بسم الله الرحمن الرحيم

Hebron University
College of Graduate Studies
M.Sc. Program in Plant Protection

Biological and Ecological Studies on Leaf Miner Flies, *Liriomyza trifolii* [Diptera: Agromyzidae] in Al-Arroub Agricultural Experimental Station, Palestine

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DEDICATION

I Would Like To Dedicate This Thesis To

My Parents

ACKNOWLEDGEMENT

I would like to thank all those whom helped me during my study:
My sincere appreciation and respect to my supervisor **Dr. Abdul-Jalil Hamdan** for his tireless supervision, serious guidance, support and encouragement.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Leaf miner flies, *Liriomyza* spp. [Diptera: Agromyzidae] are phytophagous insects attacking about 25 plant families, and feed on the tissue between the upper and lower epidermal layers of the leaves. Leaf miner flies had spread quickly and widely and had become a serious pest of many ornamentals and vegetables in both the temperate and tropical regions. Leaf miners of the genus *Liriomyza* spp. are among the most difficult insect pests to manage on ornamentals and numerous vegetable crops (e.g. tomato and bean). Damage caused by the feeding of the leaf miner larvae resulted in loss of plant vigor and reduces the photosynthetic capacity of the infested plants.

This research was designed to investigate the following biological and ecological aspects of the leaf miner flies *Liriomyza trifolii* (Burgess): flight activity of leaf miner flies within tomato and bean plantation in open field and in greenhouse plantations; the susceptibility of different tomato and bean cultivars to leaf miner infestation, under field conditions, greenhouse and standard laboratory conditions of 26ºC, 75% R.H. and continuous light; In addition, the life cycle of *L. trifolii* on bean cultivars under laboratory conditions was studied.

Results showed that, flight activity of *L. trifolii* started on the end of April and continued till the end of January next year. The yellow traps proved to be more attractive to *L. trifolii* than other colored traps. Lifecycle studies, indicated that the average duration of development for *L. trifolii* from egg to adult was 16 days on three bean cultivars, and the average total eggs laid per female was 149-194 eggs on the same plants. In addition, significant differences in susceptibility was observed between tomato cultivars as well as bean cultivars and *L. trifolii* infestation showed significant preference for bean than for tomato plants especially under green house conditions.

INTRUDUCTION

Liriomyza spp [Diptera: Agromyzidae] includes many potentially serious leaf mining flies. The damage caused by *Liriomyza spp.*, to their host plants occurred when the larval stages feed within the leaves of the host plants and, at high densities, this feeding reduce of the yield and/or kill the infested plants (Spencer, 1989).

Liriomyza flies are characterized by their high degree of polyphagy. Within the old and new world regions, farmers who grow vegetables, horticultural industries and ornamental flower producers were affected by one or more of these polyphagous leaf miners. Besides the damage caused by the larvae, feeding punctures cause loss of vigor due to reduction in the photosynthetic capacity and mesophyll conductance of the infested plant leaves (Johnson *et al.*, 1983). Yield losses in general can be considerable, e.g. *Liriomyza. sativae* caused losses in tomato crops up to 70% (Waterhouse & Norris, 1987).

Management of agromyzid leaf miners has been extensively of researched in the past 30 years or so (Altier *et al.*, 1983; Mikenberg & Lenteren, 1986; Waterhouse & Norris, 1987; Spencer, 1989; Martinez *et al.*, 1993; Kawate, & Coughlin. 1995).

Synthetic and natural insecticides have been extensively used for the leaf miner control by small holder farmers and large-scale producers. The effectiveness of these insecticides has been dogged by their indiscriminate use; impact on natural enemies; and the development of resistance within fly populations (Waterhouse & Norris, 1987).

Other control techniques such as yellow board traps and host plant resistance have been also developed in Western Europe and are now used on a very local basis within some countries (Mikenberg & Lenteren, 1986; Waterhouse & Norris, 1987).

In addition agromyzid leaf miners are known to have rich natural enemy communities, particularly in their areas of origin and much attention has been paid to augmentative and classical biological control with insect parasitoids (Mikenberg & Lenteren, 1986; Waterhouse & Norris, 1987). The results of these programs have been mixed with most successes being achieved in glasshouses (Mikenberg & Lenteren, 1986). As for many damaging insects, the optional method for the management of leaf miners is to integrate several techniques together. In order to minimize the disturbance effect of the control measure on the natural components of the agro-ecosystems (Altier; *et al*, 1983),

OBJECTIVES

This research was proposed for the following objectives:

1. To investigate the flight activity of leaf miner flies within tomato and bean plantation in open field and in green houses in Al-Arroub Agricultural Experimental station.

2. To study the susceptibility of different tomato and bean cultivars to leaf miner infestation, under field conditions and laboratory conditions.

3. To study the life cycle of *L. trifolii* on bean cultivars under laboratory conditions.

CHAPTER ONE: LITERATURE REVIEW

CHAPTER 1: LITERATURE REVIEW

1.1. Biology of *Liriomyza* spp.

1.1.1. Identification

Vegetable and ornamental leaf miners are flies in the genus *Liriomyza spp.*, and belons to order Diptera. The most common species of *Liriomyza* flies that were reported attacking vegetables and ornamentals are: vegetable leaf miner, *Liriomyza sativae* (Blanchard); tomato leaf miner, *Liriomyza trifolii* (Burgess); cabbage leaf miner, *Liriomyza brassicae* (Riley); and pea leaf miner, *Liriomyza huidobrensis* (Blanchard) (Spencer & Steyskal 1986).

Identification of *Liriomyza* species is difficult since most are similar in appearance with varying degrees of black and yellow markings. However, (Spencer 1973) had published a key that is used as protocol for classification of *Liriomyza* to its species. In addition Keys for the identification of agromyzid leaf miners is found by Spencer and Steyskal in1986.

Adult *L. sativae* is shiny with black colored upper thorax surface and the area between the eyes is yellow, whereas the area just behind the eyes is black. *L. trifolii* has a more grayish upper thorax due to the presence of bristles and the area behind the eyes is mostly yellow. *L. brassicae* is very similar in appearance to *L. sativae* and can only be distinguished by dissection of the male genitalia by an experienced taxonomist. *L. huidobrensis* is slightly larger and darker in addition to the more pale yellow color than the other species.

1.1.2. Life cycle of *L. trifolii*

Liriomyza trifolii have a relatively short life cycle. (Leibee, 1984) reported that rate of development increased with temperature up to about 30°C, and larvae experienced high mortality above 30°C the time required for a

complete life cycle in warm climates is often 21 to 28 days and several generations annually occurs in the tropics .

L. trifolii required 19 days from egg deposition to emergence of the adult at a constant temperature of 25°C (Leibee, 1984, Minkenberg, 1988) indicated that, at 25°C the egg stage required 2.7 days for development; the following three active larval instars required 1.4, 1.4, and 1.8 days, respectively. The time spent in the puparium was 9.3 days; there was an adult pre-ovipostion period that averaged 1.3 days. The lowest temperature threshold for development of the various stages was 6 -10°C but egg laying occurred above 12°C.

1.1.2.1. Eggs

The eggs are whitish, translucent deposited through the adaxial or abaxial leaf surface. Eggs are laid singly, but often in close proximity to each other. Eggs tend to be deposited in the middle of mature plant leaves. The female insert its eggs just below the epidermis of the lower surface of the leaf and hatch in 2-4 days (Leibee, 1984, Minkenberg, 1988)..

The eggs increase in size after oviposition, possibly through the imbibitions of fluids from plant tissue (Dimetry, 1971). The period of egg development varies with temperature and ranges from 2-8 days. Considerable variation in the relationship between temperature and development, and in the developmental threshold (6.2-13.4°C), is probably because of differences in host plants, and in experimental methodology (Liebee, 1984).

1.1.2.2. Larvae

There are three larval stages. Each larval instar is completed in 2 - 3 days and the body size and length of mouth part can be used to differentiate between instars (Leibee, 1984, Minkenberg, 1988). For the first instars, the

mean lengths of body and of mouth parts are 0.39 mm and 0.10 mm respectively. For the second instars, the mean lengths of body and of mouth parts are 1.00 mm and 0.17 mm, respectively. For the third instars, the mean lengths of body and of mouth parts are 1.99 mm and 0.25 mm, respectively.

1.1.2.3. Pupae

Prepupa occurs between puparium formation and pupation, but usually ignored by authors as pupa stage does not feed and does not cause damage. The pupa is initially golden brown in color, but turns darker brown with time and took 5 to 12 days depending on temperature.

1.1.2.4. Adults

Adults are small, measuring less than 2 mm in length, with a wing length of 1.25-1.9 mm. The head is yellow with red eyes. The thorax and abdomen are mostly gray and black although the ventral surface and legs are yellow. The wings are transparent.

Key characters that serve to differentiate *L. trifolii* from *L. sativae*, are that *L. trifolii* has matte, grayish black mesonotum and yellow hind margins of the eyes, meanwhile, *L. sativae* has shining black mesonotum and black hind margin of the eyes. The small size of *L. trifolii*, as well serves to distinguish it from *L. huidobrensis*, which has a wing length of 1.7-2.25 mm. Also, the yellow femora of *L. trifolii* help to separate it from *L. huidobrensis*, which has darker femora (Leibee, 1984).

1.1.3. Adult longevity

Most longevity studies have been conducted using caged flies in close association with a host plant (Parrella, *et al.,* 1985, Parrella & Keil, 1984). Under these conditions, females live 15-20 days and males 10-15

days. Longevity generally decreased at higher temperatures meanwhile, the presences of honey dramatically increase longevity (Parrella & Keil, 1984). Although no studies have examined the longevity of *Liriomyza* flies in the field because of the difficulty associated with studies on individual flies in nature.

1.1.4. Survival ship

In laboratory rearing studies (Parrella, *et al*. 1989) observed that when survivorship of adults emerging from these pupae was collected for observed plant was examined as cohorts based on the day of adult emergence, different survivorship profiles were produced. It is possible that a short larval development time may be correlated with adult vigor. (Oatman & Michelbacher, 1958).

Liriomyza trifolii, which is native to the southern part of the Nearctic, was considered incapable of over wintering in more northern areas. However, the survival of adults and pupae at low temperatures suggests that this species may be able to survive in these areas.

1.1.5. Fecundity

(Leibee, 1984), worked with celery as a host plant, estimated that oviposition occurred at a rate of 35 to 39 eggs per day, and the total fecundity was 200 eggs. (Parrella *et al.*, 1983) reported similar results on egg production rates on tomato as host plant, but the total fecundity was lower, and suggested that tomato was less suitable host for the larvae.

