Sudan University of Science and Technology

College of Graduate Studies

Role of cultural practices in management of the invasive fruit fly *Bactrocera invadens* (Drew) (Diptera: Tephritidae) in Kassala State, Sudan

دور العمليات الفلاحية في الإدارة على ذبابة الفاكهة الغازية *Bactrocera invadens* (Drew) (Diptera: Tephritidae) بولاية كسلا، السودان

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الآية

بسم الله الرحمن الرحيم

قال تعالي:

(يُّأَهَا النَّاسُ ضُربَ مَثَلٌ فَاسْتَمِعُوا لَهُ إِنَّ الَّذِينَ تَدْعُونَ مِنْ دُونِ اللَّهِ لَنْ يَخْلُقُوا ذُبَابًا وَلَو اجْتَمَعُوا لَهُ وَإِنْ يَسْلُبْهُمُ الذُّبَابُ شَيْئًا لَا يَسْتَنْقِذُوهُ مِنْهُ ضَعُفَ الطَّالِبُ وَالْمَطْلُوبُ)

صدق الله العظيم

سورة الحج الآية (٧٣)

Dedication

To my mother، father، brothers and sisters

To my extended family

To my dear wife

To all my teachers and friends with love and respect

Acknowledgements

Thanks first and lastly to Almighty Allah who gave me the ability to complete this work.

All Thanks to my supervisor Prof.Dr Awad khalaf Allah Taha, for his guidance during all the study period.

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Thank to all those who gave me hand and helped me.

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ملخص البحث

أجرى مسح حقلي لعام واحد في كل من الرملة والسبيل بالسواقي الجنوبية في ولاية كسلا لتحديد التوزيع الموسمي وخروج الحشرة الكاملة لذبابة الفاكهة الآسيوية Asian fruit fly *Bactrocera invadens* (Drew) علي الجوافة.

كما أجريت مقارنة بين كل من منطقة الرملة والسبيل في السواقي الجنوبية. وتم تصنيف لذباب الفاكهة الذي ظهر في العينات المجموعة. وتم معرفه العلاقة بين نسبة توفر ذبابة الفاكهة والعوامل الجوية. كما تمت دراسة لمعرفة أكثر أطوار نضج الفاكهة عرضة للإصابة. تم عمل تجربة لمعرفة العائل المفضل لذبابة الفاكهة.

تم دراسة لتأثير ضوء الشمس والغمر بالماء وعمق التربة على عذارى الحشرة وأيضا عمل استبيان للمزارعين في كل من السواقي الشمالية والجنوبية والشرقية.

أوضحت هذه الدراسة وجود ذروتين لتواجد أعداد هذه الحشرة في العام (واحدة خلال فصل الخريف والأخرى في الشتاء) وأقل تواجد للحشرة كان خلال الصيف.ووجد أن خروج الحشرة الكاملة كان منتظما طوال العام وأقل خروج كان في الصيف.ووجد في العينات المجموعة كل من الذبابة الآسيوية وذبابة فاكهة البحر الأبيض المتوسط بنسبة ٩٨% - ٢%علي التوالي.

وجد أن كثافة ذبابة الفاكهة يكون أكثر خلال شهور الخريف والشتاء من الصيف. وأيضا الكثافة تزيد بزيادة نسبة الرطوبة النسبية خلال الخريف والشتاء.

خلال أطوار نضج الفاكهة وجد أن الثمار كاملة النضج أكثر عرضة للإصابة بذبابة الفاكهة من تلك التي أقل نضجا وغير الناضجة. وأن ذبابة الفاكهة تفضل الجوافة ثم المانجو والبرتقال ولا توجد إصابة في الليمون.

وجد أن نسبة انبثاق الحشرة الكاملة تتناقص مع الزيادة لفترة الغمر بالماء . و وجد أن نسبة موت العذارى تزداد بازدياد فترة تعرضها للشمس كما أن نسبة الموت تتناقص كلما زاد عمر العذراء في نفس فترة التعريض. و أن نسبة انبثاق الحشرة الكاملة يتناقص عندما العمق يزداد ونوع التربة أيضا عامل مهم حيث أن الطين يعطي أقل نسبة انبثاق والرملية والطمي تعطي أعلي نسبة انبثاق.

من الاستبيان يتضح انه لا توجد جوافة في كل من السواقي الشرقية والشمالية. و الاستبيان يدعم نتائج البحث حيث أن المزارع يقوم بجمع ودفن وحرق الثمار المصابة.والقيام بالحصاد المبكر للثمار وتعريض التربة لضوء الشمس بقص الأفرع وغمر التربة بالماء بالإضافة إلى ذلك تضمن الاستبيان معلومات عن معرفة المزارع بالذبابة والعمليات الفلاحية الأخرى التي لم تذكر في الدراسة ودور وقاية النباتات في الإرشاد الزراعي.

Abstract

A one-year survey was carried out at two fields, Al-Ramla and Al-Sabil in El-sawagi El-ganobia in Kassala State to identify the Fruit determine the seasonal abundance of the Asian fruit fly *Bactrocera invadens* (Drew) on guava fruit and adult emergence of the flies. A comparison was made between Al-Ramla and Al-Sabil in El-sawagi El-ganobia and Classification the fruit fly that appears in the collected specimens. In addition, to know the relationship between relative Abundance (%) of fruit fly and climatic factors and the most susceptible fruiting stage of maturity to flies infestation. An experiment was also made to identify the most preferable host plant to fruit flies. A study on the depth that constrains the adult emergence and the effect of sun light and water flooding on the pupae was also investigated. Also, a questionnaire was made among the farmers in Al- sawagi Al-ganobia,Al- shemalia and Al-shargia.

This study revealed that, the population B.invadens flies has two peaks, one in autumn (July and August) and the other in winter (January and February), and the lowest infestation was in the summer. The emergence of the adult was found to be regular all the year, but the lower emergence percentages were in the summer. Identification of the collected specimens showed the presence of Asian fruit fly and Mediterranean fruit fly at a percentage of 98% and 2%, respectively. the relative abundance increased with the increase of the relative humidity percentage particularly during autumn and winter. Within the fruiting stage of guava, the ripe stage was found to be highly infested .and was the most susceptible stage for flies' infestation, followed by the mature and the immature stage. The fruit fly prefers guava, mango and orange and no infestation was found in lemon.

Regarding the role of cultural practices the adult eclosion decreases with the increase of flooding period. The exposure of pupae to direct sun light and heat showed that the death of the pupae increased with increase in period of exposure, and the mortality rate was found to decrease with the increase of pupae age in the same period of exposure and the percentage of adult emergence decreases when depth increased. The type of the soil was also an important factor the clay soil gave the lowest eclosion percentage while the silt and sandy soils the highest percentage of eclosion

From the questionnaire, it was shown that no guava found in Al-swagi Al-shargia and Al-swagi Al- shimalia. In addition, the questionnaire supported the results in the study. Where the farmer used of collect, burn up, bury the infested fruit, early harvesting, flooding the soil with water for long time, and cut the branch for exposure the soil to the sun light. In addition, the questionnaire included information about knowledge of the farmer with fruit fly and cultural control methods that were not mentioned in the study, and the role plant protection in the extension.

CHAPTER ONE

INTRODUCTION

Family Tephritidae, the true fruit flies, the longest family among all dipterans is consisted 4000 species assigned to500 genera. Generally the genus *Bactrocera* is the most important with about 40 pests' species (White and Elson- Harris,1992).

E.i of fruit flies includes direct yield losses and increasd the cost % control%. In Sudan many species of fruit flies were reported to cause sever economic losses to different fruit trees such as *c.capitata* and *c.cosyra*. The damage of fruit was extremely increased of the invasion of *B. invadens* to the country in 2005 (Drew et.al , 2005).

The new pest invaded all status of Sudan leading to economic losses reached 80%. Different control options to reduce the damage that fruit flies cased are applied worldwide those options include chemical control, biological control and the cultural control is the oldest methods that have been used to manage pest population, they are preventive rather than curative, it is a long term planning. In addition, they are dependent on detailed knowledge of the bio-ecology of the crop-pest natural controls, most of which, in the past, were poorly understood. The results of this method very variable, and it was often difficult to evaluate its effectiveness. Recently, after the increase of knowledge of crop producers and crop protectionists about the bio ecological relationship within the crop system and the social demanding of organic farming, world gave more attention to the cultural practices as main item in every integrated pest control program (Hill, 1989).

. In Sudan, there is very meager work to develop effective control measure for fruit flies. Due to the heavy infestation by *B.invadens* and availability of all host plants, guava, citrus and mango Kassala was selected to conduct this study.

With specific objectives

1.To investigate the role of ecological factorson the population of fruit flies. hoping to contribute in future control plans.

2. Monitor the seasonal % of percentage infestation of Fruits by fruits flies in kassala State.

3. To determine the most susceptible stage for infestation by fruit flies of guava fruits.

3. Assessment of role of some cultural practices (early harvesting, soil ploughing expose of immature insect stages to direct sunlight and water flooding to smother pupae),as control measures.

4. Assessment of collected information for possibility of a pest management approach to the control of the fly.

CHAPTER TWO

LITERATURE REVIEW

2.1 Fruit flies

2. 1.1Taxonomy

The fruit flies are a group of insects belonging to the order Diptera, family Tephritidae and sub family Dacinae. Most of the Tephritidae species, which attack fruits, belong to the genera: *Ceratitis*, *Bactrocera*, *Dacus*, *Anastrepha* and *Rhagoletis*. (White and Elison-Harris,1992).

2. 1.2 Distribution of fruit flies

The family Tephritidae is represented in all the continent regions but the major pest genera have a limited natural distribution (Drew, 1989). Thus, *Anastrepha* spp. occurs in South and Central America and the Caribbean. *Bactrocera* spp. is native to tropical Asia, Australia and South Pacific, while Ceratitis and *Dacus* are native to tropical Africa (Drew, 1989). In a few cases, species have been accidentally introduced and have become established outside these natural ranges, mainly as a result of human activity (White and Elson-Harris, 1992).

In Sudan, fruit flies *Ceratitis cosyra* were reported at Khartoum State by Venkatraman and Elkhidir, (1965). Ali (1967) found fruit flies in the Northern region (Shendi, Hudeba), Khartoum, Kassala and the southern region (Yambio, Meridi, Yei, and Juba). Now they are wide spread in Sudan, occurring in all regions of fruits and vegetables.

Deng (1990) stated that *Ceratitis cosyra* has been recorded in Khartoum, while Bieje (1996) recorded it from Kassala *C. capitata* and *C.cosyra*.

2.1.3 Damage caused by fruit flies

The greatest damage of fruit started with the ovipuncture made by the sharp long female ovipositor. The larvae tunnel in the fruit and gradually destroy it. Usually, in association with bacteria and fungi rotten fruit are also attacked by the dried fruit beetle *Carpophilus hemipterus* L. and the small flies *Drosophila melangaster* (Schumtterer, 1969and Deng,1990).

2.1.4 Biology and life cycle of Fruit Flies

Adult fruit fly' females lay their eggs beneath the skin of suitable hosts, especially in physiologically mature, ripening or ripe fruits. The eggs are laid depend on the fruit fly species and the host plant attacked. The eggs are laid singly or in a cluster. Some species such as *C. capitata*, and several *Anastrepha* and *Rhagoletis* species, have been shown to use oviposition deterrent pheromones to signal their co-specifics that the fruit has been already attacked (Averill and Prokopy, 1989). The hatching larvae shed their skins twice as they feed and grow, and the third instars larva emerges from the fruit and drops to the ground. The larvae of most fruit feeders can jump along the ground to find suitable sites for puparia. At the completion of the third instars, the larval skin hardens to form pupation with inactive fourth-instars larvae inside (Christenson and Foote, 1960). Eventually the larva within the puparium sheds its skin, forms a pupa, from which the adult will later emerge. The emerging adults tend to crawl upward through the soil usually at an angle. They make use of cracks and crevices that lead to the surface, especially when the soil is hard and compact (Christenson and Foote, 1960).

