences were shown between different concentrations, while no significant differences were recorded in the other days. The highest repellent effects were reported when neem leaves was applied as powder 98.7% at10% concentration in the 2nd day.

Table 14: The repellency effect of Ushar seeds powder and aqueous extract to adult stage of *T. castaneum*

	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
2.5%	19.40a (6.12)	45.0a (2.12)	20.00a (6.56)	55.5a (8.17)	20.00a (6.56)	60.5a (1.05)
5%	5.50a (3.57)	80.40a (3.75)	19.40a (6.12)	80.40 (3.75)	34.7a (6.06)	80.40a (3.75)
10%	50.00a (5.00)	98.6a (3.36)	55.5a (8.17)	95.2a (7.31)	55.5a (8.17)	92.0a (3.55)
S.E a ±	4.15**		5.11**		4.09**	
S.E c ±	5.09**		6.25*		5.01*	
CV%	31.51		36.60		28.42	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT

Table 15: The repellency effect of Neem leaves powder and aqueous extract to adult stage of *T. castaneum*

	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
2.5%	92.0a (73.55)	94.7a (76.72)	88.4a (70.08)	60.5a (51.05)	70.5a (57.11)	34.2a (35.78)
5%	88.4a (70.08)	94.7a (76.72)	92.0a (73.55)	75.4a (60.27)	94.7a (76.72)	84.6a (66.91)
10%	98.7a (83.36)	94.7a (76.72)	98.7a (83.36)	80.4a (63.75)	88.4a (70.08)	94.7a (76.72)
SE a ±	4.48		4.12**		3.92	
SE c ±	5.49		5.04		4.81**	
CV%	20.37		21.28		21.27	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT)

4.2.4 The repellency effect of Neem seeds powder and aqueous extract on the adult stages of *T. castaneum*

Result in Table (16) showed that 84.6% and 100% were the minimum and maximum repellent effect caused by 2.5% and 10% of neem seed powder and neem seed aqueous extract respectively.

Generally, no significant differences were obtained between the different treatments.

4.2.5 The repellency effect of Hargel leaves powder and aqueous extract on the adult stages of *T. castaneum*

Table (17), showed that Hargel leaves possessed a moderately to a relatively high repellency effect. Hargel aqueous extract showed higher effect than Hargel powder all over the test period, with highly significant differences between the repellency effect in different concentrations in the 2^{nd} day. The 10% concentration resulted in increasing effect of repellency allover the test period.

Table 16: The repellency effect of Neem seeds powder and aqueous extract to adult stage of *T. castaneum*.

	1st day		**2nd days**		**3rd day**	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
2.5%	94.7a (6.72)	88.7a (0.39)	94.7a (6.72)	88.4a (0.08)	84.6 a (6.91)	84.6a (6.91)
5%	94.7a (6.72)	98.7 a (3.36)	98.7a (3.36)	88.4a (0.08)	100a (0.00)	94.5a (6.72)
10%	100a (0.00)	100a (0.00)	100a (0.00)	98.7a (3.36)	98.7a (3.36)	94.5a (6.72)
S.E a ±	4.01		3.61		4.07	
S.E c ±	4.92		4.43		4.98	
CV%	17.12		15.86		18.36	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT)

Table 17: The repellency effect of Hargel leaves powder and aqueous extract to adult stage of *T. castaneum*

	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
2.5%	44.5a (1.83)	94.7a (6.72)	55.0a (7.89)	50.0a (5.00)	34.7a (6.06)	60.0a (0.77)
5%	45.0a (2.12)	98.7a (3.36)	60.5a (1.05)	88.4a (0.08)	55.0a (7.89)	80.0a (3.44)
10%	60.5a (1.05)	98.7a (3.36)	75.9a (0.58)	98.7a (3.36)	70.5a (7.11)	98.7a (3.36)
S.E a ±	3.83**		3.56*		2.05**	
S.E c ±	4.69		4.36**		2.51**	
CV%	21.04		20.68		12.60	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT)

4.2.6 The repellency effect of Hargel seeds powder and aqueous extract on the adult stages of *T. castaneum*

Results in Table (18), showed that the highest repellency took place in the 1st day scoring the repellency of 98.7%, 94.7% and 92%.

These percentages of repellency decreased with time until the reached 88.4, 84.7% and 45% in the last day with the concentrations of 10%, 5% and 2.5% respectively of Hargel seed aqueous extract. Hargel aqueous extract at different concentrations showed significant differences from the different dose used. On the other hand the results showed that, Hargel aqueous extract caused significantly higher repellency effects than the powder during the 1st and 2nd day and not the 3rd day.