Egg-laying capacity varies considerably within the genus *Liriomyza*, mean egg production per female ranged from less than 100, to greater than 600 (Hendriske *et al.*, 1980). Females generally lay the majority of eggs between days 4 and 10 of adult life, depending on temperature (Clanahan, 1980; Parrella, *et al.*, 1983). Fecundity is strongly related to food source

and temperature and maximum oviposition occurs between 20-27°C (Dimetry, 1971; Parrella, *et al*., 1983). In addition, it was observed that unfertilized females oviposited hundreds of eggs that failed to develop, although ovarian development, egg laying, and other responses appeared to be normal.(Parrella, *et al*., 1983).

1.1.6. Feeding and oviposition behavior

Leaf puncturing may occur with equal frequency on the abaxial and adaxial leaf surfaces (Parrella & Keil, 1984). But this may depend on the species. Leaf puncturing and feeding by adult *Liriomyza* undoubtedly serves an important role in host plant assessment. It has been suggested that host feeding is more important in this regard than leaf puncturing (Bethke & Parrella, 1985). Several researchers have examined the ratio of total punctures to oviposition punctures in an attempt to determine host plant suitability or a general biological description of *Liriomyza* spp. (Wolfenbarger, 1947; Fagoonee & Toory, 1984). These ratios have ranged from 1:1 to 40:1 and vary with temperature leaf quality, and host plant. (Parrella & Keil, 1984).

Females make numerous punctures in the leaf mesophyll with its ovipositors, and use these punctures for feeding and egg laying. The proportions of punctures receiving an egg were about 25% in chrysanthemum and celery, but only about 10% in tomato, which is considered as less suitable for larval survival and adult longevity. Although females apparently feed on the exuding sap at all plant wounds, they spend less time feeding on unfavorable hosts (Parrella, *et al*., 1983; Leibee, 1984).

Males were reported to live only 2-3 days, possibly because they cannot puncture foliage and hence fed less than females, whereas females survived for about a week. Their feeding and oviposition activity were

carried out during much of the daylight hours, and especially near mid-day. Excellent description of leaf puncturing, feeding and oviposition activity of *Liriomyza* fly was reported by Dimetry (1971).

Bethke & Parrella, 1985 reported that *L. trifolii* deposited eggs in tubular leaf punctures. After every leaf puncture the female backs over the wound and feeds from it. The female feeds from all punctures, regardless of whether or not they are used for oviposition. Hence, all leaf punctures can be considered as feeding punctures. However (Musgrave *et al.*, 1975) reported that males were unable to create their own punctures, but they fed from punctures created by females.

Feeding and oviposition by adults proved to occur primarily during the morning, and the frequency of these activities was positively correlated with temperature (Parrella & Keil, 1984). Little adult activity was observed at night (Fagoonee & Toory, 1984).

1.2. Origin and distribution

The genus *Liriomyza* contains more than 360 species which are widely distributed in the new and old world. Most species were reported to be originally from temperate regions (Spencer, 1965; 1973; 1989 and Parrella, 1987). *L trifolii* is widely distributed in the new and old worlds and oceanic islands; it's invasion and expansion in the old world has been recorded since about the mid 1970s (Spencer, 1973); *L huidobrensis* has still yet to get a foothold in continental Africa.

L. trifolii is found in the eastern United States, Canada, and the Caribbean. In recent years it has been reported in California, Europe, Middle East and elsewhere (Spencer, 1981; 1992, Martinez *et al*, 1993).

1.3. Host plants

L. trifolii leaf miner flies was reported attacking a large number of plant species, but seems to favor those from the families Leguminosae, Solanaceae and Cucurbitaceae, (Stegmaier, 1966) Among the numerous weeds especially, the nightshade, *Solanum americanum* and Spanish needles, *Bidens alba* are especially suitable hosts (Schuster, *et al*., 1991).

1.4. Damage

Punctures caused by females during the feeding and oviposition processes result in a stippled appearance on foliage, especially at the leaf tip and along the leaf margins (Parrella, *et al.,* 1985). However, the major form of damage is the mining of leaves by larvae, which cause destruction of leaf mesophyll. The mine become noticeable about three to four days after oviposition and becomes larger in size as the larvae mature.

The pattern of mining is irregular. Both leaf mining and stippling caused great depression in the level of photosynthesis in plants. Extensive mining also cause premature leaf drop, which may induce sun scalding of fruit due to reduction in plant shading. Wounding of foliage also allows entry of bacterial and fungal diseases (Parrella, *et al*., 1985).

Although leaf mining can reduce plant growth crops such as tomato are quite resilient, and capable of withstanding considerable leaf damage. It is often necessary to have an average of one to three mines per tomato leaf before yield reductions occur (Levins, *et al*., 1975, Schuster, *et al*., 1976).

1.5. Management

1.5.1. Monitoring

In field vegetables, sticky traps or sweep nets are used to monitor adult flies, however the numbers of adult leaf miner flies do not necessarily correlate with leaf damage. In greenhouse crops, where the use of

biological control is prevalent, commercially-available natural enemies were released at the first sign of mining in leaves and regular and consistent monitoring of the crop is necessary (Orozco-Santos, *et al*., 1995).

Thresholds for leaf miners in field vegetables are not established since relatively high numbers of flies and mines in leaves are needed to cause severe economic damage. The exception to this is in the floriculture industry where leaf miner damage directly affects the marketable portion or in vegetable crops where the leaves are the marketable portion, i.e. spinach, beet greens, Asian greens, lettuce and leeks.

1.5.2. Crop susceptibility to leaf miners

Crops vary in this susceptibility to leaf mining. This has been noted, for example, in cultivars of tomato, cucumber, cantaloupe, and beans (Hanna, *et al.*, 1987). However, the differences tend to be moderate, and not adequate for reliable protection.

1.5.3. Cultural practices

Nitrogen level and reflective mulches are sometimes said to influence leaf miner populations, but responses have not been consistent (Chalfant et al. 1977, Hanna *et al*., 1987). Placement of row covers over cantaloupe has been reported to prevent damage by leaf miner (Orozco-Santos *et al*., 1995). The same study evaluated the benefits of transparent polyethylene mulch, and found no reduction in leaf miner populations. Sometimes crops are invaded when adjacent crops are especially suitable, as was reported in California, where cotton was an important source of invaders (Sharma, *et al*., 1980). Weeds were found to be a source of flies, but also a source of parasitoids (Parkman, *et al*., 1989).

1.5.4. Chemical control

Chemical insecticides are commonly used to protect foliage from injury, but insecticide resistance is a major problem. Insecticide susceptibility varies widely among populations, and level of susceptibility is directly related to frequency of insecticide applications. Therefore reduction in dose level and frequency of insecticide application, as well as preservation of susceptible populations through non treatment of some areas are suggested as means to preserve insecticide susceptibility among leaf miner populations (Mason, *et al*., 1989). However Insecticides also are highly disruptive to naturally occurring biological control agents, particularly parasitoids. Use of many chemical insecticides exacerbates leaf miners problems by killing their parasitoids.

1.5.5 Biological control

Several parasitoids of the families Braconidae, Eulophidae, and Pteromalidae have been recorded are important natural enemies against leaf miner flies including: *Chrysonotomyia punctiventris* (Crawford); *Ganaspidium hunteri* (Crawford); *Opius dissitus* Muesebeck; *Chrysocharis parksi* Crawford; *Chrysonotomyia formosa* (Crawford); *Hemitarsenus semialbiclavus* (Girault); *Diglypus begini* (Ashmead); *Diglyphus intermedius* (Girault); *Cothonapsis pacifica* Yoshimoto; and *Haliticoptera circulus* (Walker). *C. punctiventris, H. circulus* and *G. hunteri* have been found to be predominant parasitoids (Lynch, 1986; Johnson, 1987). In addition, klapwijk (1995) reported that the predatory mired bug, *Macroolophus caliginosus* was observed feeding on larva of leaf miner on vegetable crops.

CHAPTER TWO: MATERIALS AND METHODS

CHAPTER TWO: MATERIALS AND METHODS

This chapter describes the materials, constructions, equipments, techniques and methodology of experiment conducted during this research.

2.1 Host Plants

Two vegetable species were used:

1. Tomato (*Lycopersicon esculentum* Mill.): three cultivars (Teba, 1370 and 1415) planted in the open field and other three cultivars (554,144 and 259) planted in the green house.

2. Bean (*Phaseolus vulgaris* L.): three cultivars (Celena, Dali and Venonica) were planted in the open field experiment; three cultivars (Ascrow, Gesica and Local variety) were planted in the green house and three cultivars (Ascrow, Celena and Platy,) were used in the laboratory experiments.

2.2 Study fields

Two fields were used in Al-Arroub Agricultural Experimental Station:

Open field with an area of one dunum was divided into two blocks half dunum each (Fig. 2.1), one block planted with three bean cultivars (Celena, Dali and Venonica) and the other block was planted with three tomato cultivars (Teba, 1370 and 1415).

BEAN	CELINA	DALI	VENONICA
	DALI	VENONICA	CELINA
	VENONICA	CELINA	DALI
TOMAT	1370	TEBA	1415
	TEBA	1415	1370
	1415	1370	TEBA

Fig. 2.1 Layout of open field planted with different cultivars of bean and tomatoes in Al-Arroub Agricultural Experimental Station during 2006 season

Greenhouse: One plastic house 9 m width * 33m length was divided into two blocks (Fig. 2.2), one block was planted with three bean cultivars (Ascrow, Gesica and Local variety) and the other block was planted with three tomato cultivars (554,144 and 259).

BEAN	GESICA	ASCROW	LOCAL
	ASCROW	LOCAL	GESICA
	LOCAL	GESICA	ASCROW
TOMAT	144	554	259
	554	259	144
	259	144	554

Fig. 2.2 Layout of greenhouse planted with different cultivars of bean and tomatoes in Al-Arroub Agricultural Experimental Station during 2006 season

2.3 Materials

2.3.1 Chemicals

Formalin 37%: added to the water trap fluid to prevent the rotting of capture insect. Detergents added to water trap fluid to decrease the surface tension of the fluid so as to permit the captured insect to settle to the bottom of the traps.

2.3.2 Agar media

Nutrient agar media was prepared by dissolving agar powder at the rate of 15g/L of distilled water, in addition to plant growth fertilizer N: P: K (20:20:20) at a rate of 2 g/L. The solution was heated with stirrer for 25 minutes on hot-plate, for mixing and dissolving of agar. Agar media was then autoclaved for about 40 minutes at 120˚C under 1.4 bar atmospheric pressure. After cooling to 45-50˚C, 0.3gm of a fungicide Mervan^{R} (Captan 50%) was dissolved in 7ml of ethanol 95% and added to 3ml of distilled water) was added at the rate of 1ml/liter of nutrient agar as described by Hamdan (1997).

An agar layer of 2-3 mm was placed in the Petri dish cage. It was used as a source of nutrients as well as a source of moisture for the leaf-discs. Filter paper was used as a layer between the leaf-disc and the agar media enabling the free movement of the adult insects and decreasing the possibility of sticking to the agar (Hamdan, 1997).