2.1.5 Host plants

In Sudan, Venkatraman and Elkhidir in (1965) first reported fruit fliesC.cosyra on eggplant (*Solanum melongena*) and guava (*Pisidium* sp.).

The med fly has been recorded as pest for the first time in different part of the world in early 20th century or late 19th century (Back and Pembberton, 1918).This pest attacks more than 260 different fruits, flowers, vegetables and nuts. Thin shrink, ripe, succulent fruits are preferred. The med fly is known to attack over than 300 different hosts, primarily temperate and subtropical fruits (Liquido *et. al.,* 1994). These include guava, apple, banana, date palm, okra, orange, papaya, peach, eggplants, tomato, cucurbits, Peach, citrus apricot, persimmon, pear, plum apple and a number of tropical citruses (Schmutterer, 1969).

Most of fruit-infesting tephritids are polyphagous. Liquido, *et. al.,* (1994) reported 353 plant species as hosts or potential hosts for this pest. Its close relatives, *C. cosyra* and *C. rosa* have fairly wide host range in Africa. Although *C. cosyra* is primarily considered to be a pest of mango, the host range of *B. cucurbitae* is primarily cucurbits.Among the fruit flies found in Sudan, *C. capitata* and *C. cosyra* are considered as devastating pests to fruit trees: mango, guava, and citrus all over the country especially at Shendi, Senga and Sennar beside The new species *Bactrocera invadens* which was reported from Blue Nile areas (Drew, *et. al.,* 2005).

2.1.6 Effects of ecological Factors on Biology and Behavior of frouit flies

2.1.6.1 Temperature

The development of the immature stages of tephritids is possible under temperature range of 10-30°C. A temperature of 45°C is the upper limit for a few hours of survival of all stages of flies (Bess, and Harmamoto, 1969). The role of temperature as determinant of abundance in tephritids is mediated either directly or indirectly through its effect on rates of development, mortiality and fecundity (Clark, 1957).

2.1.6.2 Moisture

Moisture is an important factor for the determination of abundance of tephritids and there is a high correlation between rainfall and the peak number of fruit flies recorded each year. However, Vargas (1983) found a negative correlation between total monthly rainfall and the number of *C. capitata* and stated that tephritids were rarely found in extreme dry parts of the world. This might be due to a limitation on the distribution of their host plants, rather than on the capacity for physiological adaptation. Shoukry and Hafiz (1979) reported that the effect of relative humidity percentage on the pupal duration had no significance, while the percentage of adult emergence was found to be high at 60% and low at 30% relative humidity.

2.1.7 Control Methods

2.1.7.1 Chemical control

The chemical or the insecticidal methods of control of fruit flies fall under three main categories: these are spraying the adult flies with suitable insecticides, trapping of the adult flies by means of chemical attractants, and bait spray that in essence consists of an insecticide mixed with bait (Narayanan and Batra, 1960).

2.1.7.2 Biological Control

2.1.7.2.1 Parasitoids

Bess, *et.al,* (1961) realized that thirty-two species of natural enemies were introduced to Hawaii between 1947 and 1952 to control the fruit flies. These parasitoids lay their eggs in the eggs, maggots or pupae of fruit flies and emerge during the pupae stage. Only three, *Opius longicaudatus* var. *malaiaensis* Fullaway, *O. vandenboschi* Fullaway, and *O. oophilus* Fullaway, have become abundantly established and are primarily effective on the oriental and Mediterranean fruit flies in cultivated crops.

Out of over 40 parasitoid species collected from Africa, only a few were used to control. *C capitata*. Three of these belong to the order Hymenopterous in family Braconidae (*Psyttalia concolor*, *P.humilis*, *Dichasmimorapha fullawayi*).

Two species belong to the family Eluphidae (*Tetrastichus giffardianus*, *Tetrastichus dacicida*, two belong to family Chalcididae; *Dirhinus giffardi*, *Dirhinus anthracica*, and one species belong to the family Diarpriidae; *Coptera silvestrii*) Lux,*et.al.,* (2003).

Dichasmimorapha longicaudata (Ashmead) and *Opius fletcheri* (silvestri) were recorded by Liquido,*et.al.,* (1994) as parasitoids associated with *Bactrocera latifrons*. Studies by Bautista *et.al .,*(1998) on the parasitism aspects of *Biosteres arisanus* (Sonan) (*Opius oophilus* Fullaway) (Hymenoptera:Braconidae) on the oriental fruit fly, *Bactrocera* (=Dacus) *dorsalis* (Hendel) revealed that the rate of parasitisation by *B. arisanus* increased with host clutch size reaching a plateau at 20/ one host egg to female parasitoid ratio.

Opiine braconids were reared from *C. anonae*, *C. cosyra*, *C. fasciventris* and *C. rosa* (Copeland,*et.al.,*2006). Mohamed,*et.al.,*(2006) reported that *Testrastichus giffardii* (Silverestri) (Hymenoptera: Eluphidae) is a gregarious, kinobiont, larval-pupal endo-parasitoid of many fruit fly species. *Tetrastichus* species exploit their host using their ingress and sting strategy, where the female parasitoid enters the fruit and parasitize the fruit fly larvae. Mohamed *et.al.,* (2006) proved that *T.giffardii* is not an egg parasitoid as suggested by Silvestri (1914).

El-Heneidy, *et.al.,* (2001) revealed eight hymenopteran parasitoids in Egypt; *Cyrtoptyx latipes* R., *Cyrtoptyx sp*., *Eupelmus sp*., *Eurytoma sp*., *Eurytoma martelh* M., *Macroneuva sp*., *Pnigalio agraules* W. and *Opius* *concolor* S. were reported from immature stages of the olive fruit fly (larvae and pupae).

2.1.7.2.2 Predators

Some predators of the families Staphylinidae, Carabidae, Chrysopidae and Pentatomidae and a few mites were known to attack tephritids (Bateman, 1972). The efficiency of two earwigs as predators of *B. dorsalis* (Hendel) in Hawaii has been studied by Marucci (1955). However, the authors stated that ant predation could be important only in localized areas and were not adequate to regulate med fly populations.

Combination of sterile flies and the braconid parasitoid *Psyttalia fletcheri* (Silvestri) produced great reduction in population of melon fly in Hawai (Vargas, 2004).

2.1.7.2.3 Fungi

Fungi of the genera *Penicillium*, *Serratia* and *Mucor* are reported to cause considerable larval and pupal mortality in *B. dorsalis* (Newell and Haramoto, 1968). A recent study by Ekesi *et.al,* (2002) revealed that some isolates of *Metarhizium anisopliae* (Met.) and *Beauveria bassiana* (Bals.) resulted in a significant reduction in adult emergence of *C. capitata*, *C. cosyra* and *C. fasciventris*.

2.1.7.2.4 Bacteria

Bacillus thuringiensis (Berliner) sub species *darmstadiensis*, when mixed into a diet of protein and sugar, was found to kill *Anastrepha ludens* (Loew) in Guatemala (Martinez *et.al.,* 1997).

2.1.7.2.5 Nematodes

C. capitata was susceptible to the Mexican strain of the entomopathogenic nematode *Steinernema feltiae* (Filipjevi). Emerging adults and pupae were not susceptible to the nematode, but the third instars (prior to pupating in the soil) suffered high mortalities (50-90%) when exposed to high nematode concentrations (150,000 - 500,000 nematodes/cup) (Lindegren, *et.al.,* 1990). On other hand, Lindegren ,*et. al.,* (1990) ported that the field exposure of mature larvae to a dose of 500 nematodes/cm2 yielded high mortality of *C. capitata* .

2.1.7.2.6 Other Natural Enemies

The Lizard, *Anolis grahami* Gray (Sauria: Iguanidae) was introduced from Jamaica to Bermuda for control of fruit flies, though its role in controlling the pest has not been evaluated (Clausen, 1987). Birds and rodents were reported to consume infested fruits resulting in a high level of larval mortality (Drew, 1987).

2. 1.7.3 Cultural control

Cultural control includes several practices, such as those below, may be regarded as part of the normal production system.

2.1.7.3.1Cleaning of orchards

The collection and destruction of fallen, damaged and overriped fruits is strongly recommended to reduce the resident population of fruit flies. To eliminate or reduce the reservoir of the resident population of fruit flies, field sanitation should be the essential component in the control programs (Allwood, *et, al.,* 2001).

The cleaning of the fruit orchards from other crop residues such as fallen, over-ripe or damaged fruits may be done by deep burying to a depth of more than 50 cm. putting crop residues and fallen leaves in compost. Addition of lime is also recommended by the previous study. Ronald (2007) and Vincent, (2004) stated that, the most effective practice in fruit fly control is field sanitation. It is concerned primarily with the destruction of all unmarketable and infested fruit and disposal of crop residues immediately after harvest.

In Sudan, Abbas (1998) recommended, cleaning of the orchards from infested and dropped fruits must be practiced to minimize the next season infestation by the fruit flies. The cleaning of orchards or field sanitation terms should include the removal of other plants that can act as fruit fly alternative hosts.

2.1.7.3.2 Ploughing

Ploughing inside orchards is adopted to improve soil physical conditions and facilitate plant root nutrition. This practice is found to contribute positively to the control of fruit fly, since the pupation of the flies mainly occurred in the soil. A series of laboratory experiments were carried out to investigate the fruit flies pupation habitats. It was mostly concluded that the larvae of the flies showed a strong preference toward pupating in shaded rather than bright areas, in moist rather than dry soil, and in soil with larger particle sizes. (Ali, 1967, Abbas, 1998, and Alyokhin *et al.,* 2001). Findings of above mentioned anthers confirmed that, ploughing practice may control the fruit flies population, where a group of different age of pupae may be exposed to sun light, heat and natural enemies, leading to their death.

2.1.7.3.3 Irrigation

The flooding of orchards with water for different periods of hours was found effective in controlling the Mediterranean fruit fly population as it impeded the pupae eclosion and adult flies' emergence. The applicability of this cultural practice in fruit orchards is quite possible from time to time to control fruit flies pupae in the soil (Abbas, 1998). Laboratory studies to investigate the mortality rate of fruit flies pupae at different ages subjected to different periods of water immersion in different types of soil, showed high mortality rate in young pupae (1-4 days old) than the oldest pupae (5-7 days old). In the heavy clay soil 6 hours of water immersion impeded the eclosion of 75% of the pupae while, 12 hours gave the same result in the sandy and silt soil (Abbas, 1998and Yokoyama, 2007).

2.1.7.3.4 Pruning

Pruning which usually carried out to shape trees and open up the centers, allowing free movement of air and sunlight into the tree .This facilitates the control of pests and diseases. The ability of sunlight to penetrate the tree enhances the colour of the fruit and improves quality (Poffey and Owens, 2006).

2.1.7.3.5 Early harvesting

The term early harvest means; harvest of the fruits at full physiological maturity and before ripening, and harvest of the fruits before pest expectant outbreak. The ripe fruits of mango, guava and citrus were found to be more susceptible to fruit fly infestation than the mature or immature fruits (Abbas, 1998 and Ahmed, 2001).

2.1.7.3.6 Production at time of low fruit fly abundance

Fruit fly activity and population vary throughout the year. The seasonal abundance data is also varying within genus, specie and area of production. The time of production at low flies population could be practiced by cropping of early maturing varieties before flies peaks of population, or late mature after the lowering of insect population. Alterations in planting date and harvesting date can frequently resulted in plants escaping from damaging pest (Ferro, 1996). In Sudan, Baladi variety of mango mature in April and May that makes this variety avoids the flies' infestation.

