

**Sudan University of Science and Technology**  
**College of Graduate Studies**



**The Effect of Some Plant Extracts on Mortality of the African bollworm**  
***Helicoverpa armigera* (Hübner), (Lepidoptera: Noctuidae)**

أثر بعض المستخلصات النباتية في موت دودة اللوز الأفريقية  
**(*Helicoverpa armigera*)**

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

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**July, 2015**

## الآية

قال تعالى:

ظَهَرَ الْفَسَادُ فِي الْبَرِّ وَالْبَحْرِ بِمَا كَسَبَتْ أَيْدِي النَّاسِ لِيُذِيقَهُمْ  
بَعْضَ الَّذِي عَمِلُوا لَعَلَّهُمْ يَرْجِعُونَ {

صدق الله العظيم

سورة الروم (٤١)

# Dedication

*To my Mother, Father, Brothers and Sisters*

*To my Wife and Daughters*

*To my extended Family*

*To all my Teachers, Friends and Colleagues*

*Great regard and respect*

## ACKNOWLEDGEMENTS

All praise and thanks are to Allah the Almighty who blessed me with the health and knowledge for preparation and completion of this work.

I would like to express my deep appreciation and sincere gratitude to **Dr. Abdelgadir Ahmed Osman** for his supervision and close following of this work with guidance, keen interest and sound advice during the course of the investigation.

Thanks are also due to Dr. Loai Mohammed Elamien Ahmed, acting head of the Department of Plant Protection, who helped me at probit analysis, and to all the staff of department of plant protection. My thanks are also extended to Mr. Abdelfattah Abdelkareem Nouri, Head Plant Protection Directorate, Kosti Station.

Grateful thanks are due to all my Colleagues for their assistance throughout in this study. I am also grateful to all staff members of the Plant Protection at Kosti Station for their help in various ways.

Finally, my great thanks to my family and friends who encouraged and helped me very much during the Course of this work especially Dr. Malik Elian, Elbasheer Al-Khalifa, Walleed Elamin Elhaj and Khansa AlphaHashim.

Thanks are also extended to all those who gave me hand and helped me in producing this work.

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## ABSTRACT

This study was conducted at the laboratory of Entomology, Plant Protection Directorate, Kosti Station, to evaluate the effect of hexane and ethanol organic extracts of Sakran, *Datura innoxia*, Usher, *Calotropis procera* leaves and Malathion 57% EC on mortality of the African bollworm *Helicoverpa armigera*. Four concentrations (4%,8%,12%and 16%) of each extract were prepared and tested against the second larval instar. The results showed that all tested concentrations gave significantly higher mortality percentages than that of the control. The LC<sub>50</sub> values of the ethanolic extract of Usher leaves after 24, 48 and 72 hrs of exposure were 20.5, 13.1 and 7.9 respectively, whereas those of hexane extracts were 14.3, 6.7 and 5.169 respectively. The LC<sub>50</sub> of the ethanolic extract of Sakran leaves after 24, 48 and 72 hrs of exposure were 14.1, 6.7 and 3.7 respectively whereas those of the hexane extract of Sakran leaves were 7.3, 4.7 and 2.2 respectively. These results clearly show that both ethanolic and hexane extracts of sakran leaves were more activity than their counterparts of usher leaves.

The results also show that the LC<sub>50</sub> obtained by hexane extract of Sakran leaves after 24, 48 and 72 hrs of exposure were consistently lower than their counterparts of Sakran leaves ethanolic extract. This may indicate that the active ingredient in Sakran leaves is easily extracted in hexane rather than in ethanol. The mortality results generated by the 16% concentration of hexane and ethanol extract of Sakran leaves were not significantly different from that of the standard, malathion, after 24, 48 and 72 hrs of exposure which is an indicative of the high potency of these extracts.

## الخلاصة

أجريت هذه الدراسة فى معمل الحشرات بالادارة العامة لوقاية النباتات-محطة كوستى.لتقييم أثر المستخلص الهكسينى والايثانولى لكل من أوراق السيكران و أوراق العشر على موت ديدان اللوز الافريقية. أستخدمت فى هذه الدراسة أربعة تراكيز مختلفة(٤%، ٨%، ١٢% و١٦%) من كل مستخلص ثم تم اختبارها على العمر اليرقى الثانى.

أظهرت النتائج أن كل التراكيز المختبرة أعطت نسبة موت أعلى من الشاهد و بفروقات معنوية، كما وجد أن التركيز النصفى القاتل لمستخلص أوراق العشر بمذيب الايثانول بعد ٢٤، ٤٨ و ٧٢ ساعة كانت ٢٠.٥، ١٣.١ و ٧.٩ على التوالي بينما أعطى مذيب الهكسين لأوراق العشر ١٤.٣، ٦.٧ و ٥.٢ على التوالي. كما نجد أن التركيز النصفى القاتل لمستخلص أوراق السيكران بمذيب الايثانول بعد ٢٤، ٤٨ و ٧٢ ساعة من التعرض كان ١٤.١، ٦.٧ و ٣.٧ على التوالي أما بالنسبة لمستخلص أوراق السيكران بمذيب الهكسين فكانت ٧.٣، ٤.٧ و ٢.٢ على التوالي وعليه فقد اظهرت النتائج ان تركيزات مستخلصى الهكسين والايثانول لاوراق السكران اكثر فعالية من مثيلاتها لاوراق العشر.

وأظهرت النتائج بصورة واضحة أن التركيز النصفى القاتل لمستخلص أوراق السيكران بمذيب الهكسين بعد ٢٤، ٤٨ و ٧٢ ساعة أقل من نظائره لمستخلص أوراق السيكران بمذيب الايثانول و هذا قد يشير الى أن المادة الفعالة لأوراق السيكران يتم استخلاصها بسهولة فى الهكسين من الايثانول.

واخيرا فقد أظهرت النتائج أن تركيز ١٦% لمستخلصات أوراق السيكران بمذيبى الايثانول و الهكسين أعطى نسبة موت لا تختلف معنوياً عن مبيد المالاثيون بعد ٢٤، ٤٨ و ٧٢ ساعة وهذا مؤشر على فعالية هذه المستخلصات.

# CHAPTER ONE

## 1. INTRODUCTION

African bollworm *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is a pest of major economic importance and is variously known as African bollworm, pod borer, Cotton bollworm, Corn earworm and Tomato fruit worm. It causes serious damage to many crops. High polyphagy, wide geographical range, mobility, migratory potential, facultative diapauses, high fecundity and ability to develop resistance against insecticides have enabled *H. armigera* to attain a key pest status among various major crop pests (Zalucki *et al.*, 1986. Fitt, 1989., and Torres- Vila *et al.*2002). In the Sudan, the pest is reported to attack cotton, sunflower, sorghum, maize, groundnuts, cowpea, tomato and green pepper (Schmutterer, 1969). The cotton bollworm can feed on most plant structures, including stems, leaves, flower heads and fruits at different development stages (Morsal Garcia, 2006). The damage of this pest appears when the young larvae feed on budding stages, mainly on bracts and bore into the developed seeds causing empty seeds (Du plessis and Van den Berg, 1999).

The control of both agricultural and medical insect pests in Sudan and worldwide depends mainly on the use of synthetic insecticides, but their problems are continuously increasing. Such problems include exposure of man

and animal to serious hazards, destruction of beneficial organisms in addition to their high cost. This situation has led to the search for other alternatives methods of control, particularly those of plant origin to reduce the heavy using of chemical insecticides and alleviate their hazards (Fernandez and Montagne, 1990).

The use of natural products for pests control can employ a combination of techniques which help achieve the required benefits and minimize the harmful side effects that may arise from exclusive use of synthetic pesticides. Also, botanical insecticides can break down readily in soil and environment and are not stored in plant or animal tissues. Botanical insecticides are therefore safe and can be applied by farmers and small scale industries with little cost (Georges *et al.*, 2008).

The solanaceae which represents one of the largest families in plant kingdom (>3000 spp.), is known to comprise several species with potent secondary metabolites of pharmaceutical and pesticidal importance. Such plants are recognized to possess numerous bioactive compounds including steroids, alkaloids and flavonoids (Silva *et al.*, 2005.and Singh and Kaushal,2007). Hence, new records of active Solanaceous plants are often declared in different regions (Silva *et al.*,2005.and Satti and Abdelrahman, 2008).

Among widely distributed wild solanaceous plant in Sudan are two species of Night shade or Devils apple, *Datura innoxia* Mill. And *Datura stramonium* L., which are called Sakran (Elhadi, 2002). as this local name implies, these plants generally induce toxic or narcotic effects on grazing animals, and therefore they have been used by traditional herbalists for different purposes. Generally, *Datura* species are widely distributed in different parts of the world including Mexico, U.S., Caribbean Island, India, China and Africa (Howard, 1989., Schultes and Hofmann, 1992.and Burkill, 2000). The phytochemical studies showed that *Datura* species are rich in alkaloids (*e.g.*, hyoscyamine, hyoscine, atropine, scopolamine, saponines, flavonoids, phenols, essential oils and cardiac glycosides (Gilman 1990.and Ayuba *et al.*, 2011). Thus, the insecticidal activities of these plants were documented against some pests in different parts of the world (Khaleguzzaman and Islam, 1992.and Lohra *et al.*, 2002).

The Usher tree (*Calotropis procera*) is a large shrub or small tree of 2-4 m high, with white latex and smooth, grey-green stems and a thick, soft bark. The simple and opposite leaves are 8-25 cm long, 4-14 cm wide, ovate, thick and waxy. They contain numerous small, brown and flat tenedy seeds, with long white hairs attached at one end (Weber, 2003). *Calotropis procera* is widely distributed in the Tropics of Asia, Africa and Northeast of South

America. Many authors reported the use of Usher plants in industry. It has been suggested for different commercial purposes since the beginning of this century like rubber extraction, textile and paper manufacturing (Shah *et al.*, 1981). The chemical constituents present in the aerial part of the plant include, alkaloids, cardiac glycosides, flavonoides, tannins, saponins, sterols and triterpenes (Sebier *et al.*, 1982). The latex has five crystalline bodies, calactin, calatropin, calotoxin, uscharidin and uscharin. Apparently all these are jointly responsible for the toxicity observed for this plant (Ahmed, 1974).

The objectives of this study are:

- 1-To investigate through laboratory screening the activity of ethanolic and hexane leaf extracts of *Datura innoxia* and *Calotropis procera* against 2<sup>nd</sup> instar larvae of African bollworm *Helicoverpa armigera*.
- 2- To determine the median lethal concentration (LD<sub>50</sub>) of both ethanolic and hexane extracts of each tested plant.



## CHAPTER TWO

### 2. LITERATURE REVIEW

#### 2.1 African bollworm *Helicoverpa armigera*:

##### 2.1.1 Taxonomic status:

The genus *Helicoverpa* of several species and sub species which include some of the most important insect pests of crops in the world. Common (1953) classified four Australian *Heliothis* species, which are *H.armigera*, *H.punctigera*, *H.assulta* and *H.rubrescem*. He also revealed that *H.punctigera* was widely spread while; *H.armigera* was restricted at the sea-side region. The two species were different with respect to the source of food, morphological and anatomical characters.

Hardwick (1965) divided all the species under the genus *Heliothis* in two groups: one under the genus *Heliothis* and the other under *Helicoverpa*, which consists of the following species in Africa: *H.armigera*. (Hubner), *H.assulta* (Hardwick), *H.fletchei* (Hardwick) and *H. peltigera* (Schifferrmuller), but *H. armigera* is the only species of major economic importance (Greathead and Girling 1989).

##### 2.1.2 Distribution:

The African bollworm *H. armigera* is one of the most important lepidoptera pests

of a wide range of crops throughout Africa, the Middle East, Europe, Australia, New Zealand and the Pacific Islands (Zalucki *et al.*, 1994, and Sharma, 2001). Surveys of the African bollworm, conducted in the Sudan during 1935-38 by Bedford, (1938) revealed the presence of this pest in Shambat, Meridi, Nuba Mountains, Yambio, Gash Delta, Gedarif area, White Nile and Gezira Scheme.

