Sudan University of Science and Technology

College of Graduate Studies

Efficacy of Two Plant Extracts Againts The Spiny Boll Worm *Earias insulana* (Boisd) (Lepidoptera: Noctuidae)

كفاءة أثنين من المستخلصات النباتية ضد دودة اللوز الشوكية

A Thesis submitted in Partial Fulfillment of the Requirements for the M. Sc.Degree in Plant Protection

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الآية

قال تعالى :

(سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ)

صدق الله العظيم

سورة البقرة الآية (32)

DEDICATION

To my mother

To my father

To my sisters and brothers

To my family

To my teachers

To my colleagues and friends

With love and respect.

Aisha

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All thanks are due to Almighty Allah (SWT) who gave me health and strength, and helped me tremendously to produce this work.

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ABSTRACT

Laboratory experiments were conducted in the Department of Plant protection, College of Agricultural Studies- Shambat, Sudan University of Science and Technology (SUST).

The objectives of the study were to evaluate the lethal effects of the aqueous extracts and powders of Jatropha (*Jatropha curcas* L.) seeds, and Argel *(Solenostemma argel* (Del.) leaves, against the 3rd larval instars of the spiny boll worm, *Earias insulana* (Boisd), to test their effects on the rate of egg hatchability of the spiny boll worm.

Three concentrations of each of the powder and aqueous extracts of each plant were used in this study (5%, 10%, and 15%). The results of treatments of the powder from both plants Jatropha seeds and Argel leaves showed no effect on eggs hatching and larval mortality at all concentrations after 72 hrs. Concerning of the results of application of aqueous extracts on the larvae, the results showed that, all tested concentrations of both plants caused higher mortality percentage of the 3rd instars larvae of the spiny boll worm, in comparison with the control. The lowest concentration (5%) of seeds aqueous extract of *J. curcas* gave 50% mortality, and highest concentration (15%) gave 80%mortality after 72 hrs of exposure. Leaves aqueous extracts of *S. argel* at 5% and15% concentrations generated 46.6 % and 73.3% mortality, respectively after 72 hrs of exposure. The mortality percentage given from the standard insecticide was (100%).

Also, the results showed reduction of egg hatchability percentage on extracts than the control. The lowest and highest concentrations 5%, 15% of seed aqueous extracts of *J. curcas* reduced hatching to (35.5%, 13.3%) respectively after 72 hrs of exposure. The lowest and highest concentrations 5%, 15% of Leaves aqueous extracts of *S. argel* reduced hatching to (38.8%, 21%) respectively after 72 hrs of exposure, compared with the control which showed hatching percentage (82.1%).

The results of the present study indicated that, the aqueous extracts of the two plants Jatropha and Argel could be considered a cheaper source for active substances for the spiny boll worm.

ملخص البحث

أجريت تجارب معملية في قسم وقاية النبات, كلية الدراسات الزراعية– شمبات , جامعة السودان للعلوم و التكنولوجيا.هدفت هذه الدراسة لتقييم الأثر القاتل للمستخلصات المائية و البدرة لبذور الجاتروفا *Jatropha curcas* L. و أوراق الحرجل *Solenostemma argel* Delile ضد الطور اليرقي الثالث لدودة اللوز الشوكية (المصرية) *Earias insulana* Boisd . **و**لاختبار اثرها علي معدل فقس بيض دودة اللوز الشوكية .

استخدمت في هذه الدراسة ثلاثة تركيزات كل من البدرة والمستخلص المائي لكل نبات (5, 10, 15%) .أوضحت نتائج الاختبارات المتحصل عليها عند استخدم البدرة لكل من النباتين , عدم تأثيرها علي كل من معدل فقس بيض و الطور اليرقي الثالث في كل التراكيز بعد 72 ساعة من المعاملة.

بخصوص نتائج استخدام المستخلصات المائية علي اليرقات أوضحت النتائج أن كل التركيزات المختبرة للمستخلصات المائية من كلا النباتين احدثت نسب موت عالية للطور اليرقى الثالث لدودة اللوز الشوكية مقارنة بالشاهد , أعطى اقل تركيز (5%) من المستخلص المائي لبذور الجاتروفا (50%) وأعلى تركيز (15%) نسبة موت (80%) بعد 72ساعة من المعاملة. و كان الأثر الفعال للتركيزين الادنى والأعلى من المستخلص المائي لأورق الحرجل (5% و15%) قد أعطيا نسب موت (46.6% ,73.3%) علي التوالي بعد 72ساعة من المعاملة. كما كانت نسبة الموت للمبيد القياسي 100%.

أيضا أوضحت النتائج المتحصل عليها أن تأثير كل من المستخلصين النباتين أدى إلى تدني معدل فقس البيض مقارنة مع الشاهد , أعطى اقل وأعلى تركيز (5% و15%) من المستخلص المائي لبذور الجاتروفا نسب فقس (35.5% ,13.3%) علي التوالي بعد 72 ساعة من المعاملة, وكلا التركيزين الأدنى والأعلى من المستخلص المائي لورق الحرجل (5% و15%) قد أعطيا نسب فقس (38.8% ,21%) علي التوالي بعد 72ساعة من المعاملة, وذلك مقارنة مع نسبة الفقس المتحصل عليها في الشاهد (82.1%).

اوضحت نتائج هذه الدراسة أن المستخلص المائي لكلا النباتين الجاتروفا والحرجل يمكن أن تعتبر مصادر رخيصة لمواد فعالة لمكافحة دودة اللوز الشوكية.

CHAPTER ONE

INTRODUCTION

Man has known natural pesticides for centuries and has discovered their values by chance and observation in combating his insect enemies. The chemical war against pests has made a rapid progress in many countries, including Sudan, following the Second World War. In fact, the conventional synthetic insecticides have been used to free the world from disease and famines. In spite of their success in controlling insect pests, pesticides have inflicted certain drawbacks on the environmental quality (Sill, 1982).

Smith (1970) summarized the disadvantages of pesticide chemicals as: development of pest resistance, distraction of the natural enemies of insect pests, toxicity to human, domestic and wild life, honey bees and other pollinators, and the disruption of the natural balance and the food chain….etc. All these made pest control even more complicated.

In Sudan, the irrigated schemes comprise the main site of annual application of large amount of the synthetic pesticides. The misuse of these chemical created problems to both man and animal. Moreover, their continuous application in Gezira Area was found to affect vital processes in the soil such as nitrification and respiration (Mukhter and EL Zorgani, 1983).

These problems of synthetic insecticides warranted the search for safer agents among the naturally occurring substances. These agents many show insecticidal activities or act as hormone mimics, repellent or antifeedant.

Sill (1982) mentioned that, in addition to the existing control measures, the use of physiological active substances produced by plants which may have less hazardous effects and can be easily incorporation in pest management programs. Recently, over 2000 plant species were reported to possess pest control properties, out of the very little are being exploited for pest control purposes (Ahmed, 1993).

The above problems warranted the search for safe methods of control such as the use of botanical insecticide, *Solenostemma argel* and seed of *Jatropha curcas* which attack insects.

Lepidoptera is one of the largest orders in Class Insecta; it includes many insects of economic importance. The order occurs widely in all climates, but numerous families occur in the tropics and the sub-tropical regions. Economically, Lepidoptera are of great importance in the larval stage. The majority of injurious species devour the foliage and shoots of trees and crops; a similar number bore in to the stems or attack the under-ground part. Some species attack the stored products, grains, dried fruit….etc. the genus *Earias* (Fam. Noctuidae) which are very important pest attack vegetables in Khartoum area.

The objectives of the present study:

1. To evaluate efficacy of the powders of Jatropha (*J. curcas*) seeds, and Argel (*S. argel*) leaves on hatchability of the Spiny Bollworm (*Earias insulana*) eggs.
2. To evaluate efficacy of the powders of Jatropha (*J. curcas*) seeds, and Argel (*S. argel*) leaves on the 3rd instar larvae of the Spiny Bollworm (*Earias insulana*).

3. To evaluate efficacy of the aqueous extracts of Jatropha (*J. curcas*) seeds, and Argel (*S. argel*) leaves on hatchability of the Spiny Bollworm (*Earias insulana*) eggs.
4. To evaluate efficacy of the aqueous extracts of Jatropha (*J. curcas*) seeds, and Argel (*S. argel*) leaves on the 3rd instar larvae of the Spiny Bollworm (*Earias insulana*).