2.1.7.3.7 Use of trap crop

Crop monocultures often damaged more severely by fmily than when the same crop is grown in an area with other crops. However, there are cases where such diversity can aggravate pest problems. (Ronald,2007) reported that one of the effective cultural methods for controlling *B. cucuribitae* is planting of trap crops knowledge).

2.1.7.4 Sterile Insect Technique (SIT)

The sterile insect technique (SIT), is a more ecologically acceptable control measure, but this approach is complicated and very expensive (Bateman, 1972). SIT may not work as a sole control strategy, particularly when the population density of the fruit flies is high (Knipling, 1992) and perhaps more importantly, when several species co-exist. On the other hand, the use of the SIT may not be compatible with grower requirements, because sterile females will continue to oviposit and damage fruits, even if the eggs were not viable (Vargas. 2004). Furthermore, SIT for control of *C. cosyra, C. rosa, C. fasciventris,* and *C. anonae* is currently not possible because no appropriate methods for mass production of these species have been developed.

2.1.7.5 Area Wide Management and IPM

In Hawaii, an area wide management program was inaugurated in 1999 using environmentally sound strategies such as field sanitation, male annihilation with male lures and attractants, protein bait sprays/traps, augmentative releases of biological control agents (*Fopius arisanus* (Sonan) and *Psyttalia fletcheri* (Silvestri) (Hymenoptera: Braconidae), and sterile insect release. This has proved to be economically viable, environmentally sensitive, sustainable, and has suppressed fruit flies below economic thresholds with the minimum use of organophosphate and carbamate insecticides (Vargas, 2004, and Klungness *et.al.*, 2005). An Integrated Pest Management (IPM) program that used field sanitation, protein bait applications, male annihilation, release of sterile flies and parasites reduced fruit fly infestation from 30 - 40% to less than 5%, and cut organophosphate pesticide use by 75 - 90% (Vargas, 2004). Area wide management program was implemented successfully in Mauritius for combating five species of fruit flies.

CHAPTER THREE

MATERISLS AND METHODS

3.1 Experimental site

This study was carried out at Elsawagi Elganobia, inkassala state, Sudan lies between latitude 15°27` North and longitude 36° 23' East and altitude of 496m above sea level(Figure1). The rainfall mean, ranges from (26.5) to (46.7) mm, occurring mainly during the period from July to September.

The climate of the experimental site is semi arid, relatively cool and dry in winter, with maximum and minimum temperatures ranging from 33 to 36°C and 17.8 to 20°C, respectively and hot in summer with maximum and minimum temperature ranging from 37 to 41°C and 19 to 23°C respectively, relative humidity (RH), ranges from 29 to 54 %.

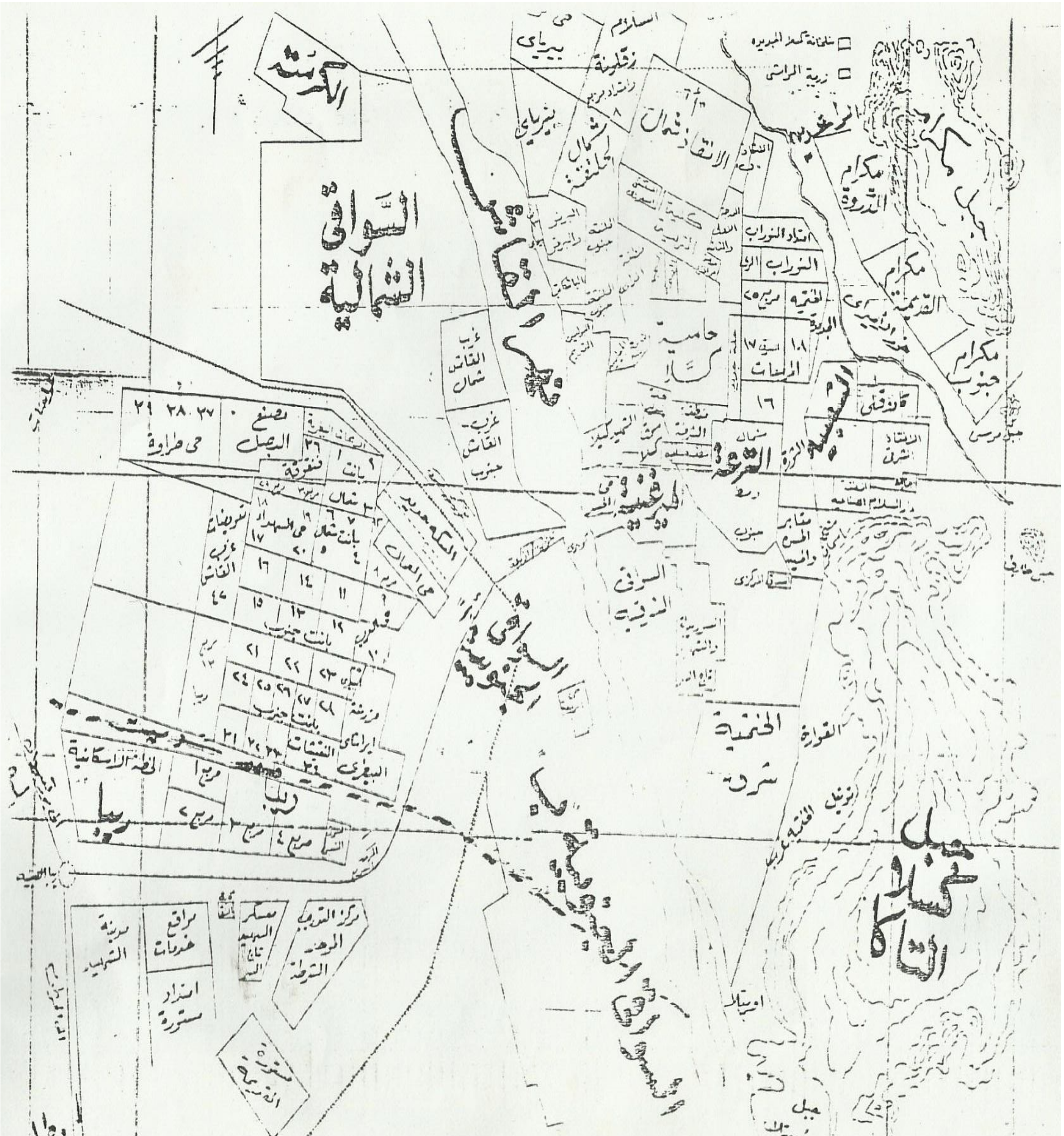

Fig.1: Study area

3.2 Clasification of fruit flies in Kassala state

To determine the different species of fruit flies found in the guava. Classification the fruit fly that appears in the collected specimens was made using ICIPE pictorial key. The adults emerged were put in a rearing cage. Bowels filled with water were fitted into the stand of the cage to keep off ants. Emerging flies were provided with diet consisting of one part yeast and four parts sugar, and water for 3-4 days until they attained their full body coloration to facilitate easy identification

3.3 Sampling procedur

Thirty guava trees, *psidium guajava* l., were collected from each of Al-Sabil and Al-Ramla in Elsawagi Elganobia. .

Each tree was divided into three zones, namely, upper, middle and lower. From each zone, three fruits of the same size were randomly collected. Fruits were then separated into infested and non – infested fruits depending on visual signs of ovipuncture made by female of *Bactrocera invadens* (and other relevant species of fruit flies).

Infested fruits were taken to the laboratory for rearing the different stages of the insect inside rearing cages and under laboratory conditions (temperature 18c – 25c and relative humidity ranged 20% - 40%)

3.4 Assessment of Seasonal abundance

To determine the seasonal abundance of fruit flies, samples were collected every ten days following the above mentioned procedure.

3.5 Host preference

To determine the host range of *B.invadens*, male and female of this species were placed in cages and provided with healthy four types of fruits mainly (guava, mango, orange and citrus).

Signs of egg laying were recorded in each fruit and fruits were transferred to other rearing cages and number of larva is recorded, Four replicates of the experiment were made and the fruits then checked every two days for oviposition up to 10days for in each replicate.

3.6 Effect of early harvest on the flies control

The experiment was initiated to study the effect of early fruit harvest on controlling the fruit flies. Guava fruits were randomly collected from three tree zones and divided into immature, mature and ripe guava. Each fruit stage was separated into infested and non-infested fruits. Infested fruits were taken to the laboratory to rear out fruit flies.

3.7 Effect of soil depth on the eclosion of pupae of *B.invadens*

Clay Pots measurer 12 inches and 12cm length diameter were filled with 1k of different soil types, namely sand, silt and clay. Pupae of similar age were buried in each soil type, at seven different depths, namely, zero at soil surface level 2, 4,6,8,10,12 cm. The pots were then covered with cotton mesh and left until adult emerged and counted.

3.8 Effect of sun exposure time on the eclosion of pupae of *B.invadens*

Pots 12 inches diameter, containing field soil (clay) were used in this experiment. Pupae were categorized in four different groups as follows: One day old, three days old, five days old and seven days old. Each group was put on the surface of the soil in a pot. Pupae were exposed to the sun for different periods of time, namely, one day, two days and more than three weeks. In the zero day groups, the pupae were not exposed to the sun but put under laboratory conditions as a control group. All pots were covered with thin perforated polyethylene sheet to control the emerged adults.

The pots containing pupae which were exposed to the sun for one and three days then transferred to the laboratory to complete their development. After one month the non- developed pupae were collected from the pots and put under humid condition to check their viability. After two weeks, unemerged pupae were considered as enviable pupae.

3.9 Effect of longitity of maintaing water on eclusion of pupae of *B.invadens*

Clay pots that were mentioned before were used to study the effect of maintaining water on soil on the eclusion of pupae .Three types of soils were used, silt, sand and clay each pot was provided with 1.5 kg of soil. In each pot 100 pupae of *B.invadens* were burned in a depth of 2 cm. After covering pupae with soil additional water was added to each pot up to the level of 2 cm above the soil surface the water was maintained to different time ,12, 24, 36 and 48 hours.

The pots were covered with cotton mesh to control the adults' emergence and kept under shade.

3.10 Assessment of farmer's knoweldge on control of fruit flies

A questionnaire was prepared to get information from farmers in Al-sawagi Al-ganobia,Al-shargia and Al-Shemalia about their knowledge on controlling fruit flies .The questionnaire contains information on,Agricultural system, Fruit fly knowledge and fruit flies control, Role plant protection and extension officers on disseminating information .

3.11 Statistical analysis

A computerized program of Statistical package for social science (SPSS) was used. Analysis of variance and mean separation (Least significant difference, LSD and Duncan's Multiple Range Test) were used in data evaluation.

Plate 1: Tools used on the study

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Clasification of fruit flies in Kassala state

In the laboratory, after the completion of rearing proceed were of the specimens from collected guava, indicated that the presence of Asian fruit fly, *Bactrocera invadens* (Drew) Plate (2) in Kassala area and Mediterranean fruit fly, *Ceratitis capitata* (Wiedmann) Plate (3).

All of the above species belong to family Tephritidae. The main distinctive characters of the adults of *Ceratitis capitata,* female characterized by yellow wing pattern and the apical half of the scutellum being entirely black with wavy yellow band across the base of the scutellum. While males are characterized by the black pointed expansion at the apex of the anterior pair of the orbital setae.

Bactrocera invadens, Is characterized by *scutum* brown to black, but with high degree of variation from dark brown to complete black. Scutellum is yellow with yellow lateral stripes, no medial stripes and male containspectins.