### **2.1.3 Morphology:**

#### **2.1.3.1 Eggs:**

Freshly laid eggs of *H.armigera* are yellowish – white, but change to dark before hatching. The eggs are sculptured in the form of longitudinal rib, the size of eggs vary from 0.42 – 0.62 mm in length and 0.40 – 0.55 mm in width (Ali *et al.*, 2009).

#### **2.1.3.2 Larvae:**

Larvae pass through six instars. First instars have black to brown head capsules and yellowish- white to reddish brown body. Second instar larvae have darker colour. Third instar Larvae are green brown in colour. As they pass through 4<sup>th</sup>, 5<sup>th</sup> and 6<sup>th</sup> instar Larvae their body colour changes according to food, and can be blue-green, yellow green, yellow, light green, pink or light brown to reddish brown. Larval size in the final instar ranges form 30 – 40 mm. in length

(Schmutterer, 1969; Mathews and Tunstall, 1994, and Nasreen and Mustafa, 2000).

### **2.1.3.3Pupae:**

Pupae range in size from 14-18 mm. in length and 4.5 – 6.5 mm in width and have

Mahogany – brown coloration with a smooth surface (Archer and Bynum, 1994.and Nasreen and Mustafa, 2000).

### **2.1.3.4 Adult**

The adult moth is about 14-18mm long and has a wing span range of 35 – 40 mm. (King 1994). Hardwick (1965) mentioned that *H.armigera* males are yellowish – olive to yellowish- grey heads and thoraces while female’s have light reddish brown heads and thoraces. The forewings are yellowish – olive in the male and dark reddish brown in the female.

### **2.1.4 Biology:**

#### **2.1.4.1The egg stage:**

Kyi and Zaluki (1991) reported that oviposition of *H. armigera* started 2-6 days after emergence, and egg laying occurred at night. Females lay eggs singly or in groups of 2-3 eggs on near the floral structure and peak egg laying occurs during

the flowering period. Moths may also lay eggs on leaf surfaces and choose hairy surface for oviposition rather than smooth leaf surface (King1994). A Single female may lay up to 3000 eggs (Shanower and Romeis, 1999). Fowler and Lakin (2001) indicated that the incubation period lasted 3-14 days, depending on temperature.

Jallow and Matsumura (2001),studied the effect of temperature on under controlled condition, using constant temperatures on development of *H. armigera* reared on tomato, and found that the egg stage lasted 3.0, 2.8, 2.6 and 2.5 days at 25.0C , 27.9 C 30.C and 35 C ,respectively. The egg incubation period took 3 days at 27C (Liu *et al.*, 2004).

Abdalla and EL-khidir (2004) studied the biology of *H. armigera* under room condition (mean of 30.5 C and 58% R.H) and showed that the mean egg incubation period was 2.6 days.

#### **2.1.4.2 The Larval stage:**

Newly hatched larvae eat the egg sheath and then wander in search for a good site to feed; preferred feeding sites include flowers, buds, bolls, fruits and leaves. King (1994) emphasized that larval development depended primarily on temperature and host plant.

In Laboratory studies, the complete larval period lasted between 12 – 36 days (Bhatt and Patel, 2002. and Fowler and Lakin, 2001). Jallow *et al.* (2001) reported that the larval stage of *H.armigera* took 19.85 days when fed on egg plant, 20-17 days on pepper, 14.50 days on maize, 14.76 days on okra and 16.20 days on tomato.

Kakimoto, *et al.*, (2003) reported that larvae duration of *H.armigera* reared at 25C

on okra, cotton, chrysanthemum, soybean, tomato and green pepper lasted for 13.0 days, 13.3 days, 14 days 13.9 days, 14.8 days and 20.7 days ,respectively.

Jallow and Matsumura (2001) studied the effect of temperature on the development of *H.armigera* Larvae reared on tomato. Total larval development averaged 3.7,2.8,2.2,2.4 and 2.0 days, respectively for instars form 1<sup>st</sup> to 6<sup>th</sup> when reared at 25 C (Archer and Bynum,1994). Investigations on *H.armigera* by Ali, *et al.*, (2009) revealed that larval period was completed through six instars, and the average duration of first, second, third, fourth, fifth and sixth instars Larvae were respectively 2.27, 2.42, 2.67, 2.83, 3.40 and 3.37 when reared on chickpea at 25 C and 65% relative humidity.

#### **2.1.4.3 The pupae stage:**

Pupation usually occurs on soil surface, and rarely occurs within a spun web on

the host plant (king, 1994). Depending on temperature, the pupal stage lasts for 6-33 days (Fowler and Laking, 2001).

Balla (1978) reported that the pupal period takes about 9 days during August and September, and up to 15.6 days during February. Schmutterer (1969) reported that the pupal stage lasted for 8-13 days. Liu *et al.*, (2004) found no much difference in the duration of the pupal stage of *H.armigera* when larvae were reared on different food. They used leaves of tobacco and fruits of cotton, corn, common bean, tomato and hot pepper; and the mean duration period were 10.14, 10.10, 9.55, 9.75, 9.35 and 9.79 days ,respectively. The pupal duration averaged 13.5, 11.1, 9.4 and 9.00 days when larvae were fed on tomato fruit at 25.0, 27.9, 30.5 and 32.5 C, respectively (Jallow and Matsumura, 2001). *H. armigera* enters facultative diapauses as pupa when larvae experience a short day photoperiod and low temperature (Shimizu and Fujisaki, 2006). Larvae also entered diapause when larvae were exposed to short day lengths and decreasing temperatures, rather than constant conditions. (Hackett and Gatehouse, 1982 and Kurban *et al.*, 2005).Moreover, Shimizu and Fujisaki, (2006) suggested that diapauses in *H. armigera* can be induced in the field mostly in response to decreasing ambient temperature. Summer diapauses during prolonged hot dry condition have been recorded in Sudan (Hackett and Gatehouse, 1982).

#### **2.1.4.4 The adult stage:**

King (1994) showed that the adult moth emerged after sunset until midnight and crawled on plants. He also mentioned that moth usually feed on nectar that are 2-5 days after adult emergence and females release a pheromone during early morning hours to attract males. Saito (1999) recorded that mating occurred 1-4 days after emergence and was strongly influenced by humidity and temperature. After a perovipostion period of 1 – 4 days females began to ovipositor in the reproductive structures of the crops (Fitt, 1989). A female may produce a maximum of 4394 eggs, but an average a female can produce 730- 1,720 eggs (CAB, 2003)

Studies conducted by Bhatt and Patel (2001) on the biology of *H.armigera* on chickpea revealed that the pre-oviposition, oviposition and post –ovipostion period were 2.8, 7.5 and 1.1 days, respectively. The average number of eggs laid by a female was 990.7 eggs. Abdlla and El- Khidir (2004) reported that the oviposition period was 8.8 days and the mean number of eggs deposited by adult reared on sunflower was 1140 eggs.

The average number of eggs oviposited by adult reared on cotton, corn, common bean, tomato and hot pepper were 708.4, 784.8, 559, 562.5 and 314.3, respectively.(Liu *et al.*, 2004). Mojeni (2008) reported that the mean number of eggs lay by on female on cotton, tomato and chickpea were 789.6, 338.2 and

829.8, respectively. According to King (1994) adult longevity ranged from 5 to 36 days and it depends on many factors including pupal weight, food supply, food quality, temperature, humidity, diseases and predators.

Longevity varied from 1 to 23 days for males and 5 -28 days for females (pearson, 1958). The average Longevity of the male was 9.15 days whereas, that of the female was 11.40 days (Bhatt and Patel, 2001). According to Akashe *et al.* (1997) Longevity was 30 40 days with females generally living 2 – 3 days Longer than males. *H. armigera* can move very easily and adult can fly up 250 Km. in search of a viable food source (Satio, 1999). Pedgley (1985) reported that *H. armigera* migrated up to 1000 Km, to reach Britain and other parts of Europe from sources in southern Europe and North Africa. Considerable mobility of *H. armigera* within the irrigation area of cotton in the Gezeira, Sudan, was suggested by Haggis (1981).

Investigations by Tripathi and Singh (1991) revealed that *H.armigera* has 2-5 generations a year in subtropical and temperate regions and up to 11 generations in tropical areas.

#### **2.1.5 Host Plants:**

*H. armigera* is a pest of many important plant families, including Cruciferae, Poaceae, Febaceae and Solanaceae; the latter including cultivated tomato. This



pest is polyphagous and is of worldwide economic importance on many agricultural and horticultural crops (Fitt, 1989).

The Larvae attack more than 60 species of cultivated and more than 90 species of wild host plants (Zalucki *et al.*, 1994). *H. armigera* is a serious insect pest of tomatoes (Hamilton and Macdonald, 1990; and Cameron *et al.*, 2001) and many other crops (Zalucki *et al.*, 1986). According to Schmutterer (1969), Twine, (1994), Jallow and Zalucki (1998), Mealzer and Zalucki (1999), Tsuyoshi *et al.*, (2003 Grundy *et al.*, (2004), Simon *et al.*, (2005), Kumari *et al.*, (2006),and Franzman, *et al.*, (2008), *H. armigera* is a major pest of the following host plants:Cotton, (*Gossypium hirsutum*), Sunflower, (*Helianthus annus* ) Tomatoes (*Lycopersicum esculentum*), Sorghum, ( *Sorghum bicolor*), Pigeon pea, ( *Cajainus cajan*) Chickpea, (*Cicer arietinum*), Maize, (*Zea mays*) Soybean, ( *Glycine max* ), Lablab been, (*Lablab purpureus*), Pepper, ( *Capsicum annum*), Ground nut, (*Archis hypogaea*), Okra, (*Abelmoschus esculentus*), Cowpea, (*Vigna unguiculata*), Beans, (*Vicia faba*), Peas, (*Pisum sativum*), Wheat, (*Triticum aestivum*), Tabaco, (*Nicotiana tabacum*) and Lucerne, (*Medicago sativa*)

#### **2.1.6 Host preference:**

*H. armigera* prefers certain host plants and appears to follow a hierarchy in food choice when host is not available (Gu *et al.*, 2001). Field studies conducted in

India over two growing seasons (2000- 2001 and 2001-2002) to examine the relative abundance of *H.armigera* on different crops including cotton, pigeon pea, chickpea, sunflower, corn and okra indicated differences in eggs and larval densities among the host plants. Eggs and larvae of *H.armigera* were found on all of the crops, but the population on pigeon pea and chickpea was significantly greater than that on cotton and others crops. Egg numbers were significantly higher on sunflower, okra and tomato than on cotton. Numbers of eggs and larvae on corn were not significantly different from those on cotton (Ravi *et al.*, 2005). Host preference, including artificial diet, has been studied in a laboratory. The results indicated that pigeon pea was the most suitable, followed by artificial diet, maize, sorghum, roselle, cowpea and marigold (Hou and Sheng, 2001). From laboratory studies, tobacco, maize and sunflower were categorized as the most preferred hosts, soybean, cotton and Lucerne were categorized as moderately preferred hosts, and cabbage, pigweed and linseed were the least preferred (Firempong and Zalucki ,1990). Tripathi and Singh (1989) studied the effect of different pulse on development of *H. armigera*, and indicated that pigeon pea was a very suitable host for development. In studies conducted by Ramnath *et al.* (1992) comparing the oviposition response to certain host plants he indicated that pigeon pea was more attractive than cotton, tomato, okra and chickpea.

Neem, (*Azadirachta indica*) proved to be an unsuitable host for *H. armigera* (Ma *et al.*, 2000). Grapevine, (*Vitis vinifera*) was also identified as an unsuitable host (Voros, 1996).

### **2.1.7 Economic importance and damage:**

The extent of damage differs according to type of plant. The adults of tomato fruit worm lay eggs on tomato foliage and soon after hatching, the second and older instars enter the fruit and feed while remaining concealed inside the fruit. Talekar *et al.*, (2006) stated that the *H. armigera* larvae can attack leaves and fruits of tomato but not the flowers due to the higher levels of proteinase in flowers.