CHAPTER TWO

LITERATURE REVIEW

2.1. The Spiny Boll Worm, Earias insulana (Boisd)

2.1.1. Synonym:

Common names: spiny boll worm, Egyptian boll worm, chenille epineuse, rouge Espinosa. In Africa, *E. insulana* is often found in mixed populations with *E. biplaga* on cotton. *E. insulana* can be distinguished by its less (spiny) appearance and by the dorsal tubercles on the 8th abdominal segment being white, instead of brown (Schumutterer, 1969).

In India, mixed populations of *E. vittella* and *E. insulana* frequently occur on cotton. *E. insulana* larvae are rather more (spiny) than *E. vittella* which is more strongly marked with a black and white coloration (Ripper, and George.1965).

2.1.2. Morphology:

The eggs are blue, spherical.0.5mm diameter. The larva grows to a length of 20mm, is stout and spindle shaped, with hairs on each segment with two pairs of fleshy tubercles, one dorsal, the other lateral, on the last two thoracic segments and all abdominal segments. These tubercles, which give the spiny bollworm is name, are shorter than those of *E. biplaga* but more pronounced than those of *E. vittella*. The larva is dull grey –brown with grey markings. (Chiaramonte, 1931).

The pupa is enclosed in a touch off-white silk cocoon, shaped like an inverted boat attached to the plant or its debris.

The moth are generally11mm long and rest with their wings folded strength along their sides the abdomen and hind wings are silvery white, The forewings are uniformly silvery-green, but tend to be straw-yellow in drier areas and seasons. There is no dark marginal fringe to the forewing. Very rarely, specimens have a brown blotch in the center of the forewing simileated to that on female *E. biplaga* (Pearson, 1958 and Yathom, 1965).

2.1.3. Life cycle and bionomics and history:

When well-fed with nectar, the female lays several hundred eggs singly on the shoots, leaves, flower buds and flowers of the host plant. The incubation period lasts for about three to four days under the conditions of the rainy season in the Central Sudan and is somewhat prolonged in winter. The larval and pupal period are a bout2-$2^{1/2}$weeks each or somewhat longer. Pupation takes place either on the plant or in soil debris in a dirty-white or grayish cocoon which is shaped like an inverted boat. There are several generations per year in the irrigated areas of the Sudan as the pest seems to have no resting stage under these environmental conditions.

Life cycle: At28c, egg incubation takes 3days, larvae 9days, and pupa 9days.The moths lay up to 300eggs. No diapauses have been recorded (Yathom, 1965).

2.1.4. Ecology:

This pest appears to survive better than other Earias spp. In the drier areas, perhaps because it generally an internal fruit feeder. (Reed, and Choyce, 1961).

2.1.5. Geographical distribution:

The distribution includes Africa, including adjacent islands, Southern Europe, Asia Minor, Pakistan, India, Southeast Asia, Japan, Taiwan, Philippines, and Australia.((Schumutterer, 1969).

E. insulana has a wide distribution range in the Old World. In the Sudan, the Spiny bollworm is found mainly in the drier, irrigated areas in the North, East and West. The pest has also been observed in the wetter parts of the Central and Southern Sudan where it is outnumbered by *E .biplaga* (Yathom, 1965).

2.1.6. Host plants:

Cotton (*Gossypium* spp.), okra, and many other Malvales, particularly Abutilon Spp. sometimes also found on (Zee mays), for instance in Egypt. (Pearson, 1958 and Yathom, 1965).

2.1.7. Economic importance:

This pest is most damaging on irrigated cotton in drier countries particularly in Egypt, Sudan, Israel, Pakistan and North India. Although the early attacks by this pest can be compensated for by later plant growth, the delayed crops are often totally destroyed by Pink bollworm (*pectinophora gossypiella*) (Pearson, 1958 and Yathom, 1965).

2.1.8. Plants infested and damage:

The spiny bollworm preferably attack Malvaceous plants belong to the genera *Gossypium, Hibiscus, Abutilon, Malva, Altbaea, Malvastrum, Thespesia, Corcborus, Grewia, Sida, Medicago*, and others. Its exact host plant range in the Sudan is not quite clear due to confusion with *E.biplaga* (Chiaramonte, 1931)

The damage caused to cotton and okra in the Gezira area of the Sudan is up to now minor economic importance. However, the pest has gained major importance in certain areas, for instance in the Kashm El Girba Schemes on Blue Nile White Nile during the 1966/1967season.

2.1.9. Control measure:

2.1.9.1. Sanitary methods:

It is important that okra and old cotton stalks should be destroyed after harvesting (Pearson, 1958 and Yathom, 1965).

2.1.9.2. Cultural practices:

Okra and cotton should be timely sown, for later sown cotton can be severely infested. In some countries the destruction of *Abutilon* spp. has been undertaken with some success (Pearson, 1958 and Yathom, 1965).

2.1.9.3. Natural enemies:

Several Hymenopterans insects have been recorded as parasites of the spiny bollworm in the Sudan namely including –*Agathus* sp., *Apanteles* spp., *Bracon brevicornis*, *Chelonus* sp., *Elasmus* sp (Reed, and Choyce, 1961).

2.1.9.4. Chemical control:

A) Insecticides. Endosulfan at 0.75kg.a.i.per/ha or carbonyl at 1kg a.i.per/ha Azinphos –methyl at 0.6kg a.i.per/ha is also reported to be effective. (Ripper and george.1965).

B) Spraying schemes. Although schedules involving weekly sprays against this and other cotton pests are frequently used, it is far better to spray against this pest only when field counts indicate damaging populations. (Reed, 1965).

C) Prognosis. Since this pest can often feed inside bolls, the cotton must be closely examined. Populations of larvae greater than one on five plants probably merit insecticides use. (Reed, 1965).

D) Resistance to insecticides. Resistance to endren, formerly widely used for the control of this pest, has been reported from Israel in 1956. DDT is widely reported to be in effective against this pest and may increase infestations by killing the natural enemies.(Ripper and George.1965).

2.2. Application of Botanicals in pest control:

2.2.1. Argel: *Solenostemma argel* (Delile) Hayne

2.2.1.1. Classification:

Class: magnoliopsida

Order: gentianales

Family: asclepiadaceae

Scientific name: *Solenostemma argel*

English name: argel

Arabic Name: Hargel

2.2.1.2. Description:

It is an erect perennial shrub that reaches up to 1.5-2 feet in height with numerous branches carrying opposite decussate leaves. The leaves are lance late to oblong-ovate, with acute or sub –acute apex and cuneate base. The leaf petiole is thick.

Fruit are solitary follicles, ovoid, lance late, acuminate at the apex and they are very hard with dark purple color. Seeds are turgid, ovoid and

they are channel down at one face; they are minutely tuberculate bearing an apical tuft hair (Andrews, 1952; ElKamali, 1991).

2.2.1.3. Distribution:

Solenostemma argel is a desert plant, which is of wide spread in central and North's parts of the Sudan, Egypt, Libya, Chad, Algeria, Saudi Arabia and Palestine. However, Sudan is regarded as the richest source of this plant (Orange, 1982).

2.2.1.4. Locality:

Solenostemma argel grows wild or cultivated in North Sudan, in the area extending from dongle to Barber. Rubatab tribe, whose capital townis Abu Hamad, is famous for argel production and wild collection (El Kamali, 1991).

2.2.1.5. Chemical Constitution of Argel:

Elkamali (1991), conducted a photochemical screening of argel (*Solenostemma argel)* constituents of the leaves, stems and roots at the pre-flowering stages. Results of photochemical screening showed the presence of number of chemical groups (Flavonoides, tannins, sterols, trite pens and saponins). The major constituents were saponins.

2.2.1.6. Insecticidal Activity of *Solenostemma argel*:

Hag-Eltayeb (2005), reported that argel aqueous extract was effective in control of the Larvae of Mosquitoes *Culex* spp and *Anopheles* spp under Laboratory conditions. Argel water extract when tested under Laboratory conditions against *E. insulana* at 5%, 10%and 15% gave60.1%, 66.7% and 75.8% mortality of the adult insects respectively (Mohamed, 2004).

