Sudan University of Science and Technology

College of Graduate Studies

effect of *Moringa oliefera* powders for the control of Khapra beetle on sorghum grains.

اثر مساحيق شجرة المورينجا *Moringa oliefera* لمكافحة خنفساء الخابراعلي حبوب الذرة الرفيعة.

A thesis submitted in partial fulfillment of the requirements for the M. Sc. degree in plant protection

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الآية

قال تعالى:

(قَالَ تَزْرَعُونَ سَبْعَ سِنِينَ دَأَبًا فَمَا حَصَدْتُمْ فَذَرُوهُ فِي سُنْبُلِهِ إِلَّا قَلِيلًا مِمَّا تَأْكُلُونَ)

صدق الله العظيم

سورة يوسف الآية (47)

Dedication

To My:

Family,

Teachers

And all Friends.

Acknowledgements

With all due humbleness and gratitude I render ultimate thanks and special praise to Allah (Almighty) who gave me health, power and patience to accomplish and conduct this work.

I would like to express my thanks to my supervisor **Dr. Ashwag Ahmed Mohammed** For helpful assistance, guidance, patience and keen supervision during this work.

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Abstract

Laboratory study was conducted at the collage of Agricultural studies, Sudan University of Science and Technology Shambat, Khartoum-Sudan, during 2016 to evaluated the insecticidal effects of powders of *Moringa oleifera* Lamp from different plant parts (leaves, flowers, seeds and branches) at three levels of concentrations 1, 2.5, and 5 g/100g grains of test plant powders and the untreated control (0g/100 g grains) against the 3rd instars larvae of khapra beetles (*Trogoderma granarium* (Everts.), were tested in sorghum grains infested with the 3rd instars larvae of khapra beetles using completely randomized design (CRD). larvae mortality of khapra beetles were assessed at 1, 3, 7 and 30 days of infestation. Results obtained from study related that all powder from plant parts exhibited that significantly ($P \leq 0.05$) protection of sorghum grains from *T. granarium* infestation compared with the control. Larvae mortality accounts increased with increasing amount of *M. oleifera* powders and time of exposure. The sorghum grains treated with *M. oleifera* seed powder gave the highest range (7.5- 15.0%) larvae mortality at 1 and 3 days, respectively. Also the highest progressive increase in larvae mortality ranging from 37.5 - 42.5% was achieved with in sorghum grains treated with *M. oleifera* seed powder, while the lowest increase in larvae mortality ranging from 17.5 – 22.5% in sorghum grains treated with *M. oleifera* flower powder was recorded at the highest concentration 5% at 7 and 30 days respectively.

M. oleifera powders can be used as alternative to synthetic insecticides for control of *T. granarium.*

ملخص التجربة

أجريت هذه الدراسة المعملية في كلية الدراسات الزراعية، جامعة السودان للعلوم والتكنولوجيا- شمبات، الخرطوم ،السودان خلال 2016 لتقييم فعالية مسحوق الأجزاء المختلفة لشجرة المورينجا *Moringa oleifera* Lamp (أوراق, أزهار, بذور وأفرع) في ثلاثة مقادير مختلفة للمساحيق 1, 2.5و 5جم/100جم حبوب ذرة رفيعة مع وجود شاهد غير معامل ضد يرقات خنفساء الخابرة (.Everts) *Trogoderma granarium* (الطور الثالث) وذلك باستخدام التصميم العشوائ الكامل (CRD). تم اخذ قيم الموت في يرقات خنفساء الخابرة عند1يوم ، 3ايام، 7ايام و30يوم من الإصابة. دلت النتيجة المتحصل عليها من هذه الدراسة أن هنالك فروق معنوية (P ≤ 0.05) لمساحيق لأجزاء الشجرة المختلفة في حماية حبوب الذرة الرفيعة من خنفساء الخابرة (.Everts) *Trogoderma granarium* مقارنة بالشاهد وأن حساب معدل الموت في اليرقات يزيد مع زيادة مقدار مسحوق المورينجا *Moringa oleifera* وزمن التعرض.

حبوب الذرة الرفيعة المعاملة بمسحوق بذرة المورينجا *Moringa oleifera* أعطت اعلي معدل موت يتراوح بين (15.0% -7.5) خلال /يوم وثلاث ايام علي التوالي. أيضا كانت الزيادة المطردة او الاعلي كثافة في موت يرقات خنفساء الخابرة (.Everts) *Trogoderma granarium* والتي يتراوح معدلها بين (37.5-42.5%) في حبوب الذرة الرفيعة المعاملة بمسحوق بذور شجرة المورينجا *Moringa oleifera*. وفي نفس الوقت كانت ادني نسبة في موت اليرقات و معدلها يتراوح بين (17.5-22.5%) في حبوب الذرة الرفيعة المعاملة بمسحوق ازهار المورينجا *Moringa oleifera* والتي سجلت في 7ايام و30يوم بعد المعاملة علي التوالي.

مسحوق شجرة المورينجا *Moringa oleifera* يمكن استخدامه كبديل للمبيدات المصنعة لمكافحة يرقات خنفساء الخابرا (.Everts) *Trogoderma granarium*.

CHAPTER ONE

INTRODUCTION

Sudan one of the largest agricultural country in Africa, with an area less than 200 million feddans that can be cultivated. This area coupled with huge amounts of production of different agricultural environments enabled the production of different agricultural commodities cereal crops, oil crops and all types of horticultural produce are grown successfully. Sorghum occupies about 40% of the country cropped lands, about 90% is rain fed and lies mainly in what is known as the central rain lands extending from Kassala State in the East to the North and South Kordofan (El Khidir, 1982).

Cereals constitute the stable diet for humans in many countries and a major component of animal feed, prior to consumption or marketing, surplus cereal grains are usually stored for variable periods under different conditions. Storage is a post-harvest practice which when properly managed can help in alleviating problems of food shortage. Recognition of this practice is widespread in developed countries but not in the developing countries. Agricultural centers in sub-tropical and tropical countries are fighting hard to increase production, but they are still unable to fill the gap between the harvest and consumption. Improvement in storage can help to maximize benefits from the existing agricultural production. It is essential, therefore, to have good storage structures, so as to minimize the quantitative and the qualitative losses, overcome scarcity, and enhance the producers' financial benefits (Adesuyi, 1993). Grains can be infested by pests at all stages following their harvest until they are processed and consumed. The most commonly attacked products are those of food grains and the least are dried fruits (William, 1991). Insects are most important since they cause economic damage to the crops throughout the world. The majority of these losses are due to insect's infestation (Ibrahim, 2001). After harvesting, approximately 1660 insect species attack the agricultural produce during different phases like transportation, processing, marketing and storage (Hagstrum and Subramanyam, 2009). Losses caused by these insect pests may reach up to 30% during storage (Haubruge *et al*., 1997). Among these insect pests *Trogoderma granarium* (Burges, 2008., Mark *et al*., 2010),. *Tribolium castaneum* (Mondal, 1994) and *Cryptolestes ferrugineus* (Suresh *et al*., 2001; Mason, 2003) are documented to be the most damaging and destructive pests of stored products throughout the world. In addition to direct losses caused by the secondary insect pest especially *Ephestia cautella* (Walker), fungi (*Aspergillus flavus*) and consequently leading to deterioration in grain characteristics (EL-Nadi *et al*., 2001). Insect infestation causes dry mass loss and increases the level of free fatty acids in the kernels which results to a reduction in quality. The larva bore into the grain, where they feed, leaving the grains hollow, the insect also contaminate the produce with their moulds and frass (Lale, 2002). The khapra beetle, *Trogoderma granarium(* Everts), is one of the world's most feared stored-product pests. In fact, it has been described as one of the 100 worst invasive species worldwide (Lowe *et al*. 2000). It's one of the most important pest which can maintain its presence in stores at a very low numbers and is able to survive long period of inactive stage (Dwivedi and Shekwat, 2004). However, the losses due to infestation by insect after harvest has been estimated at 5-10% . But the losses vary according to the geographical, location and climatic conditions within the country and it fluctuates between 5% in North to 20% in the South (FAO, 1977).

In Sudan, sorghum is the staple food for most people lived in the country, which ranks first, followed by wheat and millet, hence they play a vital role in food security. The dominant varieties grown in rain fed are the traditional Feterita types which they used for commercial purposes and are sold mainly in the local markets, with some of them for export, sorghum in the irrigated schemes for 35% of total sorghum production (Hamid, 2006). In Sudan most of the stored products insect species occur throughout the more humid areas. In these area *Sitophillus oryzae* (L.), *Sitotroga cerealella* (Olivier) are more common. In the dry Northern and Eastern Sudan, two primary pests, namely *Rhizopertha dominica* (F.) and *Trogoderma granarium* (Everts.) are the dominant species. *T. granarium* (Everts.) is known as serious primary pest. It thrives in warm and dry climates. Although the populations build-up increased rapidly in a short time under hot and dry conditions, but also they can survive in colder climates when provided with heated situations such as warehouses, food plants and stored grains. Khapra beetle may have one to nine or more generations per year as a result of high humidity has a depressing effect on population buildup (Ramzan and Chahal, 1986).