The result revealed that *B.invadens* is the most dominant species (98%) that C.capitata (2%) Table (1)

Table. 1: Relative abundance of fruit fly species on guava in Kassla State

Total No. of pupae developed	Total No. of pupae emergence	Species	No.	Relative abundance
10148	**7160**	*Bactrocera invadens*	**7017**	**98%**
		Ceratitis capitata	**143**	**2%**

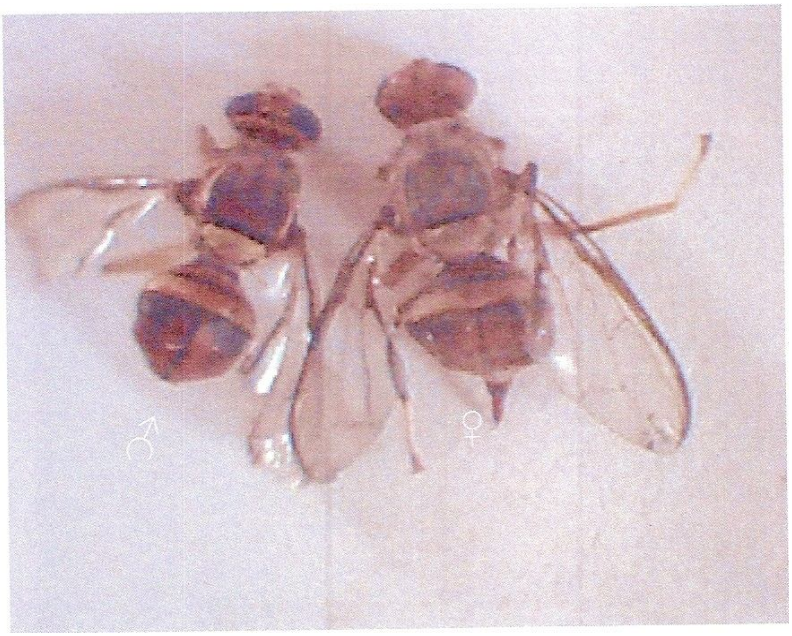

Plate. 2: Asian fruit fly, *Bactrocera invadens* (Drew).

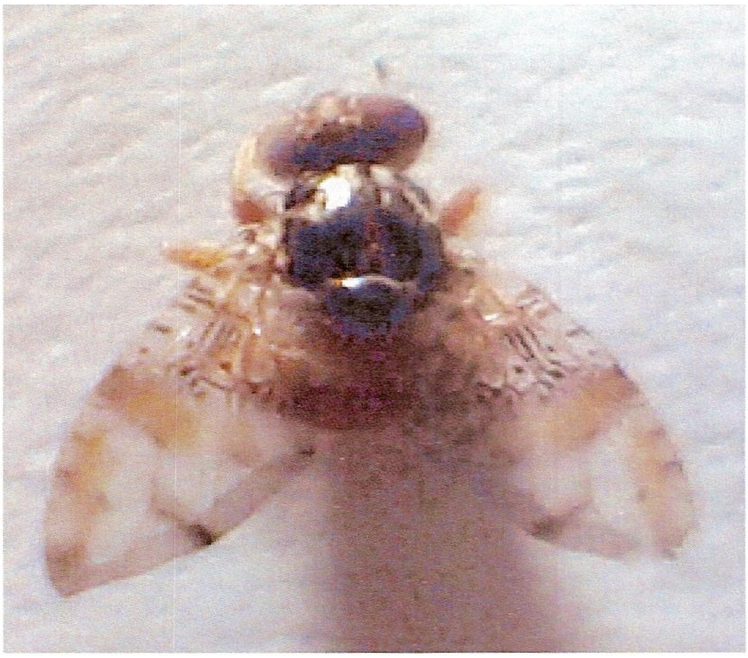

Plate. 3: Mediterranean fruit fly, *Ceratitis capitata* (Wiedmann)

4.2 Assesment of seasonal abundance of *Bactrcera invadens*

Assessment of infestation percentage of guava fruit by fruit flies:

The infestation percentage of guava fruits by *B.invadens* seems to be same at the two sites for the period from May 2011 to April 2012. In both sites the population started to increase from July 2011 with 88% and reached the highest peak on August of the same with 94%. During September, October and November the presentation was (88.9 , 91,7) , (73.5 , 69.2) and (66.3 ,65.9) For Elsabil and alramla respectively. The population in the tow sites was decreased drastically to (40.9, 44.8) respectively on December and increased to ranges of 70% for January and February and then decreased to 20% in March and to less than 10% in April (Table 2) and (Figure 1).

Assessment of development of pupa of *B.invadens*:

The development of larva to reach pupae was assessed of larva reared from both sites from 270fruits resulted in from number in May 2011 (10, 15) pupae for Elsabil and Alramla respectively. The number of developed larvae to pupae started to flame up in June with (300,330) pupae / 270 fruit the number of pupae highly increased to reach over 600 in both sites while in August it boosted in Elramla to 840 pupae. The population of pupae then fluctuated between (700 to 300) and (840 to 457) for the period of September 2011 and February 2012 for Elsabil and Elramla. At Elramla two peaks over 800 pupae /270 fruit were observed during August,2011 and Febrauary,2012. The number of developed pupae decreased in March and April 20% to less than 20for both sites.

This finding is in agreement with Deng (1990) who found that med fly's emergence took place throughout July to January and the peak of emergence occurred in August. Ali, *et. al.,* (2008) stated that in the Gezira State *B.invadens* was found to occur throughout the year and the species showed several population peaks. The highest peak was recorded in August while the lowest populations were noticed in April. The current results also agreed with the finding of Ahmed (2001) who reported that, population of *C.cosyra* is largely dependent on the climatic factors, temperature and relative humidity, with the peak of its population reported during August.

Table. 2 : Seasonal abundance of *B.invadens* on guava fruits at El-Sabil and Al-Ramla in El-sawagi Al-ganobia during the period May 2011 to April 2012.

Month	% of infestation		No. of pupae developed		% eclosion	
	El-Sabil	El-Ramla	El-Sabil	El-Ramla	El-Sabil	El-Ramla
May 2011	7.03	9.62	10	25	41.11	17.02
June	15.18	20.99	300	330	44.3	61.52
July	88.33	88.11	664	649	73.74	73.13
August	94.07	94.81	668	840	74.78	76.46
September	88.88	91.77	537	594	71.74	73.5
October	73.5	69.16	713	649	60.74	72.47
November	66.34	65.9	420	549	67.93	69.15
December	40.93	44.8	297	593	70.19	73.92
January2012	70.36	83.88	618	840	71.88	75.67
February	68.72	67.16	310	457	55.75	75.69
March	20.03	22.88	20	36	31.88	34.92
April	5.07	8.11	9	20	39.30	50.9

In each month, 270 fruit were collected from each area.

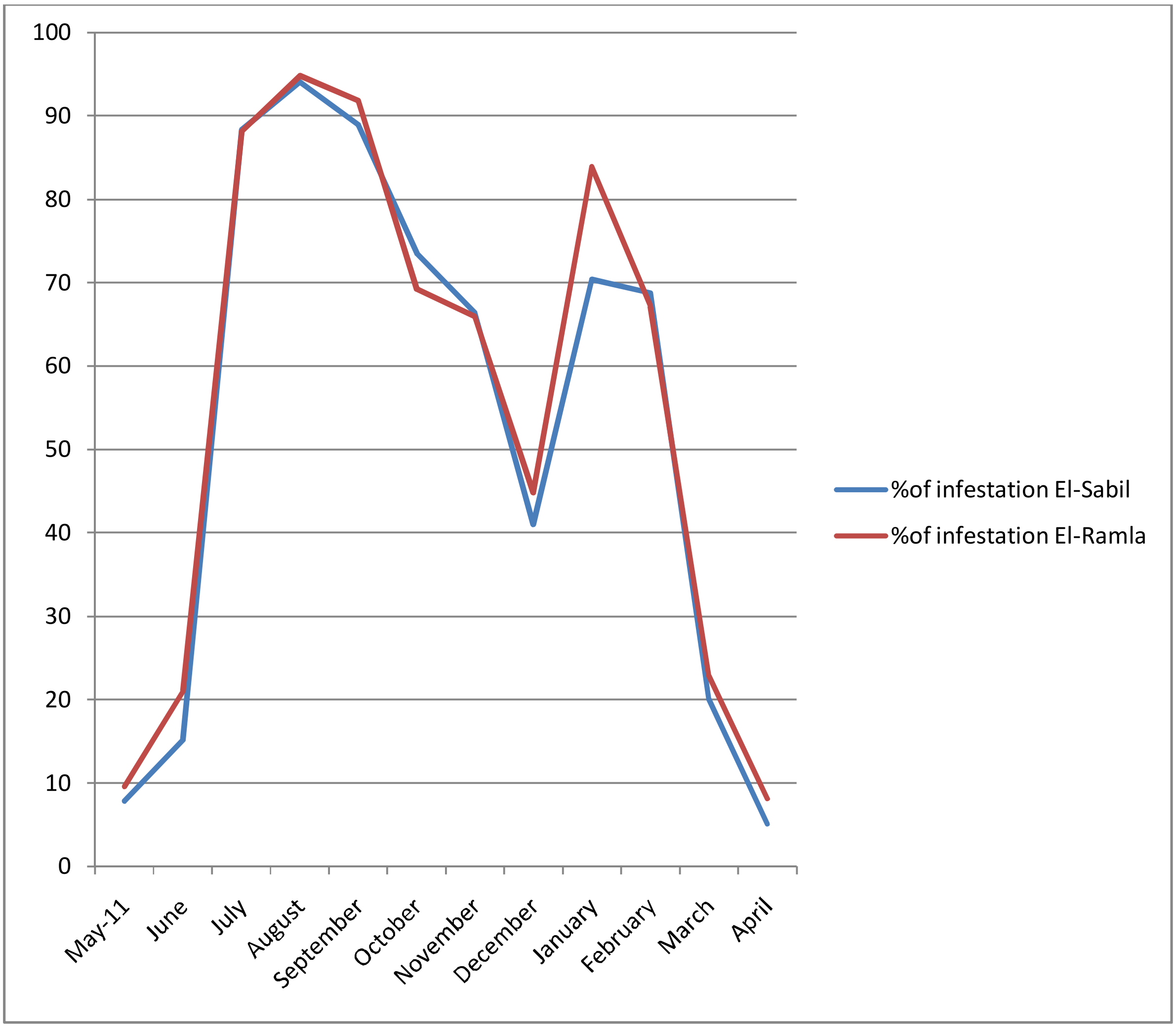

Fig. 2: Percentage of guava fruits infestation during May, 2011-April, 2012 .