4.2.7 The Repellency effect of Ushar leaves powder and aqueous extract on the 4th larval instar of *T. castaneum*

Results in Table (19), showed that, Ushar leaves applied, as aqueous extract form was significantly higher in its repellent effect for the 4th larval instars than the powder form in all test period. No significant differences were noticed between the different concentrations.

Table 18: The repellency effect of Hargel seeds powder and aqueous extract to adult stage of *T. castaneum*.

	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
2.5%	34.2a (5.78)	92.0a (3.55)	45.0a (2.12)	88.4a (0.08)	40.0a (9.23)	45.0a (2.12)
5%	65.8a (4.22)	94.7a (6.72)	70.5a (7.11)	80.0a (3.44)	70.5a (7.11)	84.7a (6.91)
10%	92.0a (3.55)	98.7a (3.36)	88.4a (0.08)	94.7a (6.72)	75.4a (0.27)	88.4a (0.08)
S.E a ±	4.50**		3.06**		2.83	
S.E c ±	5.51*		3.75*		3.46**	
CV%	23.54		16.76		17.51	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT

Table 19: The repellency effect of Ushar leaves powder and aqueous extract to 4th larval instar of *T. castaneum*.

	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
2.5%	8.30a (6.73)	50.40a (5.28)	19.40a (6.12)	60.50 (1.05)	29.0a (2.61)	45.0a (2.12)
5%	5.50a (3.57)	55.00a (7.89)	24.6a (9.73)	71.40a (7.69)	20.00a (6.56)	65.80a (4.22)
10%	15.60a (3.23)	60.50a (1.05)	29.50a (2.90)	65.80a (4.22)	56.0a (8.47)	75.90a (0.58)
S.E a ±	4.32**		4.48**		4.71*	
S.E c ±	5.30		5.49		5.77	
CV%	45.45		37.00		37.00	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT

Five and half percent with a concentration of 5% powder in the 1st day versus 75.9% by applying 10% aqueous concentration in the last day were the minimum and maximum repellent effects recorded.

4.2.8 The repellency effect of Ushar seeds powder and aqueous extract on the 4th larval instar of *T. castaneum*

The repellency effects were significantly shown between Ushar aqueous extract and powder in the 1st and last day were the aqueous extract gave highest effects. No significant differences between the different concentrations used in all days except in the 2nd day where the difference was significant between the concentrations with a repellency 24.6%, 45% and 65.8% using the concentrations 2.5%, 5% and 10%, respectively of Ushar seed aqueous extract (Table 20).

4.2.9 The repellency effects of Neem leaves powder and aqueous extract on the 4th larval instar of *T. castaneum*

Results in Table (21), showed that the repellency effects of neem leaves varied between 24.6 with 2.5% aqueous extract concentration in the last day and 70.5% with 10% aqueous extract concentration in the 1st day. No significant differences were noticed between neem leaves powder and aqueous extract except in the last day where the powder gave

Table 20: The repellency effect of Ushar seeds powder and aqueous extract to 4th larval instar of *T. castaneum*.

	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
2.5%	19.80a (6.40)	34.20a (5.78)	29.00a (2.61)	24.60a (9.73)	15.6a (3.23)	39.0a (8.67)
5%	34.20a (5.78)	55.5a (8.17)	29.50a (2.90)	45.00a (2.12)	24.60a (9.73)	50.5a (5.28)
10%	34.70a (6.06)	55.5a (8.17)	45.00a (2.12)	65.8a (4.22)	50.00a (5.00)	50.00a (5.00)
S.E a ±	3.55*		3.00		3.19*	
S.E c ±	4.35		3.67*		3.91	
CV%	32.08		26.66		29.26	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT

Table 21: The repellency effect of Neem leaves powder and aqueous extract to 4th larval instar of *T. castaneum*.

	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
2.5%	50.00a (5.00)	34.7a (6.06)	50.0a (5.00)	34.2a (5.78)	45.0a (2.12)	24.6a (9.73)
5%	60.5a (1.05)	60.5a (1.05)	45.0a (2.12)	40.0a (9.23)	40.0a (9.23)	29.5a (2.90)
10%	50.5a (5.28)	70.5a (7.11)	50.0a (5.00)	65.8a (4.22)	45.0a (2.12)	29.5a (2.90)
S.E a ±	2.58		2.34		1.72**	
S.E c ±	3.16*		2.86		2.11	
CV%	18.80		18.58		16.35	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT

a higher effect of repellency than aqueous extract. The significant differences between the concentrations were just achieved in the 1st day.