Sid-Ahmed (2006) reported that, argel aqueous extract when tested under field conditions against the date palm white scale insect (*Parlatoria blanchardii*) at 1, 2&3ounces/6Lof water/tree increased the mortality of *Parlatoria blanchardii* significantly compared to the untreated control .In the Northern state of Sudan at Shaygia area in Eshishi and Elbalel villages to the south of Nouri town, farmers used argel as traditional method to control insect pests on okra especially the bollworms. The farmers put the vegetative parts of Argel in main irrigation canals. The extract of argel is leached with water to okra field where it is absorbed by roots and transolcated to all plant parts causing mortality of the feeding Larvae (Sir Elkhatim, 2005). Also, the aqueous extract of *Solenostemma argel* leaves increased mortality of the Adult green pit scale insect (*Asterolicanium phoenicis* Rao) Taha *et al.,* (2012). And the aqueous extract of leaves, flower, root and stem of *S. argel,* gave high mortality rate when tested in the laboratory for activity against the 3rd instar larvae of the mosquito *Culex quiquefasciatus.* ELkamali, (2001)

2.2.2. Jatropha (*Jatropha curcas L.*):

Jatropha is a genus of approximately 175 succulent plants, shrubs and trees (some are deciduous, like *Jatropha curcas* L.). The name is derived from Greek words, iatros = physician and trophe =nutrition, andhence the common name physic nut.Jatropha is native to Mexico and Central America (Little *et al.,* 1974).

2.2.2.1. Classification:

Kingdom: Plantae
Class: Magnoliopsida
Order: Malpighiales
Family: Euphorbiaceae
S.N : *Jatropha curcas*

2.2.2.2. Description:

Jatropha or physic nut can grow to a height of about 3 to 5 meters. If the conditions are favorable they can grow to height of about 8 to 10 meters, with spreading branches and stubby twigs with smooth grey bark and they emit white water latex when they are chopped (James 1983). Normally five roots are formed from seeds, one tap root and 4 lateral roots. Leaves are deciduous broad and usually simple alternate but apically crowded, ovate, acute to acuminate, basally chordate, deeply palmate 3 to 5 lobed, green or pale green in color. Flower: several too many in greenish cymes, yellowish, bell shaped are formed terminally on branches. Fruits: small capsule-like round fruit about 2.5-4cm in diameter there green and fleshy when immature. Seed: 2 or 3 black seeds and each one is about 2cm long (Morton, 1977, little *et al.*, 1974).

2.2.2.3. Distribution:

Though native to America the species is almost tropical now and it is widely planted as a medicinal plant. It is listed as a weed in Brazil, Fiji, Honduras, India, Jamaica, Panama, Puerto Rico, and Salvador. The plant was spread as a valuable hedge plant to Africa and Asia by Portuguese traders (Holm, *et al.,* 1979). In Sudan Jatropha is found in many areas such as Khartoum State, in Central Sudan, Kassala State, in the East and Kordofan State, in the West. It is also dominant in the Southern states especially in Bahr eljebel and Bahr elgazal State where the farmers use it as hedges to protect houses and gardens. Jatropha project was in Kutum, North Darfur, with participation of the German Development Service (List and Horhammer, 1969). Growth can occur readily, from cuttings or seeds. Cuttings roots is so easy and the plant can be used as energy-

producing material as well living fences post (Morton, 1977: Little *et al.*, 1974).

2.2.2.4. Yield and Economics:

According to Gaydou, *et al.,* (1982) seed yields approach 6-7 MT/ha with 37% oil. They calculated that such yields could produce the equivalent of 2,100-2,800 liters fuel oil /ha in Madagascar where, they have 10,000 ha of purging nut, each producing 2,400 oil/ha for a potential production of 24,000,000 liters. The plants yield more than four times as much fuel per hectare as soybean, as and more than ten times that of maize (Michael, 2006).

2.2.2.5. Chemistry:

Per 100g, the seed is reported to contain 6.6g H2O, 18.9g protein 38.0g fat, 33.5g total carbohydrate, 15.5g fiber and 4.5g ash (Duke and Atchley, 1983). Leaves, which show anti-leukemic activity, contain a-amyrin, b-sitosterol, stigmastterol, and compesterol, 7-Keto- 6 sitosterol, stigmast-5-,ene-3-6,7-a-diol (Morton,1981). Leaves contain isovitexin and vitexin, Saccharose, raffinose, stachyose, glucose, fructose, galactose, protein and oil. Oleic and linoleic-acid (List and Horhammer, 1979).Curcasin, arachidic, linoleic-, myristic-, oleic-, palmitic-, and steric-acids are also reported (Perry, 1980).

2.2.2.6. Seeds and its toxicity:

The seed of physic nut are a good source of oil, which can be used as a diesel substitute. However, the seed of *J.curcas* are in general toxic to humans and animal. Curcin, a toxic protein isolated from the seeds ,was found to inhibit protein synthesis in invitro studies .The high concentration of phorbol esters present in Jatropha seed has been

identified as the main toxic agent responsible for Jatropha toxicity (Makkar, *et al.*, 1997). Several cases of *J. curcas* nut poisoning in humans after accidental consumption of seeds have been reported with symptoms of giddiness, vomiting and diarrhea and condition even death have been recorded (Becker and Makkar, 1998). Ionizing radiation treatment could serve as a possible additional processing method for in activation or removal of certain anti nutritional factors such as phorbol esters, phytates, saponins and lectins. It is not possible to destroy phorbol ester by heat treatment because they are heat stable and can withstand roasting temperature as high as 160c for 30 min. However, it is possible to reduce its concentration in the meal by chemical treatments. This treatment is promising, but in economic term it is expensive to produce Jatropha meal from it (Areqheore *et al.*, 2003).

Martinez- Herrera*et al.*, (2006). Also studied the nutritional quality and the effect of various treatments to inactivate the anti-nutritional factors in defatted Jatropha kernel meal of both toxic and nontoxic varieties from different regions of Mexico. Complete removal of the toxins is therefore necessary before jatropha oil can be used in industrial application or in human medicineThe oil must be completely innocuous before it is used commercially. The petroleum ether extract of Jatropha seed oil gave high mortality against Adult of Cowpea beetle *Callosobruchus maculates* Boateng and Kusi (2008). Also the extracts of the Jatropha seed oil significant mortality percentage against the 3rd nymphal instar of the desert locust *Shistocerca gregaria*. Bashir and EL shafle, (2013).

2.2.2.7. Use of Jatropha:

According to Ochse (1980), they are favored for cooking with goat meat, said to counteract the peculiar smell. Though purgative, the nuts are

sometimes roasted and dangerously eaten. In India, pounded leaves are applied near horses' eyes to repel flies. The oil has been used for illumination, soap, candles, adulteration of olive oil, and making Turkey red oil. Nuts can be strung on grass and burned like candlenuts (Watt and Breyer-Brandwijk, 1962). Mexicans grow the shrub as a host for the lac insect. Ashes of the burned root are used as a salt substitute (Morton, 1981). Agaceta *et al.,* (1981) conclude that it has strong molluscicidal activity. Duke and Wain (1981) list it for homicide, piscicide, and raticide as well. The latex was strongly inhibitory to watermelon mosaic virus (Tewari and Shukla, 1982). Bark used as a fish poison (Watt and Breyer-Brandwijk, 1962). In South Sudan, the seed as well as the fruit is used as a contraceptive (List and Horhammer, 1969). Sap stains linen and can be used for marking (Mitchell and Rook, 1979). Little *et at.,* (1974) list the species as a honey plant.

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CHAPTER THREE

MATERIALS AND METHODS

This study was conducted at the Entomology laboratory of the, Department of Plant Protection, College of Agricultural Studies - Shambat, Sudan University of Science and Technology (SUST), during November, 2014 – March, 2015.

3.1. Insect culture:

The larvae of the spiny boll worm (*Earias insulana*) (SBW) were collected from okra fields at Alfao City, Gazera State, and from the Central Market of Bahry, in Khartoum State. The collected larvae were kept in Petri-dishes (9 cm diameter) containing fresh okra fruits **(Plates No. 1 & No. 2**).

The spiny bollworm adults were kept inside Plastic Cages (20 x20 x30 cm), covered on the top with white cotton cloth **(Plate No. 3)**. Adults mate, and the females lay eggs on the cotton cloth .Also, 4 pieces (half) of filter papers were placed in the cage's corners, for egg laying by females. Eggs are removed from the cotton cloth, and from the filter papers, and incubated in sealed glass jars until hatching.