On maize the larvae of *H. armigera* initially fed on the silk and penetrated the tips of cobs (Scholz, *et al.*, 1998), while in sorghum, larvae damaged developing grains from the milk to soft dough stages (Obopile and Mosinkie, 2007). on cotton, damage is characterized by feeding on flower buds, flowers and cotton bolls (Nibouche *et al.* 2007). In cowpeas and pigeon pea, the larvae feed on buds, flowers and bore into developing pods (Sigsgaard and Ersboll, 1999). on chickpea, larvae fed on leaves, tender shoots and young pods. Larvae make holes in pods and insert half their body inside the pod to attack the developing seeds (Abdalla *et al.*, 2007). Young larvae of *H. armigera* usually occur during the budding stages of sunflower and feed mainly in bracts (Du Plessis, 1997). In addition to feeding on a vast array of hosts (more than 180 species of plants in

over 45 families), *H. armigera* has rapidly developed resistance to insecticides (Fitt and Wilson 2000, and Yang *et al.*, 2013). Tomato fruit worm is an important pest which causes considerable losses in quantity as well as in quality of tomato fruits in different parts of the world. In Punjab, northern India, Singh and Singh (1975) reported that 30% of fruits were lost to fruit worm infestation. This pest also causes significant tomato crop loss in New Zealand, particularly in unsprayed or late season varieties (Cameron *et al.*, 2001). In southern Moravia, Czech Republic, the highest damage level in tomato was 5% (Marek and Navratilova, 1995). In Khartoum and Gezira (Sudan). Hassan (1990) and Ali (1999) reported that fruit infestation percentages in tomato crop were 11.8% and 16.5%, respectively. Torres Vila *et al.*, (2003) recorded that the yield loss caused by *H.armigera* ranged from 3% to 7% in Extremadura, south western Spain.

In Tamil Nadu, India, Selvanarayanan and Narayanasamy (2003) reported 5-55% yield losses in tomato crop caused by *H.armigera*. In Tanzania the African bollworm damage on tomatoes led to losses in quality and quantity amounting up to 50% (Maerere *et al.*, 2010).

Worldwide, annual losses from *H.armigera* on chickpea are approximately 10% equaling 300 million dollars (Shanower *et al.*, 1997, and Sidde Gowda *et al.*, 2000). Malik *et al.*,(2004), during 1997-1998 season found that infestation of *H.armigera* on cotton in Gezira scheme, Sudan resulted in a damage of 1.7% in

buds, 7.6% in flowers and 1.2% in bolls. In Queensland Australia, *H.armigera* damage accounted for 7% yield loss in cotton in spite of pest control costs of \$800/ha in 1998 (Sequeria, 2001). Field surveys conducted during 2003 in the Bacsal region showed that 83.6% of sunflower heads were infested (Horvath *et al.*, 2004).

### **2.1.8 Seasonal abundance:**

The seasonal abundance of the African bollworm is directly influenced by temperature, host sequence and host suitability. Rainfall indirectly influences seasonal abundance by inducing germination and growth of host plants. According to Balla (1981), *H.armigera* was found all the year round but it was more abundant during the period of August to October, although under natural conditions, the build –up starts as early as June on weeds that grow with the advent of the rainy season. The survival of these early populations is important for the future increase of populations during August October. Suliman *et al.* (2004<sub>a</sub>) studied seasonal abundance of *H.armigera* during season 1997, in the Rahad and Gezira Research Station farms, they reported that the first appearance of this pest in the field was in mid August of 1977 in the Rahad and Gezira Research Station Farms, respectively. At both sites, the pest was first recorded on weeds such as Tabar, (*Ipomea cordofana*). The pest invaded sorghum on 12 and 13/9/1997 in Gezira and Rahad sites, respectively and two annual generations of

the pest were recorded during the season; the first and second generations in both sites took 28 days to develop. Field surveys of the cereal lepidoptrous pests and their natural enemies conducted at Shambat area, Khartoum, Sudan during 2001-2002 indicated that the population *H. armigera* was higher in winter than in summer and autumn (Satti, 2007). Boukhris *et al.* (2007) studied the seasonal activity of *H. armigera* by sampling methods on foliage and using pheromone traps over a three year period. Two traps were located within each tomato crop in the Tunisia regions of Korpa and Manouba. Weekly catch data showed that moths were active from late May to early November and the maximum trap catch occurred in July; the largest number of eggs and larvae were observed in July, which coincided with the maximum moth activity. Field trapping conduction in Egypt showed that, the most preferred host of *H.armigera* was tomato, followed by okra and maize. The highest population density in tomato, okra and maize was recorded in August during 2005 and 2006(Salem *et al.*, 2008). The level and timing of infestations by *H. armigera* were studied in western Tanzania on maize, tomato, sorghum, cotton and chickpea. The flowering stage of these plants was attractive o the pest throughout the year. The expansion of chickpea and introduction of tomato production enabled the pest survive better during the dry season (Nyambo, 1988). Madaf and Kulkarni (2006) studied the seasonal incidence of *H. armigera* and *Spodopter litura* on chilli, (*Capsicum annum*) during autumn 2001 at Dharwad district of Karnataka. Peak incidence of

*H.armngera* eggs was recorded during September and incidence of the larvae was highest during November. During cropping period *H.armigera* egg load ranged from 1.63% to 2.22 per plant whereas, larvae ranged from 1.45 to 2.02 larvae per plant.

In India, Barihar and Singh (1986) found that larval population of *H. armigera* on tomato was 100 until the first week of February but it increased rapidly thereafter, reaching a peak in the last week of March. The seasonal incidence of *Heliothis* spp on tomato in north central Queensland was determined by rearing adults from eggs collected from March to November during 1982 and 1984. *H. armigera* was abundant from March to May, its numbers were low in June-July, and it was abundant again after July (Kay, 1989). Hazara *et al.*, (2000) studied the population dynamics of *H. armigera* on peas, tomato and apple fruits in Quetta Balochistan (Pakistan), results indicated that the insect appeared first on apple and peas and caused considerable damage on pods and apple fruits. During summer the insect was found on tomato crop with very high infestation levels. Rao *et al.*, (2001) reported that the incidence of gram pod borer in chickpea was observed at the flowering stage, 38 days after sowing (2 larvae/ 10 plants ) and the peak incidence was reported (20 larvae/ 10 plants ) in January . Survey of *H. armigra* on different plants conducted by Jadhav *et al.*, (2010) in north eastern region of Karnataka during 2004-2005 revealed that the activity of *H.armigra*

first appeared in last week of July on sunflower and cotton and remained active up to end of September. The pest was observed on pigeon pea from last week of September to January and during this period it migrated to sorghum and chickpea crops.

### **2.1.9 The effect weather on the development of *H. armigera*:**

Weather factors, especially temperature, relative humidity, winds and rainfall have great impact on the incidence and development of *H. armigera*. Tripathy *et al.*, (1999) indicated that extremely high temperatures have negative effect on *H. armigera*. Important factors that may help to increase build-up of *H. armigera* on chickpea were the relative humidity (below 70%) and low rainfall. Heavy rainfall reduced eggs by directly washing them off the plant and break down pupation chambers in the soil, preventing adult emergence (Tripathi and Sharma, 1985).

Maelzer and Zalucki (1999) reported that heavy rainfall and strong winds can reduce the population of *H. armigera* at the egg and larval stages. Correlations of weather factors and bollworm infestation on green bolls of different cotton genotypes were studied by Javed *et al.*, (2007) in Pakistan during season 2003 which showed that temperature, relative humidity and rainfall were negatively correlated with population development and infestation of bollworm. Field studies were conducted on insecticide free cotton during the season of 2003 and 2004 at Haryana Agriculture University, Hisar, India identify natural mortality



factors in the egg stage of *H. armigera*. Important factors responsible for egg mortality were identified as *Trichogramma chilonis*, strong winds and heavy rains (Kumar *et al.*, 2009).

Wagas (2010) studied the distribution of tomato fruit worm, *H. armigera* and the effect of weather factors on its population in tomato fields at different localities in Punjab province, Pakistan. The maximum larval population (5.2 larvae per plant) was recorded in Bahawalpur district with 32% fruit infestation. However the minimum larval population (1.4 larvae per plant) inflicted 14.7% fruit infestation in Rawalpindi district. Temperature was positively correlated while relative humidity was negatively correlated with the larval population and fruit infestation.

#### **2.1.10 Plant parts preferred by the African bollworm:**

Cameron *et al.*, (2001) reported that the leaves of tomato plants were more attractive than flowers or fruits as oviposition sites. Also Saouer and Causse (1993) indicated that leaves of tomato plants in the upper half of the plant were selected by *H. armigera* for oviposition. Duffield and Chapple (2001) Recommended that first fully expanded compound leaves in the upper third of the plant were to be used to determine the presence and damage by *H. armigera*.

## **2.1.11 Control:**

### **2.1.11.1 Cultural control:**

An alternative programme for management of *H. armigera* is the control of overwintering pupae through the practice of pupae busting which has been used in several cropping areas (Duffield, 2004). Ploughing the soil after harvesting increases the mortality of pupae formed in the crop land by exposing them to adverse weather conditions and natural enemies.

Hand picking of eggs larvae can be effective in small plots or when infestations were low. Negash and Abate (2002) reported that, in Ethiopia when damage in sorghum was not severe farmers shook the plant to force larvae to drop from the sorghum heads and then pick them by hand.

Avoiding planting tomato after tomato or other crops susceptible to *H. armigera* like cotton, maize, sorghum, tobacco, soybean and pigeon pea may help to reduce the buildup of *H. armigera* populations. Dobson *et al.*, (2002) suggested that crop rotation will be effective when done over large areas, because the moths can fly long distances. Trap cropping and planting repellent hosts in strips or around the field, have been widely applied. Hussain and Sheik Bilal (2007) reported that, damage to fruit by tomato fruit borer could be reduced when African marigold was planted intercropped with tomato. Intercropping of cotton with chickpea,

onion, pigeon pea and marigold in strips was reported to divert the populations of the African bollworm from cotton (Dejen and Tesfaye, 2002). Field experiments conducted during 2001 and 2002 at Kennedy, central Queensland indicated that planting of field pea *Pisum sativum* as a trap crop for chickpea reduced *H. armigera* infestation on chickpea (Grundy *et al.*, 2004).

#### **2.1.11.2 Host plant resistance:**

Since 1980, most of host plant resistance research in tomato has been carried out at the Asian Vegetable Research and Development Center (AVRDC). In 1980, an initial screening of 800 accessions of cultivated wild species of tomato for resistance *H. armigera* resulted in identification of two wild *Lycopersicon*, particularly *L. hirsutum* and *L. pennellii* that were free of *H. armigera* infestation (Talekar *et al.*, 2006).

Levels of entrapment and mortality of *H. armigera* on accessions of *L. hirsutum* and *L. pennellii* were compared with those on *L. esculentum* 24, 48 and 72h. After placement on leaflets with trichomes intact, accessions had a significantly greater number of neonates trapped after 24 and 48 and dead after 27h. Than on *L. esculentum* (Simmons *et al.*, 2004).

Selvanarayanan and Narayanasamy (2006) studied the factors of resistance of three

tomato accessions *Lycopersicon* spp against the fruit worm, *H.armigera* in comparison with a susceptible check at Annamalaigagar, Tamil Nadu, India . They found that among the factors of resistance in these accessions, ortho dihydroxy phenols, trichome density in foliage and acidity of the fruit exerted significant negative correlations on larval feeding.

Selvanarayanan and Muthukumaran (2005) reported that, the density of three types of non-glandular and two types of glandular trichomes and phenol content in the foliage, lycopene and ascorbic acid content in the fruits, were the major factors of resistance in four accessions of tomato namely, Varushandu local, Seijma Jeisei, Ac 238 and Roma against *H. armigera*, Antixenosis resistance to *H.armigera* was studied by Selevanaryanan and Narayanasamy (2003) in 10 tomato accessions selected from a germplasm of 321 accessions at Tamil Nadu, India, using free- choice and no-choice laboratory experiments. The foliage and fruits of two accessions, namely PT 4287 and hanadu local were the least preferred for feeding in both tests. In the free- choice test, these accessions were the east preferred for ovipositor. Isman and Duffey (1982) indicated that, the chlorogenic acid and major phenolic constituents of tomato foliage, as well as a phenolic-rich aqueous extract of tomato foliage inhibit early larval growth of *H. zea* when added to an artificial this insect. Waiss *et al.*, (1981) repeated that organic compounds which include flavonoids, tannins terpenoids, cyopenoid

acids and cycitols that were isolated from corn, cotton, tomato, sunflower and soybean plants, inhibit growth and activity of lepidopterous larvae.