4.2.10 The repellency effects of Neem seeds Powder and aqueous extract on the 4th larval instar of *T. castaneum*

Results in Table (22), showed that the highest repellency took place in the 1st day resulting in repellency value of 94.7% with 10% aqueous extract concentration. These percentages decreased with time were the lowest repellent effect of 24.4% was obtained in the 2nd day with 2.5% aqueous extract concentration. The neem powder resulted in a significantly higher repellent effect than neem aqueous extract except in the 1st day where the difference was not significant. The significant differences were obtained between the repellent effects among different concentrations used except in the last day where the difference was not significant.

4.2.11 The repellency effects of Hargel leaves powder and aqueous extract on the 4th larval instar of *T. castaneum*

Results in Table (23), showed a high repellent effect especially with 10% aqueous extract concentration in the 1st day, 92%. The highly significant differences were seen between the effect of Hargel leaves

Table 22: The repellency effect of Neem seeds powder and aqueous extract to 4th larval instar of *T. castaneum* .

	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
2.5%	70.5a (7.11)	44.5a (1.83)	55.0a (7.89)	24.4a (9.57)	55.5a (8.17)	34.2a (5.78)
5%	84.6a (6.91)	55.5a (8.17)	80.4a (3.75)	39.5a (8.95)	71.9a (7.98)	39.0a (8.67)
10%	88.4a (0.08)	94.7a (6.72)	84.6a (6.91)	76.3a (0.86)	75.4a (0.270	60.5a (1.05)
S.E a ±	3.73		4.71*		4.06*	
S.E c ±	4.57**		5.76*		4.98	
CV%	21.51		31.77		28.93	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT (DMRT).

Table 23: The repellency effect of Hargel leaves powder and aqueous extract to 4th larval instar of *T. castaneum*.

	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
2.5%	11.8a (0.06)	15.6a (3.23)	11.8 a (0.06)	29.5a (2.90)	20.0a (6.56)	29.5a (2.90)
5%	29.5a (2.90)	45.0a (2.12)	20.00a (6.56)	34.7a (6.06)	11.8a (0.06)	24.6a (9.73)
10%	39.5a (8.95)	92.0a (3.55)	34.7a (6.06)	75.4a (0.27)	24.6a (9.73)	65.4a (3.94)
S.E a ±	3.74**		2.18**		2.18**	
S.E c ±	4.58**		2.67**		2.67**	
CV%	33.64		21.40		23.51	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (DMRT

powder and aqueous extract, where the aqueous extract gave the highest effect and between different concentrations all over test period.

4.2.12 The repellency effects of Hargel seeds powder and aqueous extract on the 4th larval instar of *T. castaneum*

The differences between effects of Hargel seeds aqueous extract and powder was just significant in the last day, whereas the differences were significant all over the test period between the different concentrations. The highest repellency 65.8% were scored in 10% aqueous extract concentration in the 1st day of the test (Table 24).

Table 24: The repellency effect of Hargel seeds powder and aqueous extract to 4th larval instar of *T. castaneum*.

	1st day		2nd days		3rd day	
	Powder	**Aqueous**	**Powder**	**Aqueous**	**Powder**	**Aqueous**
2.5%	24.6 c (9.73)	24.6 c (9.73)	20.00 c (6.56)	34.6 bc (6.06)	34.2 bc (5.78)	24.6 c (9.73)
5%	50.00 ab (5.00)	29.5 bc (2.90)	45.0 ab (2.12)	24.6 c (9.73)	60.5 a (1.05)	24.6 c (9.73)
10%	45.0 bc (2.12)	65.8 a (4.22)	50.00ab (5.00)	60.5a (1.05)	45.0abc (2.12)	55.0 ab (7.89)
S.E a ±	2.20		1.88		2.30*	
SE c ±	2.69**		2.31**		2.81*	
CV%	19.52		16.99		20.21	

Numbers in parenthesis are transformed values.
Means having the same letter were not significant at 5% level according to Duncan's Multiple Range Test (D

CHAPTER FIVE

DISCUSSION

The search for safe naturally occurring pesticides for field crops and storage pests has been intensified. There is a continuous search for natural products that can reduce insect pest population in a manner that is less hazardous. The most promising are those derived from plants.