Synthetic insecticides (pyrethroids and organophosphates) and fumigants (methyl bromide and phosphine) are commonly used to control these insect pests throughout the world. Out of these control strategies, fumigants (because of their broad spectrum action and rapid penetration without residues) are known to be convenient and economical control measure (Mueller, 1990; Varma and Dubey, 2001; Ogendo *et al.*, 2008). Methyl bromide is completely phased out as it was found one of main causes of ozone depletion (Butler and Rodriguez, 1996; Shaaya and Kostyukovsky, 2006). The control of stored product insect pests mainly depends on application of phosphine (Varma and Dubey, 2001). Almost all major pests of stored products have developed resistance against phosphine (Pimentel *et al*., 2007; Lorini *et al*., 2007; Nayak *et al*., 2012).There are also many problems associated with its application, such as adverse effects on non target organisms and environment, human health safety concerns and pest resistance and resurgence (Ogendo *et al*., 2008). This situation demands a serious effort to find out some safe, viable, biodegradable, environment friendly and effective substitute to these conventional fumigants. Botanicals extracted from higher plants have been found suitable after investigating their fumigant insecticidal properties by many scientists (Isman, 2008., Rajendran and Sriranjini, 2008). Botanicals are materials or products of plants origin valued for their pesticidal, medicinal or therapeutic properties (Prakash and Rao, 1996). A wide number of plant essential oils and their constituents have been proved for their fumigant insecticidal action against stored product pests (Singh *et al*., 2005; Opolot *et al*., 2006; Tripathi *et al*., 2009; Lopez and Pascual-Villalbos,2010). The main objective of this study was to evaluate the powder of *Moringa oliefera* different parts (leaves, flowers, seeds and branches) to control khapra beetle *Trogoderma granarium,* (Evarts) as botanical insecticide.

CHAPTER TWO

LITERATURE REVIEW

2.1. Khapra beetle

2.1.1. Classification

Order	Coleoptera
Family	Dermestidae
S.N	*Trogoderma granarium*
Common name	khapra beetle (Everts,1898)

2.1.2. Distribution

The Khapra beetle, *Trogoderma granarium* (Everts), is a dermestid beetle native to the Indian sub-continent and now a serious pest of stored grain in most parts of the world (Konemann, 1993). It has been found in a wide range of cargo including non- agricultural goods, which appear to become infested through contact with infested goods (Anonymous, 2001). Khapra beetle is a cosmopolitan, multivoltine and polyphagus pest throughout the tropics (Hill, 1983; Hill and Waller, 1988; Odeyemi, 1989). The beetle is present in tropical and sub-tropical regions except South and Central America, South East Asia. Accurate distribution records for the khapra beetles are difficult to obtain, because admission of its presence in a country may result in trade restrictions being imposed (Banks, 1977). Its endemic zone extends from Burma to western Africa and is limited by the 35° parallel to the north and the equator to the south. It has been introduced by commerce into some areas of similar climatic conditions (Anonymous 1981). Khalifa (1960) identified a specimen from Gadarif as *T. granarium* (Everts.). According to Khalil (1967), the khapra beetle was found in Toker and Gash Delta, Sinkat area, Khashm El Girba district and Port-Sudan. Saad (1969), considered it the most serious and destructive pest in warehouses at Port-Sudan. He observed it in infested groundnuts kernels, cakes and Dura. In Sudan, this beetle is now distributed in most parts of the country as a major pest, (Anonymous, 2009). A number of primary species *T. granarium, Sitophilus oryzae, Rhizopertha dominica, Sitotroga cereallela, Corcyra* spp. and *Ephestia* spp. are found in humid areas in the Nuba Mountains, Red Sea and Central Rain Lands. Temperature and humidity, moisture grain size and water content, are the major factors affecting occurrence and abundance of stored pest insects (Darling, 1959 and Loschiaco and Okumura, 1975). *T. granarium* and *R. dominica* were also found in northern Sudan. (Darling, 1959; Ibrahim, 2001).

Khapra beetle is readily transported with agricultural products in packaging (especially second hand bags), shipping containers, vessels, or vehicles carrying agricultural produce. Some larvae may hitch a lift on birds, rodents or farm animals, but it is transportation by humans (also on clothing) that allows them to cover long distances quickly (Rees and Banks, 1999). Mass incidence happen especially in India, Burma, Sudan, Tunisia and Nigeria (Kranz, *et al*., 1977).

2.1.3. Description

The genus *Trogoderma* in recent years has been reported to 134 species (Hava, 2011).

Adults and larvae have numerous fine hairs on the body surface. The larval instars have varying colours from whitish yellow to dark brown at the last instars. The male is distinguished by the elongate apical segment of the club bate antennae (Beal, 1956).

The adults are oblong-oval beetles, approximately 1.6 to 3.0 mm long and 0.9 to 1.7 mm wide. Males are brown to black with indistinct reddish brown markings on their elytra. Females are slightly larger than males and lighter in color. The head is small and deflexed with short 11-segmented antennae. The antennae have a club of three to five segments, which fit into a groove in the side of the pronotum. The adults are covered with hairs (Buss and Fasulo 2006).

The larvae at hatching are approximately 1.6 to 1.8 mm long, more than half of this length consisting of a tail made up of hairs on the last abdominal segment. Larvae are uniformly yellowish white, except head and body hairs are brown. As the larvae increase in size, their body color changes to a golden or reddish brown, more body hairs develop, and the tail becomes proportionally shorter. Mature larvae are approximately 6 mm long and 1.5 mm wide. Larvae bear characteristic body hairs: (1) simple hairs in which the shaft bears many small, stiff, upwardly directed processes, and (2) barbed hairs with a constricted shaft in which the apex is a barbed head as long as the preceding 4-segmented-like constrictions (Hadaway 1955, Anonymous 1981).

Pupa is of exarate type, average length being 3-5 mm and 5 mm for male and female respectively (Hadaway, 1956).

Initially eggs are milky-white, later pale-yellowish; typically cylindrical, 0.7 mm long and 0.25 mm broad; one end rounded, the other more pointed and bearing a number of spine-like projections, broader at the base and tapering distally (OEPP/EPPO,1981).

2.1.4. Life cycle

The life cycle of dermestid beetles shows a typical holometabolous development; the larvae being the destructive stage of the insect pest. The adults possess wings but are not capable fliers and do not feed. (Dfuya and Lale, 2001). More food was consumed in constant darkness; however, constant light accelerated development but reduced oviposition (Sohi, 1947). Optimum conditions for development are 33-37°C, 45-75% R.H (Howe, 1958). Optimum temperature for development is 35°C. If the temperature falls below 25°C for a period of time or if larvae are very crowded, they may enter diapauses. They can survive temperatures below -8°C. In diapauses, the larvae can molt but are inactive and may remain in this condition for many years (Anonymous 1981).

Mating occurs about five days after emergence, and egg laying begins almost immediately at 40 º C. Egg laying may begin at one or three days at cooler temperatures, Eggs hatch in three to 14 days after the female lays, the female lays an average of 50 to 60 eggs that are loosely scattered in the host material (Anonymous. 1981). Laid loosely and singly in the host material (APHIS, 1984). The adults are short-lived, mated females living 4-7 days, unmated females 20-30 days and males 7-12 days. They do not fly and feed very little, if at all. Mating occurs about 5 days after emergence. The beetle can lay a full complement of eggs following a single mating, but a second mating greatly increases the total number of eggs produced: once-mated females lays about 60 eggs, whereas twice-mated individuals laid about 60 and then 500 eggs after the respective mating. Delay in mating of 15-20 days results in up to 25% reduction in fecundity. The pre-oviposition period, which is not affected by humidity, is negligible at 40°C, 1 day at 35°C, 2 days at 30°C, 2-3 days at 25°C, and, at 20°C, no eggs are produced. Under optimum conditions, the female lays an average of about 50-90 eggs loosely in the host material. The eggs hatch in 3-14 days (OEPP/EPPO, 1981). On hatching the larvae are about 1mm long. There are five molts in the development of the larvae, and the cast skin is shed following each molt (Morschel, 1972). As the larva increases in size, the colour changes progressively from the pale yellowish-white of the first-instars larva to a golden or reddish-brown. The density of the body hairs increases but these hairs and the tail become much shorter in proportion to the length and breadth of the larval body, and in the 4th instars the hairs give the appearance of four dark transverse bands. The mature larva is approximately 6 mm in length and 1.5 mm in breadth (OEPP/EPPO, 1981). Larva have three pairs of legs (APHIS, 1984). At the last ecdysiasts, the larval skin splits, but the pupa remains within this skin for the whole of its life. The pupa is of the execrate type; male smaller than female, average lengths being 3.5 mm and 5 mm, respectively (OEPP/EPPO, 1981). The pupa whitish colour (APHIS, 1984). Hadway (1956) reported that, pupal stage lasted in 3-6 days for males and 3.8 days for femles. In favorable temperatures, eggs, pupae, and adults each took about a week for development. While the larval stage may survive a month to several years under diapause condition (Burges, 1962).