2.4 Constructions

The following rearing cages were modified for conducting the research:

2.4.1 Perspex cages:

These cages were made from transparent Perspex material as with 40cm width x 40cm height x 60cm depth. To allow ventilation a door of 50 mesh

net (20x20cm, width x high) provided on the front of the cage and 10cm diameter hole covered with 50 meshes net was provided in the rear side. The Perspex cages were placed on a tray on laboratory bench with approximately 60cm high in room condition. And used for keeping bean transplant that used for the laboratory experiment.

2.4.2 Petri dishes:

Petri dishes (9cm x 1.5cm) were used .Each dish had a 2 cm diameter hole in the middle of the lid, and covered with 50 mesh net to provide ventilation. Petri dish cage was used for rearing leaf miner insect on bean leaf discs under fix conditions.

2.4.3 Water traps:

Colored water traps (red, yellow, green and blue) were used in monitoring the fight activity of leaf miner flies in the open field and greenhouse experiments. Those traps are rectangle plastic containers 30 cm length, 15 cm width and 15 cm depth. The trap contained of 3L of water, 100ml (37% formalin) and 50ml liquid detergent.

2.4.4 Pan Traps

Pan traps consisted of polystyrene trays used for the collection of pupa of *Liriomyza trifolii* from the infested plant. Trays 30*30 cm, were used and placed under the selected plants for observation. Trays were monitored twice a week for collection of the pupa of the leaf miner.

2.4.5 Woody cages

Two cages with dimensions of 1m length x1m width x1m height were constructed with woody arms and covered with 50 meshes net from all sides. One cage was used to keep healthy transplants of tomato and the other cage was used to keep the healthy transplants of bean.

2.5 Laboratory equipments and tools

The following laboratory equipments and tools were used.

2.5.1 Dissecting Microscope:

All observations, handling and transfer of the leaf miner insects were made under 40X magnification dissecting binocular microscope (Model: Fluxum-24ED, Company: CETI Belgium) .

2.5.2 Aspirator

A hand aspirator was used for the transfer of the adult insect because they are highly active and flew quickly. Care was therefore needed in their capturing and transferring. The entry tube of the aspirator was made as short as possible to minimize the distance traveled by the insect. The suction tube was made long enough to enable easy handling. A single layer of cloth 50 mesh was placed at the end of the entry tube to keep the adult fly in the tube while transferring of the fly from certain cage to another.

2.5.3 Incubator

Laboratory experiments were conducted in an incubator (Model: MLR-350HT / Company: SANYO) supplied with operation panel that enabled control of the temperature, photoperiod and humidity to the conditions required for the experiments. Experiments were carried out in the growth cabinet under the standardized conditions of 25±1◦C, 75+5% R.H and continuous light. The relative humidity for the experiments was fixed by placing uncovered small box with saturated salt solution (NaCl) which provided the relative humidity of 75%.

2.6 Methodology of the research;

Following experiments were conducted during 2006:

2.6.1. The effect of color of water traps on their efficiency in monitoring the flight activity of leaf miner, *Liriomyza spp*

Four colored water traps (yellow, green, blue and red) were used. Three water traps/each color (prepared as mentioned in Section 2.4.3), were randomly distributed within one dunum open field planted with tomato and bean cultivars (Fig 2.3).

The traps were placed in the field on 20th May (after two weeks of planting the field). First observation of trapped *Liriomyza* flies was recorded on 5th June and observations were done weekly throughout the season till 21st August 2006. Insects captured by the traps were collected by filtering the fluid using a cloth through a plastic funnel. The cloth placed in a 9cm diameter Petri dish and transferred to the laboratory where insects were immersed in ethanol 75%; leaf-miners flies were identified and counted under 40X binocular dissecting microscope.

Fig. 2.3. Layout of open field with colored water traps used for monitoring the flight activity of the leaf miner flies within bean and tomato plants.

2.6.2. Monitoring the seasonal flight activity of vegetable leaf miner, *Liriomyza* spp., using yellow water traps, within open field and greenhouse planted with the different cultivars of beans and tomatoes during 2006 season

Three yellow water traps were randomly distributed within the open field (one dunum area), and one yellow water trap was placed in the middle of the greenhouse (0.3 dunum area). Each trap consisted of a yellow colored rectangular plastic container (prepared as mentioned in Section 2.4.3).

The traps were placed in the field on 20th May (after two weeks of planting the field). First observation of trapped *liriomyza* flies was recorded on 5th June and observations were done weekly throughout the season till 31st December 2006. Weekly observations were done and captured insects were collected, identified and counted under 40X dissecting microscope (as mentioned in Section 2.6.1).

2.6.3. Susceptibility of different tomato and bean cultivars to leaf miner infestation in open field

An area of one dunum was used; the field was divided into two blocks, half dunum each as shown in Fig. 2.1. One block was planted with three cultivars of bean (Dali, Celena and Venonica) and the other block was planted with three cultivars of tomato (Teba, 1370 and 1415).

The experiment started on 5th May 2006, where bean and tomato transplants were planted in the field. Three replications of each cultivars of each crop were randomly distributed within the specific block as shown in Fig. 2.1.

Each replicate consisted of three lines (10 m length * 1 m width), each line was planted with 20 plants of the specific cultivar at spaces of 0.5 m between plants along the line. A border of one meter was left between blocks without planting.

Pan traps consisted of polystyrene trays prepared as mentioned in Section 2.4.4, were placed under the observed plants for collection of the leaf miner pupae from the infested plant (Fig 2.4).

Weekly observations were done on four plants from the middle line of each replicate. First observation of *L. trifolii* infestation was recorded on 4th June and the following parameters were recorded:

1. Number of infested leaves/plant: where at least one mine recorded on the infested leaf.
2. Number of mines/leaf (Fig 2.5): mine that contained one larva was recorded on the infested leaf.
3. Number of pupae/plant; the pupae were collected from the pan traps twice a week.

2.6.4. Susceptibility of different tomato and bean cultivars to leaf miner infestation under greenhouse conditions

One plastic house 9 m width and 33m length was planted with seedling of tomato and beans on 5th` May 2006. The greenhouse was divided into two Blocks with three lines each. One block was planted with three cultivars of bean (Ascrow, Gesica and Local) and the other block was planted with three cultivars of tomato (554, 144 and 259) as shown in Fig. 2.2.

Three replications of each cultivars of each crop were randomly distributed within the specific block as shown in Fig. 2.2. Each replicate consisted of one lines (10 m length * 1 m width), planted with 20 plants of the specific cultivar at spaces of 0.5 m between plants along the line. A border of one meter was left between blocks without planting.

Pan traps consisted of polystyrene trays prepared as mentioned in Section 2.4.4, were placed under the observed plants for collection of the leaf miner pupae from the infested plant (Fig 2.4).

Weekly observations were done on four plants per each replicate. First observation of *liriomyza* infestation was recorded on 4th June and number of infested leaves/plant; number of mines/leaf and number of pupae/plant were weekly recorded till end of August 2006.

Fig 2.4. Pan traps placed under tomato and bean plants for collection of *Liriomyza* pupae.

Fig. 2.5. Symptoms of leaf mines done by larvae of *L. trifolli* on tomato and bean leaves.

2.6.5. Laboratory studies on the susceptibility of different bean cultivars to *L. trifolii* infestation under fixed conditions

Three cultivars of bean (Ascrow, Celina and Platy) were used with two replications of each cultivar. Each replicate consisted Perspex cage (40*40*60cm) that contains one transplant from each cultivar. A couple of freshly emerged adults of leaf miner flies (male + female) were released in each Perspex cage, placed inside the incubator (MLR-350HT/Sanyo) under the fixed conditions of 26ºC, 75% RH and continuous light. Leaf miner adults that used to start the experiment were obtained from pupae which were collected from the experiment fields using pan traps as mentioned in Section 2.6.3. Pupae were placed in Petri dishes prepared as mentioned in Section 2.4.2., and kept under fixed conditions of 26ºC, 75% RH and continuous light, till emergence of the adult stages.

Pan trap consisted of polystyrene trays prepared as mentioned in Section 2.4.4, was placed under each plants inside the Perspex cage for collection of the leaf miner pupae from the infested plant.

Number of infested leaves/plant; number of mines/leaf and number of pupae/plant were daily recorded on each plant in the Perspex cages.

2.6.6. Laboratory studies on the life cycle of *Liriomyza trifolii* on three bean cultivars

2.6.6.1. Duration of development of *L. trifolii* on three bean cultivars under fixed conditions

Adults of *L. trifolii* obtained from pupae collected from the field experiment were used in this experiment. Couple of female and male of *L. trifolii* were released in each Petri dishe containing leaf disc of bean placed upside down on 2-3 mm agar media and kept in the incubator under fixed conditions of 26ºC, 75% RH and continuous light.

Leaf discs of three bean cultivars (Platy, Ascrow and Celena) were used with ten replications per each cultivar; each replicate consisted of one Petri dish with bean leaf disc containing eggs of leaf miner of one day old. Petri dishes were kept in the incubator under the fixed conditions of 26ºC, 75% RH and continuous light, and observations were daily done recording the developmental stages including egg hatching; larval molting; pupation and adult emergence.

2.6.6.2. Adult longevity and fertility under fixed conditions

This experiment was also conducted in an incubator under fixed conditions of 26ºC, 75% RH and continuous light. Three bean cultivars (Platy, Ascrow and Celena) were used, five replications for each cultivar. Each replicate consisted of couple of freshly adults leaf miner fly (male + female) released in Petri dish that contains leaf disc of the specific cultivars.

Each couple was observed daily throughout its adulthood and transferred to freshly prepared Petri dish cage contains bean leaf disc of the specific cultivar. Adult survival, longevity and number of eggs laid were daily recorded for each replicate.

2.7. Statistical Analysis

Statistical analysis was done using MINITAB package. Comparisons were done using One Way ANOVA to find out if there was a significant effect of the plant cultivar on the susceptibility to leaf miner infestation in open field, greenhouse and under laboratory conditions. In addition, T-test analysis was used to find out if there was a significant difference between bean and tomato as host plants preference for the leaf miner flies.

2.8 Survivorship curves

For statistical comparison between treatments to be biologically meaningful, the data are best presented in a way that shows the cohort survival curves of insect population, which show the fraction of each cohort surviving at a particular moment in time (Jervis and Copland, 1996). There are three categories of survivorship curves (Fig. 2.3).