A number of investigations, identified and screened a variety of promising chemical compounds from leaves and seeds of many botanical families as insect feeding deterrents and growth inhibitors (Jacobson *et al*., 1979; Sebier *et al*., 1982; Sharma, 1985; Jones *et al*., 1989; Ruskin, 1991; Siddig, 1991).

In the present work various aspects of the efficacy of three widely spread plants in Sudan (Ushar, Neem and Hargel) were tested against the 4^{th} larval instar and adult of *Tribolium castaneum* Herbst. The investigations included evaluation of the efficacy of Ushar, Neem and Hargel powders and aqueous extracts from various plant parts as pesticides (toxicity and repellency).

The mortality rates on adults and 4th larval instars of *T. castaneum* were high in Ushar leaves compared to Ushar seeds and in powder compared to aqueous extract. The adults were more susceptible to Ushar products than the 4th larval instars. This may be attributed to the two following factors, the exposure period was longer in adults (7 days) compared to 4th larval instars (3 days) and sluggish behaviour of the 4th larval instars when exposed to different treatments.

The present findings which showed significant repellency effects of different Ushar applications agreed with the results obtained by Jahan *et al* (1991) Ahmed (1993) and Osman (1999) who stated that the Ushar plants has antifeedant, repellent and insecticidal action against different stored products insect pests.

As for Neem, the results showed a relatively light efficacy on mortality which reached 42.5% using 10% concentration of Neem seed aqueous extract against the 4th larval instars. Ruskin (1991) state that the azadirachtin, the responsible ingredient of the effect on insect pest, doesn't kill most insect immediately but instead it repels and disrupts or regulator growth and feeding deterrent of insects. This agreed with the

above mentioned findings which showed light efficacy on the mortality of the insect.

As for the effect of Neem leaves and seeds, powder and aqueous extract on *T. castaneum* adults and 4th larval instars, the Neem seeds aqueous extract showed the best effect, followed by Neem leaves powder, Neem seeds powder and the Neem leaves aqueous extract. The effect of different Neem applications on mortality was higher in the 4th larval instars compared to the adults. This did not agree with the findings of Mohammed (2003) who maintained that neem effect of application on mortality was higher in adult than fouth larval instar of *T. castaneum.* Looking into the result obtained for repellency and mortality effects of the Neem product, one can see that the former is much clear than the latter. These findings agreed with many workers who stated that the repellency effect was more clear than the mortality, (Pruthi, 1937); Jotwani and Sircer, 1965; Ghulain, 1973; Schmutter *et al*., 1981; Schmutterer and Ascher, 1984 and 1987 and Mohammed, 2003).

Results obtained from Hargel plant indicated a relatively less mortality effect on the adults and 4th larval instars compared to other plants (Ushar and Neem) in both powder and aqueous products. But the

effect on mortality was relatively higher on adult insects than on 4th larval instars. In case of Hargel leaves, the powders were found to be more effective compared to aqueous extract, however, Hargel seeds powder were, generally, found more effective than Hargel leaves products. The maximum mortality (13.66%) was obtained using Hargel seeds powder at the concentration of 10%. However, the present work on effect of Hargel plant products on stored grain pests is the first study in the Sudan. The only available work found in the literature was on the mosquito *Culex quinquefasiatusI* (Say.) by El Kamali, (2001) who stated that the products have adverse effect on the above mentioned Dipterous species.

This work revealed that all tested plant parts product have repellent effects on the tested insects. Neem was the most repellent, followed by Hargel and Ushar plants. Adults insects were more affected by the repellency effect than 4th larval instars in all treatments. The reasons behind this may be due to the higher susceptibility of the adults compared to 4th larval instars as reported by Mohamed (2003).

The maximum repellency effect (100%) was obtained using Neem seeds powder and aqueous extract at the concentration of 10%

against the adult stages by the end of the 1st day. The maximum repellency was observed in Neem treatment when there is a high concentration of Azadirachtin (first ingredient isolated) which is responsible of about 90% of the effect on insect pests (Ruskin, 1991). However, the above results agreed with Sahayaraj and Paulraj (2000) who reported that, the leaf extract of *Azadirachta indica* was found to be the most effective repellent against *T. castaneum* on groundnut seed.

The repellency test of Ushar plant indicated that Ushar leaves, seeds powder and aqueous extract showed a good repellent effect against both the adults and the 4th larval instars.