Newly hatched larvae were transferred to the diet's Petr-dishes using a small sheep's hairbrush. Larval rearing takes about 13 days at 26.5°C, 75% RH, and a photoperiod of 12L: 12D. Larvae pupate inside the diet. Pupae were collected at the beginning of day 16, and were kept at 26.5°C and 75% RH in Petri-dishes. Then, 50 pupae were placed inside the plastic cages (covered with cloth fixed with a rubber band) prior to emergence. Emerging moths were collected and sexed daily, then placed in other cages for mating and egg laying. Twenty-five to thirty pairs are

kept per cage. The adult room is maintained at 26.5°C, 75-85% RH and a photoperiod of 12L: 12D. A 10% sucrose solution was supplied for adult nutrition (**Plate No. 4**). Oviposition on cloths was removed, and Sucrose solution was changed, daily. Collected eggs were maintained at 4 -6°C. At this temperature, eggs can be held for about 3-5 days. Later, Eggs were incubated at 26.5°C for hatching.

Plate 1: Larvae feeding inside okra fruits

Plate 2: Larval Rearing

Plate 3: Hatchability and Adult Emergence Cages

Plate 4: Sucrose Solution for Adult Nutrition

3.2. Equipment used in the experiment:

A compound microscope (10 ×40 magnification) was used during the study. Petri-dishes, 9Cm in diameter, filter papers and a locally made cage was used. It consisted of a Kilner Jar placed on top of which a lantern glass. A cotton cloth was used as a cover for the cage. A piece of sponge saturated with 10% sugar solution was partially inserted in a plastic tube and used to feed the adults.

Other equipment and materials used in the experiments were as follows:
Equipment:

1-Collection sample tube	11-Plastic cages
2-Micropipette	12-Brush
3-Petri-dishes	13-Hand lens
4-Marker pen	14-Forceps
5-Regestration form	15-Sensetive balance
6-Pencil	16-Electronic blender
7-Gloves	17-Thimble
8-Masks	18-Cotton
9- knife	19-Rotary evaporator
10-Camera	20-Morter and pestle

Materials:

1- ethanol	6-Argel leaves
2- UHU	7Jatropha seeds
3-Muslin cloths	8- Okra fruit
4- Filter paper	9- Sugar
5-Fastac®EC(standard)	10- Distilled water

3.3. Application of botanical:

3.3.1. Preparation of plant materials for extraction:

Leaves of Argel, *Solenostemma argel* (**plate No. 5)** and seeds of Jatropha, *Jatropha curcas* (**plate No. 6**) were obtained from commercial market. The dried leaves and seeds were first crushed by hand, or by a mortar and pestle, then ground by an electric blender- mixer (Molineux-model 2001).The powder obtained from Argel leaves and Jatropha seeds were passed through a 25-mesh sieve. The powder was then stored in tightly covered glass jars, and kept at room temperature in the laboratory ready for extraction.

3.3.2. Preparation of the plant extracts:

The aqueous extracts of Jatropha seeds and Argel leaves powder were prepared by mixing 15g of powder with 85 ml distilled water in conical flasks. The mixture was left to stand for 24 hours at room temperature, according to method applied by (Environmental and National Resources and Desertification Research Institute (ENRDRI), and it was then thoroughly shaken by hand every 8 hours for 10 minutes within a period of 24 hrs, the mixture was then strained using a light cloth, and then filtered by what-man filter paper.

The filtrate or the stock solution (15 w\v) was kept in the refrigerator at (5 ˚C) until it was used for bioassay.

3.4. The standard insecticide (Fastac 10 EC):

Fastac 10 EC, a broad spectrum insecticide, controls with both contact and residual activity, registered for a wide range of crops, including row and vegetable crops. Chemical group: pyrethroid-fourth generation. Active ingredient: alpha-cypermthrin. The chemical company BASF.

Plate 5: Argel plant

Plate 6: Jatropha tree and seeds

3.5 Bioassay:

3.5.1. Effect of plant powders on hatchability of SBW eggs:

Thirty eggs of *E. insulana (*0 -24 hrs old) were treated with the 3 concentrations (5, 10 and 15mg/w) of the powders from Jatropha (*J. curcas*) seed and Argel (S. *argel*) leaves, and were placed in plastic cages (20cm diameter). Another 30 eggs were introduced into another cage using a fine brush; three replicates were made with each treatment, in addition to untreated control. Plastic cages were checked out after 24 h to count the number of egg hatch and after 48 and 72 hrs, to calculate the egg hatching Percentage.

3.5.2. Effects of plant powders on the 3rd instar larvae of SBW:

Based on preliminary experiments, the Argel leaves and Jatropha seed powders were tested at 3 concentrations (5, 10, 15 mg/ w). The amount of each concentration was placed in a Petri-dish containing okra fruits, and the powder and okra fruits were mixed thoroughly. Ten larvae of the spiny boll worm were put in each Petri-dish. Untreated Larvae were placed in Petri- dishes containing okra fruits, as control. Three replicates were made with each concentration; the number of dead larvae in each replicate was counted after 24, 48, and 72 hrs.

3.5.3. Effect of aqueous extracts on hatchability of SBW eggs:

Three groups, each of Thirty eggs of *E. insulana,* were sprayed with 5 ml of each of the 3 concentrations (5%, 10%, and15%) of the aqueous extracts of *J. curcas and* S. *argel,* and were placed in plastic cages (20cm diameter). Another group of 30 eggs was used as control. Three replicates were made with each treatment, in addition to untreated control. After 24, 48 and 72 hrs cages were checked for eggs that failed to hatch and the Percentage of egg hatching was calculated.

3.5.4. Effects of aqueous extracts on the 3rd instar larvae of SBW:

Groups of, 650 mg each, of Okra fresh fruits were dipped in each of the 3 concentrations of the aqueous extract of the two plants, and then were allowed to dry for 5 minutes at room temperature, then placed each in a Petri-dish. Groups of ten 3^{rd} instar larvae were introduced into each of the Petri-dishes. Another group of 10 larvae were used as control. The control was dipped in distilled water. Also, a 5^{th} group of larvae was treated with the standard insecticide. Each treatment was replicated three times. All treatments were kept at a room temperature of 27 ± 1°C, 75 ± 5% RH, with a 12hrs L: 12hrs D cycle. All Petri dishes were checked out after 24 hrs, 48 and 72 hrs to calculate the total mortality of the larvae of the spiny boll worm.

3.6. Experimental design:

These experiments were carried out in a Completely Randomized Design (CRD).

3.7. Statistical analysis:

The obtained data were statistically analyzed according to analysis of variance (ANOVA); Duncan's Multiple Range Test was used for means separation.

CHPTER FOUR

RESULTS

4.1. Effect of the powders of *J. curcas* seeds and *S. argel* leaves on hatchability of *E. insulana* eggs, after 24, 48, and 72hrs.

The data in table (1) and figure (1) showed the treatment of the powder from both plants Jatropha seeds and Argel leaves no effect on eggs hatching and no significant different between controls in all concentrations after 72 hrs.

Table 1: Effect of the powders of *J. curcas* seeds and *S. argel* leaves on hatchability of *E. insulana* eggs, after 24, 48, and 72hrs.