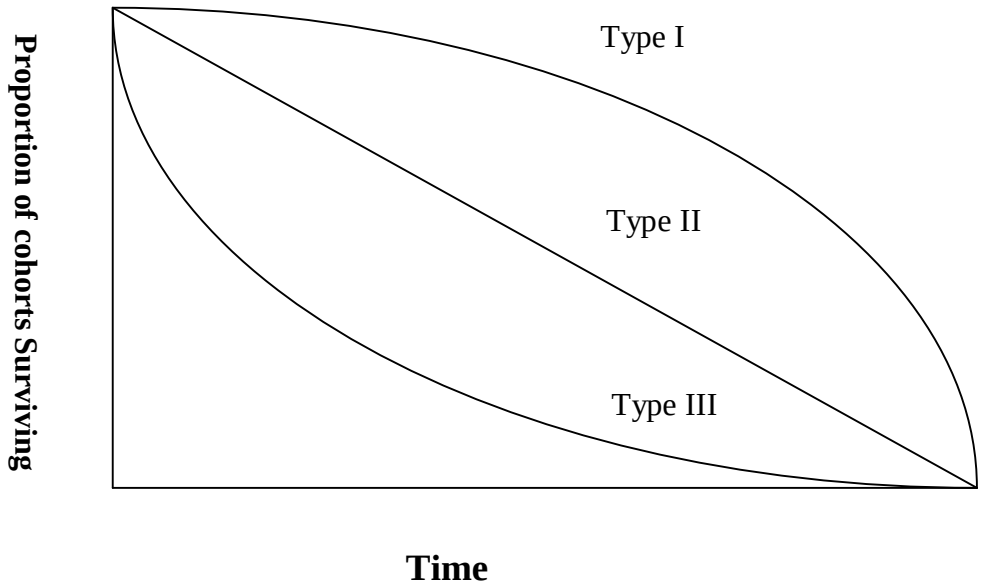

Fig. 2.1 Types of survivorship curve of insect population: Type I - mortality concentrated in the oldest age classes; Type II – constant risk of death; Type III – mortality concentrated in the youngest age classes.

Therefore, results of survivorship were analyzed to find out the type of survival curve of *L. trifolli* when fed on three bean cultivar under laboratory conditions.

2.9. Meteorological data

Metrological Data including temperature and R.H of the Hebron district for the period of study 1st April – End August 2006 was obtained from the Palestinian Meteorological Department (2006).

Table 2.1 Metrological data including temperature and R.H of the Hebron district during 2006 season

Date of end of the week	Average Min Temp ºC	Average Max Temp ºC	Average Mean Temp ºC	Average R.H %
6th`May	16.55	26.65	21.1	51.3
13th`May	17.15	27.2	22.1	53.24
20th`May	17.8	27.35	22.57	37.3
27th`May	11.78	20.71	16.24	53.9
4th Jun.	17.25	28.5	21.6	41.75
11th Jun.	17	26.9	22	52.57
18th Jun.	12.3	25.3	19.8	62.42
25th Jun.	18.5	28.4	23.47	42.14
2nd Jul.	18.2	27.5	22.85	52.14
9th Jul.	17.4	26.4	21.91	62.85
16th Jul.	16.7	26.4	21.51	62.57
23rd Jul.	17.6	28.5	22.98	52.28
30th Jul.	18.2	27.4	22.8	51.85
7th Aug.	20	29.5	24.88	50.14
14th Aug.	17.2	27.3	22.27	70.0
21st Aug.	21	30.5	25.7	50.71
28th Aug.	21	30.3	25.6	42.28

Data in Table 2.1 show that during the period of study the average field temperature was in the range of 20-25ºC and average relative humidity was in the range of 40-70 %. These data are within the favorable condition required for the development and flight activity of the leaf miner (Leibee 1984, Minkenberg 1988).

CHAPTER THREE: RESULTS

CHAPTER THREE: RESULTS

3.1. Flight activity of *Liriomyza* spp.,

3.1.1. Effect of color of water traps on it's efficiency in monitoring the flight activity of the vegetable leaf miner, *Liriomyza* spp. in open field

Results presented in Fig. 3.1 show the weekly average number of adult *L. trifolii* captured by four colored water traps (yellow, red, green and blue).

First observation of trapped *Liriomyza* flies was recorded on 4th June, 2006, and flight activity of *L. trifolii* was recorded throughout the season till 21st August, 2006. Statistical analysis shows that, yellow water traps were significantly the most efficient in monitoring the flight activity of leaf miners throughout the season (at *P value* ≤ 0.05, using one way ANOVA), meanwhile, no significant differences were observed between the red, blue and green colors in capturing *L. trifolii.*

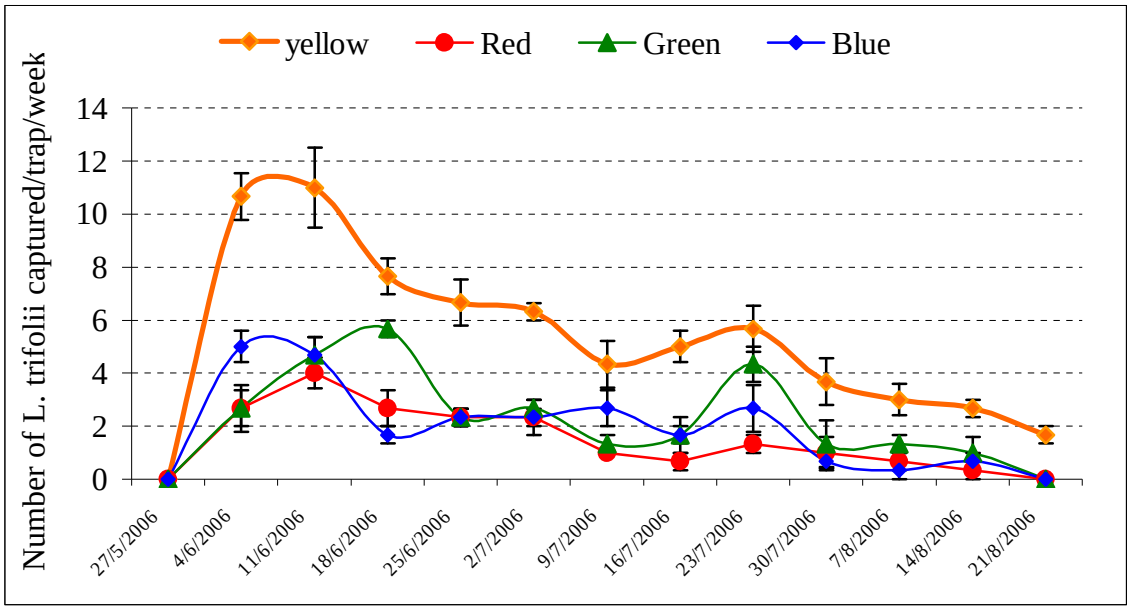

Fig. 3.1. Flight activity of *L. trifolii* flies as monitored by yellow, red, green and blue water traps in open field planted with bean and tomato plants during spring 2006.

3.1.2. Effect of cropping system on flight activity of vegetable leaf miner, *Liriomyza trifolii*

Results presented in Fig. 3.2 shows the mean number of alate *L. trifolii* which was captured by the yellow water traps during spring 2006 within greenhouse and open field planted with both tomato and bean cultivars**.**

Results showed that, during summer months from the beginning of the season till 9th of July, the flight activity of *L. trifolii* was significantly higher in the open field than that in greenhouse. However, during the period of 9th` July till end of August the flight activity under green house condition became significantly higher than that in the open field

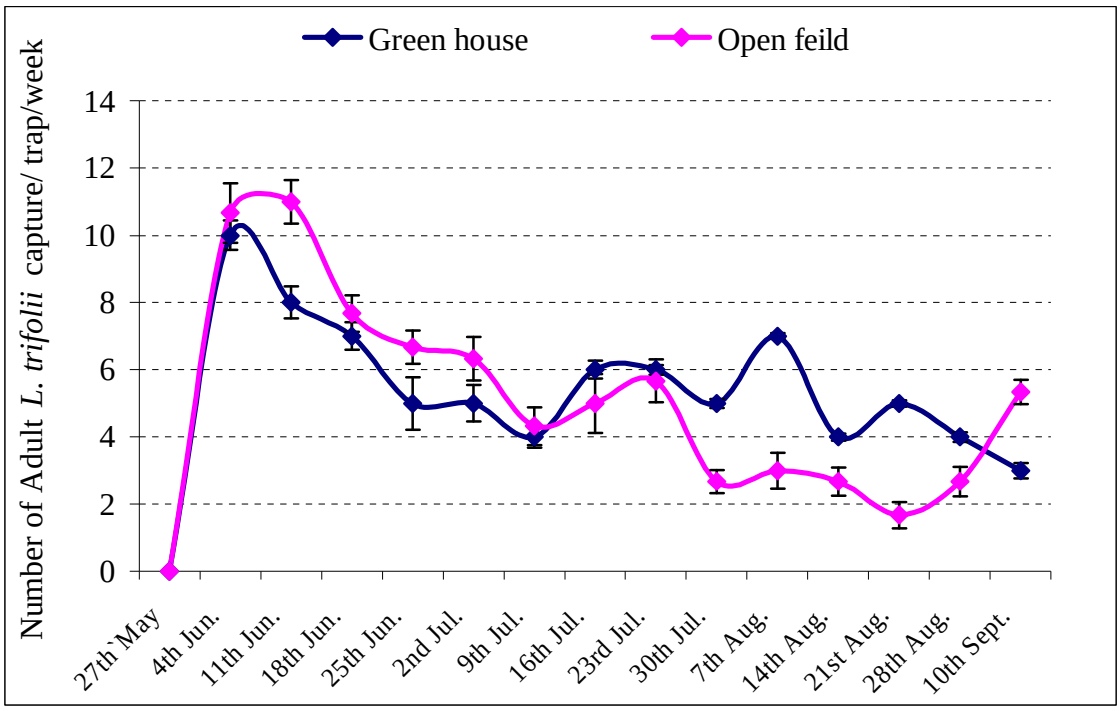

Fig. 3.2. Flight activity of *L. trifolii* flies as monitored by yellow water traps in green house and open field planted with bean and tomato plants during spring and summer of 2006.

3.1.3. Seasonal flight activity of *Liriomyza* spp. within open field throughout 2006

Results presented in Fig. 3.3 shows the mean number of alate *L. trifolii* which were captured by the yellow water traps throughout 2006 season (from 20th May 2006 till the end of December 2006), within open field planted with both tomato and bean cultivars.