2.1.5. Economic Importance

Trogoderma granarium larvae feed on a wide variety of stored products and dried foods. They prefer whole grain and cereal products such as wheat, barley, and rice, but larvae have been recorded on the following: oats, rye, corn, dried blood, dried milk, fishmeal, ground nuts, flour, bran, malt, flax seed, alfalfa seed, tomato seed, pinto beans, black-eyed cowpeas, sorghum seed, grain straw, alfalfa hay, noodles, cottonseed meal, dried fruits, lima beans, coconuts, garbanzos, lentils, powdered yeast, and many others (Lindgren *et al*. 1955, Lindgren and Vincent 1959).

T. granarium is a serious pest of stored products under hot dry conditions. Reproduction may be so rapid that larvae are found in large numbers in the surface layers of binned grain. Its discovery in a non-infested area usually leads to an immediate quarantine of suspected goods and an expensive eradication and control effort. This beetle has never been observed to fly; therefore, its spread is probably dependent on movement of infested goods or in containers where it may be transported while in diapauses. Khapra beetle is able to survive almost anywhere in storage facilities that are protected from cold environments. Storage facilities can be artificially heated, or become much warmer when insect activity causes the temperature to rise (Howe and Lindgren, 1958). If the beetle is left undisrupted it can cause significant grain weight loss in the store. It may lead to significant reduction in seeds viability too. The larvae feed on different kinds of seeds such as cereals, oil, and legume seeds as well as on other foods. Infestation affects grain quality as well as quantity. Infestation of commodities with khapra beetle can lead to the following consequences: Economic loss of valuable grain or other domestic or export products, lowered quality of products due to contamination, costs associated with prevention and treatment and consumer health risks when exposed to products contaminated with insect parts (Dwivedi Shekhwat. 2004 and Gustavasson, *et al.* 2011). Reduction in these losses would increase the amount of food available for human consumption and enhance global food security, a growing concern with rising food prices due to growing consumer demand, increasing demand for biofuel and other industrial uses, and increased weather variability (Mundial, 2008; Trostle, 2010). A reduction in food also improves food security by increasing the real income for all the consumers (World Bank, 2011). In addition, crop production contributes significant proportion of typical incomes in certain regions of the world (70 percent in Sub-Saharan Africa) and reducing food loss can directly increase the real incomes of the producers (World Bank, 2011).

2.1.6 Control

2.1.6.1 Physical control.

Heat treatment is very effective against diapauses larvae of *Trogoderma granarium.* During their investigations, a30 minutes exposure at 60°C gave 100% kill of all stages of the khapra beetle (Ismail *et al*, 1988). The LT values for diapausing and non-diapausing larvae at 50°C were 7.4 and 3.0 hours, respectively. They further reported that mortality of larvae began at 42.5°C; complete mortality however required 8 days exposure at that temperature. However, it has been reported that some natural mortality of larvae during the diapausing occurred in stores due to warming caused by activities of the khapra beetle itself. Diapausing larvae are more resistant to high temperature than non-diapausing larvae (Battu *et al,* 1975).

2.6.2 Biological control

Several natural enemies for *Trogoderma granarium* have been reported, these include: *Amphiblus venators* (Klirg) Hemipteran (Battue, *et al*., 1975) Mites *Acarapis docta* (Berlesse) (Sochandhany and Mukherjee, 1971; Kapil and Bhanet, 1971), *Pymotes sp*, the protozoan *Adelina tribolli* (Bhatia), parasitic wasps *Anisopetromalus calandrae* (Howard), *Divarnus basilis* (Rondani), *Holeryris spp* and *Synopeas spp*. (Haines, 1991). *Laeluis pedatus* is parasitoid of khapra beetle. The venom this parasitoid caused 6% larvae mortality (Al-kirshi , 1999).

2.1.6.3 Chemical control

The stored insects pest are mainly controlled by synthetic chemicals, the authorized fumigant and pesticides include the following: Phosphine, Methyl bromide, Malathion, Permethrin, Cypermethrin and Bifenthrin. Besides immediate quarantine to prevent further spread of *Trogoderma granarium* , fumigation with methyl bromide at a rate of 2.4 kg per hundred cubic metres, applied as a hot gas, injected from several points outside the building and diverted to points within the building/ infested material would probably still be the best control option (Dillon, 1968) . The usual treatments for rats and common pests do not kill Khapra beetles, because the pest is extremely resistant to normal dosages of fumigants. Dosage rate and duration of fumigation would vary with temperature. Other possibilities towards eradication include combinations of phosphine and methyl bromide, treatment with specific controlled atmospheres at temperatures above 20°C, cold and heat treatment. (Rees and Banks, 1999). However, methyl bromide is deem harmful for the ozone layer and has been banned/restricted in some countries

(Pasek, 1998). Hole *et al*., (1976) stated that, khapra beetle appears relatively tolerant to insecticides and many fumigants especially at larvae stage. In 1982 a report of field resistance to phosphine were verified in Bangladesh and later in other countries including Pakistan and India, and also in Africa and Southeast Asia (Taylor, 2002). In Pakistan, *T. granarium* has been observed to have gone resistance to phosphine due to substandard techniques of fumigation (Irshad and Iqbal, 1994; Stibick , 2007). At least 11species of stored-product insects including *T. granarium S. granarius* and *T. castaneum* etc. are now known to have developed resistance to phosphine (Alam *et al*, 1999 and Chaudhry, 2000).

2.1.6.4 Miscellaneous other control

A combination of traps, food attractant and pheromone will help to attract beetles, and allow for the necessary control measures to be adopted (ISSG 2004). Treatment with fast electron, using a linear accelerator, could provide an efficient method of controlling khapra beetle in store grain (CERIS, 2004; ISSG 2004). Kansu, 1962, found that, 6000r of gamma radiation or more reduced reproduction capacity when applied to the male pupae of *T. granarium* and 15000r sterilized all the males in two of three tests while 7500r applied to female pupae had no effect on reproduction. Ashfaq *et al*. (2012) reported that *Moringa oleifera* leaf powder was effective on both the larvae and adults of *T. granarium* and showed repellent properties. Al–Moajel (2004), showed insecticidal activity in *Allium cepa* L. against *T. granarium* in wheat. Extracts of turmeric and lemon grass proved effective in increasing adult mortality of *T. granarium* in stored groundnut (Asawalam and Igwe , 2011). According to Makanjuola (1989) an aqueous extracts of neem oil, neem kernel powder and neem press cake are effective against the Khapra beetle.

2.2. Sorghum

2.2.1. Taxonomy

Order:	Poales
Family:	poaceae
Subfamily:	Panicoideae
Tribe:	Andropogoneae
S.N:	*Sorghum bicolor*(Moench,1794)

2.2.2 Origin of sorghum

Sorghum is an ancient crop. Mann *et al* (1983) indicated that the origin and early domestication of sorghum took place in northeastern Africa north of the Equator and east of 10˚E latitude, approximately 5,000 years ago. However, carbonized seeds of sorghum with consistent radiocarbon dates of 8,000 years BP have been excavated at an early Holocene archaeological site at Nabta Playa near the Egyptian- Sudanese border (Wendorf *et al*, 1992; Dahlberg and Wasylikowa, 1996). These sorghums are 3,000 years older and 10-15˚ latitude further north than had been previously reported and suggests an early interest in sorghum by hunter and gathers and early agriculturalists. These early domestication events followed major trading and migratory paths of early Africans and Asians. As these early domesticated sorghum spread throughout Africa and Asia, plants were selected and dispersed throughout a broad range of environments and utilization giving rise to a widely adapted genetic base that has been further exploited throughout the agricultural process to create the current crop known as cultivated sorghum. Several authors have discussed the systematics, origin, and evolution of sorghum (de Wet and Huckabay, 1967de Wet and Harlan, 1971., Dahlberg, 2000).

2.2.3. Description

Sorghum is an upright, short-day, summer annual that is a member of the Poaceae family. The grass blades are flat, stems are rigid, and there are no creeping rhizomes. Sorghum has a loose, open panicle of short, few-flowered racemes. As seed matures, the panicle may droop. Glumes vary in color from red or reddish brown to yellowish and are at least three quarters as long as the elliptical grain. The grain is predominately red or reddish brown (Kearney *et al*, 1969 and Barkworth, 2003). Previously species 271 cultivars were recognized, however these cross readily without barriers of sterility or difference in genetic balance, therefore it makes sense to group them into a single. The leaves look much like those of maize, they sometimes roll over. A single plant may more than tow leaves. The flower head carries two types of flowers, one type have no stalk and has both male female parts, and the other flower is stalked and usually male. The roots of the sorghum plant can be divided into primary and secondary root system.The primary roots are those which appear first from the germinating seed and have limited growth. Secondary roots develop from nodes below the soil surface. (Amsalu and Endashaw, 1998).