Treatments	Concentration	Mean of egg hatchability		
		mean24	Mean48	Mean72
Jatropha	5 mg	9.3± (3.3) b	15.6± (4.4) a	23± (5.2) a
	10 mg	11.3± (3.7) ab	17.3± (5.2) a	24.6± (5.3) a
	15 mg	12.6± (3.8)ab	16.3± (4.5) a	21± (5.0) a
Argel	5 mg	12± (3.9) ab	18.3± (4.7) a	24.6± (5.4) a
	10 mg	11.6± (3.8) ab	17± (5.1) a	23.3± (5.2) a
	15 mg	11.6± (3.7) ab	18.3± (4.8) a	22.6± (5.1) a
Control		15.3± (4.3) a	22± (5.1) a	25.3± (5.0) a
SE		0.2436	0.3683	0.1592
C.V%		11.02%	13.17%	5.22%
LSD		0.7388	1.117	0.4828

Means between brackets are transformed according to $\sqrt{X + 0.5}$

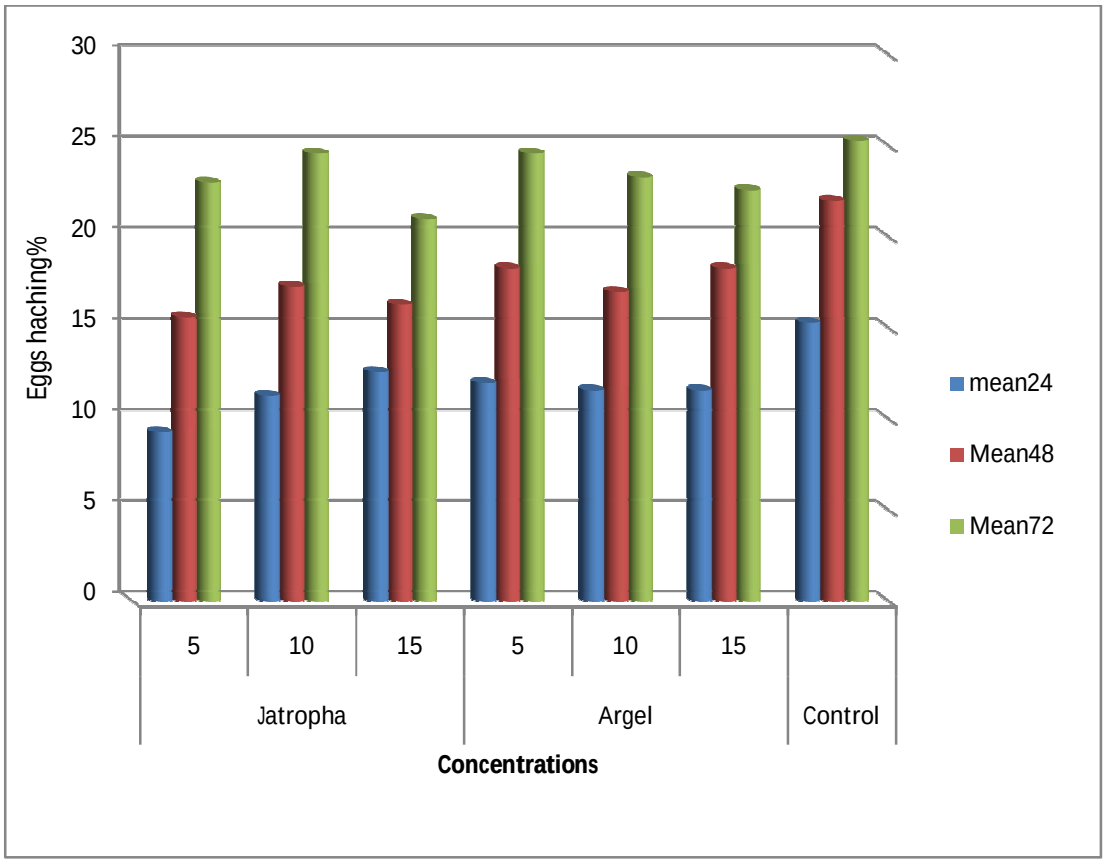

Figure 1: Effect of the powders of *J. curcas* seeds and *S. argel* leaves on hatchability of *E. insulana* eggs, after 24, 48, and 72hrs.

4.2. Effect of powders of *J. curcas* seeds and *S. argel* leaves on the 3rd larval instar of *E. insulana*, after 24, 48 and 72 h.

The data in table (2) and figure (2) showed the treatment powder no effect or no mortality percentage on spiny boll worm larvae from both plants Jatropha seeds powder and Argel leaves powder than the stander. Highest concentration (15%) from both plant give 0.0% mortality after 72 hrs.

Table 2: Effect of powders of *J. curcas* seeds and *S. argel* leaves on the 3rd larval instar of *E. insulana*, after 24, 48 and 72 h.

Treatments	Concentration	Mean mortality of larvae		
		mean24	Mean48	Mean72
Jatropha	5 mg	0.0± (0.7) b	0.0±(0.7)b	0.33±(0.8) c
	10 mg	0.0± (0.7) b	0.0±(0.7)b	0.66±(1.1) b
	15 mg	0.0± (0.7) b	0.66±(1.0) b	0.66±(1.4) b
Argel	5 mg	0.0± (0.7) b	0.33±(0.8)b	0.66±(1.03)b
	10 mg	0.0± (0.7) b	0.0± (0.7) b	0.0±(0.7) c
	15 mg	0.0± (0.7) b	0.0±(0.7)b	0.0±(0.7) c
Standard		100.0(10.0) a	100.0(10.0) a	100.0(10.0) a
Control		0.0±(0.7) b	0.0±(0.7) b	0.0±(0.7)c
SE		2.60	2.58	2.56
C.V%		5.60%	12.87%	11.76%
LSD		0.1410	0.3454	0.3328

Means between brackets are transformed according to $\sqrt{X + 0.5}$

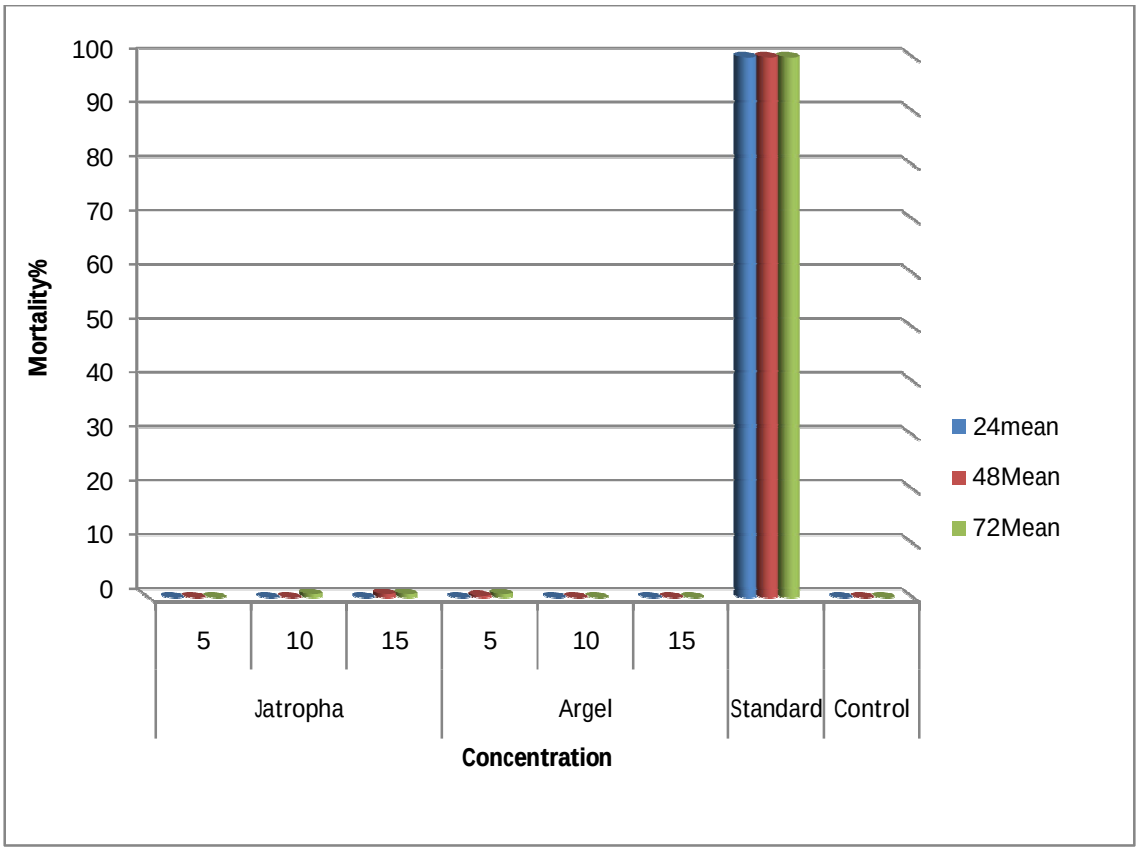

Figure 2: Effect of powders of *J. curcas* seeds and *S. argel* leaves on the 3rd larval instar of *E. insulana*, after 24, 48 and 72 h

4.3. Effect of aqueous extracts of *J. curcas* seeds and S. *argel* leaves on hatchability of *E. insulana* eggs, after 24, 48, and 72 hrs.