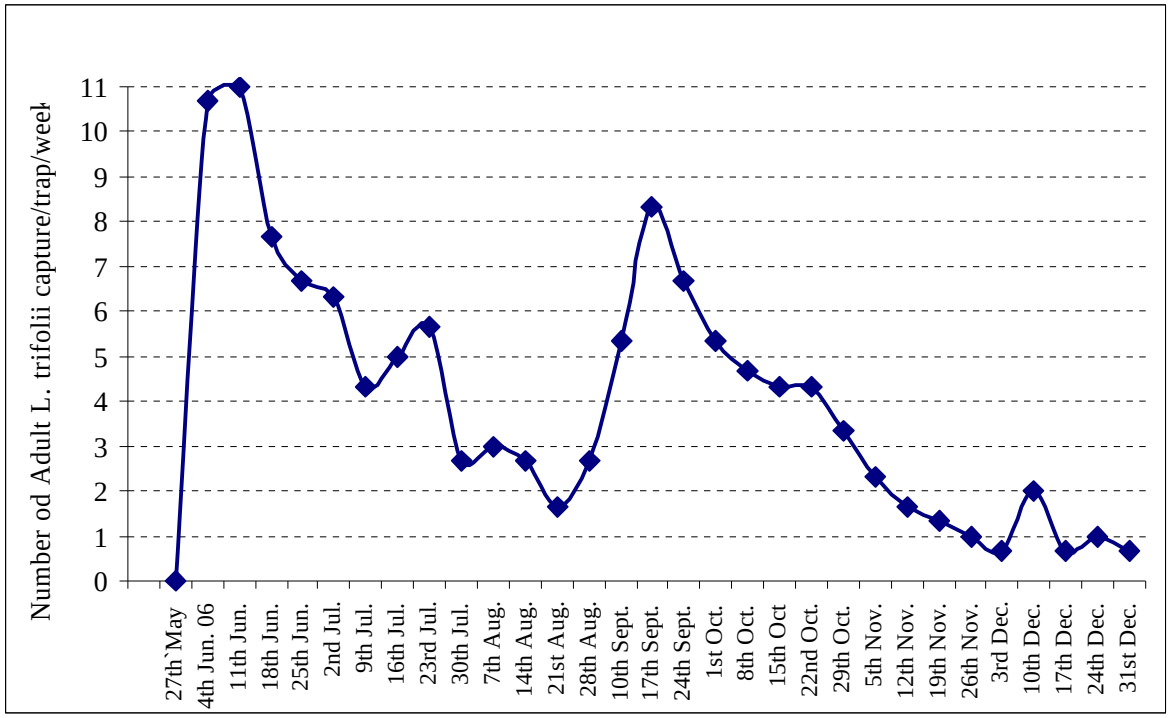

Fig. 3.3. Flight activity of *L. trifolii* flies as monitored by yellow water traps in open field planted with bean and tomato plants during 2006 season.

First observation of trapped *Liriomyza* flies was recorded on 4th June, 2006, and flight activity of *L. trifolii* was recorded throughout the season till 31st December 2006. Two peaks were recorded: summer peak on 10th of June and the fall peak on mid of September (Fig. 3.3).

3.2. Susceptibility of different tomato and bean cultivars to *L. trifolii* infestation in open field

3.2.1. Susceptibility of Different tomato cultivars to *L. trifolii* infestation in open field

3.2.1.1. *L. trifolii* infestation on tomato cultivars in open field

Results presented in Table 3.1 shows that leaf miner infestation was recorded on three tomato cultivar throughout the season from 3rd` June till 26th` August.

Table 3.1. Mean number of *L. trifolii* infested leaves/plant of tomato cultivars in open field. (Mean ± S.E)

Date	Teba	1370	1415	*P value*
3/6/06	1.33±0.14	1.17±0.21	1.17±0.24	0.796NS
10/6/06	2.67±0.36	2.83±0.42	2.33±0.26	0.597 NS
17/6/06	1.42±0.15	1.17±0.11	0.92±0.23	0.132 NS
24/6/06	1.00±0.12	1.08±0.19	0.58±0.15	0.070 NS
1/7/06	1.58±0.19	2.08±0.23	1.50±0.26	0.167 NS
8/7/06	1.67±0.19	1.83±0.17	1.67±0.21	0.450NS
15/7/06	2.92±0.40	2.50±0.29	2.42±0.38	0.577 NS
22/7/06	2.42±0.29	1.92±0.23	1.92±0.42	0.454 NS
29/7/06	1.58±0.38	1.33±0.14	1.00±0.21	0.305 NS
5/8/06	3.17±0.42	2.75±0.46	2.67±0.36	0.664 NS
12/8/06	2.17±0.32	2.17±0.30	1.75±0.25	0.512 NS
19/8/06	1.67±0.23	1.25±0.18	1.42±0.19	0.345 NS
26/8/06	0.42±0.15	0.50±0.20	0.67±0.23	0.648 NS

NS: No significant differences at P value ≤0.05.

The highest infestation was recorded on Teba in 5th August 2006 , Statistical analysis showed that no significant differences were found between the three cultivar of tomato in their susceptibility to leaf miner infestation in the open field at *P value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons

Results in Fig 3.4 shows the accumulative infested leaves /plant of the three tomato cultivar in open field. The average total of the accumulated number of infested leaves/plant on three cultivars of tomato (Teba, 1370 and 1415) that were recorded at the end of the season were 23.92, 22.5 and 19.5 infested leaves /plant respectively.

Statistical analysis showed that a significant difference was recorded between tomato cultivars (at *P value* ≤ 0.05) from 8th July until the end of the season. And Teba and 1370 were significantly higher in susceptibility to leaf miner infestation than 1415 cultivar.

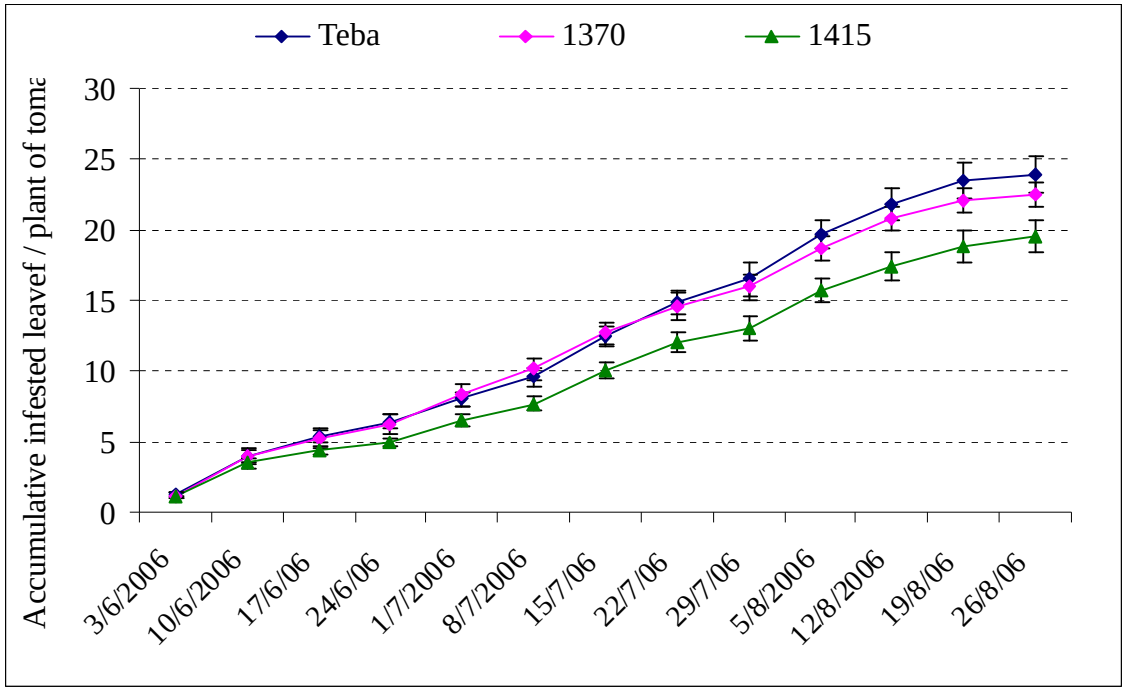

Fig. 3.4. Accumulated mean number of *L. trifolii* infested leaves/plant of tomato cultivars in open field.

3.2.1.2. Mean number of *L. trifolii* mines/plant of tomato cultivars in open field.

Results presented in Table 3.2 shows the mean number of mines/plant found on tomato cultivar (Teba, 1370, 1415) throughout the season (3rd` June-26th` August 2006). The highest mines number were recorded on Teba and 1370 cultivar in (15th` July and 5th` Augusut 2006).

Table 3.2. Mean number of *L. trifolii* mines/plant of tomato cultivars in open field. (Mean* ± S.E)

Date	Teba	1370	1415	*P value*
3/6/06	1.08±0.23	1.08±0.19	1.33±0. 19	0.611NS
10/6/06	3.92±0.61	3.92±0.83	3.50±0.49	0.875 NS
17/6/06	2.00±0.28	1.67±0.21	1.67±0.3	0.101 NS
24/6/06	1.33±0.26	1.58±0.29	0.92±0.19	0.176 NS
1/7/06	2.42^{b}±0.23	3.50^{a}±0.54	2.08^{c}±0.26	0.029
8/7/06	2.58^{b}±0.23	2.92^{a}±0.26	1.83^{c}±0.167	0.005
15/7/06	4.83±0.44	4.92±0.51	4.00±0.37	0.270 NS
22/7/06	3.50±0.36	3.83±0.39	2.67±0.28	0.062 NS
29/7/06	2.50±0.23	1.92±0.19	2.00±0.25	0.154 NS
5/8/06	4.83±0.44	4.75±0.48	4.00±0.33	0.316 NS
12/8/06	3.42±0.38	3.83±0.39	2.67±0.28	0.075 NS
19/8/06	2.42±0.23	1.92±0.19	2.67±0.28	0.092 NS
26/8/06	0.42±0.15	0.58±0.19	0.75±0.29	0.466 NS

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons.

NS: No significant differences at P value ≤0.05.

Statistical analysis showed that significant differences were only found between the numbers of mines/plant during the period from 1st – 8th June (at *P value* ≤ 0.05).