Chhabra *et al.* (1990) studied sources of resistance in cultivars of chickpea of *H. armigera*. The result revealed that a high percentage of crude fiber, non-reducing sugars and low incidence of the pest in the cultivar of chickpea. Suliman *et al.* , (2004<sub>b</sub>) tested twenty varieties of sorghum under irrigated condition in the Rahad and Gezira Schemes , to study the effects of tannin contents on the percent damage caused by , *H. armigera* ,Wad Ahmed and Wad Akar varieties were high in content (1.1 and 1.5%, respectively) the damage inflicted was 8.2 and 8.8% ,respectively.

#### **2.1.11.3 Biological control:**

Many species of natural enemies have recorded attacking the immature stages of *H.armigera* on different host plants (Kuklinski and Borgemets, 2002; Walker *et al.*, 2005; Obopille and Mosinkie, 2007and Andrew and Myron, 2008). Over 170 parasitoids and a large number of predators were recorded in Africa, most of them from Southern and East Africa (Cherry *et al.*, 2003). A number of parasitic Hymenoptera (Trichogrammatidae and Braconidae) and parasitic Diptera (Tachinade and Phoridae) were recorded as parasites on *H. armigera*. Also several predators which prey on the eggs and young larvae of this pest, related to five insect orders, Diptera (Asilidae), Neuroptera (Chrysopidae), Hemiptera

(Miridae, Nabidae and Anthocoridae), Coleoptera (Carabidae and Coccinellidae) and Hymenoptera (Eumenidae and Formicidae) were reported in Gezira, Sudan (Herrera 1986, and Beiji and Ahmed 1997). According to Munir *et al.*, (1992) the egg parasitoid, *Trichogramma pretiosum* was introduced from Texas, USA and released in cotton fields Rahad, Gezira and New Halfa Agricultural Schemes during 1988, 198 and 1990.

Michael *et al.*, (1990) found that *Trichogramma pretiosum* was an important mortality factor of *H. armigera* eggs on tomato cultivars grown in California. This egg parasite also caused high parasitism of *H. armigera* eggs on chickpea in India (Romies and shanower, 1996), on cotton in Sudan (Munir *et al.*, 1992) and on sunflower in India (Ballal and Singh, 2003).

Mortality rates of *H.armigera* Larvae from two Braconids parasites, *Cotesia Kazak* and *Miicroplitis corceipes* were studied in processing tomato crops, and in sweet corn, Lucerne and soybeans in New Zealand. *C.kazak* was the dominant parasitoid in tomatoes and soybeans; it emerged from small *H.armigera* larvae *M. corciepes* emerged from large larvae. Death rates from parasitism of *H.armigera* larval in tomatoes was 24- 54 % in 1988 and 80% in 1996. *M.croceipes* was the most common parasitoid in Lucerne and total mortality from all parasitoids was similar to that in tomatoes while , in sweet corn low rates of parasitoids was recorded 3% ( Cameron *et al.*, 2006).

Ghadiri *et al.*, (2007) reported that, two parasitoid wasps belonging to the family Ichneumonidae were recorded on tomato from worm, *H.armigera* in Iran. These two parasitoids were *Hyposoter didymator* which was collected during 2002 and *Ctenichneumon panzeri* which was collected during 2003. Weems (1954) indicated that the Ichneumon *Diplazon Laetatorius* had a wide range of dipterous hosts; it also attacked some (Coleoptera and Lepidoptera families). Zanuncio *et al.*, (1999) reported that the parasitoids Larvae of *Nomophlia* spp. (Lepidoptera: Pyralidae) collected in Vicosa, Barzil were identified as *D. Laetatorius* and *Eiphosoma* spp. Nikam (1990) indicated that 17 parasitoides species were reared on *H.armigera* in India. Among these parasitoides the Ichneumonidae parasites, *Porizomtine comoletis* and *Eeiborus argentiopilosus* were the promising key parasitoids which parasitise 10- 80% and 1- 67% *H.armigera* larvae, respectively.

The effect of host plant on parasitism of *H.armigera* larvae by Ichneumonids parasite *H. didymator* and *Braconids C. kazak* was studied by Murray *et al.*,(2007) in a glasshouse experiment parasitism was lowest on chickpea (5.4% for *H.didymator* and 11.8% for *C.kazak*). Higher levels of parasitism (50.1– 85 %) for *H.didymator*) and (25.7 – 55.3% for *C.kazak*) were recorded in sorghum, sunflower, cotton, soybean and pigeon pea. Six parasitic of (Diptera and Hymenoptera) emerged from a total of 635 *Heliothis* spp. Larvae collected from sunflower crops in south Queensland over 3 seasons, 1997 – 1980 to 1981 –

1982. These parasitoids were *Cuohocera* spp., *Exsorista* spp, *Copsilura concinnata*, *Chelcmus* spp., *Nelelia* spp. and *pestomers* spp (Broadley,1984).

Abdalla (2003) reported that the predators recorded during 2002 – 2003 in cotton pests at New Halfa Scheme were *Chrysoperlla* spp., *Cheilomenes propinqua vicina*, *Champyllomma* spp. and *Scymuns* spp. Hassanpour *et al.*, (2011) revealed that the Larvae of *Chrysoperlla carnea*, especially the third instar Larvae, had a good predation potential in controlling *H.armigera*. *Chrysoperlla* spp. inhabits many different agroecosystems and they were tolerant to many insecticides (Wetzel *et al.*, 1991). In Kenya the main predators of *H.armigera* were *Orius thripoborus*, *Orius tantillus* and *Orius albidipenizis*. Also *Pheidole* spp and *Myrmicaria* spp were the main predators on this pest, while *Chrysoperlla* spp and Coccinellidae *Cheilomenes propinqua vicina* were less common (Van den Berg and Cock, 1993).

Lutwama and Matanmi (1988) tested a commercial preparation of *Bacillus thuringiensis* and *Baculovirus heliothis* against *H.armigera* on tomato in Nigeria. The results showed that Larvae were susceptible to both pathogens, the 0.5 kg/ha and 1.0 kg/ha application of *B. thuringiensis* gave good field control of the larvae.

A study was conducted at Gezira Research Station (GRS) and Hudeiba Research Station (HR), Sudan during seasons 2004 – 2006, to evaluate biopesticide formulations derived from *B. thuringiensis* and *Saccharopolyspora spinosa* plus



the pyrethroid, fenvalerate against the gram pod borer, *H.armigera*. Each product was tested at three rates. All treatments reduced the number of larvae and damaged pods plant and increased yield at both season and sites compared with control (Abdalla *et al.*, 2007). Predators associated with *H.armigera* on cereal crops were mainly species of Coccinellidae, Chrysopids and spiders. The parasitoids detected on *H.armigera* Larvae were *Cotesia sp* (62.9%) and tachinid fly 1.0% (Satti, 2007). Observation in India indicated that spiders (*Agropis spp.* and *Thomisus spp*) were the main predators recorded on *H. armigera* in tomato (Ravi *et al.*, 2008). Also in India Dhawan *et al.* (2009) noted that predatory bugs, coccinellids (*Coccinella septempunctata* and *Cheilomenes sexmaculata* ), *Chrysoperlla spp.* and spiders were the dominant predators of sucking pests small larvae of bollworm in cotton.

#### **2.1.11.4 Chemical control:**

Insecticides are widely used for controlling, *H. armigera* on tomato and several other crops including cotton. As a result, this insect has now developed resistance to a wide range of insecticides (Torres- Vila *et al.*, 2002 and kranthi *et al.*, 2001).

Mahadi and Ishraga (2007) evaluated 5 insecticides control of insect pests of tamato in Sennar Research Station farm during seasons 2005/06 and 2006/07. Treatment with kung Fu 5% EC at 0.15 litter /fed and Karate Zeon 10% at 0.75

litter/fed., significantly reduced leaf miners, whitefly infestation and African bollworm. Hussain and Sheikh Bilal (2007<sub>b</sub>) carried out control tests with sex insecticides against *H.armigera* on tomato during autumn season 2003 – 2004 at farmer s fields in India. Among the treatments, imidacloprid at 0.03% was most effective followed by deltamethrin and fluvalinate. The spraying on these insecticides on tomato resulted in significant reduction of larval population.

Among the new insecticide molecules evaluated against tomato fruit borer, *H.armigera* beta cyflthrin 9% SC + Imidaclacloprid 21% (at 15.75 + 36.75 g.a.i./ha) were very effective in reduction of damage caused by *H.armigera*, followed by monocrotophos 36 SL, 450 g.a.i/ha, beta cyfluthrin 25 SC 18.g.a.i/ha alnba cyhalothrin 5% EC + thiamethoxam 25 WG 15.62 + 31.25 g.a.i/ha imidacloripd 200 SL 42 g.a.i/ha , trizophos 40% ES 400bg.a.i/ha and endosulfan 35% ES 2437.5 h.a.i/ha ( Ashokkumar and Shivaraju, 2009). Ghosh *et al.*, (2010) evaluated the efficacy of spinosad 45% SC, quinalphos 25% EC, Lambda cyhhalothrin 5% EC and cypermethrin 10% EC against tomato fruit borer, *H.armigera* in field studies during two seasons ( 2006 – 2007 )at Gayespur village , West Bengal, India . They found that spinosad was effective against *H.armigera* on tomato at 73–84 gm.a.i/ha than quinalphos, Lambda cyhalothrin and cypermethrin. Spinosad at 73 – 84 gm.a.i/ha was very safe to predators (C.

*carenea* and *Menochillus sexmaculata*) associated with *H.armigera* in tomato fields.

#### **2.1.11.5 Integrated pest management:**

According to Manisegaran and Soundararajan (2010) integrated pest management (IPM) is a system that in the context of the associated environment and the population dynamic of the pest species, utilizes all suitable techniques and methods in as compatible manner as possible and maintains pest populations at level below causing economic injury.

Integrated pest management for *Helicoverpa armigera* includes the following management tools (Manisegaran and Soundararajan, 2010):

- Synchronize the sowing of cotton preferably with short duration varieties.
- Avoid continuous cropping of cotton both during winter and summer in the same area as well as ratooning.
- Avoid monocropping by growing of less preferred crops like green,black gram, Castor, Soybean and Sorghum along with cotton as border crop or alternative crop to reduce the insect infestation.
- Remove and destroy crop residues to avoid carryover of the pest.
- Avoid the use of excessive nitrogenous fertilizers.

- Judicious water management to prevent excessive vegetative larval harborage.
- Monitor the pest through light and pheromone traps.
- Apply NPV at 500LE/ha in the evening hours at 7<sup>th</sup> and 12<sup>th</sup> sowing.
- Conserve and augment the natural predators and parasitoides.
- Inundative release of egg parasite, *Trichogramma* spp. as tricho-cards at 6.25cc/ha at weekly interval, 3 times from 45 days.
- Release of egg larval parasitoid, *Chelonus blackburnii* and 10% crude sugar, 0.1% of each of tinopal and teepol.
- Discourage the indiscriminate use of insecticides particularly pyrethroids, carbamate and organophosphates.
- Use of proper insecticides which are comparatively safer to natural enemies such as endosulfan, phosalone at correct dosage and alternative different groups of insecticides for each round of spray.
- Avoid the combination of insecticides as tank mix.
- Spray any one of the following insecticides/hr. Early stage endosulfan 1 Litter/ha, maturity stage phosalone 2.5 lit, quinalphos 2 lit carbaryl 50 WP 2.5 kg and pyraclofos 1.5 lit/ha.

kumar and Kumar (2004) evaluated transgenic tomato plants, expressing a cry IAB gene from *B.thuringiensis*, to control *H.armigera* in Laboratory, green

house and field at the Proagro Research Station, Gurgaon, India during 1997 – 2000. The transgenic *Bt.* tomato plants expressing a cry Ab protein of *B. thuringiensis* were significantly less damaged by *H.armigera* than the non – transgenic control plants in the laboratory, greenhouse and field. The *Bt.* plants caused 100% mortality of the larvae.