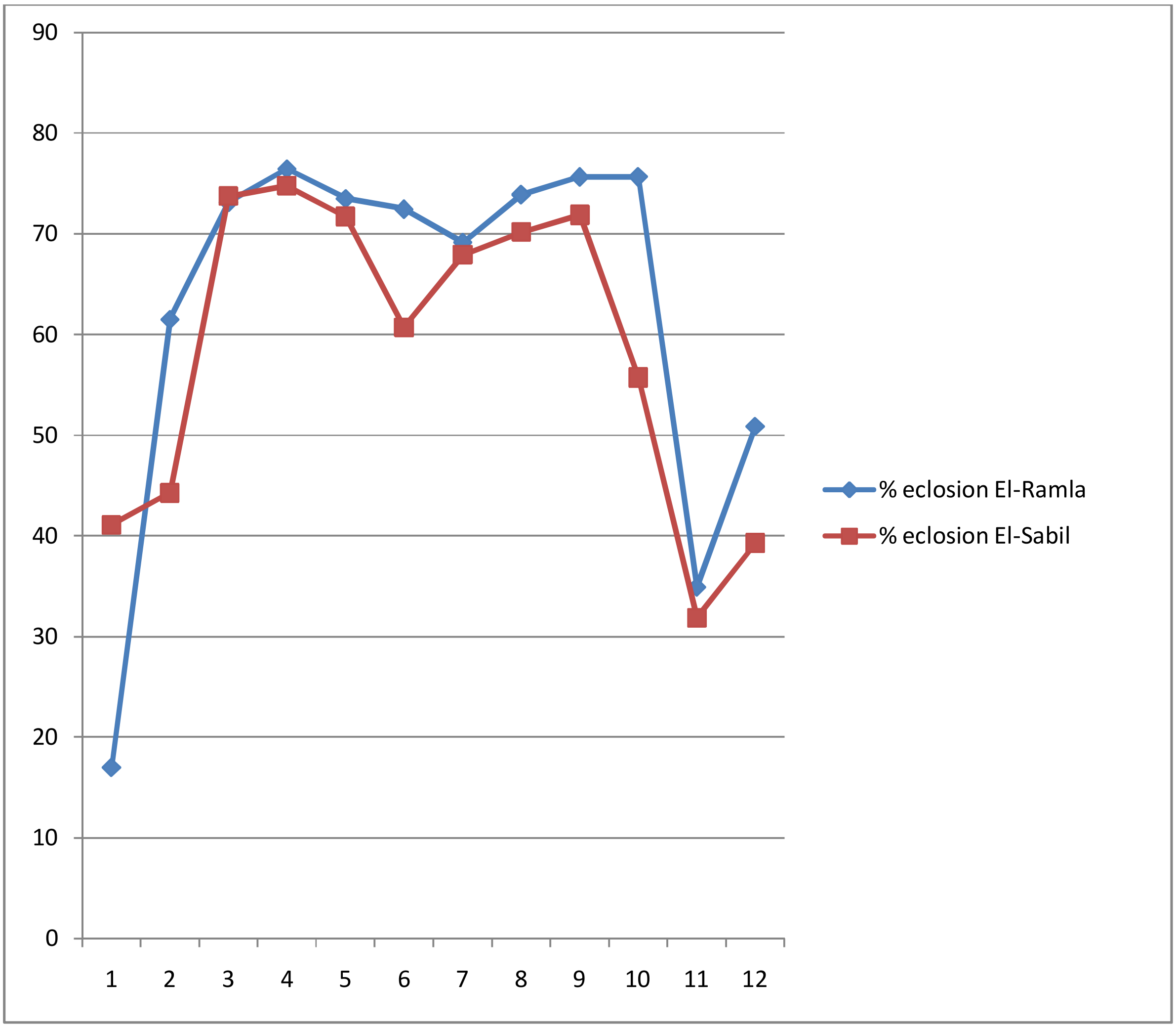

Fig. 3:Percentage of pupa eclosion during May,2011-April,2012

4.2 Comparison of population between Al-Sabil and Al-Rala

The result of table (3) and that of figure (2) indicated highest population of *B.inadens* atAl-Ramla in comparison to Al-Sabil. Because the percent age of infestation is highest and also percent age of pupa eclosion , this may be due to the fact that Al-Ramla area mainly cultivated by guava tree.

The above results are in agreement with those reported byAli *et. al.,* (2008) who stated that, hosts infested by *Bactrocera* spp. were guava, mango, banana, papaya and citrus.

In addition, Mardi (2008) reported mango (*Mangifera indica*), guava (*Psidium guajava*) and grapefruit (*Citrus paradisi*) as commercial host fruits for *B. invadens*. Other citrus species, cucurbits, papaya (*Carica papaya*) and tomato (*Lycopersicon esculentum*) were not infested.

Table. 3 : Comparison of population *B. invadens* at Elsabil and Alramla during May 2011 and February 2012

Analysis of Variance Table for Infest

Source	DF	SS	MS	F	P
Area	1	173.7	173.66	2.37	0.1303
Time	11	73572.4	6688.40	91.26	0.0000
Area*Time	11	252.1	22.92	0.31	0.9796
Error	48	3518.1	73.29		
Total	71	77516.2			

Grand Mean 54.719   CV 15.65

Analysis of Variance Table for Emeg

Source	DF	SS	MS	F	P
Area	1	188.7	188.67	4.61	0.0369
Time	11	19229.5	1748.13	42.69	0.0000
Area*Time	11	2126.6	193.33	4.72	0.0001
Error	48	1965.6	40.95		
Total	71	23510.3			

Grand Mean 60.016   CV 10.66

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LSD All-Pairwise Comparisons Test of Infest for Area

Area	Mean	Homogeneous Groups
Alramla	56.272	A
Alsabil	53.166	A

Alpha 0.05   Standard Error for Comparison 2.0179
Critical T Value 2.011   Critical Value for Comparison 4.0572
Error term used: Error, 48 DF
There are no significant pairwise differences among the means.

LSD All-Pairwise Comparisons Test of Infest for Time

Time	Mean	Homogeneous Groups
August	94.440	A
September	90.922	A
July	88.127	A
January	77.120	B
October	74.607	BC
February	67.940	BC
November	66.120	C
December	42.865	D
March	21.455	E
June	18.130	EF
May	8.315	FG

April	6.590	G

Alpha	0.05	Standard Error for Comparison	4.9428
Critical T Value	2.011	Critical Value for Comparison	9.9381

Error term used: Error, 48 DF
There are 7 groups (A, B, etc.) in which the means are not significantly different from one another.

LSD All-Pairwise Comparisons Test of Infest for Area*Time

Area	**Time**	**Mean**	**Homogeneous Groups**
Alramla	August	94.810	A
Alsabil	August	94.070	A
Alramla	September	92.960	A
Alsabil	September	88.883	AB
Alramla	July	88.143	AB
Alsabil	July	88.110	AB
Alramla	January	83.880	ABC
Alramla	October	75.920	BCD
Alsabil	October	73.293	CD
Alsabil	January	70.360	CD
Alsabil	February	68.720	D
Alramla	February	67.160	D
Alsabil	November	66.340	D
Alramla	November	65.900	D
Alramla	December	44.800	E
Alsabil	December	40.930	E
Alramla	March	22.880	F
Alramla	June	21.107	FG
Alsabil	March	20.030	FGH
Alsabil	June	15.153	FGHI
Alramla	May	9.597	FGHI
Alramla	April	8.110	GHI
Alsabil	May	7.033	HI
Alsabil	April	5.070	I

Alpha	0.05	Standard Error for Comparison	6.9901
Critical T Value	2.011	Critical Value for Comparison	14.055

Error term used: Error, 48 DF
There are 9 groups (A, B, etc.) in which the means are not significantly different from one another.

LSD All-Pairwise Comparisons Test of Emeg for Area

Area	**Mean**	**Homogeneous Groups**
Alramla	61.635	A
Alsabil	58.398	B

Alpha	0.05	Standard Error for Comparison	1.5083
Critical T Value	2.011	Critical Value for Comparison	3.0326

Error term used: Error, 48 DF
All 2 means are significantly different from one another.

LSD All-Pairwise Comparisons Test of Emeg for Time

Time	**Mean**	**Homogeneous Groups**
August	76.317	A
January	73.775	AB

```
July        72.615  ABC
December    72.055  ABC
September   70.282  ABC
November    68.540   BC
October     66.602   BC
February    65.723    C
June        53.910     D
April       37.910      E
March       33.400      EF
May         29.067       F

Alpha              0.05     Standard Error for Comparison  3.6945
Critical T Value  2.011     Critical Value for Comparison  7.4284
Error term used: Error, 48 DF
There are 6 groups (A, B, etc.) in which the means
are not significantly different from one another.
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LSD All-Pairwise Comparisons Test of Emeg for Area*Time

```
Area    Time          Mean  Homogeneous Groups
Alramla August      77.850  A
Alramla February    75.697  A
Alramla January     75.670  A
Alsabil August      74.783  A
Alramla December    73.920  AB
Alramla July        73.110  AB
Alramla October     72.473  AB
Alsabil July        72.120  AB
Alsabil January     71.880  AB
Alsabil September   70.797  ABC
Alsabil December    70.190  ABC
Alramla September   69.767  ABC
Alramla November    69.150  ABC
Alsabil November    67.930  ABC
Alramla June        63.520   BCD
Alsabil October     60.730    CD
Alsabil February    55.750     D
Alsabil June        44.300      E
Alsabil May         41.110      EF
Alsabil April       39.300      EF
Alramla April       36.520      EF
Alramla March       34.920      EF
Alsabil March       31.880       F
Alramla May         17.023        G