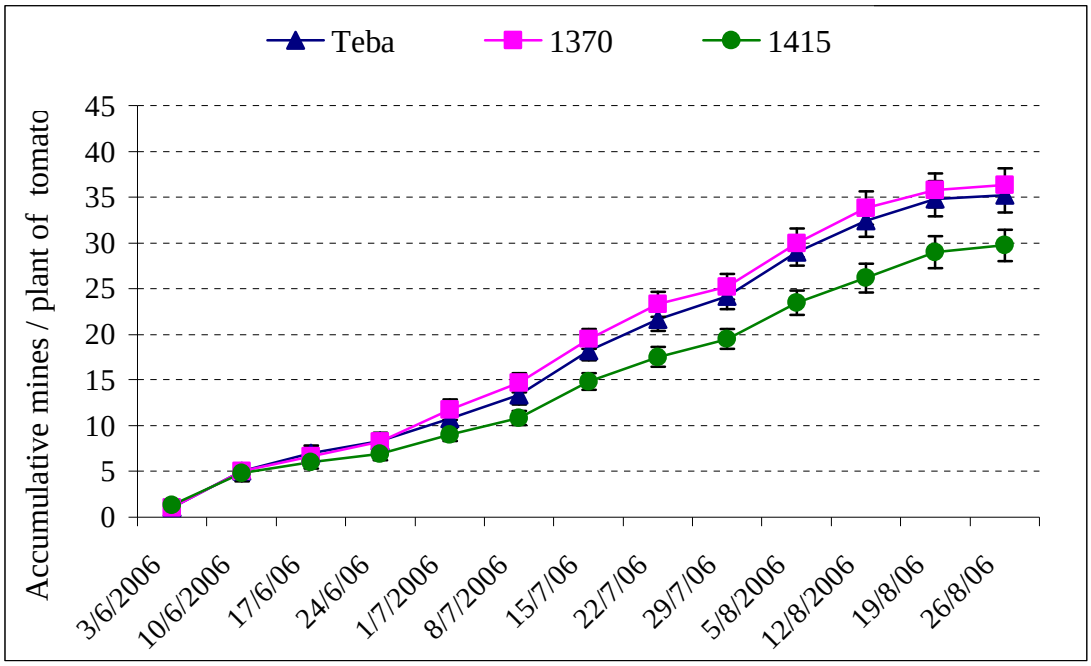

Fig. 3.5. Mean accumulated number of *L. trifolii* mines/plant of tomato cultivars in open field

Results presented in Fig 3.5 shows that the cumulative total number of mines /plant on three tomato cultivar in open field. The accumulative total number of mines that were recorded on the three tomato cultivars at the end of the season was 36.33, 35.25 and 29.75 on 1370, Teba and 1415 cultivars respectively.

Statistical analysis showed that the accumulated number of miner/plant was significantly higher on both Teba and 1370 cultivars than that on 1415 (at *P value* ≤0.05).

3.2.1.3. Mean number of *L. trifolii* mines/leaf of tomato cultivars in open field

Results presented in Table 3.3 shows the mean number of mines/leaf found on tomato cultivar (Teba, 1370, 1415) throughout the season (3rd, June-26th, August 2006). Statistical analysis showed that significant differences were found between the numbers of mines/leaf only at 17th June (at *P value* ≤ 0.05).

Table 3.3. Mean number of *L. trifolii* mines/leaf of tomato cultivars in open field (Mean* ± S.E)

Date	Teba	1370	1415	P-value
10/6/2006	1.58 ± 0.21	1.45 ± 0.23	1.88 ± 0.47	0.638NS
17/6/2006	1.54 [a] ± 0.24	1.54 [a] ± 0.24	0.83[b] ± 0.16	0.040
24/6/2006	1.26 ± 0.26	1.25 ± 0.21	0.83 ± 0.21	0.305 NS
1/7/2006	1.67 ± 0.18	1.71 ± 0.23	1.6 ± 0.25	0.439 NS
8/7/2006	1.85 ± 0.3	1.74 ± 0.24	1.58 ± 0.22	0.763 NS
15/7/2006	2.15± 0.44	2.59 ± 0.55	2.22± 0.41	0.778 NS
22/7/2006	1.69 ± 0.28	2.38 ± 0.29	1.73 ± 0.31	0.251 NS
29/7/2006	1.55 ± 0.26	1.58 ± 0.2	1.7 ± 0.25	0.886 NS
5/8/2006	1.71 ± 0.18	2.11 ± 0.33	2.02 ± 0.43	0.678 NS
12/8/2006	1.79 ± 0.22	2.17 ± 0.35	1.64 ± 0.28	0.37 NS
19/8/2006	1.68 ± 0.28	1.58 ± 0.23	2.14 ± 0.28	0.252 NS
26/8/2006	1.34± 0.29	1.67 ± 0.35	0.82 ± 0.09	0.092 NS

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons.

NS: No significant differences at P value ≤0.05

Results presented in Fig 3.6 shows that the accumulative total of mines /leaf on three tomato cultivar in open field. The accumulative total number of mines that were recorded on the three tomato cultivars at the end of the

season were 21.77, 19.87 and 18.99 mines / leaf on 1370, Teba and 1415 cultivars respectively. Statistical analysis showed that no significant differences were found between the accumulative numbers of mines/leaf that were recorded on the three tomato cultivar throughout the season in open field.

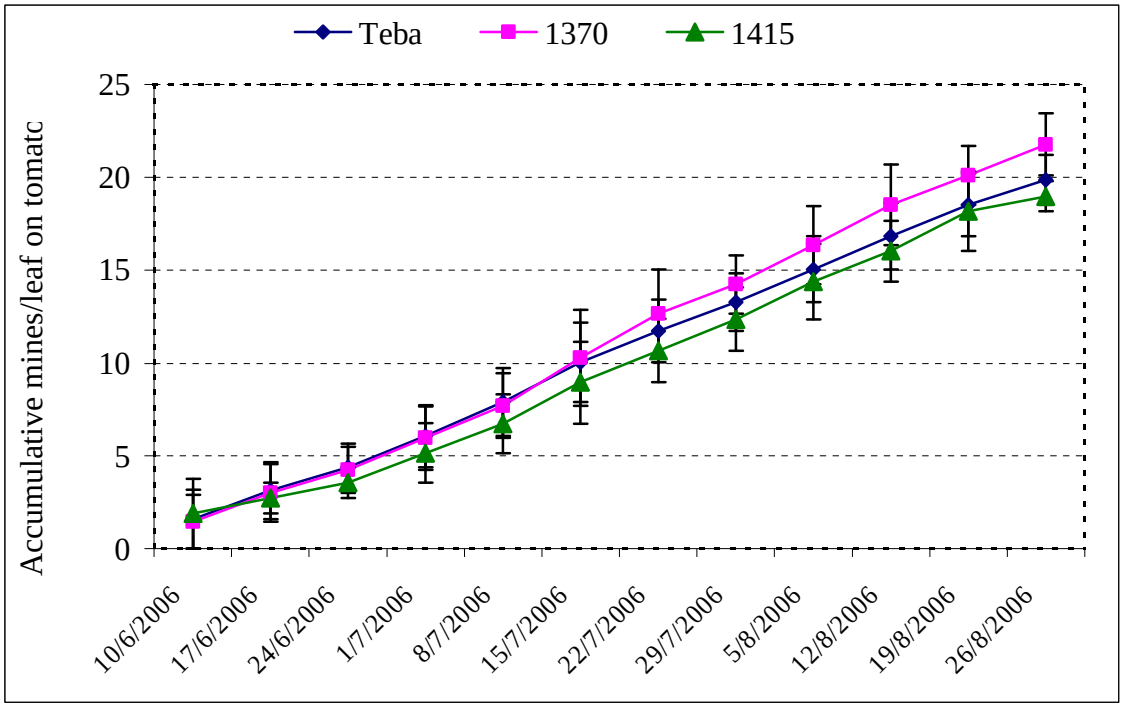

Fig. 3.6. Accumulative number of *L. trifolii* mines/leaf of tomato cultivars in open field

3.2.1.4. Mean number of *L. trifolii* pupa/plant of tomato cultivars in open field

Results presented in Table 3.4 shows the mean number of pupa/plant/week recorded on three tomato cultivar (Teba, 1370, 1415) throughout the season (10th` June -12$^{th}$` August 2006). By the end of the season, the total numbers of pupa /plant that were recorded on cultivars tomato were 19.67 on Teba cultivar , 19.00 on cultivar 1370 and 17.9 on cultivar 1415) and

the highest average number of pupa/plant/week was recorded on the Teba cultivar 3.92 pupa / plant in 29th July .

Statistical analysis showed that significant differences were found between the numbers of pupa/plant/week only during the period from 22nd – 29th June (at *P value* ≤ 0.05).

Table 3.4. Mean number of *L. trifolii* pupa/plant of tomato cultivars in open field. (Mean* ± S.E).

Date	Teba	1370	1415	*P value*
10/6/06	0.25±0.13	0.33±0.14	0.50±0.151	0.453 NS
17/6/06	1.08±0.43	1.08±0.26	1.42±0.36	0.751 NS
24/6/06	0.25±0.13	0.97±0.37	0.75±036	0.147 NS
1/7/06	1.33±0.40	2.00±0.37	2.33±0.56	0.270 NS
8/7/06	1.58±0.36	1.42±0.40	1.00±0.17	0.434 NS
15/7/06	2.33±0.26	2.67±0.28	2.33±0.31	0.636 NS
22/7/06	3.75^{a}±0.33	3.25^{a}±0.35	2.50^{b}±0.23	0.024
29/7/06	3.92^{a}±0.23	3.00^{b}±0.30	2.58^{c}±0.23	0.003
5/8/06	3.17±0.30	2.58±0.23	2.83±0.17	0.233 NS
12/8/06	2.00±0.25	1.75±0.25	1.67±0.23	0.599 NS

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons

NS: No significant differences at P value ≤0.05

3.2.2. Susceptibility of different bean cultivars to *L. trifolii* infestation

3.2.2.1. Mean number of *L. trifolii* infested leaves/plant of bean cultivars in open field

The results in Table 3.5 shows the mean number of infested leaves/plant that were recorded on three bean cultivars (Celena, Dali and Venonica) in open field throughout the season from (3rd، June -26th August 2006).the highest number of infested leaves was recorded on venonica cultivar in 22nd، July and the lowest number was recorded on venonica cultivar in 26th، August 2006.

Statistical analysis showed that significant differences were found between the numbers of infested leaves/plant only at 15th July and at 5th August (at *P value* ≤ 0.05).