Scholz *et al.*, (1998) tested the field effect of *H. zea* involving nuclear polyhedrosis virus (HzNPV), plus *Trichogramma brassicae* releases, *B.thuringiensis*, *Trichogramma* alone and Deltamethrin against sweet corn borer, *H.armigera* 1997 in Quessnslant. Plots treated with HzNPV + *Trichogramma* had the lowest cob damage (6.0%) followed by the *B.thuringiensis* plots (12.0%) and *Trichogramma* alone 20.2%), control plots (23.2%) and Deltamethrin Plots (53.5%).

Gupta (2007) carried out field trials at College of Agriculture, Tikamgarch (Madhya Pradesh) to determine the effectiveness of indigenous product neem leaf and kernel extract, neem oil, cow butter milk, buffalo butter milk, garlic and red pepper extract and *B.thuringiensis* with chemical pesticides against the incidence of gram pod borer, *H. armigera* on chickpea during 2001 -2004. Indigenous products garlic + red pepper (0.5, 1 %), cow butter (4 – 8%). Buffalo butter milk (8%) and, *B.thuringiensis* (0.2%) was highly effective when compared with quinalphos (0.5%) and cypermethrin (0.01%).

## **2.2. *Datura innoxia* Mill. (Datura)**

### **2.2.1 Scientific classification**

Kingdom: Plantae

Order : Solanaceae

Family : Solanaceae

Genus : *Datura*

Species : *innoxia*

Binomial name: *Datura innoxia* Mill.

Common name(s): Night shade, thorn apple, stink weed, devils apple, jimson, angels trumpet, toloache, sacred, datura, apple datura, Indian apple and devils trumpet.

Local name(s): *Datura* and Sakran.

### **2.2.2 Origin and distribution**

The origin of *datura* appears to have been in Mexico, USA and also found in India, China, and South West of the Island (Howard, 1989 and Schultes and Hofmann, 1992). There are related species in all these areas and ancient traditions of its use (Schultes and Hofmann. 1992, and Bonde, 2001). The species apparently cultivated in Africa hundreds of years ago (Burkill, 2000). Today,

devils trumpet grows throughout the tropics, and can be found throughout the world (Conklin, 1976). In Sudan, more than one species of *Datura* are distributed in different parts of the country especially along the Nile bank, Northern States as well as in Kordofan and Darfur (Braun *et al.*, 1991 and Elhadi, 2002).

### **2.2.3 Description**

*Datura* species is a shrub or woody herb, 2m in height that is often grown as an annual in temperate zones. The stems are semi woody and suffruticose in the moist tropics. In drier environments, it dies to the ground annually. The alternate leaves have petioles 3 to 7 cm long and ovate to elliptic blades 6 to 15 cm long with sinuate to irregularly toothed edges. The tubular flowers are axillaries and usually solitary. They are erect or nodding, have a five toothed calyx 5 to 7 cm long and a white, purple, or yellow corolla 8 to 20 cm long, often double in horticultural varieties. The ovoid capsule is nodding, about 3 cm in diameter and covered with stout, soft prickles 2 to 4 mm long. The capsules remain on the plant for a long period. The yellowish-brown seeds are flat, kidney-shaped, about 5 mm long, and have a small fleshy aril. *Datura* species normally have 12 pairs of chromosomes (Howard, 1989; Liogier, 1995; Burkill, 2000; Bonde, 2001 and Stevens *et al.*, 2001).

## 2.2.4 Chemical constituents

Twenty alkaloids were found in the roots of *Datura* (Elhadi, 2002). The alkaloids include hyoscyamine, hyoscine, atropine and scopolamine (Gilman, 1990).

## 2.2.5 Insecticidal activity

The insecticidal activity of *Datura* has been reported by several authors. According to Khalequzzaman and Islam (1992). Leaf extracts *D. spp* were toxic to *Tribolium spp.* and the methanol extract was the most toxic. Also, aqueous extract of the plant caused 50% mortality of Spodoptera larvae (Behera and Satapathy, 1997). Georges *et al.*, (2008), reported that *D. innoxia* Mill. (Solanaceae) compounds possess insecticidal activity (*e.g.* mosquitocidal against *Ocherotatus triseriatus* (Say) (Diptera: Culicidae), and the whitefly *Bemisia tabaci* (Genn), (Homoptera: Aleyrodidae). Yogita *et al.*, (2001) stated that *Datura spp* extracts showed significant control when used against the flour beetle *Tribolium cofusum*. Dry leaf powder of *Datura spp* at 5 and 10%w/w significantly reduced the adult emergence of *Tribolium castaneum*. Also, oviposition and development of such insects were affected (Maheshawari and Dwivedi, 1996). Oudhia(1999) studied the effect of *Datura* leaf extract on the hatchability of Blumae leaf beetle (*Chrysolina madrasae*) egg. The study recorded maximum inhibition of 57.1%. Moreover, preliminary use of extracts as



biocide caused more than 95% mortality against the larvae of *Culex pipiens* in China (Gang *et al.*, 2000).

## **2.3 *Calotropis procera* Ait. (Usher)**

### **2.3.1 Scientific classification**

Kingdom: Plantae

Order : Gentianales

Family : Asclepiadaceae

Genus : *Calotropis*

Species : *procera*

Binomial name: *Calotropis procera* (Ait.)

Common name(s): *Calotropis*, Dead Sea fruit, desert wick, giant milkweed, mudar fiber, rubber bush, rubber tree, Sodom apple and swallow-wort.

Local name: Usher.

Synonyms: *Asclepias procera* (Ait.) Andrews (1952).

### **2.3.2 Origin and distribution:**

*Calotropis procera* is native to Africa (i.e. Algeria, Egypt, Libya, Morocco, Eritrea, Ethiopia, Somalia, Sudan, Kenya, Tanzania, Uganda, Cameroon, Equatorial Guinea, Gambia, Ghana, Guinea-Bissau, Mauritania,

Nigeria, Senegal and Sierra Leone), and also found in Arabian Peninsula (i.e. Saudi Arabia, Oman and Yemen), Middle East (i.e. Iran, Palestine, Jordan ) and southern Asia ( Afghanistan, Pakistan, Nepal, India, Myanmar, Thailand and Vietnam). This species is widespread in the drier northern parts of Australia. It is mostly found in northern Queensland, Western Australia and in the northern parts of the Northern Territory. It has also become naturalized in parts of Central America, Northern South America, Caribbean, South-Western USA (i.e. California) and in Hawaii (Singhal and Kumar, 2009).

### **2.3.3 Description:**

According to Erdman (1983) the plant *C. procera* is large with broad leaf ever green, and grows abundantly in arid and semi-arid regions of the world without irrigation, fertilizers, pesticides, or other agronomic practices. Andrews (1952) described the plant as a soft wooded shrub or small tree up to 18 ft. high with a clean stem 6-8 ft. long, bark is yellow brown, thick and corky. Young parts are covered by a white tomentum, leaves are pale-green, fleshy, sessile or shortly petiolated. They are obviated, obtuse and often with a short abrupt point at the apex. Cordite at the base, 5.5-12 inch long and 1.5-7 inches broad. Flowers are in 3-10 flowered sub-umbellate, cymes arising from between the bases of the leaves on peduncle up to 3 inches long. Corolla is campanula with 5 greenish white lobes and with purple tips, 1-3 inches in diameter. Corona is purple at the top with white spurs below. Fruit is green subglobose to obliquely ovoid, 3-6 inches long with a thick spongy inflated per carp (Von, 1986).

### **2.3.4 Chemical constituents:**

Hesse and Reicheneder (1936) and Seiber *et al.*, (1982) reported that the chemical constituents in the aerial parts of *C. procera* include alkaloids, cardiac glycosides, flavonoides, tannins, saponins, sterols and triterpenes. Hesse and Ludwig (1960) reported that some sulfur containing heart poisons have been found in the latex. Sharma (1934) reported many active principles from different plant parts of *C. procera*. The latex contains calation, calotropin calotoxin, usharin, voruscharin and calotropagenin. The seed contains coroglaucigenin. Also, Garg *et al.*, (1980) reported that the resin from the latex is a mixture of triterpene esters of a lower aliphatic acid. Qudrat *et al.*, (1969) have isolated the polysaccharide from the leaves of *C. procera*.

### **2.3.5 Insecticidal activity**

According to Watt and Breyer-Brandwijk (1962) *C. procera* was reported to contain insecticidal ingredients and the leaf is used for destroying fowl lice in Senegal. The roots extracts had shown strongly positive antibiotic activity. Sharma (1983) reported that flower extract of *C. procera* has no antifeedant action against the adults of *Rhizpoertha dominica*. But two years later, the same author (Sharma, 1985) reported antifeedant action against larvae of the previous insect. Extracts of flower of *C. procera* when mixed with wheat flour and provided to first, second

and fourth instars larvae of *R. dominica* in the laboratory, larval mortality increased and adult emergence decreased as the concentration of the extract was increased from 0.1 to 1000 ppm. The youngest larvae were more susceptible than the older ones. Giridhar *et al.*, (1984) reported that *C. procera* latex had toxic effect to the larvae of *Anopheles stephensi*, *Culex fatigans*, *Culex quinquefasciatus* and *Aedes aegypti*, giving 100% mortality to eggs and larvae under laboratory conditions. Ahmed (1993) found that *C. procera* has antifeedant, repellent and insecticidal action against *Trogoderma granarium* larvae. Two fifth grams of powder of flowers, roots and leaves of *C. procera* when mixed with 20 grams of flowers, roots and leaves of *C. procera* when mixed with 20 grams of wheat seeds and provided to the first, second, third and fourth instars larvae of *T. granarium* retarded the larval development. However, water and ethanolic extracts of flower, root, and leaves showed good antifeedant effects against this insect. The leaves ethanolic extract was the most effective treatment in retarding larval development (Ahmed, 1993). Hamza (1996) found that, the ethanol extract of Usher *C. procera* leaves was able to completely deter larvae of *Henosepilachna elaterii* feeding at concentration as low as 2.5% Ethanolic extract of flowers followed the same trend but with less efficacy. This indicated that leaves are better antifeedant source than flowers.

Osman (1999) reported that Usher, *C. procera*, leaves extract had repelling, antifeedant and insecticidal actions against *Bruchidius incarnates* (Boh).

## CHAPTER THREE

### 3. MATERIALS AND METHODS

This study was conducted at the laboratory of the Entomology, Plant Protection Directorate (PPD).Kosti Station.Ministry of Agriculture, Irrigation and Forests. White Nile State.The purpose of this study was to evaluate the toxic effect of *Datura innoxia* (Datura) and *Calotropis procera* (Usher) leaves ethanolic and hexane extracts against the larvae of African bollworm *Helicoverpa armigera*.

#### 3.1 Insect rearing method:

Sixty larvae of the African boll worm were collected from unsprayed sorghum fields in Elabassya farm located south of Kosti city, and placed in plastic cages(31× 20 ×23 cm). Each cage was supplied with pieces of fresh okra pods and brought to laboratory. Larvae were transferred singly to plastic dishes (9.0 cm.indiameter.5.0 cm depth) and covered with muslin cloths (plate 1). Each larva was supplied with small pieces of okra pods. The food was renewed daily and frass discarded until they reach the pupation stage. The pupae were then transferred into plastic cages. Newly emerged adults were kept in moth's cages (plate2). Emerging moths were examined to determine their sex they were then paired, and transferred into plastic cages (31× 20× 23 cm). Each plastic cage contained 10 moths. The cages supplied with 10% sugar solution (sucrose) in

pieces of cotton in small plastic cups (5 cm in diameter and 2cm depth) to feed adults. The oviposition site was a stripe of black cloth clipped to the plastic cage cover and hanging inside it. The black cloth stripes containing the eggs were then transferred by means of a moist fine camel hair brush into Petri dishes lined with moistened filter papers to keep up the humidity. The eggs were examined daily until hatching (after 2-3days). The newly hatched larvae were transferred by using fine camel hair brush to new plastic dishes lined with filter paper and daily provided with small pieces of okra pods.