Data in Table (3) and Figure (3) showed the effect aqueous extract of *J.curcas & S.argel* on hatchability eggs of spiny boll worm. It is obvious that the Jatropha tested level (5, 10 and 15%) reduced the percent of hatchability with 35.5, 17.7 and 13.3 for 72hrs, respectively. Also Argel at the level (5, 10 and 15%) reduced the hatchability percent with 38.8, 27.7 and 21 for 72 hrs.' respectively than the control 82.1%.

Table 3: Effect of aqueous extracts of *J. curcas* seeds and S. *argel* leaves on hatchability of *E. insulana* eggs, after 24, 48, and 72 hrs.

Treatments	Concentration	Mean of egg hatchability		
		mean24	Mean48	Mean72
Jatropha	5%	13.3± (4.8) ab	31± (5.5) bc	35.5± (5.9) bc
	10%	5.5± (2.1) cd	14.4± (3.8) d	17.7± (4.2) ef
	15%	2.2± (1.3) d	12.1± (3.4) d	13.3± (3.7) f
Argel	5%	24.4± (4.9) ab	35.5± (6.1) b	38.8± (6.2) b
	10%	12.2± (3.5) bc	21± (4.5) cd	27.7± (5.2) cd
	15%	13.3± (3.6) bc	15.5± (3.9) d	21±(4.6) de
Control		42.1± (6.4) a	63.3± (7.9) a	82.1± (9.0) a
ES		1.91	1.59	1.72
C.V%		29.10%	12.10%	7.63%
LSD		2.005	1.072	0.7430

Means between brackets are transformed according to $\sqrt{X + 0.5}$

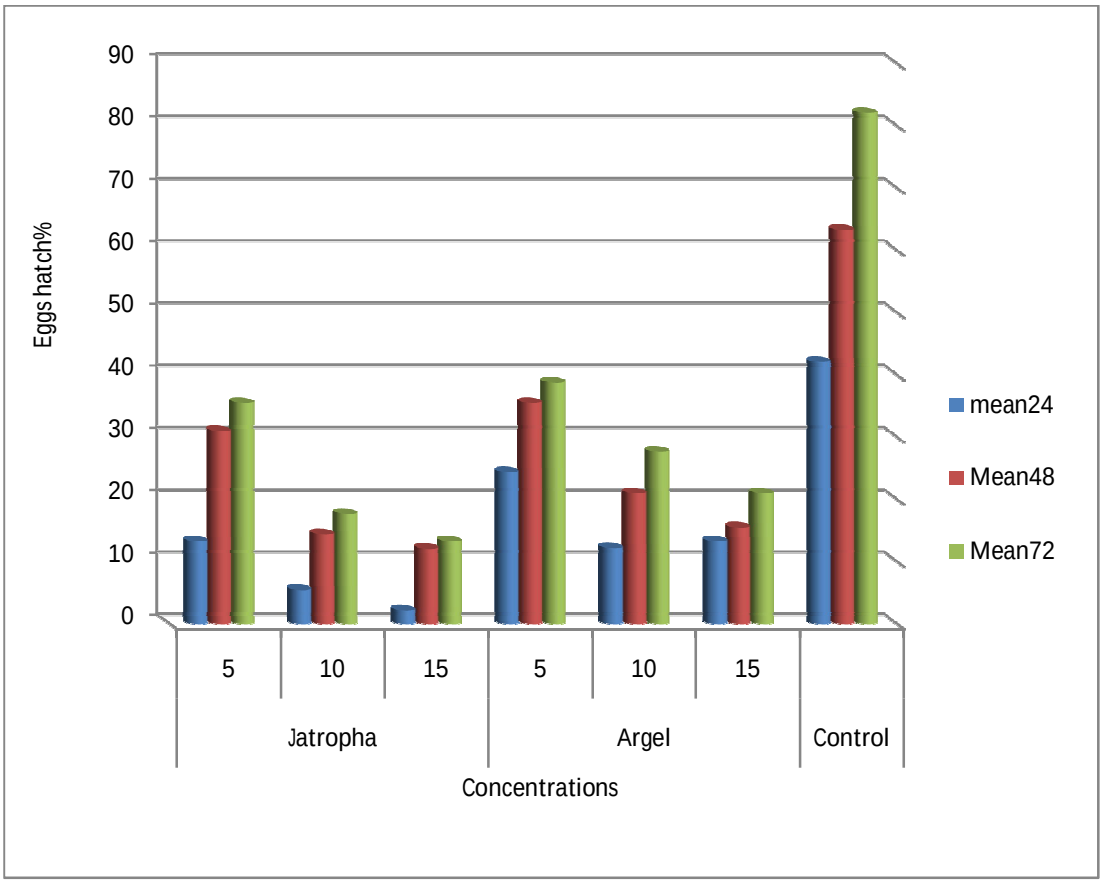

Figure 3: Effect of aqueous extracts of *J. curcas* seeds and *S. argel* leaves on hatchability of *E. insulana* eggs, after 24, 48, and 72 hrs.

4.4. Effect of aqueous extract on *J. curcas* seeds and *S. argel* leaves on the 3rd instar larval of *E. insulana,* after 24, 48 and 72 h

Table (4) and figure (4)summarizes the concentration-mortality responses of feeding SBW in 3rdinstars larvae for three days i.e. 72 hours on various concentrations of tested materials (Jatropha seed and Argel leaves). Result indicates that the mortality rates increased with the increase of the use concentration and the period after treatment. The corrected mortality percentage after 24 hours of aqueous extract of Jatropha seeds treated range from 23.3% using the lowest concentration (5%), to43.3% using the highest concentration (15%). As the aqueous extract of Argel leaves, the corrected mortality percentages ranged from 13.3 to36.6% at the lowest and the highest concentrations, respectively. The illustrated concentration-mortality of data analysis confirmed the same results as a positive relationship between the applied concentration and the mortality percentage. After 2days of treatment with aqueous extract of Jatropha seeds mortality % ranged from 26.6 to 53.3%, while, the mortality percentages 3days of treatment were increased and ranged between 50.0 to 80.0%. Nearly, the same was obtained with aqueous extract of Argel leaves, the mortality percentage. After 2 day of treatment ranged between 23.3 to 46.6% and after 3days 46.6 to73.3% in the cases of argel treatment respectively compere with standard insecticide given 100 % mortality.

Table 4: Effect of aqueous extract *J. curcas* seeds and *S. argel* leaves on the 3rd instar larval of *E. insulana,* after 24, 48 and 72 h.

Treatments	Concentration	Mean mortality		
		mean24	Mean48	Mean72
Jatropha	5%	23.3±(4.83) cd	26.6±(5.16) d	50±(7.03) c
	10%	30.0±(5.43) bc	43.3±(6.56) bc	56.6±(7.50) c
	15%	43.3±(6.50) b	53.3±(7.30) b	80±(8.90) b
Argel	5%	13.3±(3.63) d	23.3±(5.16) d	46.6±(6.38) c
	10%	16.6±(4.06) d	36.6±(6.03) c	53.3±(7.23) c
	15%	36.6±(6.03) bc	46.6±(6.83) b	73.3±(8.50) b
Standard		100.0(10.0) a	100.0(10.0) a	100.0(10.0) a
Control		0(0.7) e	0(0.7) e	0(0.7)d
ES		2.61	2.53	2.71
C.V%		13.25%	7.07%	6.98%
LSD		1.182	0.7303	0.8567