2.2.4. Environment all requirement

2.2.4.1 Soil requirements

Sorghum will grow in low fertility, moderately acidic and highly alkaline soils, but it is best adapted to fertile, well drained soils at a pH between 6.0–6.5. Sorghum is not tolerant of frost, shade, or sustained flooding (Clark, 2007; FAO, 2012 and Undersander, 2003).

2.2.4.2 Water Requirement

Sorghum water use is mainly affected by its growth stages and environmental demands. Hybrid differences in water use also exist because of differences in growth habit and maturity (Kidambi, *et al* 1990). For high production, a medium-tolate maturing sorghum cultivar (maturity within 110 to 130 days) requires approximately 450 to 650 mm of water during a growing season (FAO, 2002 and Tolk *et al*., 2001.).

2.2.4.3 Factors limiting yields

Several factors limit sorghum yields including: drought, prolonged dry periods, or delayed rainfall; nutrient deficiencies; weeds, insects, and diseases; cool, wet weather at planting or harvest; lodging; excessive or erratic rainfall; early frost, snow, and extreme cold conditions; washing rain and hail; high temperature; hot, dry summers; high-wind conditions and bird attacks (Assefa and Staggenborg, 2010). Before consumption or export grains are usually stored for variable periods under different conditions, however during storage the grains are ravaged by insects and other pests. Insects are the main pests which caused the greatest damage to stored grains all over the world sorghum grains are attacked by a large number of insects in stores. *Trogoderma granarium* is among the most serious and of widest occurrence in tropical and sub-tropical region of Asia and Africa (Atwal, 1976; and Viljoen, 1990).

2.3. Moringa

2.3.1 Scientific classification

Order:	Brassicales
Family:	Moringaceae
Genus:	*Moringa*
S.N:	*Moringa. Oliefera* (Lamb)
	(Nadkarni, 1976; Ramachandran *et al.*, 1980).

2.3.2 Distribution

Moringa oleifera, native of the western and sub- Himalayan tracts, India, Pakistan, Asia Minor, Africa and Arabia (Somali *et al.*, 1984 and Mughal *et al.*, 1999) is now distributed in the Philippines, Cambodia, Central America, North and South America and the Caribbean Islands (Morton, 1991). *M. oleifera* native of India but introduced into the tropics area (Hutchinson and Dalziel, 1966). In some parts of the world *M. oleifera* is referred to as the 'drumstick tree' or the 'horse radish tree', whereas in others it is known as the kelor tree (Anwar and Bhanger, 2003). The taxon name *moringa* comes from murunggi or muringa from Tamil and Malayalam. *Moringa* is available and known by more than 50 common names in Asia Africa, Europe South and Central America, Caribbean. Some are Drumstick tree, Horse radish tree, Mother's best friend, West Indian ben are in English , Ben, Árbol del ben, Morango, *Moringa* in Spanish**,** Mupulanga in Zimbabwe:, Aleko, Haleko in Ethiopia: and Bèn ailé, Benzolive, in French. Suhanjna is the common name in Pakistan *(*Nasir *et al* 1972 Duke , 1987, and Manzoor *et al*, ,2007.). *Moringa oleifera* Lamb (syn. *M. ptreygosperma* Gaertn.) is one of the best known and most widely distributed and naturalized species of a monogenetic family *Moringaceae* (Nadkarni, 1976; Ramachandran *et al.*, 1980). There are about 13 species of *moringa* trees in the genus *Moringa* of family *Moringaceae.* These are: *Moringa oleifera M. arborea, M. borziana, M.*

concanensis, M. drouhardii, M. hildebrandtii, M. longituba, M. ovalifolia, M. peregrine, M. pygmaea ,M. rivae, M. ruspoliana, and M. stenopetala The most widely known species *Moringa oleifera reported as "Mpringa*"(Nasir and Ali,1972).

2.3.3. Description

The tree is rather slender with a dropping branch that grows approximately 10 metres in height and grows best in hot and semi-arid tropics (Morton, 1991). Moringa is easily recognized by the compound pinnate leaves (2 or 3 times pinnate) and the long narrow angular fruits containing large, usually winged seeds (Hutchinson and Dalziel, 1966). Branches bearing a gummy bark Each tripinnately compound leaves bear several small leaf legs. The flowers are white and the three wings seeds are scattered by the winds. The flowers, tenders leaves and pods are eaten as vegetables. The leaves are rich in iron and therefore highly recommended for expected mothers (Anwar and Bhanger, 2003 and Prabhu *et al.*, 2011).

2.3.4. Environment Requires

It is found wild and cultivated throughout the plains, especially in hedges and in house yards, thrives best under the tropical insular climate, and is plentiful near the sandy beds of rivers and streams (The Wealth of India, 1962; Qaiser, 1973). It can grow well in the humid tropics or hot dry lands, it can survive destitute soils, and is little affected by drought (Morton, 1991). It tolerates a wide range of rainfall with minimum annual rainfall requirements estimated at 250 mm and maximum at over 3000 mm and a pH of 5.0–9.0 (Palada and Changl, 2003).

2.3.5. Chemicals structures

According to Kasolo *et al* (2010), *Moringa oleifera* was found to contain photochemical which are non-nutritive chemicals that plant produce as a self defense mechanism. Photochemical present in *M. oleifera* include catechol tannins, Gallic tannins, steroids, triterpenoids, flavonoids, saponins, anthraquinones, alkaloids and reducing sugars. (Makkar and Becker, 1996). The high concentrations of ascorbic acid, oestrogenic substances and β-sitosterol, iron, calcium, phosphorus, copper, α-tocopherol, riboflavin, nicotinic acid, folic acid, pyridoxine, β-carotene, protein, and in particular essential amino acids such as methionine, cystine, tryptophan and lysine present in *Moringa* leaves and pods make it a virtually ideal dietary supplement.

2.3.6. Economic importance

In Pakistan, *M. oleifera* is locally known as 'Sohanjna' and is grown and cultivated all over the country (Qaiser, 1973; Anwar *et al.*, 2005). *Moringa oleifera* is an important food commodity which has had enormous attention as the 'natural nutrition of the tropics'. The leaves, fruit, flowers and immature pods of this tree are used as a highly nutritive vegetable in many countries, particularly in India, Pakistan, Philippines, Hawaii and many parts of Africa (D'souza and Kulkarni, 1993; Anwar and Bhanger, 2003 and Anwar *et al.*, 2005). According to Fugile (2000), there are many uses for *Moringa* include: alley cropping (biomass production), animal forage (leaves and treated seedcake), biogas (from leaves), domestic cleaning agent (crushed leaves), blue dye (wood), fencing (living trees), fertilizer (seed cakes), foliar nutrient (juice expressed from the leaves), green manure (from leaves), gum (from tree trunks), honey and sugarcane juice clarifier (powdered seeds), honey (flower nectar), medicine (all plant parts), ornamental plantings, bio-pesticide (soil incorporation of leaves to prevent seedling damping off, etc.), pulp (wood), rope (bark), tannin for tanning hides (bark and gum), water purification (powdered seeds). In the past, the paste of the seeds had been used by nomads as a natural coagulant for water purification in the Sudan and other parts of Africa (Eleirt *et al.*, 1980). *Moringa* is very impressive and amazing plant due to its tested, trusted and potential benefits from nutritional as well therapeutical point of views. This friendly plant is of great significance as shown to be useful in water purification, cosmetics, livestock fodder, plant growth enhancer and biogas. In the last ten years, hundreds of research articles, theses, reports, and patents have been published on *Moringa*. Newspapers, scientific journals, documentaries (Discovery Channel) feature Moringa more and more. The Church World Service recently organized the first ever *Moringa* Tree International Conference to educate about *Moringa's* use as an indigenous resource for fighting hunger and malnutrition (Fuglie , 1999, Fuglie , 2000, Fuglie , and Lowell ,2001, Monica and Marcu, 2005). In the Philippines, it is known as 'mother's best friend' because of its utilization to increase woman's milk production and is sometimes prescribed for anemia (Estrella *et al.*, 2000; Siddhuraju and Becker, 2003). The indigenous knowledge and use of *Moringa* is referenced in more than 80 countries including Pakistan and known in over 200 local languages. *Moringa* has been used by various societies (Roman, Greek, Egyptian, and Indian to mention a few) for thousands of years with writings dating as far back as 150 AD. The history of Moringa dates back to 150 B.C. Historical proofs reveal that ancient kings and queens used *Moringa* leaves and fruit in their diet to maintain mental alertness and healthy skin. Ancient Maurian warriors of India were fed with Moringa Leaf Extract in the warfront. The Elixir drink was believed to add them extra energy and relieve them of the stress and pain incurred during war. These brave soldiers were the ones who defeated "Alexander" the Great. " (Fuglie and Lowell , 2001 and Manzoor *et al* 2007).

Besides, *Moringa* is also suggested as a viable supplement of dietary minerals. The pods and leaves of *Moringa* contains high amount of Ca, Mg, K, Mn, P, Zn, Na, Cu, and Fe (Aslam *et al*., 2005). Although, minerals content of Moringa shows variation in composition with changes in location (Anjorin *et al*., 2010).