At the fourth instars stage the larvae were placed separately into new plastic dishes to prevent cannibalism. Each larva was reared on an okra pod which was cut in two parts. The development of the larvae stages was followed until pupation. The black cloth stripe and small plastic cups were replaced daily.

The rearing experiment described above was carried out under laboratory conditions (mean temperature.26 c<sup>0</sup>, RH 45%). The insects were left to multiply until a sufficient number was collected for conducting the bioassay.

### **3.2 Collection and Preparation of plant materials:**

Fresh Sakran (*Datura innoxia*) leaves were collected from river bank- Kosti area, whereas fresh Usher (*Calotropis procera*) leaves were obtained from Ellyia South

of Kosti area. The leaves were thoroughly cleaned, left to dry under shade for 7 days, crushed into fine powder and then used for extraction.

### **3.3 Extraction method:**

Extraction processes were conducted at the laboratory of the chemistry. Department of food Technology, College of Agricultural Studies, Sudan University of Science Technology (SUST), Shambat. 120 grams of each of previously prepared powder of Sakran and Usher leaves were divided equally into three parts. Each part was placed separately in a thimble and then placed in the extraction chamber of the Soxhlet extractor apparatus (plate 4), and then extracted with 500ml of ethanol (99.7%) for each sample. The extraction continued until the extract was completely colorless, and then ethanol was removed by a rotary evaporator (plate 5) in order to obtain the crude materials of Datura and Usher leaves. The same process was followed for the hexane extract.

### **3.4 Bioassay procedure:**

According to volumetric law, 4%, 8%, 12%, and 16% concentrations were prepared from each extract. 0.1% liquid soap was used in the preparation of the different concentrations of the extracts hexane used in this study. The recommended dose of malathion 57%EC was also used as Standard.

Second larval instars of the African bollworm were used in this study. Twelve



Plastic dishes were lined with filter paper and used for each extract (plate 3). Then 2 mls of the desired concentration were added to each plastic dish and rotated in such a way that an even distribution was achieved. Ten larvae were then placed in each of the treated dishes for 4 hrs. Each treatment was replicated three times in a completely randomized block design; the treated larvae were then moved into plastic dishes and covered with fresh small pieces of okra fruits for larvae feeding. Thirty larvae were used as a control and were treated with only 2ml distilled water and 0.1 % liquid soap. Mortality counts were taken and recorded 24, 48 and 72 hours after exposure.

### **3.5 Statistical and probit analysis:**

The data obtained was statistically analyzed according to analysis of variance (ANOVA) using MSTAT program, whereas Duncan multiple range tests (DMRT) were used for means separation. Results with  $P > 0.05$  were considered to be statistically significant. EPA probit analysis program (Version 1.5) was used for calculating  $LC_{50}$  values and other statistical parameters for each plant extracts.



Plate (1) Larvae rearing



Plate (2) Adults cages



Plate (3) Experiment Design



Plate (4) Soxhlet Extractor Apparatus



Plate (5) Rotary Evaporator





**Eggs**



**Larvae**



**Adult**



**Pupae**

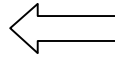


Plate (6) life cycle of African bollworm



Plate (7) *Datura innoxia*



Plate (8) *Calotropis procera*(Ait)

## CHAPTER FOUR

### 4. RESULTS

The mortality results exhibited in table (1) and figure (1) show that all tested concentrations of ethanol extract of data level gave significantly higher mortality percentages than the control after 24, 48 and 72 hrs of exposure. The data also showed that there was no significant difference in the mortality generated by the Malathion 57%EC and the highest concentration of Datura ethanol leaves extract (16%) after 24, 48 and 72 hrs of exposure which is a good indication of the effectiveness of Datura ethanol leaves extract. It was also clear that as the concentration increases the mortality percentage increases.

Table (2) and figure (2) show that all concentrations of ethanolic extracts of Usher leaves gave significantly higher mortality percentages than that of the control after 24, 48 and 72 hrs of application. The results also showed that there was no significant difference in mortality percentages among the different concentrations after 48 hrs of application. However, there was a significant difference between the mortality percentage caused by lowest concentration and the three highest concentrations and also between the lowest concentration and the two highest concentrations, after 24 and 72 hrs of exposure respectively. The malathion 57%EC gave significantly higher mortality percentage than all tested concentrations after 24, 48 and 72 hrs of exposure.

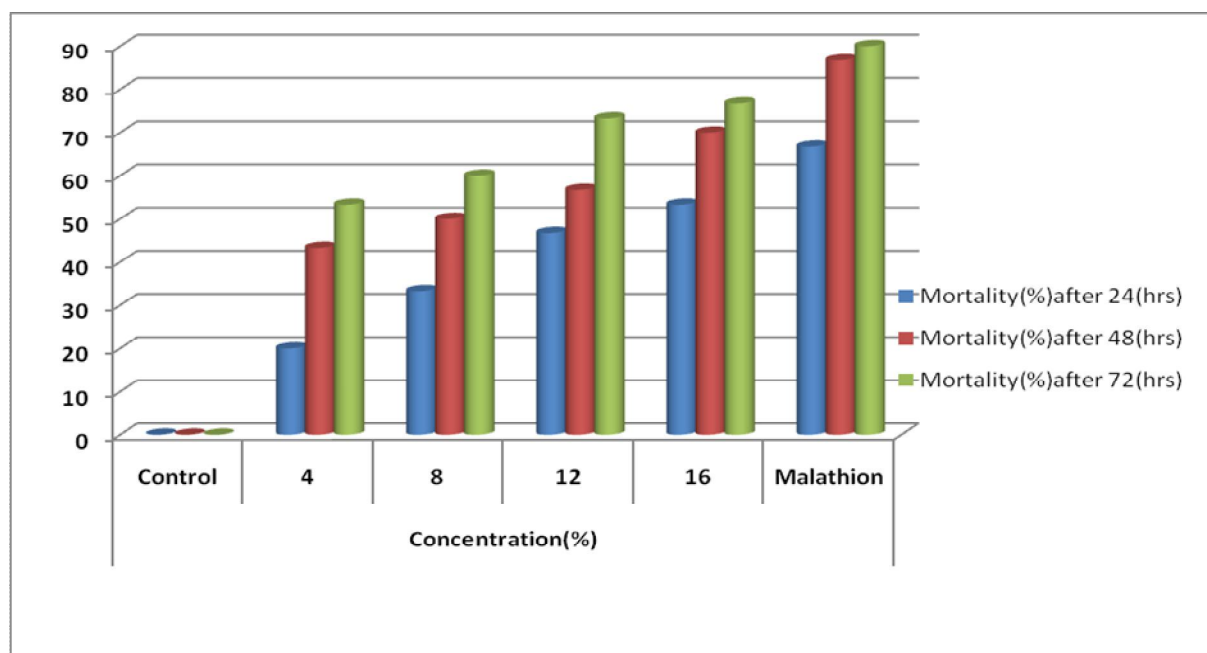
**Table1. Mortality percentage among larvae of *Helicoverpa armigera* tested with *Datura innoxia* ethanolic extract**

Conc.%	Periods(hrs)after exposure		
	24	48	72
4	20(4.4)d	43.3(6.5)c	53.3(7.3)c
8	33.3(5.8)c	50(7.1)c	60(7.7)bc
12	46.7(6.8)cb	56.7(7.5)bc	73.3(8.6)ab
16	53.3(7.3)ab	70(8.4)ab	76.7(8.8)ab
Malathion	66.7(8.2)a	86.7(9.3)a	90(9.4)a
Control	0(.7)e	0(.7)d	0(.7)d
SE±	.3755	.3847	.3751
CV%	11.72	10.09	9.13

Means  
ns

followed by the same letter (s) are not significantly different at (P<0.05).

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



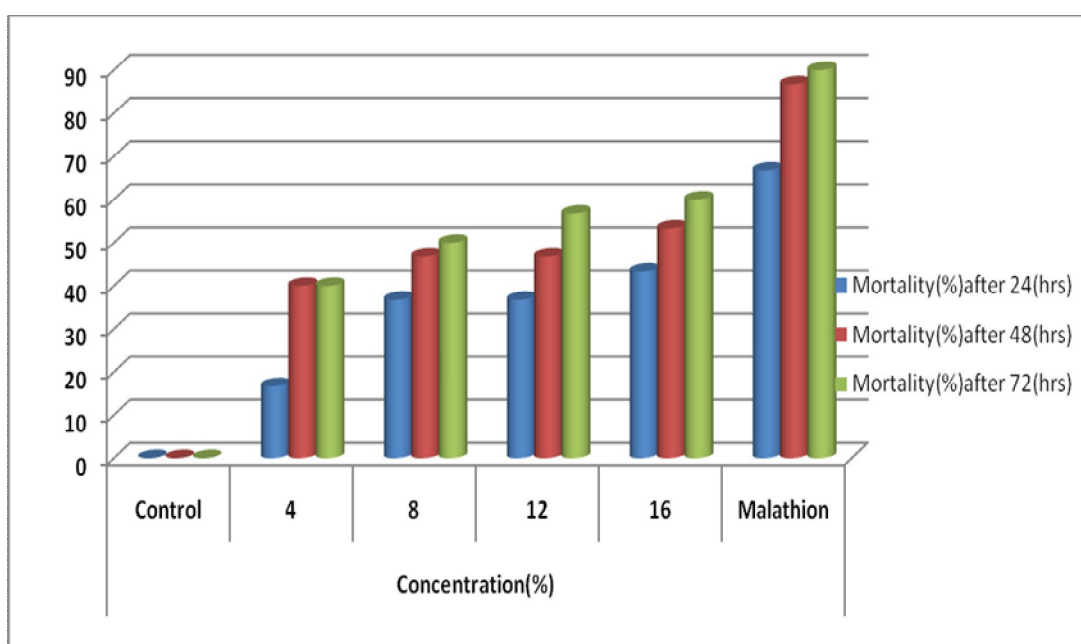
**Fig1. Mortality percentage among larvae of *Helicoverpa armigera* tested with *Datura innoxia* ethanolic extract**

**Table2. Mortality percentage among larvae of *Helicoverpa armigera* tested with *Calotropis procera* ethanolic extract**

Conc.%	Periods(hrs)after exposure		
	24	48	72
4	16.7(4)c	40(6.3)b	40(6.3)c
8	36.7(6.1)b	46.7(6.8)b	50(7.1)bc
12	36.7(6)b	46.7(6.8)b	56.7(7.5)b
16	43.3(6.6)b	53.3(7.3)b	60(7.7)b
Malathion	66.7(8.2)a	86.7(9.3)a	90(9.4)a
Control	0(.7)d	0(.7)c	0(.7)d
SE±	.4095	.3168	.3401
CV%	13.54	8.80	9.08

Means followed by the same letter (s) are not significantly different at (P<0.05).

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



**Fig2. Mortality percentage among larvae of *Helicoverpa armigera* tested with *Calotropis procera* ethanolic extract**

It is interesting to note that even the highest concentration (16%) generated less than 50% mortality after 24 hrs of exposure.

As seen in Table (3) Figure (3) all concentrations of hexane extracts of Datura leaves gave significantly higher mortality percentages when compared with the control after 24, 48 and 72 hrs of exposure. The data also showed that there was no significant difference in the mortality generated by the malathion 57%EC and the two highest concentrations of Datura leaves hexane extract (12% and 16%) after 24, 48 and 72 hrs of exposure. Generally as the concentration increases the mortality percentage increases. It is interesting to note that the highest concentration (16%) gave an equal mortality percentage to that of malathion 57%EC after 24 hrs of exposure.

As seen in Table (4) and Figure (4) all concentrations of hexane extracts of usher leaves gave significantly higher mortality percentages than that obtained by the control after 24, 48 and 72 hrs of exposure. Moreover, the mortality percentages generated by the highest concentration (16%) after 24, 48 and 72 hrs of exposure were not significantly different from the standard, similarly there was no significant difference in mortality between concentrations 12%, 16% and malathion 57%EC after 24 hrs of exposure.