Table 3.5. Mean number of *L. trifolii* infested leaves/plant of bean cultivars in open field. (Mean* ± S.E)

Date	Celena	Dali	Venonica	*P value*
3/6/06	1.92±0.26	1.08±0.26	1.83±0.27	0.793NS
10/6/06	2.75±0.21	2.00±0.17	2.75±0.54	0.231 NS
17/6/06	1.25±0.13	1.25±0.22	1.58±0.19	0.347 NS
24/6/06	1.25±0.13	1.00±0.17	1.42±0.26	0.330 NS
1/7/06	2.58±0.19	1.67±0.23	2.50±0.29	0.019 NS
8/7/06	2.50±0.34	2.00±0.25	2.33±0.23	0.430 NS
15/7/06	3.25 ^{c} ±0.45	4.08 ^{b} ±0.56	5.92 ^{a} ±056	0.003
22/7/06	4.83±0.66	5.00±0.58	6.17±0.71	0.300 NS
29/7/06	3.75±0.69	3.58±0.48	4.67±0.64	0.412 NS
5/8/06	3.33 ^{b} ±0.38	3.94^{b}±0.53	5.83 ^{a} ±0.61	0.004
12/8/06	4.42±0.58	5.00±0.76	6.17±0.76	0.217 NS
19/8/06	3.75±0.43	3.58±0.57	4.33±0.62	0.599 NS
26/8/06	1.08±0.29	1.08±0.26	0.83±0.27	0.758 NS

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons
NS: No significant differences at P value ≤0.05

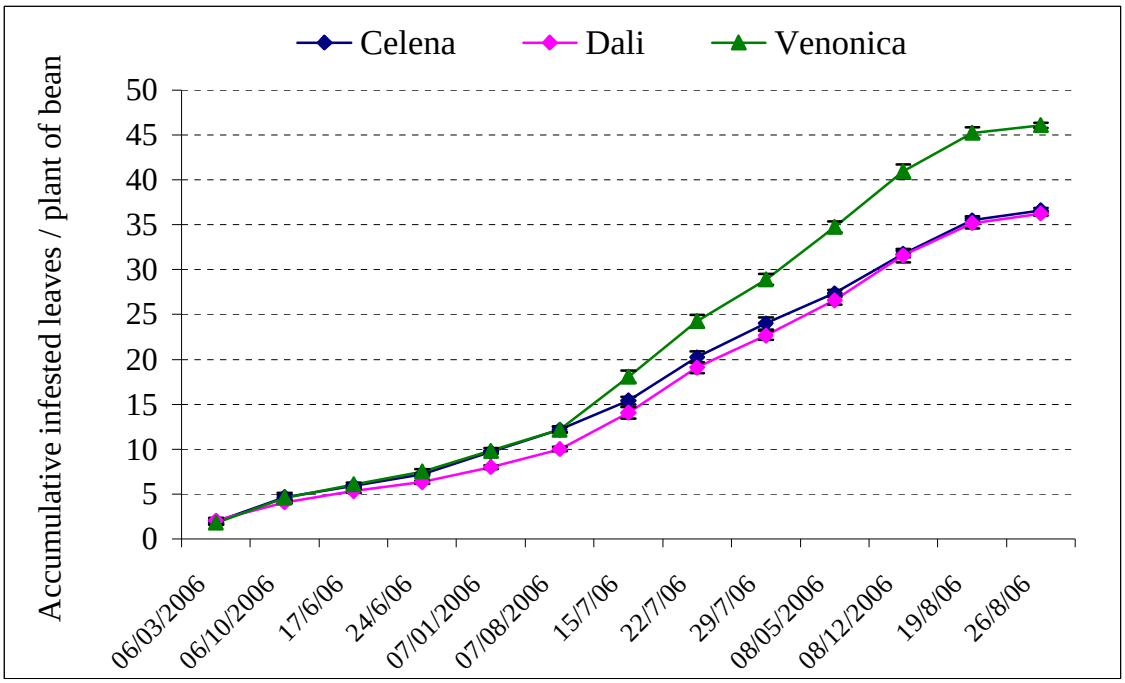

Fig.3.7. Mean accumulated number of *L. trifolii* infested leaves/plant of bean cultivars in open field.

Results presented in Fig 3.7 shows the accumulative number of infested leaves/plant that were recoded between bean cultivars in the open field throughout the season (3rd June – 26th`Augest 2006). By the end of the season the average accumulated of infestations leaves / plant were 46.0 on Venonica and 35.0 on both Celena and Dali.

Statistical analysis showed that a significant differences of leaf miner infestations was found between three cultivar of bean from 15th`July until end of season and infestation was significantly higher on Venonica than that on Celena and Dali cultivars.

3.2.2.2 Mean number of *L. trifolii* mines/plant of bean cultivars in open field.

Results presented in Table 3.6 shows the mean number of mines/plant that were recorded on bean cultivars through the season (3rd June till

26th`Augest 2006), the highest mines number was recorded on venonica cultivar at 12th`August and the lowest numbers were recorded on Celena and Dali at 26th`Augest 2006.

Statistical analysis showed that no significant differences were found between the three cultivar of bean until 24th June 2006, and later on, most records were significantly higher on venonica cultivar than that on Celena and Dali cultivars.

Table 3.6. Mean number of *L. trifolii* mines/plant of bean cultivars in open field. (Mean* ± S.E)

Date	Celena	Dali	Venonica	*P value*
3/6/06	1.92±0.26	2.08±0.26	2.17±0.32	0.817 NS
10/6/06	3.58±0.53	2.67±0.19	4.00±0.96	0.336 NS
17/6/06	1.75±0.25	1.67±0.26	2.25±0.31	0.273 NS
24/6/06	1.92±0.26	1.50±0.23	2.33±0.45	0.214 NS
1/7/06	4.08^{a}±0.29	2.92^{b}±0.23	4.67^{a}±0.41	0.002
8/7/06	4.42±0.54	3.42±0.29	4.75±0.41	0.086 NS
15/7/06	7.50^{b}±0.38	7.42^{b}±0.58	10.67^{a}±0.64	0.000
22/7/06	9.75^{b}±0.80	9.75^{b}±0.71	12.42^{a}±0.71	0.022
29/7/06	7.42±0.65	7.58±0.63	9.08±0.63	0.180 NS
5/8/06	7.50^{b}±0.38	7.42^{b}±0.58	10.67^{a}±0.64	0.000
12/8/06	9.75^{b}±0.80	9.83^{b}±0.69	12.42^{a}±0.71	0.023
19/8/06	6.00^{b}±0.43	6.42^{b}±0.56	7.67^{a}±0.33	0.034
26/8/06	1.08±0.29	1.08±0.23	1.33±0.26	0.735 NS

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons.

NS: No significant differences at P value ≤0.05

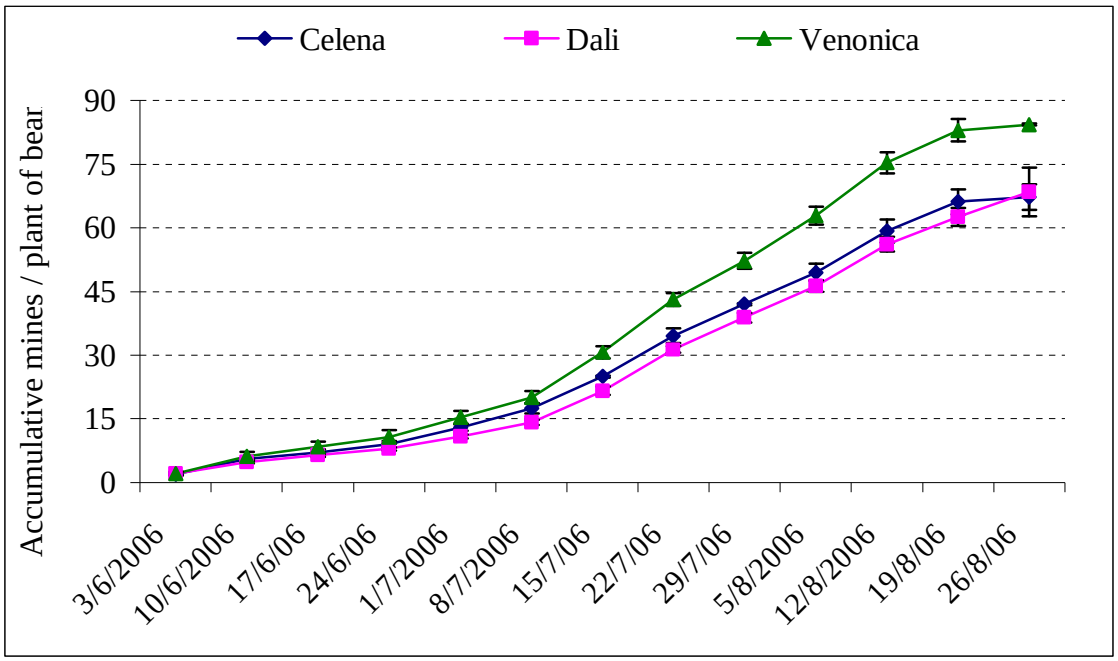

Fig.3.8. Mean accumulated number of *L. trifolii* mines/plant of bean cultivars in open field.

Results presented in Fig 3.8 shows the accumulated number of mines /plant of bean cultivars throughout the season in the open field throughout the season, Venonica culture was with highest infestation than both Celena and Dali culture. Statistical analysis show that significant differences were found between of three tomato cultivar and Venonica was significant higher in infestation than on Celena and Dali cultivars.

3.2.2.3. Mean number of *L. trifolii* mines/leaf of bean cultivars in open field.

Results presented in Fig 3.7 shows the mean number of mines/leaf that were recorded on bean cultivars through the season from 3rd June till 26th`Augest 2006. Statistical analysis showed that no significant differences was found between the three cultivar of bean at P value ≤0.05

Table 3.7. Mean number of *L. trifolii* mines/leaf of bean cultivars in open field. (Mean ± S.E)

Date	Celena	Dali	Venonica	P-value
3/6/2006	1± 0.0	1± 0.0	1.13± 0.13	0.379 NS
10/6/2006	1.49 ± 0.28	1.51±0.23	1.53±0.22	0.994 NS
17/6/2006	1.46±0.23	1.35±0.23	1.58±0.27	0.788 NS
24/6/2006	1.71±0.27	1.38±0.24	1.32±0.26	0.516 NS
1/7/2006	1.64±0.13	1.990.21	2.44±0.57	0.3 NS
8/7/2006	2.18±0.48	1.94±0.24	2.31±0.39	0.745 NS
15/7/2006	2.84±0.41	1.99±0.17	2.01±0.23	0.071 NS
22/7/2006	2.8±0.68	2.27±0.32	2.38±0.34	0.702 NS
29/7/2006	2.61±0.28	2.44±0.57	2.33±0.29	0.84 NS
5/8/2006	2.57±0.28	2.61±0.57	2.08±0.27	0.578 NS
12/8/2006	2.7±0.43	2.21±0.39	2.42±0.36	0.887 NS
19/8/2006	1.83±0.25	2.36±0.44	2.31±0.38	0.528 NS
26/8/2006	0.67±0.14	0.54±0.14	0.9±0.23	0.322 NS