2.3.7. Medicinal uses

Moringa has been used in the traditional medicine passed down for centuries in many cultures around the word, for skin infections, anemia, anxiety, asthma, blackheads, blood impurities, bronchitis, catarrh, chest congestion, cholera, conjunctivitis, cough, diarrhea, eye and ear infections, fever, glandular, swelling, headaches, abnormal blood pressure, hysteria, pain in joints, pimples, psoriasis, respiratory disorders, scurvy, semen deficiency, sore throat, sprain, tuberculosis, for intestinal worms, lactation ,diabetes and pregnancy. The healing properties of Moringa oil, have been documented by ancient cultures, Moringa oil has tremendous cosmetic value and is used in body and hair care as a moisturizer and skin conditioner. *Moringa* oil has been used in skin preparations and ointments since Egyptian times. (Gopalan *et al* 1971, Mahatab *et al* 1987, Manzoor *et al* 2007, Monica and Marcu, 2005) *Moringa* leaves have been reported to be a rich source of carotene, protein, vitamin C, calcium and potassium and act as a good source of natural antioxidants; and thus enhance the shelf-life of fat containing foods due to the presence of various types of antioxidant compounds such as ascorbic acid, flavornoids, phenolics and this plant has many potential uses both in agriculture and industries (Faidi *et al*., 2001). Moringa benefits are quite plentiful, and these are clearly evident in its exceptional nutritional values and remarkable medicinal properties. This miracle plant is overflowing with vitamins such as vitamins A, B, C, D and E and minerals which include potassium, calcium, iron, selenium and magnesium and is completely safe for consumption (Madukwe *et al*., 2012). A comparative study of *Moringa* fresh leaves gram for gram with other foodstuffs puts *Moringa* on top. It contains (seven times the vitamin C of oranges); (four times the vitamin A of carrots), (four times the calcium of milk), (three times the potassium of banana) and (two times the protein of yogurt).But the micro-nutrient content is even more in dried leaves; (ten times the vitamin A of carrots), (17 times the calcium of milk), (15 times the potassium of bananas), (25 times the iron of spinach) and (nine times the protein of yogurt). However, Vitamin C drops to half that of oranges (Gopalan *et al* 1971, Mahatab *et al* 1987, Monica and Marcu, 2005 and Manzoor *et al* 2007,.).

2.3.8. Toxicity.

Ashfaq *et al*. (2012) reported that *Moringa oleifera* leaf powder was effective on both the larvae and adults of *T*rogoderma *granarium* and showed repellent properties and The water extract of *Moringa oleifera* seeds was gave 98.89 % mortality within 24 hours exposure of *Culex quinquefasciatus* (Diptera: Culicidae) larvae to the treatment. Ojo *et al*. (2012) gave a report on the efficacy of *Moringa* leaf powder as protectant against *Callosobruchus maculatus* on stored cowpea. Babarinde *et al*., (2011) reported that adults of *T. granarium* were more susceptible to *M. oleifera* leaf powder than larvae. Dwivedi and Bajaj (2000) assessed leaf extracts for its repellent activities against Khapra beetle, which is in line with the work of Musa (2013) who recorded 100% mortality of *T. granarium* at 6% w/w in groundnut seeds treated with two plant powders, *Moringa oleifera* leaves and *Allium sativum* cloves, at 5 days after treatment,. Ajayi, (2008) found that methanol extract of *M. oleifera* root gave 100% mortality within 24 hours exposure of Anopheline larvae to the treatment. Nath *et. al*.,(2006) indicated that root extract of *Moringa oleifera* showed larvicidal activity against *Aedes albopictus* and *Culex quinquefasciatus* at higher doses. Adenekan, *et al* (2013), reported that cowpea seeds treated with *M. oleifera* flower, leaf and stem powders were effective against the bruchid beetles and showed 100 %, 85% and 70% mortality respectively at 24 hrs of insect infestation compared with 10 % mortality achieved in the control.

CHAPTER THREE

MATERIALS AND METHODS

This experiment was conducted in insect laboratory of Sudan University of Science and Technology,(Shambat), Khartoum, Sudan, during 2016.To evaluated the insecticidal effects of powders of *Moringa oleifera* Lamp from different plant parts (leaves, flowers, seeds and branches) against the 3rd instars larvae of khapra beetles (*Trogoderma granarium* (Everts.).

3.1. Insect Culture

Adults of *Trogoderma granarium* (Everts.), was obtained from the both, College of Agriculture Studies , Sudan University of Science and Technology, Khartoum State and White Nile State. They were cultured in a 2kg glasses container covered with a muslin cloth and held by the side with an expansible rubber band to allow for aeration and avoid suffocation of the insects and equally prevent escape of the insects. The culture was raised under ambient temperature and relative humidity condition (28±3c and 70±5% R.H) respectively on this enhance availability of *T. granarium* for this experiment (Plate 1).

3.3. Preparation of Moringa powder

Different parts *Moringa. oleifera* (leaves, flowers, seeds and branches) , were collected from the Khartoum state, Sudan Each part was washed with tap water and they were left to dry under shade for 7 days, before bioassay test then grounded using a motor pestle and sieved to obtain a fine powder. Each powder was kept separately in air-tight jar for less than 7days. (Plate 2, 3,4 and 5).

Plate 1. Rearing culture of *Trogoderma granarium*

Plate 2. ***Moringa oleifera*** **leaves**

Plate 3. ***Moringa oleifera*** **flowers**

Plate 4. ***Moringa oleifera*** **seeds**

Plate 5. ***Moringa oleifera*** **branches**

3.3. Bioassay procedure

Four experiments were conducted to evaluate the insecticidal action (mortality effects) of the different plant parts of *M. oleifera* against the 3^{rd} larval instar of *Trogoderma granarium* , as the test insect. All above experiments were executed separately in Petri-dishes according to the number of treatments. All four plant powders are applied separately at 1:100, 2.5:100 and 5:100 grams (wt/wt) of each powder: sorghum grain. The Petri-dishes were shaking manually to enable the powder to spread evenly over the grain. Each rate was replicated four times. Ten larvae were placed in each Petri-dish (Plate 5, 6, 7, 8, 9 and 10). The experiment was subjected to the complete randomized design (C R D), Mortality of larvae was recorded after 1,3,7 and 30 days. Larvae were taken as dead of they did not move away when touched or tiled. Untreated control treatment was considered grains and *T. granarium* but no botanical (experimental control).The mortality percentage of larvae was calculated by the method of Parugrug and Roxas (2008) using the following formula:

$$\text{Mortality \%} = \frac{\textbf{No of dead insects}}{\textbf{total No of insects}} \text{x}100$$

3.4. Data Analysis

Data collected were subjected to Analysis of Variance (ANOVA), and significantly different means were separated using Least Significant Difference (LSD).