Alpha              0.05     Standard Error for Comparison  5.2249
Critical T Value  2.011     Critical Value for Comparison  10.505
Error term used: Error, 48 DF
```

4.4 Assement of the role of early harvest on control of *B.invadens*

According to the result shown in table (4) it is clear that the number of emerged fruit flies from ripen fruits (48.8) is greater than that emerged from mature fruit (44) and less the lowest number emerged from that harvested immature (20.5).

The ripe fruits are characterized by their strong aroma and their shiny yellow colure (plate4) which might have an attractive effect on the flies.

The obtained result in this study is in line with the finding of Myburgh (1963) who reported that the larvae of med flies develop and survive in soft tissues of ripe fruit more than in the firm tissues of the unripe ones. Prokpy, *et al.,* (1978) found that the yellow fruits were the most attractive among other shapes and colures of fruits.

Table. 4 : Effect of harvesting fruits in different maturity stages on the emerge of fruit flies

Month	Stage of maturity			Mean	S d
	Immature	Mature	Ripe		
June	20	45	46	37	12.02
July	21	40	48	36.33	11.32
August	23	45	50	39.33	11.72
September	18	46	51	38.33	14.52
Mean	20,5	44	48.75	37.74	12.40
S d	1.8	2.34	1.92	1.16	1.25

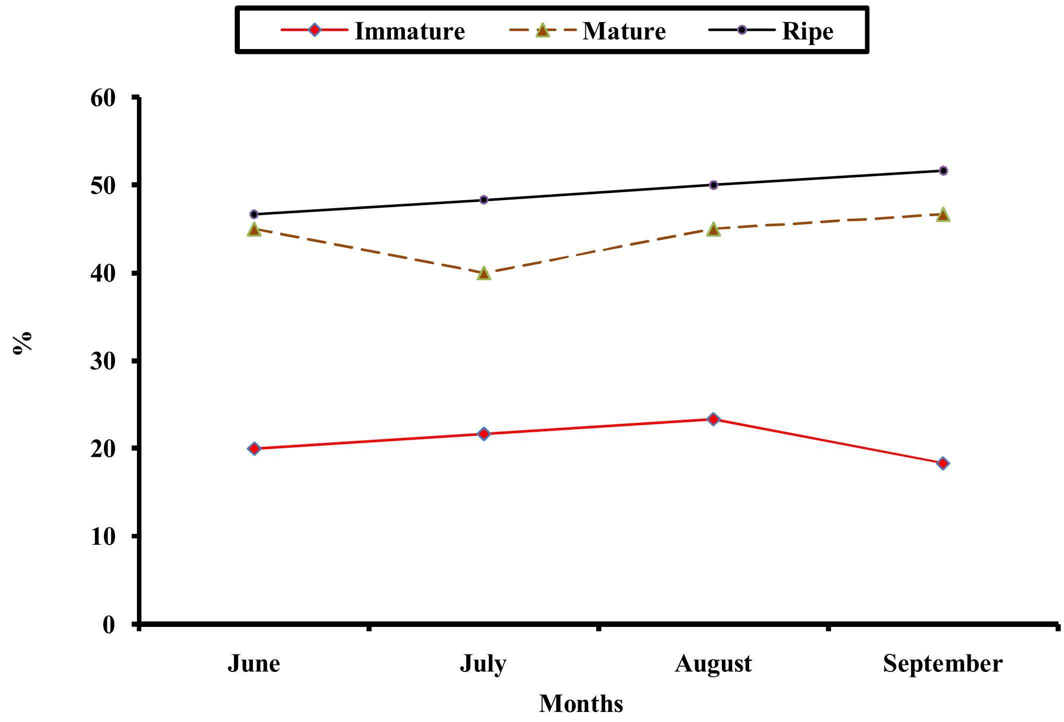


Fig. 4: Assessment of the role of early harvest on control of *B.invadens*

Plate. 2 : Different stages of maturity of guava fruit

4.5 Determination of host prefrence of *B.invadens*

These results showed that *B invadens* prefers guava, in which a mean number of survival larvae per fruit was found to be (18.50), other fruits preferred were as follows: mango (9.00), Orange (0.75). No infestations were found in lemon. The full results of this experiment are shown in table (5) & Figure (5).

These results are supported by similar results reported by Mwatawala, *et.al.,* (2006), who stated that, the major commercial hosts yielding the highest number of *B. invadens* flies per kilogram were mango, loquat (*Eriobotrya japonica*- Japanese citrus tree), guava and grapefruit (*Citrus paradisi*) to be the favoured commercial host fruits. Other Citrus species, cucurbits, papaya (*Carica papaya*) and avocado (*Persea americana*) were less favoured. Other results were also reported by Ali, *et.al.,* (2008) who stated that, hosts infested by *Bactrocera* spp. were guava, mango, banana, papaya and citrus.

In addition, Mardi (2008) reported mango (*Mangifera indica*), guava (*Psidium guqjava*) and grapefruit (*Citrus paradisi*) as commercial host fruits for B. invadens. Other citrus species, cucurbits, papaya (*Carica papaya*) and tomato (*Lycopersicon esculentus)* were not infested.

Table. 5: Host preference of *B.invadens*

Type of fruit	No. of survival larvae				Total	Mean
	R1	R2	R3	R4		
Guava	17	19	22	16	74	18.5
Mango	9	10	11	6	36	9
Orange	2	0	0	1	3	0.75
lemon	0	0	0	0	0	0
C.V%	3.63%					
$Lsd_{0.05}$	3.082					
SE	0.9635					

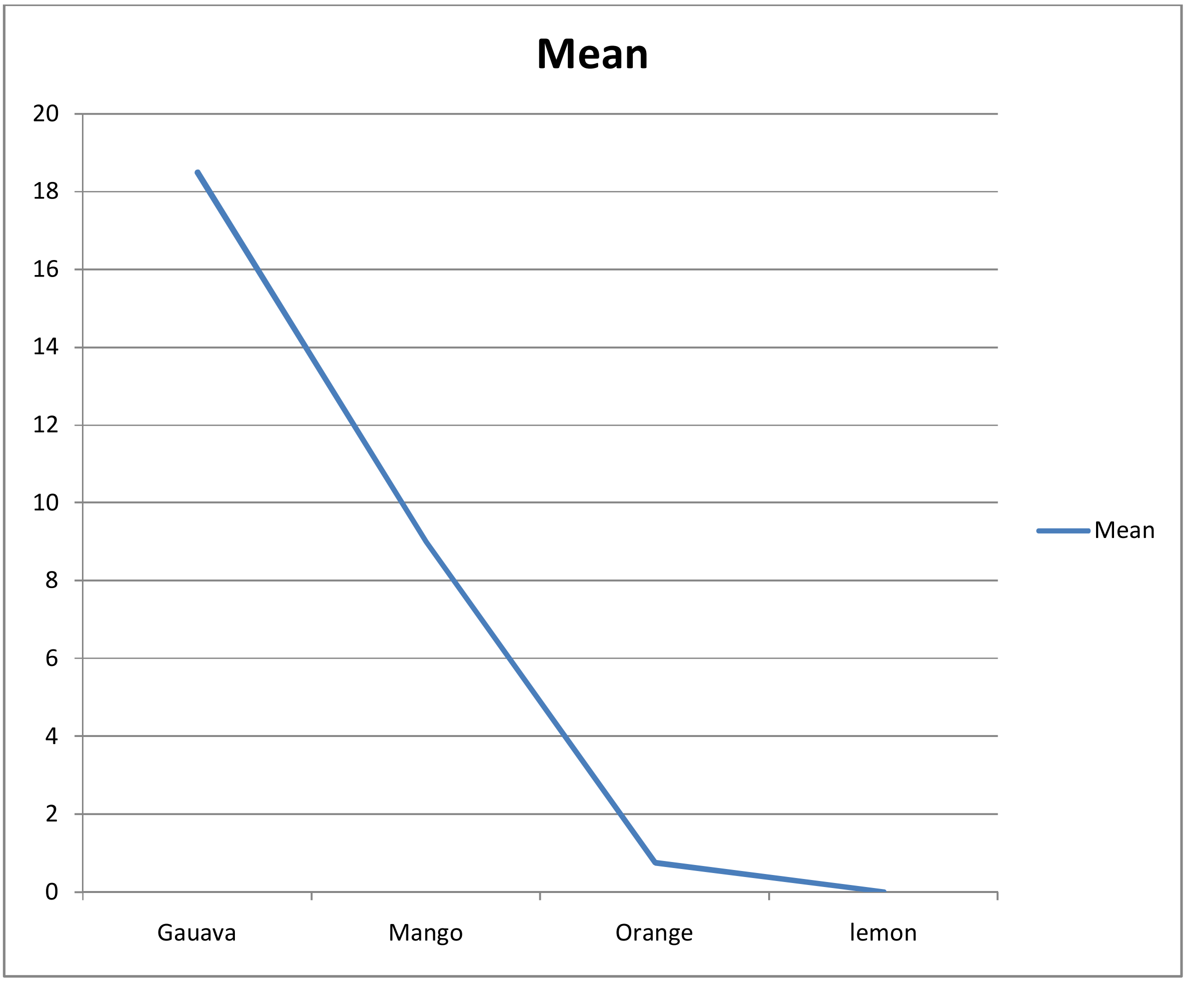


Fig 5: Host preference of *B.invadens*

Plate 3 : Host preference of *B.invadens*

Plate 4 : Host preference of *B.invadens*

4.6: Effect of sunlight and heat on percentage of adult emergence of *B.invadens*

The results of this experiment shown in table (6) and figure (6).The percentage of pupae emergence decreased with the increase of the period of exposure to sunlight.This was found to depend on the age of the pupae. The most sensitive group is the one-day old pupae which gave high mortality rate, while seven day-old pupae were more tolerant.

The result of are work is in agreement with Batman (1972) who stated that, the most susceptible stage to desiccation is the mature larvae and new adults. Tsitsipis (1969) reported that young pupae were sensitive to desiccation and puparias were not hard enough to protect the pupae. This explains the high mortality rate and failure of emergence in young pupae.

Table. 6: Effect of sunlight and heat on the percentage of adult emergence of *B. invadens*

Period of exposure	Age of pupae (days)				Mean	S d
	1	3	5	7		
Control	55	66	70	75	66.5	7.36
One day	4	5	10	20	9.75	6.34
Two day	1	3	3	5	3	2.06
More than one week	0	0	0	0	0	0
Mean	15	18.5	20.75	25	19.81	3.77
S d	23.14	27.80	28.23	29.79	27.18	2.48

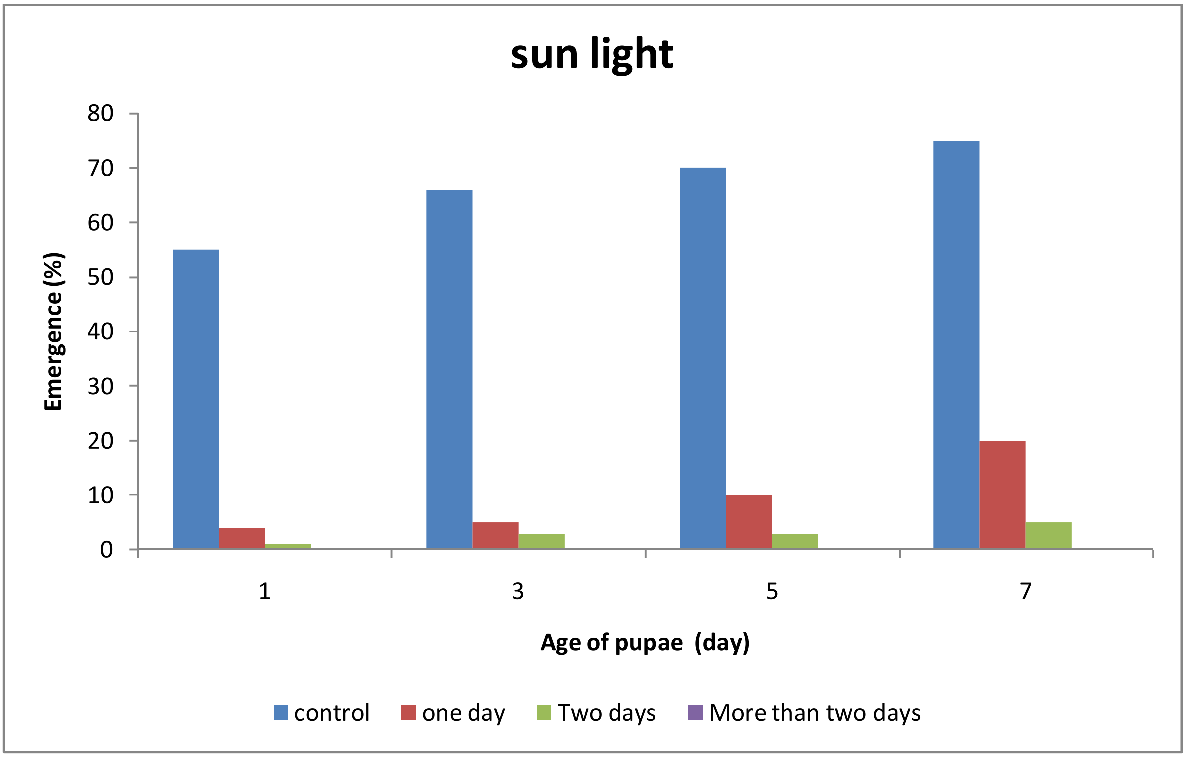


Fig 6: Effect of sun light and heat on the percentage of emergence of*B.invadens* adult

Plate 5 : Cages used to study effect of sun light on emergence of *B.invadens*

4.7 Effect of amauntitis of water on the adult emergenceof *B.invadens*

The percentage of adult emergence decreases with the increase of period of amount of water. The type of the soil was also an important factor .the results in table (7) and figure (7) showed that the sand soil needs a longer period of flooding than other two types of soil.

Results of this experiment the findings Vargas (1983) who stated that there was a negative correlation between total monthly rainfall and the number of *Ceratitis capitata*.

Table. 7 : Effect of application of different amenities of water in different types of soils on adult emergence of *B.invadens*

Treatments (hrs)	Type of soil			Mean	Sd
	Silt	Clay	Sand		
Control	70	75	73	72.66	2.05
12	18	13	30	20.33	7.13
24	8	3	11	7.33	3.29
36	0	0	0	0	0
Mean	24	22.75	28.5	25.08	2.46
Sd	27.31	30.55	27.84	28.56	1.41

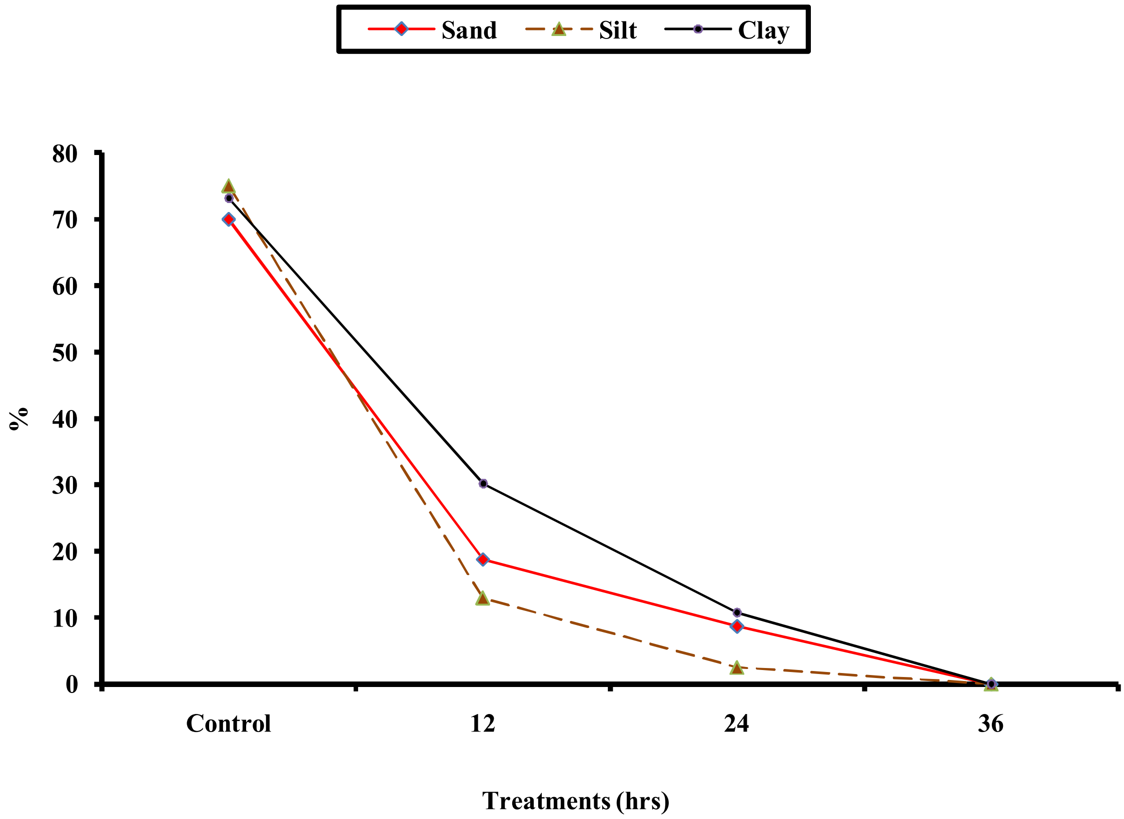


Fig 7: Effect application of different amenities of water in different types of soil son the Percentage of *B. invadens* adult emergence

4.8Effect of depth of burial of *B.invadens* pupae on emergence:

The result s of this experiment are shown in table (8) and figure(8) The Pupa emergence decreases when depth increased .The type of the soil was also an important factor ,The clay soil gave the lowest emergence percentage while the silt soil gave the highest percentage emergence.

This result is in line with that of Deng (1990) who found that the optimum depths of pupation of med fly to be 2.5 cm. He stated that the third instars' of med fly larvae was too weak to penetrate deeper in to the soil and the adult may not be able to emerge from the soil.

In contrast, kranz *et al*. (1979) found that pupation depth of med fly to range from 5cm to 10cm. Hill (1983) reported a depth of 5.20cm for a similar species (*Ceratitis rosa*).

Table. 8: Effect of different depths of soil on the emergence of *B. invadens*

Depth (cm)	Percentage of emerge of *B.invadens* according to type soil			Mean	S d
	Sand	Silt	Clay		
Top soil	72	70	75	72.33	2.05
2	60	68	64	64	3.26
4	49	45	42	45.33	2.86
6	33	31	20	28	5.71
8	21	28	9	19.33	7.84
10	8	10	2	6.66	3.39
Mean	40.5	42	35.33	39.27	4.19
S d	22.12	21.64	27.32	23.55	1.97

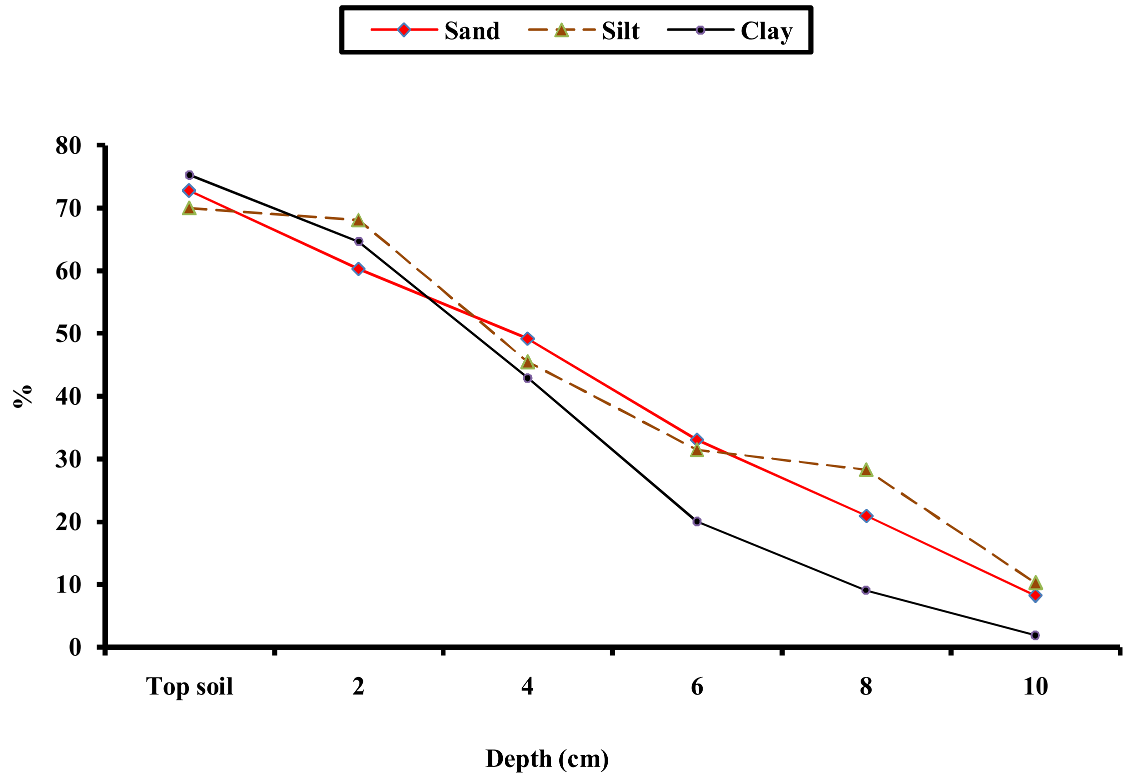


Fig 8: Effect of depth of *B.invadens* pupae on the percentage of adult emergence in different soil types