In case of Ushar leaves, there were no significant differences between powder and aqueous extract, whereas Ushar seeds gave better effect when compared to Ushar leaves. The maximum repellent effect (98.6%) was obtained using Ushar seeds aqueous extract at concentration of 10% on the adult stages by the end of the 1st day of the test. These results agreed with the finding of Ahmed (1993); and Osman (1999) who reported that *C. procera* has antifeedant, repellent and insecticidal action against some stored pests.

The repellency effect of Hargel against the adults and the 4th larval instars of *Tribolium castaneum* showed some adverse effect against insect. This agreed with the farmers in the North regions (Shaygia area) who used Hargel plant as traditional method for controlling insect attacking the vegetables, particularly the bollworm. However, the present findings assured the effect of Hargel against insect pests.

CONCLUSION AND RECOMMENDATIONS

Ushar *Calotropis procera* Ait, Neem *Azadirachta indica* A. Juss. and Hargel *Solenostemma arge*l (Del.) Hayne where selected for this study are all available in big quantities in the Sudan. The present study revealed that all these plants scored different levels of insecticidal and repellency effect on the adults and the 4th larval instars of *T. castaneum.* Since these plants are available and cheap. Farmers in rural areas can make use of them for controlling insect pests in their farms. The easy preparation of the powders and water extract will encourage the farmer to benefit from them. However, further work on Ushar and Hargel plants to clarify their biocidal effects is recommended and the following questions need to be answered:

1. Are there any side effects of the tested plant parts and their extracts on humans and environment?
2. What are the appropriate methods for the isolation of the active substances?
3. What are the possibilities for the screening of the active substances against different insect species under laboratory and field conditions, particularly the insects of economic importance.

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Appendix

A.No. 1. Mortality effect of Usher leaves on the adult stage of *Tribolium Castaneum*

Source of variation	D. F.	M. S.						
		1	2	3	4	5	6	7
Application	1	1.3415	2.5793*	15.9556**	2927.2726**	5377.1042**	6847.7178**	11961.0178**
concentration	3	1.3415	1.9489*	7.8184**	950.5166**	1211.0244**	1254.8273**	1834.8021**
Error	24	0	0.4443	0.3434	18.2133	18.4548	25.3966	25.0376

A. No.2. Mortality effect of Usher seeds on the adult stage of *Tribolium Castaneum*

Source of variation	D. F.	M. S.						
		1	2	3	4	5	6	7
Application	1	1.7331	2.1747*	7.0745**	7.9411**	9.8246**	9.8246**	4.5557**
Concentration	3	1.5602*	3.5509*	2.4141*	2.7807**	3.4085**	2.3102*	3.6697**
Error	24	0.4378	0.4413	0.5419	0.5335	0.5002	0.5561	0.3633

A.No. 3. Mortality effect of Neem leaves on the adult stage of *Tribolium Castaneum*

Source of variation	D. F.	M. S.						
		1	2	3	4	5	6	7
Application	1	0.3354	2.0961*	3.5932*	4.2180**	4.9762**	5.5411**	2.3097*
Concentration	3	0.1118	1.4254*	1.8345**	2.8697**	4.7439**	4.6314**	6.9577**
Error	24	0.1677	0.4192	0.4722	0.4413	0.4957	0.4449	0.4018

A.No. 4. Mortality effect of Neem seeds on the adult stage of *Tribolium Castaneum*

Source of variation	D. F.	M. S.						
		1	2	3	4	5	6	7
Application	1	0.00	2.0961*	4.3292**	6.4055**	6.9425**	12.9261**	8.1073**
Concentration	3	0.00	1.6490*	3.7556**	9.2355**	13.2461**	9.8132**	9.6688**
Error	24	0.00	0.3636	0.4860	0.1973	0.2050	0.3895	0.2810

A.No. 5. Mortality effect of Hargel leaves on the adult stage of *Tribolium Castaneum*

Source of variation	D. F.	M. S.						
		1	2	3	4	5	6	7
Application	1	2.0961*	2.5793*	1.8045	1.1104	1.4689*	6.3520**	5.5411**
Concentration	3	0.3074	1.6642*	3.7765**	4.7501**	5.3114**	5.4483**	5.4958**
Error	24	0.3074	0.3325	0.4443	0.4163	0.3354	0.3168	0.4391

A.No. 6. Mortality effect of Hargel seeds on the adult stage of *Tribolium Castaneum*

Source of variation	D. F.	M. S.						
		1	2	3	4	5	6	7
Application	1	0.00	0.5437	0.2005	0.0343	0.0003	0.0003	0.1572
Concentration	3	0.6708	1.7838	3.2501**	3.3696*	5.8429**	5.9594**	5.6438**
Error	24	0.2795	0.6145	0.5002	0.5560	0.3756	0.3331	0.4620