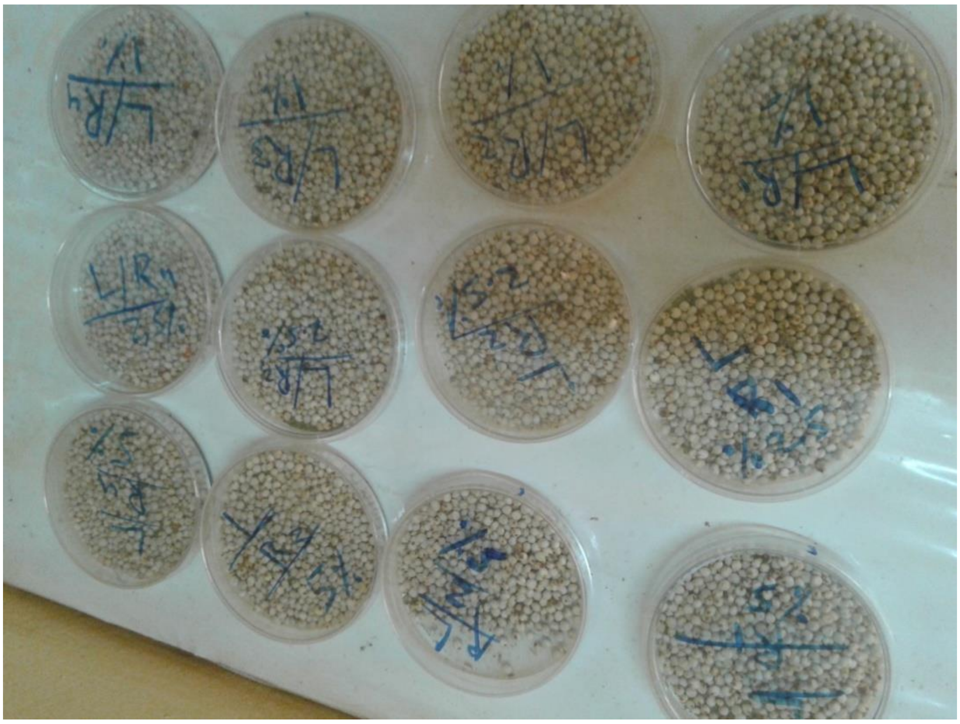

Plate 6. Sorghum grains treated with *Moeinga oleifer* leaves powder

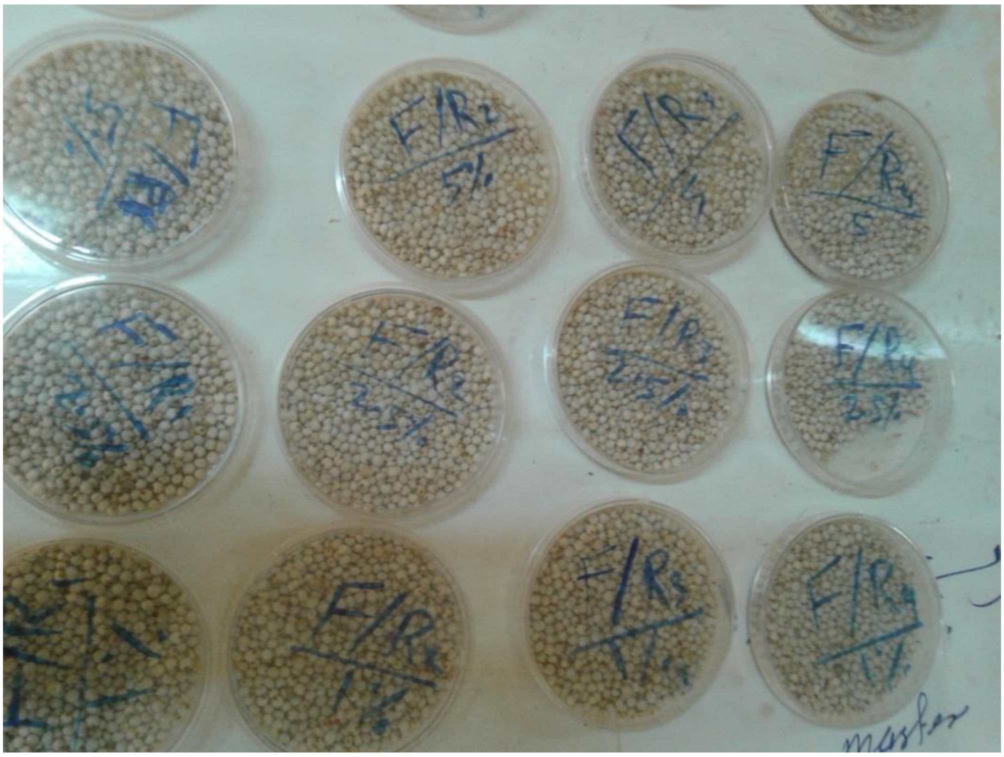

Plate 7. Sorghum grains treated with *Moeinga oleifer* flowers powder

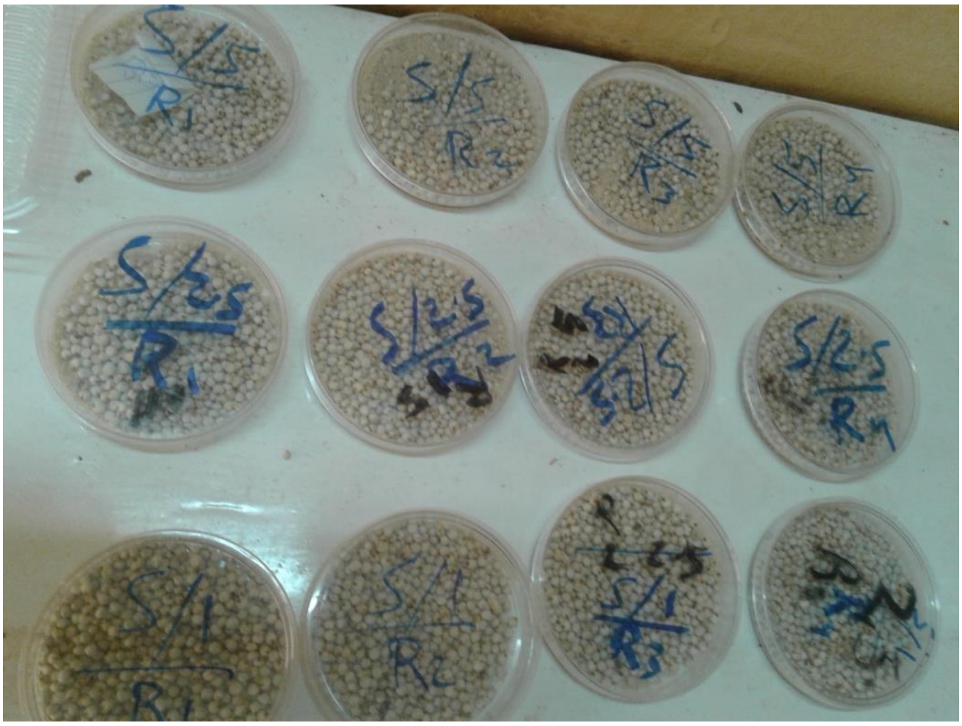

Plate 8. Sorghum grains treated with *Moeinga oleifer* seeds powder

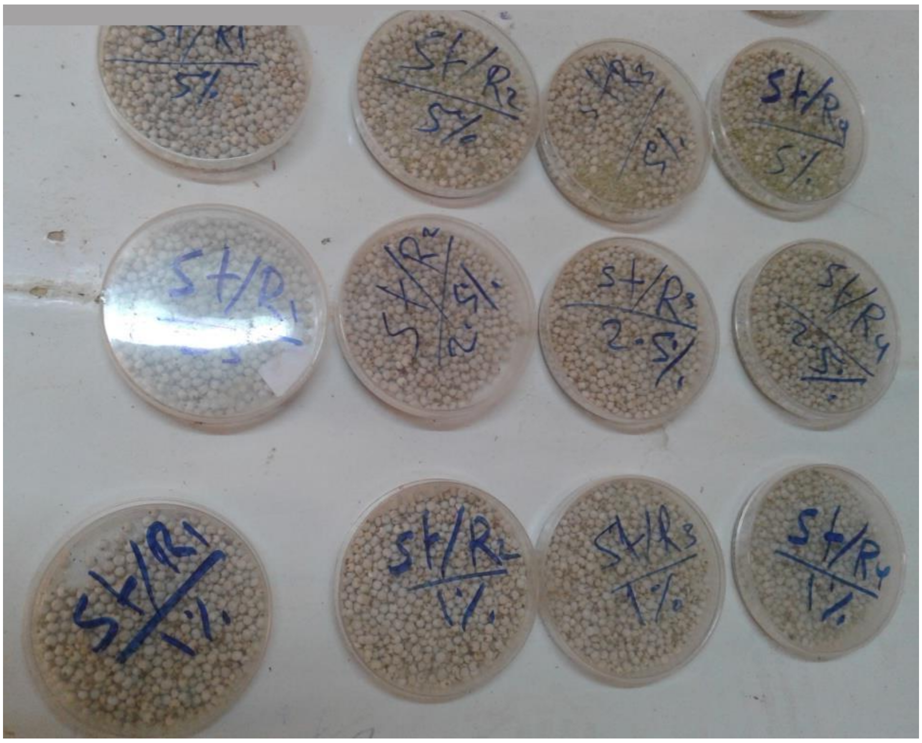

Plate 9. Sorghum grains treated with *Moeinga oleifer* branches powder

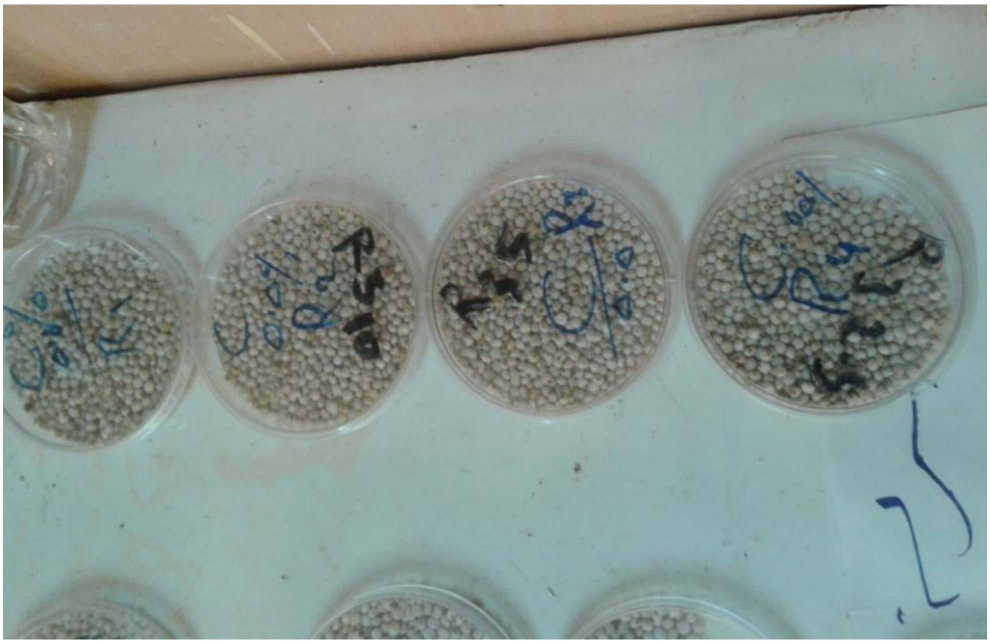

Plate 10. Control (untreated sorghum grains)

CHAPTER FOUR

RESULTS

4.1. Effect of *Moringa oleifera* leaves powder on the 3rd larval instar of *Trogoderm granarium* :

Result in table 1, showed that all rates of *Moringa oleifera* leaves powder had no significant effect ($P \leq 0.05$) on the mortality of the larvae after 1 and 3 days. There was significant effect on larvae mortality after 7 and 30 days of the application when compared with the control. No mortality was recorded on the control treatment except after 7 and 30 days from exposure. After 7days, the mortality was not high but as exposure time increased, there was a progressive increase in the toxicity of *M. oliefera* leaf powder to the tested insect and the mortality effect increased with the rates of treatment. High range of mortality percentage (17.5-25%) of *T. granarium* larvae was achieved with 5% grain (w/w), while the lowest percentage mortality (12.5%) was achieved with 1% grain (w/w), after 7 and 30days period (Table1, Figer1 Appendixes,1.)