4.9 Questionnaire

In table, No (9) the results showed that the density of fruit flies in Alsawagi Alganubia is greater than that in Alsawagi Alshamalia and Alshargia. This seems mainly due to the presence of large number of guava trees Alsawagi Alganubia while no trees available in Alshmalia and Alshargia

In table No (10) the results indicated that all farmers in all Alsawagi know all methods of cultural control.

In table, No (11) the result showed that the plant protection directorate has the main duty in the identification and control of fruit flies.

Hill, (1989) also reported that the world is giving more attention to cultural practices as main item in every integrated pest control program. This is because of the increase in crop producers and crop protectionist's awareness and knowledge about the bio-ecological relationship within the crop system and the social demand for organic products. Aliwood and Leblanc, (2001) stated that to eliminate or reduce the reservoir of the resident population of fruit flies, field sanitation should be the essential component in the control programs. Ronald, (2007) also stated that the most effective practice in fruit fly control is field sanitation. The cleaning and removing of infested and dropped fruits from the orchards were considered one of the important practices in the control of fruit flies in Nigeria. (Vincent, 2004).

RESULTS OF THE QUESTIONNIRE

Table. 9 : Frequency distribution of farmers according to cultivated crops and areas

[1] Orange	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
<1 fed.	-	-	-	-	1	3.33
1 fed.	4	26.67	3	20.00	2	6.67
2 fed.	5	33.33	3	20.00	11	36.67
3 fed.	-	-	-	-	3	10.00
[2] Guava	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
<1 fed.	-	-	-	-	3	10.00
1 fed.	-	-	-	-	5	16.67
2 fed.	-	-	-	-	11	36.67
3 fed.	-	-	-	-	6	20.00
4 fed.	-	-	-	-	2	6.67
5 fed.	-	-	-	-	2	6.67
>5 fed.	-	-	-	-	1	3.33
[3] Lime	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
<1 fed.	-	-	-	-	-	-
1 fed.	4	26.67	4	26.67	7	23.33
2 fed.	4	26.67	3	10.00	9	30.00
3 fed.	-	-	-	-	1	3.33

4 fed.	-	-	-	-	4	13.33

Table 9 Continued).

[4] Grapefruit	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
<1 fed.	1	6.67	-	-	-	-
1 fed.	5	33.33	-	-	2	6.67
2 fed.	1	6.67	-	-	8	26.67
[5] Mango	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
<1 fed.	2	13.33	-	-	4	13.33
1 fed.	1	6.67	-	-	5	16.67
2 fed.	-	-	-	-	1	3.33
[6] Banana	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
<1 fed.	1	6.67	-	-	-	-
1 fed.	1	6.67	-	-	3	10.00
2 fed.	-	-	-	-	11	36.67
3 fed.	-	-	-	-	-	-
4 fed.	-	-	-	-	1	3.33
[7] Vegetables and onion	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
4 fed.	-	-	6	40.00	-	-
5 fed.	-	-	5	33.33	1	3.33
6 fed.	-	-	2	13.33	-	-
7 fed.	-	-	1	6.67	-	-

Table. 10 : Frequency distribution of farmers according to knowledge about fruit fly

	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
Q_1	No.	%	No.	%	No.	%
Yes	15	100	15	100	30	100
No	-	-	-	-	-	-
Q_2	**Elsawagi Elshargia (n=15)**		**Elsawagi Elshamalia (n=15)**		**Elsawagi Elganobia (n=30)**	
	No.	%	No.	%	No.	%
Yes	15	100	15	100	30	100
No	-	-	-	-	-	-
Q_3	**Elsawagi Elshargia (n=15)**		**Elsawagi Elshamalia (n=15)**		**Elsawagi Elganobia (n=30)**	
	No.	%	No.	%	No.	%
Yes	15	100	15	100	30	100
No	-	-	-	-	-	-
Q_4	**Elsawagi Elshargia (n=15)**		**Elsawagi Elshamalia (n=15)**		**Elsawagi Elganobia (n=30)**	
	No.	%	No.	%	No.	%
Yes	15	100	15	100	30	100
No	-	-	-	-	-	-
Q_5	**Elsawagi Elshargia (n=15)**		**Elsawagi Elshamalia (n=15)**		**Elsawagi Elganobia (n=30)**	
	No.	%	No.	%	No.	%
Yes	-	-	-	-	-	-
No	15	100	15	100	30	100
Q_6	**Elsawagi Elshargia (n=15)**		**Elsawagi Elshamalia (n=15)**		**Elsawagi Elganobia (n=30)**	
	No.	%	No.	%	No.	%
Yes	-	-	-	-	-	-
No	15	100	15	100	30	100
Q_7	**Elsawagi Elshargia (n=15)**		**Elsawagi Elshamalia (n=15)**		**Elsawagi Elganobia (n=30)**	
	No.	%	No.	%	No.	%
Yes	-	-	-	-	-	-
No	15	100	15	100	30	100
Q_8	**Elsawagi Elshargia (n=15)**		**Elsawagi Elshamalia (n=15)**		**Elsawagi Elganobia (n=30)**	
	No.	%	No.	%	No.	%
Yes	15	100	15	100	30	100
No	-	-	-	-	-	-

Table 10 (Continued)

Q_9	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
Yes	15	100	15	100	30	100
No	-	-	-	-	-	-
Q_{10}	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
Yes	15	100	15	100	30	100
No	-	-	-	-	-	-
Q_{11}	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
Summer	15	100	15	100	30	100
Autumn and winter	-	-	-	-	-	-
Q_{12}	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
Summer	-	-	-	-	-	-
Autumn and winter	15	100	15	100	30	100
Q_{13}	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
Yes	-	-	-	-	-	-
No	15	100	15	100	30	100
Q_{14}	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
Al-Sabil	-	-	-	-	30	100
Al-Ramla	-	-	-	-	-	-
Q_{15}	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
Guava		100	15	100	30	100
Mango	-	-	-	-	-	-
Orange	-	-	-	-	-	-
Limon	-	-	-	-	-	-

Table. 11 : Frequency distribution of farmers according to source of information

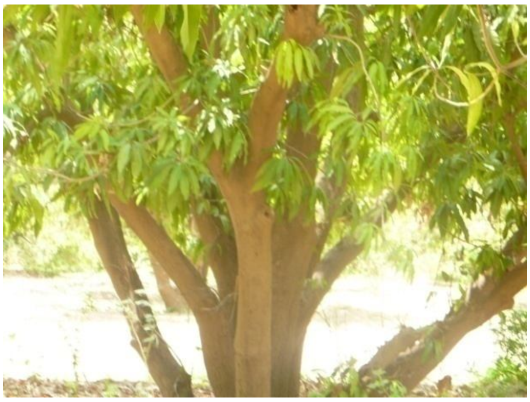
Q_1	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
Agric. Extentionist	-	-	-	-	-	-
Farmers' schools	-	-	-	-	-	-
Multimedia	-	-	-	-	-	-
Plant protect	15	100	15	100	30	100

Q_2	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
Agric. Extensionist	-	-	-	-	-	-
Farmers' schools	-	-	-	-	-	-
Multimedia						
Plant protect	15	100	15	100	30	100

Q_3	Elsawagi Elshargia (n=15)		Elsawagi Elshamalia (n=15)		Elsawagi Elganobia (n=30)	
	No.	%	No.	%	No.	%
Agric. Extension	15	100	15	100	30	100
Agric. Researches	-	-	-	-	-	-
Plant protection						

Banana

Limon



Mango

Guava

Plate 6: Trees of fruits on Al-sawagi Alganobia

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

1-The seasonal abundance of the *B.invadens* in Kassala State showed that there were two peaks of infestation. One peak of infestation on July and August and the second one was in January. They showed that the emergence of *B.invadens* to adult seemed to be higher from July to August up to January and it showed the lowest values in May.

2-Monitoring of Tephritidae fruit flies in Kassala area revealed the existence of two fruit fly species, under the genus *Ceratitis* and *Bactrocera*. These are: The Mediterranean fruit fly, *Ceratitis capitata* and Asian fruit fly, Bactrocera invaden. The Asian fruit fly is the dominant species in Kassala area, found all year round .

3- The seasonal activity of fruit flies varies according to climatic factors. It's generally observed that population level of fruit fly was higher during autumn and winter months than summer month.

4- The ripe fruits were found to be the most susceptible stage to fruit flies. Therefore, early harvest of immature fruit may save a considerable quantity of fruits from the infestation.

5- Guava was the most preferable host.