- **Means between brackets are transformed according to $\sqrt{X + 0.5}$**

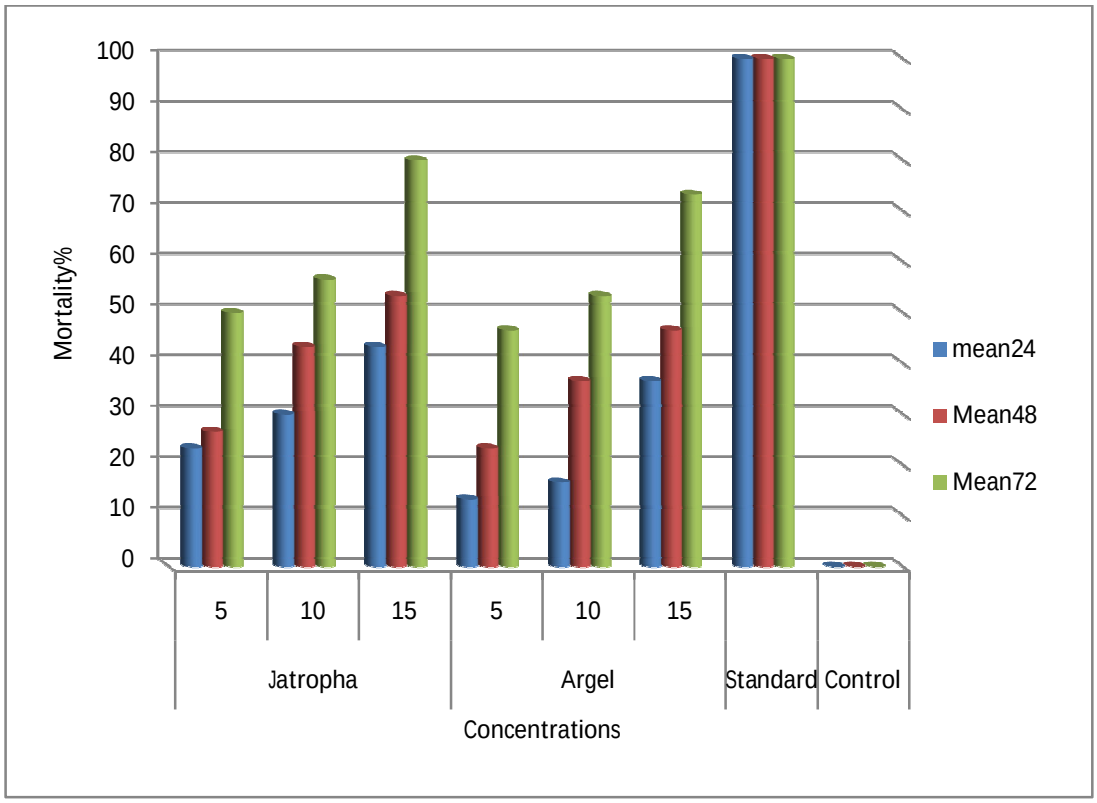

Figure 4: Effect of aqueous extract of *J. curcas* seeds and *S. argel* leaves of the 3rd instar larval of *E. insulana*, after 24, 48 and 72 h

CHAPTER FIVE

DISCUSSION

Pesticides are often considered as the most potent control agents for pests. However, continuous or heavy usage of some pesticides has created serious problems arising from factors such as, direct toxicity to man and beneficial animals such as parasites, predators, pollinators and fishes, resistance to pesticides and increased susceptibility of crop plants to insect pests (sill, 1982).

Around the world, and also in Sudan, many research studies were carried out using extracts of local plants from different groups to discover their potentials in pest control. Example of these studies are [Kani *et al*., (2012) using petroleum ether extract of Jatropha against rice moth *Corcyra cephalonica*, Hegab and Abd-ELatty (2012) using aqueous extract of Neem against spiny boll worm,Taha *et al.*, (2012) using the aqueous extract of Argel against the green pit scale insect, *Asterolicanium phoenicis* Rao , ELamin (2014) using ethanolic extracts of Coffee senna, *Cassia occidentalis* L. and Damas, *Concorpus lancifolius* Engl. against the African melon ladybird *Henosepilachna elaterii* Rossi].

In the same line , This study was conducted to test the efficacy of the Aqueous extracts and powders of Two Plants, Argel, ,*Solenostemma argel* (Del.) and Jatropha, *Jatropha curcas* L., in laboratory studies against larval mortality and egg hatchability of the Spiny Boll Worm *Earias insulana* (Boisd) (Lepidoptera : Noctuidae).

The results of the application of the powder and aqueous extract of J. *curcas* seeds indicated that, the highest concentrations of the aqueous

extract used in this study induced a high mortality percentage than the powder. These results are in agreement with those of Boateng and Kusi (2008) who stated that, petroleum ether extract of Jatropha seed oil gave high mortality after 15 day of storage, against Adult of Cowpea beetle *Callosobruchus maculatus*. Also, the present results are in agreement with those of Bashir and EL shafle, (2013) who reported that, extracts of the Jatropha seed oil at concentrations (5, 10, 15,and 20 %) caused significant mortality percentage against the 3rd nymphal instar of the desert locust *Shistocerca gregaria*.

Concerning application of Argel leaves aqueous extracts, the results showed insecticidal activity against the 3rd instar larvae of *E. insulana* for 3 days (the test period of the study). On the other hand, the application of Argel leaves powder against 3rd instar larvae of *E. insulana* showed no mortality or no significant difference than the control.

Similar to the previous tests of Jatropha, these results also indicated that, the Argel leaves aqueous extract was more effective than the Argel leaves powder at all the concentrations compared to the control, and mortality percentage increased with increase in concentration. In a set of experiments, Mahmoud *et al.,* (2015) reported that, the ethanolic extracts of *S. argel* leaves gave high mortality percentages against the 3rd instar larvae of *Trogoderma granarium*. Taha *et al.,* (2012) reported that, the aqueous extract of *Solenostemma argel* leaves increased mortality of the Adult green pit scale insect (*Asterolicanium phoenicis* Rao) and its effect was similar to the standard insecticide Actara. Also, ELkamali, (2001) reported that, the aqueous extract of leaves, flower, root and stem of *S. argel,* gave high mortality rate when tested in the laboratory for activity against the 3rd instar larvae of the mosquito *Culex quiquefasciatus.*

Generally, this study demonstrated that, the tested materials were effective in causing mortality of SBW larvae. The larval mortality increased by increasing concentrations and feeding period. Such results coincide with those of Amer (2004) who reported that, the mortality among 2 species of bollworm larvae increased by increasing either the concentration or the feeding period, using Chinmix (a Pyrethroid), Spintor, and Biorepel (Bioinsecticides) compounds against cotton boll worm in filed and laboratory.

In both tests of the present study, the standard insecticide Fastac caused 100% larval mortality of SBW larvae, compared to 80% and 73.3% mortality caused by Jatropha and Argel, respectively by highest concentration after 72 hours.

The results of the experiments on *E. insulana* egg hatchability showed that, the egg hatchability was reduced by the effects of the aqueous extracts of the two plants, *J. curcas* and *S. argel* than the powders. Significant reductions in egg hatchability of *E. insulana* revealed the harmful effects of the aqueous extracts compared with the non-effects of the powders of the two plants. This observation is in agreement with that of Khanam *et al*., (2008) who reported that, food treated with *Jatropha gossypifolia* seed extract strongly inhibited the fecundity of *Tribolium castaneum* compared with *Tribolium confusum*at doses of 8000 and 16000ppm. These results were attributed to the physico-chemical action of the compound, including piperine, caryophyllene, limonene, oleic acid, linoleic acid, menthone, menthol, α-pinene and β-pinene. Also, the present results are in agreement with that of Bashir and EL shafle, (2013) who reported that, extracts of the Jatropha seed oil at concentrations (5, 10, 15,and 20%) caused significant reduction in hatching percentage of the desert locust *Shistocerca gregaria* eggs. Also, the present results are

in agreement with those of Boateng and Kusi (2008) who stated that, petroleum ether extract of Jatropha seed oil was highly effective in reducing hatching percentage of Cowpea beetle *Callosobruchus maculatus* eggs.

Finally, the results of various studies using botanical extracts in pest control, in addition to the results of the present study, indicated that the use of the plant materials in pest control could become an important supplement to imported synthetic pesticides, especially in developing countries like Sudan. Developing more appropriate and handy methods for direct preparation of the botanical extracts at the farm level are necessary for those resource-poor farmers who have no access to commercial pesticides or cannot afford them.

CONCLUSION AND RECOMMENDATIONS

The present results indicated that, both Jatropha seeds and Argel leaves aqueous extracts showed a definite insecticidal activity on the 3rd larval instar and egg hatchability of the SBW. This study also indicates that, the aqueous extracts of Jatropha and Argel are effective than the powders and can constitute a cheaper source of active substances that could help farmers in the rural areas to control pests. The two plants are available in every part of Sudan, and preparation of water extract is very easy for farmers.