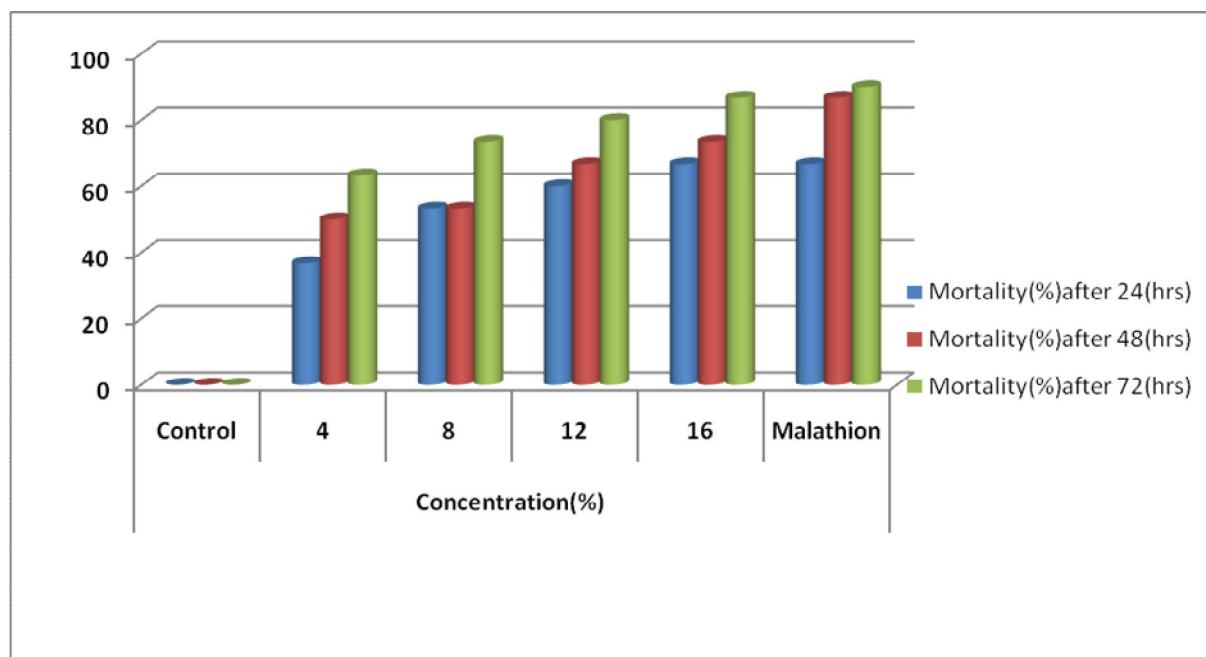


**Table3. Mortality percentage among larvae of *Helicoverpa armigera* tested with *Datura innoxia* hexane extract**

Conc.%	Periods(hrs)after exposure		
	24	48	72
4	36.7(6)b	50(7)c	63.3(8)b
8	53.3(7.3)a	53.3(7.3)cb	73.3(8.6)ab
12	60(7.7)a	66.7(8.2)abc	80(8.9)ab
16	66.7(8.2)a	73.3(8.6)ab	86.7(9.3)a
Malathion	66.7(8.2)a	86.7(9.3)a	90(9.4)a
Control	0(.7)c	0(.7)d	0(.7)c
SE±	.3838	.4524	.3406
CV%	10.19	11.42	7.86

Means followed by the same letter (s) are not significantly different at (P<0.05).

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



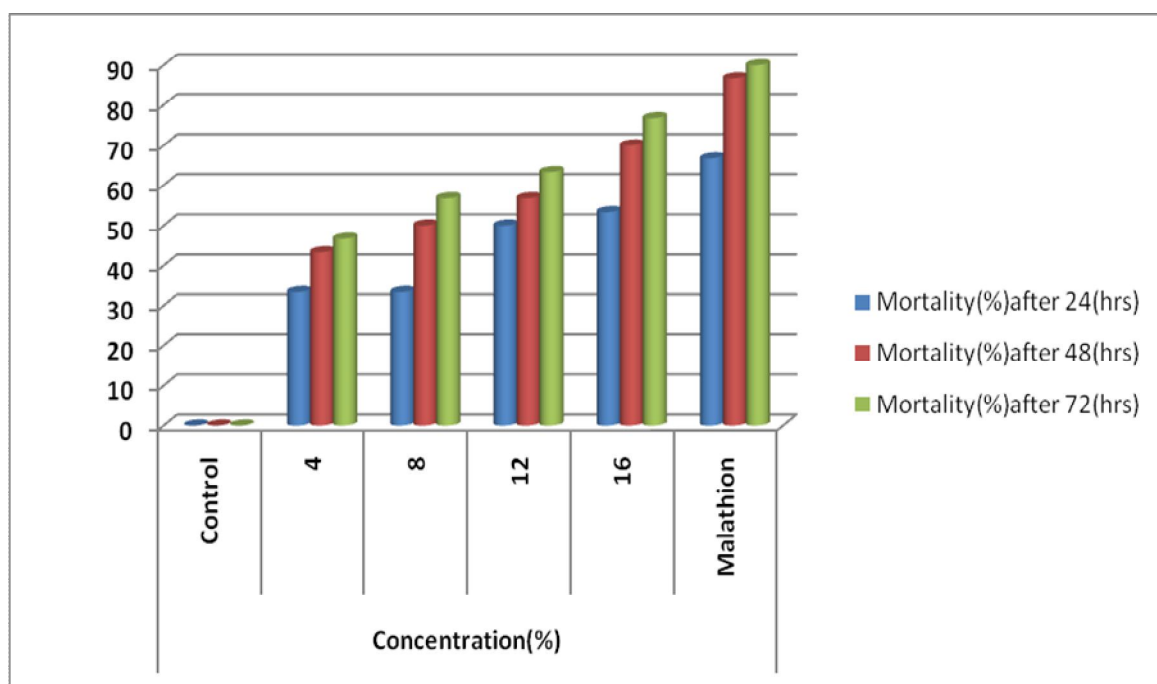
**Fig3. Mortality percentage among larvae of *Helicoverpa armigera* tested with *Datura innoxia* hexane extract**

**Table4. Mortality percentage among larvae of *Helicoverpa armigera* tested with *Calotropis procera* hexane extract**

Conc.%	Periods(hrs)after exposure		
	24	48	72
4	33.3(5.8)b	43.3(6.6)c	46.7(7)c
8	33.3(5.7)b	50(7.1)c	56.7(7.5)c
12	50(7.1)a	56.7(7.5)bc	63.3(8)bc
16	53.3(7.3)a	70(8.3)ab	76.7(8.6)ab
Malathion	66.7(8.2)a	86.7(9.3)a	90(9.4)a
Control	0(.7)c	0(.7)d	0(.7)d
SE±	.3531	.3864	.3141
CV%	10.52	10.13	7.86

Means followed by the same letter (s) are not significantly different at (P<0.05).

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



**Fig4. Mortality percentage among larvae of *Helicoverpa armigera* tested with *Calotropis procera* hexane extract**

As seen in Table (5), (6) and (7) the results showed that the  $LC_{50}$  obtained by the hexane leaves extract of *Datura* after 24, 48 and 72 hrs of exposure were consistently lower than their counterparts of the ethanolic extract. The results may suggest that the active ingredient is extracted more easily in hexane than in ethanol and hence hexane leaves extract of *Datura* stands a good chance as a source of a potential insecticide. (Move here the  $LC_{50}$  of the ethanolic leaves extract of *Datura* after 24, 48 and 72 hrs of exposure were 14.1, 6.7 and 3.7, respectively whereas those of hexane leaves extracts of *Datura* were 7.3, 4.7 and 2.2, respectively). It is interest and to note that ethanolic leaves extract of *Datura* and hexane leaves extract of *Usher* generated the same  $LC_{50}$  value after 48 hrs of exposure. The  $LC_{50}$  values of the ethanolic leaves extract of *Usher* after 24, 48 and 72 hrs of exposure were 20.5, 13.1 and 7.9, respectively whereas those of hexane extract were 14.3, 6.7 and 5.2, respectively.

The obtained results showed that all tested concentrations of both plant extracts generated higher mortality percentage compared to the control.

Table5.Probit analysis parameters of tested plant extracts against larvae of *Helicoverpa armigera* after 24 hrs

Treatments	Slope $\pm$ SE	Intercept $\pm$ SE	Chi-square	LC <sub>50</sub>
-Datura ethanolic extract	1.571	3.194	0.053	14.122
-Usher ethanolic extract	1.235	3.381	0.688	20.461
-Datura hexane extract	1.261	3.912	0.030	7.283
-Usher hexane extract	0.933	3.923	0.930	14.279

Table6.Probit analysis parameters of tested plant extracts against larvae of *Helicoverpa armigera* after 48 hrs

Treatments	Slope $\pm$ SE	Intercept $\pm$ SE	Chi-square	LC <sub>50</sub>
-Datura ethanolic extract	1.040	4.144	0.670	6.659
-Usher ethanolic extract	0.497	4.445	0.121	13.08
-Datura hexane extract	1.031	4.306	0.652	4.715
-Usher hexane extract	1.039	4.144	0.670	6.659

Table7.Probit analysis parameters of tested plant extracts against larvae of *Helicoverpa armigera* after 72 hrs

Treatments	Slope $\pm$ SE	Intercept $\pm$ SE	Chi-square	LC <sub>50</sub>
-Datura ethanolic extract	1.111	4.367	0.364	3.708
-Usher ethanolic extract	0.854	4.232	0.005	7.906
-Datura hexane extract	1.204	4.586	0.154	2.208
-Usher hexane extract	1.217	4.131	0.592	5.169

## CHAPTER FIVE

### 5. DISCUSSION

Regarding the current situation of pest control, chemical technology has expanded tremendously during the past fifty years. For example, approximately 70,000 different chemicals are currently used and released into the environment. An estimated 100,000 chemicals are used worldwide (Nash, 1993). However, the implications of such huge amount of pesticides on various aspects of the ecological lives are unpredictable. The World Health Organization (WHO, 1992) reported that roughly three million pesticide poisonings occur annually and result in 220,000 deaths worldwide. Both economically and in terms of human life, these poisonings represent an enormous threatening for society. Therefore, the searches for new environmentally friendly alternatives are justifiable.

Botanical insecticides have long been considered as attractive alternatives because they reputedly pose little threat to the environment and human health. Although, literature documenting bioactivity of plant derivatives to arthropod pests continues to expand, yet only few botanicals are currently used in agriculture, and there are prospects for commercial development of new products. It is estimated that only about 10% of the over 250,000 different plant species in the world today have been examined chemically (Farnsworth, 1990). Thus, more potential sources of plant chemicals with insecticidal properties are still exist in

Tropical Forests and need to be investigated (Jacobson and Crosby, 1971, and Chopra *et al.*, 1994).

This study was aimed to evaluate the lethal effect of organic extracts of Sakran (*D.innoxia*) and Usher (*C. procera*) leaf and malathion on mortality of the African bollworm *H. armigera*.

The two highest concentrations of Sakran leaves hexane used in this study (12% and 16%) induced high mortality percentages which were not significantly different from that of malathion. Ahmed *et al.*, (2012).found that the hexane extracts of Sakran leaves (8%) gave significantly higher mortality percentage than that of the methanol and water extracts against the cluster bug *Agonoscelis pubescens* (Thunberg). This variation in insecticidal activity of the different extracts may be attributed to the different ingredients extracted by the different polarity solvents. It is obvious that the solvents used in this study included both ethanol which is polar and hexane which is apolar. According to Javaid *et al.*, (2008) different types of compounds may be extracted from the same part of the plant when different solvents are used in the extraction process and consequently this may lead to variable activity of the extracts.