4.2. Effect of *Moringa oleifera* flowers powder on the 3rd larval instar of *Trogoderm granarium*:

Result in table 2,showed that all rate of *Moringa oliefera* flowers powder were not significantly effect at all rate of ($P \leq 0.05$) after 1 and 3days from the treatment, but after 7 and 30 days there were significant effect at ($p \geq .05$) on the mortality of the larvae, when no mortality was noticed in the control after the first three days, the highest range of the mortality percentage (17.5-22.5%) achieved with the highest rate 5% (w/w), after 7 and 30 days respectively. Whereas the lowest mortality percentage (12.5%) was achieved with the lowest rate 1% (w/w) after 30 days, (Table, 2. Figer,1 Appendixes,2.,).

Table 1. Mortality percentage of *Trogoderm granarium* larvae feed on stored sorghum grains treated with different rates of *Moringa oleifera* leaf powder after 1, 3, 7 and 30days

Rates (w/w)	Mortality% after (Days)			
	1	3	7	30
5	0.0 (0.00) A	5.0 (1.25) A	17.5 (4.38) A	25.0 (6.25) A
2.5	0.0(0.00) A	7.5 (1.88) A	17.5 (4.38) A	17.5(4.38) AB
1	2.5 (0.63) A	5.0 (1.25) A	12.5 (3.13) AB	12.5(3.13) B
Untreated	0.0 (0.00) A	0.0 (0.00) A	2.5 (0.63) B	7.5 (1.88) B
LSD (0.05)	0.96	2.42	2.94	2.55
SE±	0.31	0.786	0.95	0.83
C.V(%)	4.00	14.38	6.11	4.23

With each column data followed with the same letter were not significantly different at $p \geq .05$ according to Least Significant Different (LSD)

Table 2. Mortality percentage of *Trogoderm granarium* larvae feed on stored sorghum grains treated with different rates of *Moringa oleifera* flowers powder after 1, 3, 7 and 30days

Rate (w/w)	**Mortality% after (Day)**			
	1	**3**	**7**	**30**
5	5.0 (1.27) A	7.5 (1.88) A	17.5 (5.00) A	22.5 (5.63) A
2.5	2.5 (0.63) A	7.5 (1.88) A	15.0 (3.75) A	15.0 (3.75) AB
1	7.5 (1.88) A	10.0 (2.50) A	12.0 (3.13)A B	12.5(3.13)B
Untreated	0.0 (0.00) A	0.0 (0.00) A	2.5 (0.63) B	7.5 (1.88) B
LSD (0.05)	2.835	3.427	2.835	2.005
SE±	O.9199	1.112	0.9199	0.6506
C.V (%)	19.62	14.26	5.88	6.20

With each column data followed with the same letter were not significantly different at p≥.05 according to Least Significant Different (LSD)

4.3. Effect of *Moringa oleifera* seeds powder on the 3rd larval instar of *Trogoderm granarium*

Result in table 3, showed that *Moringa oliefera* seed powder at all rate, were not significantly different at ($P \leq 0.05$) after 1 and 3 days from treatment when compared with the control, but after 7 and 30 days there were significant ($p \geq .05$) effect on the mortality of the larvae, while no mortality was observed in the control after 3 days and the rate of the mortality increase in time of exposure. The highest range of the mortality percentage among the *T. granarium* larvae (37.3-42.5%) achieved with 5% rate (w/w) and the lowest range of the mortality percentage (10.0-12.5) was achieved with 1% rate (w/w) of *Moringa oleifera* seed powder after 7 and 30 days respectively. (Table, 3. Fig, 1, Appendixes,3.).

4.4. Effect of *Moringa oleifera* branches powder on the 3rd larval instar of *Trogoderm granarium*

Table (4), showed that there were significantly effect at ($P \leq 0.05$) on the mortality of the larvae , feed on stored sorghum grains treated with *Moringa oleifera* branches powder at different rate (5, 2.5and 1%) (w/w) when compared with the control. After 1day there were no significant different between the treatments. The highest mortality percentage of larvae (25.0%) achieved with 5% (w/w) of *M. oleifera* branches powder, While the lowest mortality percentage (7.5%) (w/w) obtained by (1%) (w/w) of *M. oleifera* branches powder after 7 days. No progressive recorded in mortality percentage of *T. granarium* larvae after 30 days. (Table 4, Fig, 1 Appendixes:4,)

Table 3. Mortality percentage of *Trogoderm granarium* larvae feed on stored sorghum grains treated with different rates of *Moringa oleifera* seeds powder after 1, 3, 7 and 30days.

Rate (w/w)	Mortality% after (Day)			
	1	**3**	**7**	**30**
5	7.5 (1.88) A	15.0 (3.75) A	37.5(9.38) A	42.5(10.63) A
2.5	2.5 (0.63) A	5.0 (1.25) A	17.5 (4.38) B	20 (5.00) B
1	7.5 (1.88) A	7.5 (1.88) A	10.0 (2.50) BC	12.5(3.13) B
Untreated	0 (0.00) A	0 (0.00) A	2.5 (0.63) A	7.5 (1.88) B
LSD (0.05)	3.194	3.970	3.194	3.194
SE±	1.036	1.289	1.036	1.036
C.V (%)	18.95	14.93	9.14	4.20

With each column data followed with the same letter were not significantly different at $p \geq .05$ according to Least Significant Different (LSD)

Table 4. Mortality percentage of *Trogoderm granarium* larvae feed on stored sorghum grains treated with different rates of *Moringa oleifera* branches powder after 1, 3, 7 and 30days.

Rate (w/w)	**Mortality% after (Day)**			
	1	**3**	**7**	**30**
5	5.0 (1.25) A	7.5 (1.88) A	25.0 (6.25) A	25.0 (6.25) A
2.5	0.0 (0.00) B	0.0 (0.00) B	15.0 (3.75) B	15.0 (3.63) B
1	0.0 (0.00) B	0.0 (0.00) B	7.5 (1.88) BC	7.5 (1.88) BC
Untreated	0.0 (0.00) B	0.0 (0.00) B	2.5 (0.63) C	7.5 (1.25) C
LSD (0.05)	1.112	1.844	2.080	2.218
SE±	0.3609	0.5983	0.6751	0.7199
C.V (%)	23.94	25.53	4.32	4.43

With each column data followed with the same letter were not significantly different at $p \geq .05$ according to Least Significant Different (LSD).

4.5. Table 5:

The propit fig was made manual and showed that the lowest Ld50 value is 0.8 and the highest Ld50 value is 3.4 whereas the lowest Ld90 value is 2.4 and the highest Ld90 value is 60 , achieved with seeds and leaves powders respectively. (Table 5, Fig 1.)

Table 5.:Ld_{50} and Ld_{90} value of powders from different parts of *Moringa olifera* against 3rd larval instar of khapra beetle after 30 days.