6- The results showed that of sunlight, water flooding and depth are very effective control measures that control.

7-The questionnaire explained that, Farmers knew that Guava is most preferred hostand the farmers know all methods of cultural control in addition, to the role of plant protection in the extention

RECOMMENDATION

1. Management of fruit flies should be based on planed packages of cultural practices such as, hoeing, cleaning of the orchards,Pruning, flooding and early harvesting, with emphasis on field sanitation, to avoid overlapping of generations of fruit flies and to reduce the growth rate of the insect's population.
2. Sanitation and quarantine measures are essential to prevent entry of infested fruits to the pest free areas.
3. Prevention of the storage of fruits on trees to catch late market and purchase with better price because it prolongs the infestation season. Left fruits on some tree branches,without harvest also act as a bridge for next season infestation.
4. Feasibility study regarding economics of cultural practices as a method of controlling fruit flies must be investigated.

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APPENDICES

APPENDIX (1) Host preference of *B. invadens*

Randomized Complete Block Design.

A N A L Y S I S   O F   V A R I A N C E   T A B L E

Source	d.f	M.S	S.S	F-cal.	Prob.
Factor A	3	897.188	299.063	107.3940	0.0000
Error	12	37.75	3.15		
Total	15	934.938			

Coefficient of Variation: 3.63%
Duncan's Multiple Range Test
LSD value = 3.28
SE = 0.9635 at alpha = 0.050
Mean 1 = 18.50A
Mean 2 = 9.000B
Mean 3 = 0.7500C
Mean 4 = 0.0000C

APPENDIX (2) WEATHER – CLIMATE DATA

MINISTY OF ENVIROMENT, FORESTRY

AND PHYSICAL DEVELOPMENT

METEOROLOGICAL AUTHORITY

WEATHER – CLIMATE DATA

Station: - KASSALA Fax:-771693

Period: - 2011-2012 Tel: -772992

Fax to: -

ELEMENT / Month	Mean Temperature C°		Relative Humidity %	Total Rainfall (Mm)
	MAX.	MIN.		
May 2011	41.1	25.8	29	8.4
June 2011	40.5	26.4	34	3.7
July 2011	37.7	24.4	45	46.7
August 2011	35.6	23.0	54	26.4
September 2011	36.8	24.5	52	36.4
October 2011	39.6	26.3	33	TR
November 2011	36.0	21.4	39	0.0
December 2011	35.1	20.1	49	0.0
January 2012	33.8	17.8	51	0.0
February 2012	37.6	19.6	51	0.0
March 2012	38.4	20.7	46	0.0
April 2012	41.1	23.4	31	0.0

Note: - Max =Maximum N = North

Min =Minimum S =South

Dir = Direction W = West

HP = Hecto Pascal (pressure units) E = East

Knot = 1.85 km/hr= 0.5 m/s TR=Trace

1.15 mile/hr =1.69 feet/s N/E= North by East

APPENDIX (3)

Detail

Al-sabil						
Date	No. 0f collection	No. of infestation	% infestation	pupa	emergence	% Emergency
1/5	90	9	10	3	1	33.33
10/5	90	7	7.77	5	2	40
20/5	90	3	3.33	2	1	50
			7.03	10		41.11
1/6	90	18	20	20	40	44.44
10/6	90	15	16.66	130	50	38.46
20/6	90	8	8.80	80	40	50
			15.18	300		44.3
1/7	90	80	83.33	255	178	69.80
10/7	90	83	92.2	199	141	70.85
20/7	90	75	88.8	210	159	75.71
			88.33	664		73.74
1/8	90	86	95.55	210	168	80
10/8	90	85	94.44	243	179	73.66
20/8	90	83	92.22	215	152	70.69
			94.07	668		74.78
1/9	90	79	87.77	210	155	73.80
10/9	90	83	92.22	155	110	70.96
20/9	90	78	86.66	173	167	67.63
			88.88	537		71.74
1/10	90	66	73.33	244	158	64.75
10/10	90	67	74.44	210	131	62.65
20/10	90	64	72.11	259	142	54.82
			73.5	713		60.74

1/11	90	66	73.5	150	110	73..61
10/11	90	63	70.22	201	123	61.03
20/11	90	50	55,30	69	48	69.15
			66.34	420		67.93
1/12	90	32	35.89	93	63	67.55
10/12	90	46	51.60	112	73	65.22
20/12	90	32	35.30	94	73	77.80
			40.93	297		70.19
1/1	90	67	74.64	191	134	70
10/1	90	68	75.33	240	159	66.04
20/1	90	55	61.11	187	149	79.60
			70.36	618		71.88
1/2	90	67	74.19	92	49	53.6
10/2	90	65	72.77	103	54	52.96
20/2	90	53	59.20	115	70	60.69
			68.72	310		55.75
1/3	90	23	26.1	5	1	32.64
10/3	90	18	19.55	11	4	35.85
20/3	90	13	14.44	4	1	27.15
			20.03	20		31.88
1/4	90	3	3.11	3	1	39.27
10/4	90	8	8.77	2	1	44.83
20/4	90	3	3.33	5	2	33.80
			5.07	9		39.30

Al-ramla						
Date	No. of collection	No. of infestation	% infestation	Pupa	Emergence	% Emergency
1/5	90	13	14.44	7	2	28.57
10/5	90	5	5.55	8	1	12
20/5	90	8	8.80	10	1	10
			9.62	25	4	17.02
1/6	90	27	30	130	79	66.76
10/6	90	17	18.88	111	77	69.36
20/6	90	13	14.44	90	49	54.44
			20.99	330		61.52
1/7	90	80	88.88	220	169	76.81
10/7	90	83	92.22	241	173	71.78
20/7	90	75	83.33	188	133	70.74
			88.11	649		73.13
1/8	90	87	96.66	323	284	87.92
10/8	90	85	94.44	247	185	74.89
20/8	90	84	93.33	270	191	70.74
			94.81	840		76.46
1/9	90	83	92.22	261	195	74.71
10/9	90	82	91.11	150	106	70.66
20/9	90	86	95.55	183	117	63.93
			91.77	594		73.5
1/10	90	73	81.11	223	158	70.85
10/10	90	61	67.77	160	120	75
20/10	90	53	58.88	190	136	71.57
			69.16	513		72.47
1/11	90	46	51.57	233	162	69.49
10/11	90	80	88.88	257	196	76.33
20/11	90	52	57.33	159	98	61.63
			65.9	649		69,15

1/12	90	42	46.88	170	127	74.93
10/12	90	47	52.22	203	164	80.69
20/12	90	32	35.30	220	146	66.14
			44.8	593		73.92
1/1	90	67	74.76	307	253	82.63
10/1	90	81	90.22	292	225	77.03
20/1	90	78	86.66	241	162	67.35
			83.88	840		75.67
1/2	90	77	85.47	132	102	77.6
10/2	90	54	60.71	125	102	81.31
20/2	90	50	55.30	200	136	68.18
			67.16	457		75.67
1/3	90	35	38.26	13	5	36.58
10/3	90	16	17.22	16	6	39.01
20/3	90	12	13.16	7	2	29.17
			22.88	36		34.92
1/4	90	8	8.4	4	1	44.37
10/4	90	7	7.13	11	4	38.16
20/4	90	8	8.88	5	1	27.03
			8.11	20		36.52

APPENDIX (4)

Questionnaire

On Fruit fly control

A\ Agricultural system

1\ Total occupancy area

2\Crops planted area

3\Fruit planted area

a- Banana planted

b- Grapefruit planted

c- Guava planted

d- Other planted

d- Orange planted

f-Mango planted

j- Limon planted

B\ Fruit fly knowledge

1) Do you know what is fruit fly?
2) Are you making a periodic elimination of the relative host?
3) Do you collect burn up and bury the infested fruits outside the farm?
4) Do you delay harvesting time?
5) Do you store the fruit on the trees?
6) Do you spray with Melathion before fruit mature?
7) Do you use the fruit as a trap after submersion in a pesticide?
8) DO you use the pheromone traps?
9) Do you flood the soil with water for long time?
10) Do you cut the branches for exposure of the soil to the sun light?

11) When the infestation with fruit fly decreases in the summer, winter or autumn?
12) When the infestation with fruit fly increases in the summer, winter or autumn?
13) Do you know how to make classification of fruit fly?
14) Which area is more infested with fruit fly Al-ramla or Al-sbeil?
15) Preference of trees to fruit fly?

a-Guava b-Mango c-Orange d-lemon

C\The extention

1) What is the source of your agricultural data?
   a- Agricultural extension b-Farmer school c-Media d- plant protection
2) What is the source of your knowledge of how to carry outfruit fly control?
   a- Agricultural extension b-Farmer school c-Media d- plant protection
3) Do you think of failure existence coming from:
   a- Agricultural extension b-Agricultural researches c-Plant protect ion