According to the results of the present study, it can be recommended that

1) The Jatropha seed and Argel leaves extracts could represent good control agents against the larvae and eggs of SBW.

2) Additional experiments should be carried out for evaluating the efficacy of these extracts against other bollworms, and other insect pests, to determine their potential when used as broad spectrum biopesticides.
3) Further studies should be conducted to determine the active ingredients of both Jatropha seeds and Argel leaves extracts.

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APPENDICES

Appendix (1) Effect of aqueous extract of Jatropha seed and Argel leaveson the 3rd larval instars of the SBW,at 24 hours.

Treatments Concs. %		Mortality%			Mean
		R1	R2	R3	
Jatropha	5%	20 (4.5)	30 (5.5)	20 (4.5)	23.3 (5.2)
	10%	30 (5.5)	20 (4.5)	40 (6.3)	30 (5.5)
	15%	60 (7.7)	40 (6.3)	30 (5.5)	43.3 (7.0)
Argel	5%	10 (3.2)	20 (4.5)	10 3.2)	13.3 (4.1)
	10%	20 (4.5)	20 (4.5)	10 (3.2)	16.6 (4.5)
	15%	40 (6.3)	30 (5.5)	40 (6.3)	36.6 (6.5)
Stander		100.0 (10.0)	100 (10.0)	100 (10.0)	100 (10.0)
Control		0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (2) Effect of aqueous extract of Jatropha seed and Argel leaveson the 3rd larval instars ofthe SBW, at48 hours.

Treatments Concs. %		Mortality%			Mean
		R1	R2	R3	
Jatropha	5%	30 (5.5)	30 (5.5)	20 (4.5)	26.6 (5.6)
	10%	40 (6.3)	40 (6.3)	50 (7.1)	43.3 (7.0)
	15%	60(7.7)	50 (7.1)	50 (7.1)	53.3 (7.8)
Argel	5%	20 (4.5)	30 (5.5)	20 (4.5)	23.3 (5.2)
	10%	30 (5.5)	40 (6.3)	40 (6.3)	36.6 (6.5)
	15%	40 (6.3)	50 (7.1)	50 (7.1)	46.6 (7.3)
Stander		100.0 (10.0)	100 (10.0)	100 (10.0)	100 (10.0)
Control		0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (3) Effect of aqueous extract of Jatropha seed and Argel leaveson the 3rd larval instars of the SBWat 72 hours.

Treatments		Mortality%			Mean
		R1	R2	R3	
Jatropha	5%	60 (7.7)	50 (7.1)	40 (6.3)	50 (7.1)
	10%	50 (7.1)	60 (7.7)	60 (7.7)	56.6 (8.0)
	15%	80 (8.9)	90 (9.5)	70 (8.3)	80 (8.9)
Argel	5%	50 (7.1)	40 (6.3)	50 (7.1)	46.6 (7.3)
	10%	60 (7.7)	60 (7.7)	40 (6.3)	53.3 (7.8)
	15%	80 (8.9)	70 (8.3)	70 (8.3)	73.3 (9.0)
Stander		100.0 (10.0)	100 (10.0)	100 (10.0)	100 (10.0)
Control		0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (4) Effect ofaqueous extract of Jatropha seed and Argel leaveson the hatchpility ofE. *insulana*egg at 24 hours.

Treatments		Egg hatchpility %			Mean
		R1	R2	R3	
Jatropha	5%	16.6 (4.1)	13.3 (3.7)	10 (3.2)	13.3
	10%	10 (3.2)	0 (0.7)	6.6 (2.6)	5.5
	15%	6.6 (2.6)	0 (0.7)	0 90.7)	2.2
Argel	5%	23.3(4.8)	33.3(5.8)	16.6 (4.1)	24.4
	10%	16.6 (4.1)	10 (3.2)	10 (3.2)	12.2
	15%	13.3 (3.7)	16.6 (4.1)	10 (3.2)	13.3
Control		33.3 (5.8)	50 (7.1)	43 (6.5)	42.1

Appendix (5) Effect ofaqueous extract of Jatropha seeds and Argel leaveson the hatchpility ofEarias *insulana*egg at 48 hours.

Treatments		Egg hatchpility %			Mean
		R1	R2	R3	
Jatropha	5%	36.6 (6.0)	26.6 (5.2)	30 (5.5)	31
	10%	20 (4.5)	13.3 (3.7)	10 (3.2)	14.4
	15%	16.6 (4.1)	13.3 (3.7)	6.6 (2.6)	12.1
Argel	5%	40 (6.3)	36.6 (6.0)	30 (5.5)	35.5
	10%	23.3(4.8)	23.3(4.8)	16.6 (4.1)	21
	15%	13.3 (3.7)	16.6 (4.1)	16.6 (4.1)	15.5
Control		60 (7.7)	80 (8.9)	50 (7.1)	63.3

Appendix (6) Effect ofaqueous extract of Jatropha seed and Argel leaveson the hatchpility of*E. insulana*egg at 72 hours.

Treatments		Egg hatchpility %			Mean
		R1	R2	R3	
Jatropha	5%	36.6 (6.0)	36.6 (6.0)	33.3 (5.8)	35.5
	10%	23.3 (4.8)	16.6 (4.1)	13.3 (3.7)	17.7
	15%	16.6 (4.1)	13.3 (3.7)	10 (3.3)	13.3
Argel	5%	43.3 (6.6)	36.6 (6.0)	36.6 (6.0)	38.8
	10%	33.3 (5.8)	23.3 (4.8)	26.6 (5.2)	27.7
	15%	20(4.5)	16.6 (4.1)	26.6(5.2)	21
Control		76.6(8.7)	86.6 (9.8)	83.3 (9.1)	82.1

Appendix (7) Effect of the powders of Jatropha seeds and Argel leaves on hatchability of *E. insulana* eggs, at 24 hours.

Treatments		Egg hatchpility %			Mean
		R1	R2	R3	
Jatropha	5%	10 (3.2)	11 (3.8)	7 (3.1)	9.3 (3.5)
	10%	11 (3.8)	13 (4.1)	10 (3.2)	11.3 (3.8)
	15%	10 (3.2)	15 (4.3)	13 (4.1)	12.6 (4.0)
Argel	5%	15(4.3)	13 (4.1)	8 (3.3)	12 (3.9)
	10%	11(3.8)	12 (3.9)	12 (3.9)	11.6 (3.9)
	15%	14(4.2)	11 (3.8)	10 (3.2)	11.6 (3.9)
Control		15 (4.3)	16 (4.5)	15 (4.3)	15.3 (4.4)

Appendix (8) Effect of the powders of Jatropha seeds and Argel leaves on hatchability of *E. insulana* eggs, at 48 hours.

Treatments		Egg hatchpility %			Mean
		R1	R2	R3	
Jatropha	5%	15 (4.3)	16 (4.5)	16 (4.5)	15.6 (4.4)
	10%	15 (4.3)	20 (4.9)	17 (4.6)	17.3 (4.6)
	15%	16 (4.5)	20 (4.9)	13 (4.1)	16.3 (4.5)
Argel	5%	22 (5.1)	18 (4.6)	15 (4.3)	18.3 (4.7)
	10%	17 (4.6)	15 (4.3)	19 (4.8)	17 (4.6)
	15%	21 (5.0)	18 (4.6)	16 (4.5)	18.3(4.7)
Control		24(5.3)	23 (5.2)	19 (4.8)	22 (5.1)

Appendix (9) Effect of the powders of Jatropha seeds and Argel leaves on hatchability of *E. insulana* eggs, at 72 hours.

Treatments		Egg hatchpility %			Mean
		R1	R2	R3	
Jatropha	5%	25 (5.5)	23 (5.2)	21(5.0)	23 (5.2|)
	10%	26 (5.5)	24 (5.3)	24 (5.3)	24.6 (5.4)
	15%	23 (5.2)	25 (5.5)	15 (4.3)	21(5.0)
Argel	5%	26 (5.5)	23 (5.2)	25 (5.5)	24.6 (5.4)
	10%	22 (5.1)	24 (5.3)	23(5.2)	23.3(5.3)
	15%	21(5.0)	24 (5.3)	23 (5.2)	22.6 (5.2)
Control		26 (5.5)	25 (5.5)	25 (5.5)	25.3(5.5)