A.No. 7. Mortality effect of Usher leaves on the 4th larva instars of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	0.00	9.9202*	4.6574*
Concentration	3	5.641**	10.6736*	15.9774**
Error	24	0.6683	1.1066	0.9469

A.No. 8. Mortality effect of Usher seeds on the 4th larva instars of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	0.4563	3.2080	1.1353
concentration	3	7.8239**	6.7472**	11.3789**
Error	24	1.0544	1.0739	0.9366

A. No. 9. Mortality effect of Neem leaves on the 4th larva instars of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	1.8046	2.4681	3.5292
concentration	3	1.8045	10.6878**	18.0583**
Error	24	0.7352	0.8266	0.8721

A.No. 10. Mortality effect of Neem seeds on the 4th larva instars of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	1.8045	7.2590*	109.4460
concentration	3	7.6859**	13.7040**	1162.8770**
Error	24	0.8688	0.9080	34.4468

A.No. 11. Mortality effect of Hargel leaves on the 4th larva instars of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	1.8046	0.2005	0.8021
concentration	3	1.2699	7.1513*	9.0895**
Error	24	0.8688	1.0025	0.9357

A.No. 12. Mortality effect of Hargel seeds on the 4th larva instars of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	0.00	5.0125*	4.0755*
concentration	3	0.00	3.9432*	10.2288**
Error	24	0.00	0.8688	0.7202

A.No. 13. Repellency effect of Usher leaves on the adult stage of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	337.500	621.998	4.0426
concentration	2	639.8868	1492.2628**	1805.4710*
Error	18	291.9051	216.1820	428.5056

A.No. 14. Repellency effect of Usher seeds on the adult stage of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	7285.7411**	5207.055**	4010.3690**
concentration	2	2101.3886**	1357.5765*	972.7491*
Error	18	206.9187	312.9538	200.8613

A.No. 15. Repellency effect of Neem leaves on the adult stage of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	6.6887	1797.2973**	399.9217
Concentration	2	94.8679	337.3429	1830.723**
Error	18	240.9331	203.3552	184.7122

A.No. 16. Repellency effect of Neem seeds on the adult stage of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	0.062	470.2890	264.5376
Concentration	2	549.0793	382.1099	605.1652
Error	18	193.2742	156.7630	198.6334

A. No. 17. Repellency effect of Hargel leaves on the adult stage of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	7839.4890**	1010.1038*	2129.4852**
concentration	2	126.4465	1308.1157**	1441.8224**
Error	18	176.1170	152.1570	50.5489

A. No. 18. Repellency effect of Hargel seeds on the adult stage of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	3274.1376**	1117.3890**	337.500
concentration	2	1135.1037*	652.1845*	1420.9365**
Error	18	242.9133	112.444	95.9783

A. No. 19. Repellency effect of Usher leaves on the 4th larva instars of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	5483.4197**	3673.1478**	1618.1910*
concentration	2	105.1613	68.0532	671.2866
Error	18	224.3688	240.8722	266.1368

A. No. 20. Repellency effect of Usher seeds on the 4th larva instars of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	765.0104*	226.6890	640.2534*
concentration	2	320.1085	590.3148*	395.5314
Error	18	151.6460	107.7987	122.4506

A. No. 21. Repellency effect of Neem leaves on the 4th larva instars of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	5.5488	5.5488	520.5222**
concentration	2	299.2074*	219.9561	6.1454
Error	18	80.0252	65.5256	35.6229

A. No. 22. Repellency effect of Neem seeds on the 4th larva instar of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	499.6850	1611.7926*	1116.1612*
Concentration	2	1185.8526**	1266.1814*	375.4254
Error	18	167.3515	265.7509	198.0288

A. No. 23. Repellency effect of Hargel leaves on the 4th larva instar of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	1472.1967**	1444.2914**	1077.8960**
Concentration	2	2400.3927**	1037.1841**	609.0173**
Error	18	167.4665	57.1294	57.1294

A. No. 24. Repellency effect of Hargel seeds on the 4th larva instar of *Tribolium Castaneum*

Source of variation	D. F.	M.S.		
		1	2	3
Application	1	0.000	6.6887	311.2561*
Concentration	2	680.0672**	596.2325**	306.0467*
Error	18	57.8329	42.6236	63.3640