The mortality percentages generated by the (16%) concentration hexane extract of usher leaves after 24, 48 and 72 hrs of exposure were not significantly different from those generated by malathion indicating its potency. Also after 72 hrs of

exposure, the two highest concentrations of *D. innoxia* leaves ethanolic and hexane extracts (12% and 16%) induced a high mortality percentages of 73.3, 76.7 and 80% and 86.7%, respectively and both results were not significantly different from that obtained by malathion. These clearly demonstrates that the *Datura* ethanolic extract and hexane extracts are very effective against the *H. armigera* (Hubner) .According to ( Sahai *et al.*,1999) the insecticidal activity of *D.innoxia* could be attributed to its constituents which include active ingredients such as atropine alkaloid and steroids. Also, previous studies mentioned that three new withanolide glycosides, namely daturametelins H- I-J, have been isolated from the methanol extract of the aerial parts of *Datura* sp. (Ma *et al.*, 2006), and these ingredients were suggested to be responsible for the insecticidal activity of this plant. Twenty alkaloids were found in the roots of *D.innoxia* and they include hyoscyamine (leaves, roots and seeds), hyoscine (roots), atropine, hyoscyamine and scopolamine (Gilman.1990). However, the insecticidal activities of *D. innoxia* extracts could be attributed to certain active secondary metabolites in the leaves. *Datura innoxia* was found to be rich in saponins, flavonoids, alkaloids, phenols, sterols, triterpenes and tannins (Gilman, 1990; Ayuba *et al.*, 2011and Sakthi *et al.*, 2011). The deleterious insecticidal effects of different compounds were proved in literature. For instances, saponins were thought to have multiple insecticidal activities against various insects, such as feeding deterrence, moulting disturbance and increasing mortality levels (Chopra *et al.*, 1986; Oliver-Bever,

1986; De Geyter *et al.*, 2007 and Chaieb, 2010), and phenolic compounds have negative effects on insects and can decrease fertility and shortening their life span (Zivanov-Curils *et al.*, 2004 and Golawska *et al.*, 2008)

Tannins in particular may cause oxidative stress and nutrients problems (Summers and Felton, 1994). Also, the growth regulatory effects of certain Plant secondary metabolites including some triterpenoids were reported by many researchers (Schmutterer, 1985 and Mordue (Luntz) and Nisbet, 2000).

Sharma (1983- 1985), revealed that extracts of usher showed an antifedant effect on *Rhyzopertha dominica*, and also increased larval mortality and decreased adult emergence. According to Ahmed (1997), leaves, flowers and bark extract of *Calotropis procera* have promising effects against *Henosepilichna elatarii*. However, Abbassi *et al.* (2003) reported that alkaloid extract from the leaves of *C. procera* caused a considerable mortality of *Schistocerca gregaria*. Also, Ahmed (1993) reported that powder, water and alcoholic extracts Sodom apple parts (leaves, flowers and roots) reduced damage on wheat caused by the Khapra beetle (*Trogoderma granarium*) as well reduction of the beetle emergence. Also, Jahan *et al.*, (1991) reported the toxicity of leaves powder of *Calotrpois procera* against the larvae of *Tribolium confusum*. According to Ahmed (1997) in the Sudan, ethanol extracts of *Calotropis procera* leaves, flower and roots contain alkaloids, cardenoloid and tannins. Hamza (1996) found that, the ethanolic extract of usher leaves completely deter larval feeding of *H. elaterii* at concentration as low as 2.5% and response was dose related. Ethanolic extract of flowers followed that same trend but with less efficacy, which indicates, that leaves are better antifeedant source than flowers. Osman (1999) reported that



usher leaves extracts had repelling, antifeedant and insecticidal action against *Bruchidius incarnatus* (Boh).

## CONCLUSION AND RECOMMENDATIONS

The *Datura (D.innoxia)* and Usher (*C. procera*) leaves contain lethal or active compounds that could be extracted and used for controlling African bollworm *H.armigera*. However, the results obtained in this research suggest the following recommendations:

- More research is needed to confirm the present results under field conditions.
- Further studies should be conducted to determine the exact nature, mode of action and structure of the active ingredient responsible for the lethal effect.
- Further studies should be conducted to formulate these plant extracts in such a way to facilitate their application in small-scale fields.

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## APPENDICES

Appendix (a) Effect of ethanolic extract of Datura leaves on the mortality of second larval instars of the African bollworm after 24 hours.

Concs. (%)	Mortality (%)			
	R1	R2	R3	Mean
<b>4</b>	10 (3.2)	30 (5.5)	20 (4.5)	20 (4.5)
<b>8</b>	40 (6.4)	30 (5.5)	30 (5.5)	33.3 (5.8)
<b>12</b>	50 (7.1)	40 (6.4)	50 (7.1)	46.7 (6.8)
<b>16</b>	60 (7.8)	60 (7.8)	40 (6.4)	53.3 (7.3)
<b>Malathion</b>	70 (8.4)	70 (8.4)	60 (7.8)	66.7 (8.2)
<b>Control</b>	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (b) Effect of ethanolic extract of Datura leaves on the mortality of second larval instars of the African bollworm after 48 hours.

Concs. (%)	Mortality (%)			
	R1	R2	R3	Mean
<b>4</b>	40 (6.4)	30 (5.5)	60 (7.8)	43.3 (6.5)
<b>8</b>	60 (7.8)	50 (7.1)	40 (6.4)	50 (7.1)
<b>12</b>	50 (7.1)	60 (7.8)	60 (7.8)	56.7 (7.5)
<b>16</b>	70 (8.4)	70 (8.4)	70 (8.4)	70.0 (8.4)
<b>Malathion</b>	70 (8.4)	90 (10.0)	100 (10.0)	86.7 (9.3)
<b>Control</b>	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (c) Effect of ethanolic extract of Datura leaves on the mortality of second larval instars of the African bollworm after 72 hours.

Concs. (%)	Mortality (%)			
	R1	R2	R3	Mean
<b>4</b>	40 (6.4)	60 (7.8)	60 (7.8)	53.3 (7.3)
<b>8</b>	70 (8.4)	50 (7.1)	60 (7.8)	60 (7.8)
<b>12</b>	80 (9)	60 (7.8)	80 (9)	73.3 (8.6)
<b>16</b>	80 (9)	80 (9)	70 (8.4)	76.7 (8.8)
<b>Malathion</b>	70 (10.0)	100 (10.0)	100 (10.0)	90 (9.5)
<b>Control</b>	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (d) Effect of ethanolic extract of Usher leaves on the mortality of second larval instars of the African bollworm after 24 hours

Concs. (%)	Mortality (%)			
	R1	R2	R3	Mean
<b>4</b>	20 (4.5)	10 (3.2)	20 (4.5)	16.7 (4)
<b>8</b>	40 (6.4)	40 (6.4)	30 (5.5)	36.7 (6.1)
<b>12</b>	30 (5.5)	30 (5.5)	50 (7.1)	36.7 (6)
<b>16</b>	40 (6.4)	40 (6.4)	50 (7.1)	43.3 (6.6)
<b>Malathion</b>	70 (8.4)	70 (8.4)	60 (7.8)	66.7 (8.2)
<b>Control</b>	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (e) Effect of ethanolic extract of Usher leaves on the mortality of second larval instars of the African bollworm after 48 hours

Concs. (%)	Mortality (%)			
	R1	R2	R3	Mean
<b>4</b>	40 (6.4)	50 (7.1)	30 (5.5)	40 (6.3)
<b>8</b>	50 (7.1)	40 (6.4)	50 (7.1)	46.7 (6.8)
<b>12</b>	40 (6.4)	50 (7.1)	50 (7.1)	46.7 (6.8)
<b>16</b>	50 (7.1)	50 (7.1)	60 (7.8)	53.3 (7.3)
<b>Malathion</b>	70 (8.4)	90 (9.5)	100 (10.0)	86.7 (9.3)
<b>Control</b>	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (f) Effect of ethanolic extract of Usher leaves on the mortality of second larval instars of the African bollworm after 72 hours

Concs. (%)	Mortality (%)			
	R1	R2	R3	Mean
<b>4</b>	40 (6.4)	50 (7.1)	30 (5.5)	40 (6.3)
<b>8</b>	50 (7.1)	50 (7.1)	50 (7.1)	50 (7.1)
<b>12</b>	60 (7.8)	60 (7.8)	50 (7.1)	56.7 (7.5)
<b>16</b>	60 (7.8)	50 (7.1)	70 (8.4)	60 (7.7)
<b>Malathion</b>	70 (8.4)	100 (10.0)	100 (10.0)	90 (9.5)
<b>Control</b>	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (g) Effect of hexane extract of Datura leaves on the mortality of second larval instars of the African bollworm after 24 hours.

Concs. (%)	Mortality (%)			
	R1	R2	R3	Mean
<b>4</b>	50 (7.1)	30 (5.5)	30 (5.5)	36.7 (6)
<b>8</b>	40 (6.4)	60 (7.8)	60 (7.8)	53.3 (7.3)
<b>12</b>	70 (8.4)	50 (7.1)	60 (7.8)	60 (7.8)
<b>16</b>	60 (7.8)	60 (7.8)	80 (9)	66.7 (8.2)
<b>Malathion</b>	70 (8.4)	70 (8.4)	60 (7.8)	66.7 (8.2)
<b>Control</b>	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (h) Effect of hexane extract of Datura leaves on the mortality of second larval instars of the African bollworm after 48 hours

Concs. (%)	Mortality (%)			
	R1	R2	R3	Mean
<b>4</b>	60 (7.8)	60 (7.8)	30 (5.5)	50 (7)
<b>8</b>	40 (6.4)	60 (7.8)	60 (7.8)	53.3 (7.3)
<b>12</b>	70 (8.4)	70 (8.4)	60 (7.8)	66.7 (8.2)
<b>16</b>	80 (9)	60 (7.8)	80 (9)	73.3 (8.6)
<b>Malathion</b>	70 (8.4)	90 (9.5)	100 (10.0)	86.7 (9.3)
<b>Control</b>	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (i) Effect of hexane extract of Datura leaves on the mortality of second larval instars of the African bollworm after 72 hours.

Concs. (%)	Mortality (%)			
	R1	R2	R3	Mean
<b>4</b>	70 (8.4)	60 (7.8)	60 (7.8)	63.3 (8)
<b>8</b>	60 (7.8)	80 (9)	80 (5.5)	73.3 (8.6)
<b>12</b>	90 (9.5)	80 (9)	70 (8.4)	80 (9)
<b>16</b>	80 (9)	100 (10)	80 (9)	86.7 (9.3)
<b>Malathion</b>	70 (8.4)	100 (10.0)	100 (10.0)	90.0 (9.5)
<b>Control</b>	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (j) Effect of hexane extract of Usher leaves on the mortality of second larval instars of the African bollworm after 24 hours

Concs. (%)	Mortality (%)			
	R1	R2	R3	Mean
<b>4</b>	40 (6.4)	30 (5.5)	30 (5.5)	33.3 (5.8)
<b>8</b>	40 (6.4)	20 (4.5)	40 (6.4)	33.3 (5.8)
<b>12</b>	60 (7.8)	40 (6.4)	50 (7.1)	50 (7.1)
<b>16</b>	60 (7.8)	50 (7.1)	50 (7.1)	53.3 (7.3)
<b>Malathion</b>	70 (8.4)	70 (8.4)	60 (7.8)	66.7 (8.2)
<b>Control</b>	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (k) Effect of hexane extract of Usher leaves on the mortality of second larval instars of the African bollworm after 48 hours

Concs. (%)	Mortality (%)			
	R1	R2	R3	Mean
<b>4</b>	40 (6.4)	50 (7.1)	40 (6.4)	43.3 (6.6)
<b>8</b>	60 (7.8)	50 (7.1)	40 (6.4)	50 (7.1)
<b>12</b>	60 (7.8)	60 (7.8)	50 (7.1)	56.7 (7.6)
<b>16</b>	80 (9)	50 (7.1)	80 (9)	70 (8.4)
<b>Malathion</b>	70 (8.4)	90 (9.5)	100 (10.0)	86.7 (9.3)
<b>Control</b>	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)

Appendix (l) Effect of hexane extract of Usher leaves on the mortality of second larval instars of the African bollworm after 72 hours

Concs. (%)	Mortality (%)			
	R1	R2	R3	Mean
<b>4</b>	40 (6.8)	60 (7.8)	40 (6.4)	46.7 (7)
<b>8</b>	60 (7.8)	50 (7.1)	60 (7.8)	56.7 (7.6)
<b>12</b>	60 (7.8)	70 (8.4)	60 (7.8)	63.3 (8)
<b>16</b>	80 (9)	70 (8.4)	80 (9)	76.7 (8.6)
<b>Malathion</b>	70 (8.4)	100 (10.0)	100 (10.0)	90 (9.5)
<b>Control</b>	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)