Treatment	Log-concentration	
	Ld_{50}	Ld_{90}
Seeds	0.8	2.4
Leaves	3.4	60
Flowers	2.8	25
Branches	1.7	9.0

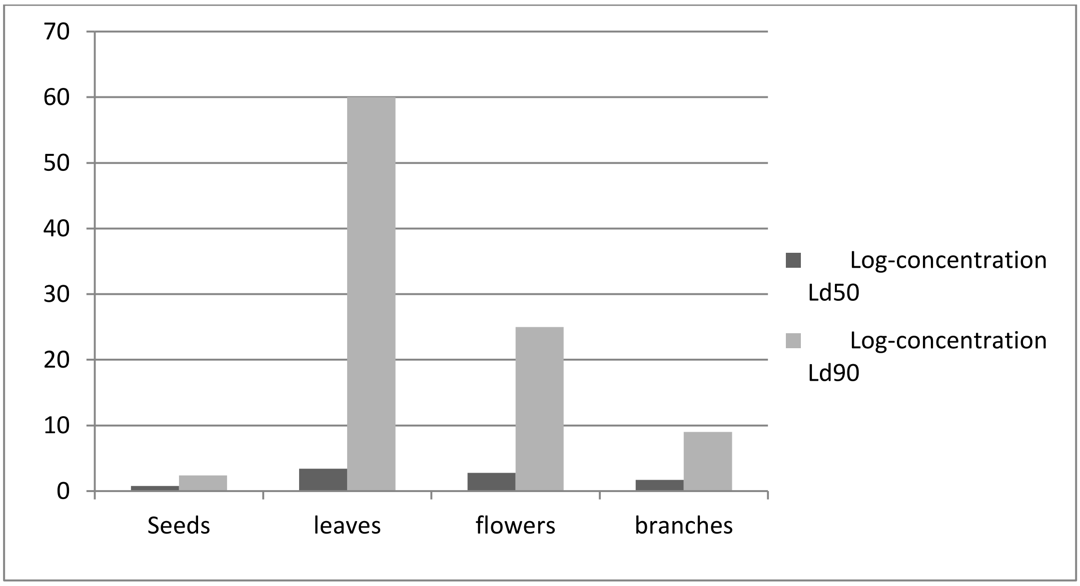

Figure 1: Log dose propid lines of powder from different parts of *Moringa olifera* against 3rd larval insta of khapra beetle.

Figure 2: Log dose propid lines of powder from different parts of *Moringa olifera* against 3rd larval insta of khapra beetle.

CHAPTER FIVE

DISCUSSION

Synthetic insecticides (pyrethroids and organophosphates) and fumigants (methyl bromide and phosphine) are commonly used to control the *Trogoderma granarium* throughout the world**.** Despite the fact that synthetic insecticides are fast acting, but we fears of problems of toxicity, pest resurgence and elevation of secondary pests, development of pesticide resistant populations, deleterious effects on populations of non-target organisms, residues in food, high cost of most of these chemicals, contamination of the environment, non-availability and the falsification and adulteration of pesticides abound. The search for alternatives to synthetic insecticides is a current approach world-wide and the use of natural plant products with their array of active components is the focal point**.** (Isman, 2008; Rajendran and Sriranjini, 2008).

In the current investigation on various powders of the different parts of *Moringa oleifer*a tree (leaves, flowers, seeds and branches) were tested against the 3rd larval instars of the khapra beetle *T. granarium*. The result indicated that all parts studied have insecticidal activity against the test insect comparing with the control and response varied with plant parts and exposure time, this may due to the fact that *M. oleifera* was found to contain Phytochemicals which include, tannins, saponins, triterpenoids and alkaloids. *Moringa oleifera* was found to contain photochemical which are non-nutritive chemicals that plant produce as a self defense mechanism. Photochemical present in *M. oleifera* include catechol tannins, Gallic tannins, steroids, triterpenoids, flavonoids, saponins, anthraquinones, alkaloids and reducing sugars as reported by Kasolo *et al* (2010).

This study shows that *M. oleifer*a seeds powder gave highly significant toxic effects against *Trogoderma granarium* larvae (3rd instars), gave high range (37.5- 42.5%) of percentage mortality at 5% concentration (w/w) after week and month respectively and this agreed with previous study by Ashfaq *et al*. (2012),they found that *M. oleifer*a seeds powder have insecticidal effects against *Culex quinquefasciatus* larvae, gave 98.89 % mortality within 24 hours exposure. Also studies with Water extract of *M. oleifera* seeds against 3rd larval instars of *Aedes aegypti,* showed 24-hour- LC_{50} value of 1260 ug/ml (Ferreira *et. al*., 2009).

Also in this, I found that the Moderate range of percentage mortality (22.5%, and 25.0%) of *T.granarium* larvae was achieved with 5% (w/w), in leaves and using branches respectively after 30 day of application. Similar report was given by Ojo *et al.* (2012), they reported that *Moringa* leaves powder was effective against *Callosobruchus maculatus* adult on stored cowpea. The percentage mortality counts of *C. maculates* adult at the highest dosage (2.0/20g) of concentrations caused 53.95%, 89.17% and 92.0% mortality after 4, 6 and 7 days after treatment respectively. Anita *et al*, (2012) recorded that pulverized leaves of Moringa at application rate of 2.0g/10g wheat gave 100% mortality in *Callosobruchuh maculates* (F) adult at 9 days after infestation. *M. oleifera* leaf powder was effective against both the larvae and adults of *Trogoderma granarium* and showed repellent properties (Ashfaq *et al*., 2012). Babarinde *et al*., (2011) reported that adults of *Trogoderma granarium* were more susceptible to *M.oleifera* leaf powder than larvae, and find that, *Piper guineense* seeds and *M. oleifera* leaf powders applied mixture (1:1; w/w) gave 77.5%. mortality against *T. granarium* larvae, after 5 days from treatment. Musa (2013), mentioned that groundnut seeds treated with two plant powders, *M. oleifera* leaves and *Allium sativum* cloves at 6% (w/w) gave 100% mortality of *T. granarium* adult after 5 days from treatment.

M. oleifera flowers powder gave the lowest range (22.5%, and 25.0%) percentage mortality of *T. granarium* larvae at 5% concentration (w/w) after month of infestation. While, Adenekan*, et al* (2013)**,** reported that cowpea seeds treated with *M. oleifera* flower, leaf and stem powders were effective against the bruchid beetles and showed 100 %, 85% and 70% mortality respectively at 24 hrs of insect infestation compared with 10 % mortality achieved with the control. Results of this study indicated that the powder of *M. oleifera* seed showed potentials in the control of 3rd larval instars of khapra beetle on sorghum grains.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIO

5.1. Conclusion.

Based on the results obtained from the study, it may be concluded that *Moringa. oleifera* seeds, leaves, flower and branches powders have insecticidal effects on the *Trogoderma granarium* 3^{rd} larval instars and the powders could have potentials as bio-insecticides on stored sorghum grains.

5.2.Recommendations

- *Moringa oleifera* seeds powder at(5% w/w rate) is recommended to farmers for the preservation of sorghum grains against infestation of khapra beetle larvae during storage.
- All part of *M. oleifera* powders can be used as chemical insecticides alternatives in order to minimize the negative side effects of chemical insecticides, human health and to save environment.
- The insecticidal activities of the Moringa plant extract for the control of storage insect pests merit further scientific investigation.

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Appendices

Appendix:**1**

Leaf/mortality/1 days

Treatment	R1	R2	R3	R4
5	0	0	0	0
2.5	0	0	0	0
1	0	0	1	0
Control	0	0	0	0

Leaf/mortality/3 days

Treatment	R1	R2	R3	R4
5	1	1	0	0
2.5	0	1	2	0
1	0	1	1	0
control	0	0	0	0

Leaf/mortality/7 days

	R1	R2	R3	R4
5	3	1	2	1
2.5	2	1	3	1
1	1	1	2	1
control	0	0	1	0

Leaf/mortality/30 days

	R1	R2	R3	R4
5	3	2	3	2
2.5	2	1	3	1
1	1	1	2	1
control	1	0	1	1

Appendix:**2**

Flower/mortality/1days

	R1	R2	R3	R4
5	0	2	0	0
2.5	1	0	0	0
1	0	0	2	1
control	0	0	0	0

Flower /mortality/3 days

	R1	R2	R3	R4
5	0	3	0	0
2.5	1	0	1	1
1	0	1	2	1
control	0	0	0	0

Flower /mortality/7 days

	R1	R2	R3	R4
5	1	3	2	2
2.5	1	2	1	1
1	1	1	2	1
control	0	0	1	0

Flower /mortality/30 days

	R1	R2	R3	R4
5	2	3	2	2
2.5	2	2	1	1
1	1	2	2	1
control	1	0	1	1

Appendix:**3**

Seed /mortality/1day

	R1	R2	R3	R4
5	0	3	0	0
2.5	0	0	0	1
1	1	1	0	1
control	0	0	0	0

Seed /mortality/3 days

	R1	R2	R3	R4
5	1	4	0	1
2.5	0	0	0	2
1	1	1	0	1
control	0	0	0	0

Seed /mortality/7 days

	R1	R2	R3	R4
5	3	6	3	3
2.5	1	2	2	2
1	1	1	1	1
control	0	0	1	0

Seed /mortality/30 days

	R1	R2	R3	R4
5	3	6	4	4
2.5	1	2	3	2
1	1	2	1	1
control	1	0	1	1

Appendix:**4**

Branches /mortality/1day

	R1	R2	R3	R4
5	1	1	0	0
2.5	0	0	0	0
1	0	0	0	0
control	0	0	0	0

Branches /mortality3days

	R1	R2	R3	R4
5	2	1	0	0
2.5	0	0	0	0
1	0	0	0	0
	0	0	0	0

Branches /mortality/7days

	R1	R2	R3	R4
5	3	2	3	2
2.5	1	1	2	2
1	1	0	1	1
control	0	0	1	0

Branches /mortality/ 30days

	R1	R2	R3	R4
5	3	2	3	2
2.5	1	1	2	2
1	1	0	1	1
control	1	0	1	0