NS: No significant differences at P value ≤0.05

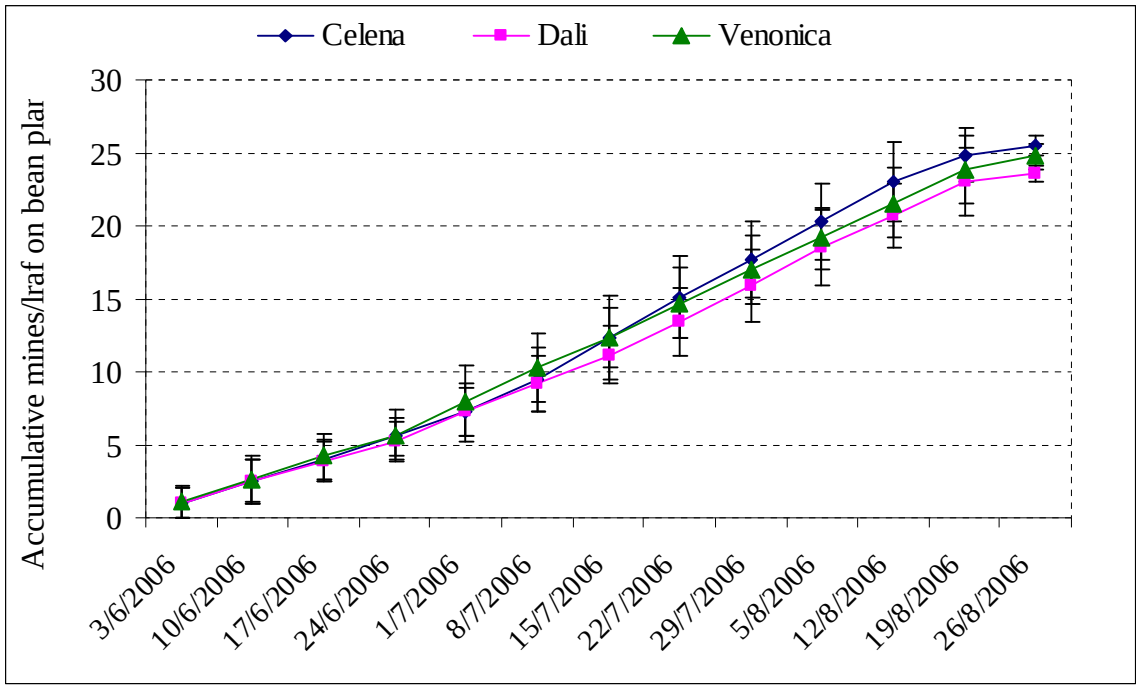

Fig. 3.9. Accumulative number of *L. trifolii* mines/leaf of bean cultivars in open field

Results presented in Fig 3.9 shows the accumulated number of mines /leaf of bean cultivars throughout the season in the open field Celena cultivar was with highest infestation than both Venonica and Dali culture but statistical analysis show that no significant differences were found between of three tomato cultivar.

3.2.2.4. Mean number of *L. trifolii* pupa/plant of bean cultivars in open field.

Results presented in Table 3.8 shows the mean number of pupa/plant that were collected on three bean cultivar (Celena, Dali and Venonica) throughout the season, (10th` June -19$^{th}$` August 2006).

Statistical analysis showed that no significant differences were found between three bean cultivar at the beginning of the season (10th`June-8$^{th}$`July 2006). However, from 15th` July, Venonica was significantly

highest in infestation than both Celena and Dali cultivars and the total number of pupa recorded from Venonica cultivar (41.0 pupa/plant) was significantly higher than that recorded on Dali (30.92) and Celena (29.67).

Table 3.8. Mean number of *L. trifolii* pupa/plant of bean cultivars in open field. (Mean* ± S.E).

Date	Celena	Dali	Venonica	*P value*
10/6/06	0.25±0.13	0.33±0.14	0.75±0.21	0.094 NS
17/6/06	0.58±0.19	0.75±0.30	1.08±0.29	0.411 NS
24/6/06	0.42±0.15	0.96±0.23	1.42±0.42	0.062 NS
1/7/06	1.0±0.25	1.67±0.43	2.50±0.63	0.089 NS
8/7/06	3.42±0.74	4.75±0.95	4.75±0.95	0.479 NS
15/7/06	3.42^{b}±0.23	4.75^{a}±0.58	5.67^{a}±0.51	0.006
22/7/06	3.75^{b}±0.25	4.08^{b}±0.38	5.83^{a}±0.47	0.001
29/7/06	3.50^{b}±0.42	3.42^{b}±0.29	5.75^{a}±0.57	0.001
5/8/06	6.25^{b}±0.46	6.75^{b}±0.51	8.17^{a}±0.53	0.030
12/8/06	3.58±0.38	3.25±0.37	4.50±0.34	0.055 NS
19/8/06	0.50±0.15	0.25±0.13	0.58±0.15	0.247 NS
Total	26.67^{b}±1.72	30.92^{b}±2.2	41.0^{a}±1.87	0.001

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons.

NS: No significant differences at P value ≤0.05

3.2.3. Comparison between susceptibility of different tomato and bean cultivars to *L. trifolii* infestation

3.2.3.1. Mean number of *L. trifolii* infested leaves/plant of tomato and bean in open field

Results presented in Table 3.9 shows the mean number of infested leaves/plant that were recorded on tomato and bean plant in the open field during (3rd June-26th`Augest 2006). Throughout the season, the average numbers of infested leaves/plant were significantly higher on bean plants than on tomato (at *P value* ≤ 0.05).

Table 3.9. Mean number of *L. trifolii* infested leaves/plant of tomato and bean in open field (Mean* ± S.E)

Date	Tomato	Bean	*P value*
3/6/2006	1.22 [b] ±0.11	1.94 [a] ±0.15	0.000
10/6/2006	2.61 [a] ±0.2	2.5 [b] ±0.021	0.000
17/6/06	1.17±0.1	1.36±0.11	0.7 NS
24/6/06	0.89±0.01	1.22±0.11	0.191 NS
1/7/2006	1.72±0.14	2.25±0.15	0.202 NS
8/7/2006	1.56 [b] ±0.12	2.28 [a] ±0.16	0.011
15/7/06	2.61 [b] ±0.2	4.42 [a] ±0.35	0.000
22/7/06	2.08 [b] ±0.18	5.33 [a] ±0.38	0.000
29/7/06	1.3 [b] ±0.15	4.0 [a] ±0.35	0.000
5/8/2006	2.86 [b] ±0.24	4.36 [a] ±34	0.001
12/8/2006	2.03 [b] ±0.17	5.19 [a] ±0.41	0.000
19/8/06	1.44 [b] ±0.12	3.89 [a] ±0.31	0.000
26/8/06	0.53 [b] ±0.1	1.0 [a] ±0.08	0.000
Total	22.03	39.75	0.000

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons.
NS: No significant differences at P value ≤0.05

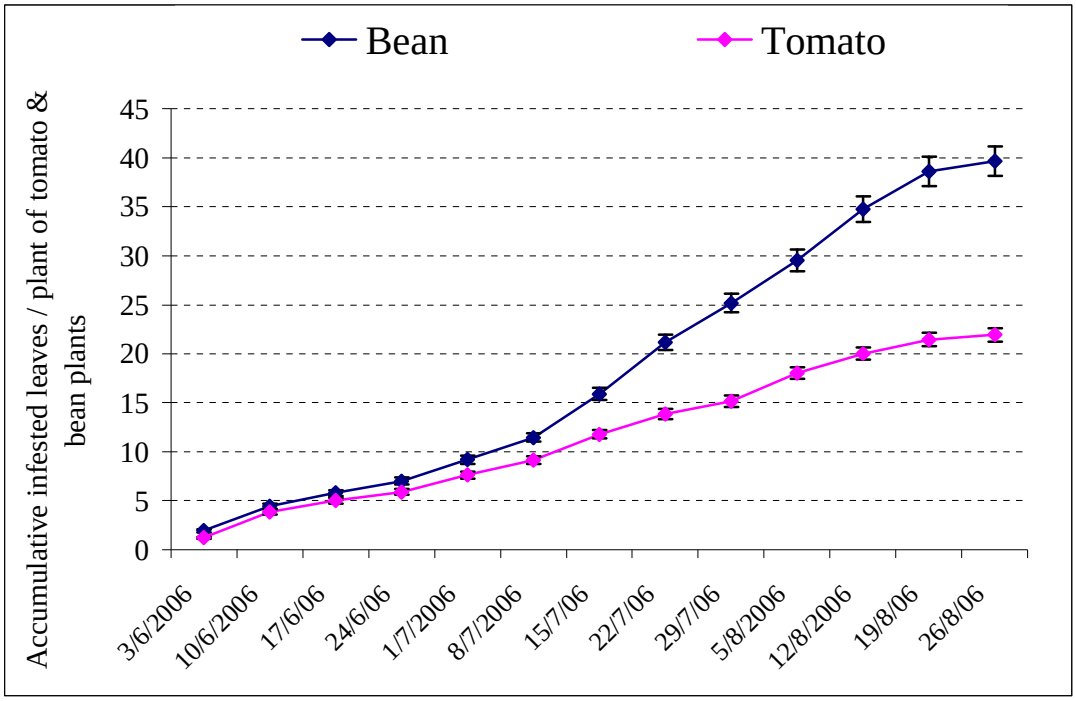

Fig. 3.10. Mean accumulated number of *L. trifolii* infested leaves /plant of tomato and bean cultivars in open field.

Results presented in Fig 3.10 shows the accumulated number of infested leaves /plant that were recorded on tomato and bean cultivars in the open field during the season (3rd` June-26th` August 2006)

Statistical analysis showed that throughout the season, the numbers of infested leaves/plant that were recorded on bean cultivars were significantly higher than that on tomato (at *P value* ≤ 0.05).

3.2.3.2. Mean number of *L. trifolii* mines/plant of tomato and bean in open field

The results presented in Table 3.10 shows the mean number of mines/plant that was recorded on the tomato and bean in open field from (3rd` June till 26th` August 2006). Statistical analysis showed that starting from 1st July till the end of the season, the mean number of mines/plant that were

recorded on bean plants, were significantly higher than that on tomato plants (at *P value* ≤ 0.05).

Table 3.10. Mean number of *L. trifolii* mines/plant of tomato and bean in open field (Mean* ± S.E)

Date	Tomato	Bean	*P value*
3/6/2006	1.17 [b] ±0.12	2.06 [a] ±0.16	0.000
10/6/2006	3.78±0.37	3.42±0.37	0.494 NS
17/6/06	1.61±0.16	1.89±0.16	0.494 NS
24/6/06	1.28±0.15	1.92±0.19	0.222 NS
1/7/2006	2.67 [b] ±0.23	3.89 [a] ±0.22	0.01
8/7/2006	2.44 [b] ±0.15	4.0 [a] ±0.26	0.000
15/7/06	4.59 [b] ±0.25	8.53 [a] ±0.40	0.000
22/7/06	3.33 [b] ±0.21	10.64 [a] ±0.47	0.000
29/7/06	2.14 [b] ±0.13	8.02 [a] ±0.40	0.000
5/8/2006	4.53 [b] ±0.24	8.0 [a] ±0.40	0.000
12/8/2006	3.3 [b] ±0.21	10.67 [a] ±0.46	0.000
19/8/06	2.33 [b] ±0.14	6.69 [a] ±0.28	0.000
26/8/06	0.58 [b] ±0.11	1.17 [a] ±0.15	0.002
Total	33.75 [b]± 1.13	71.61 [a] ±2.12	0.000

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons.

NS: No significant differences at P value ≤0.05

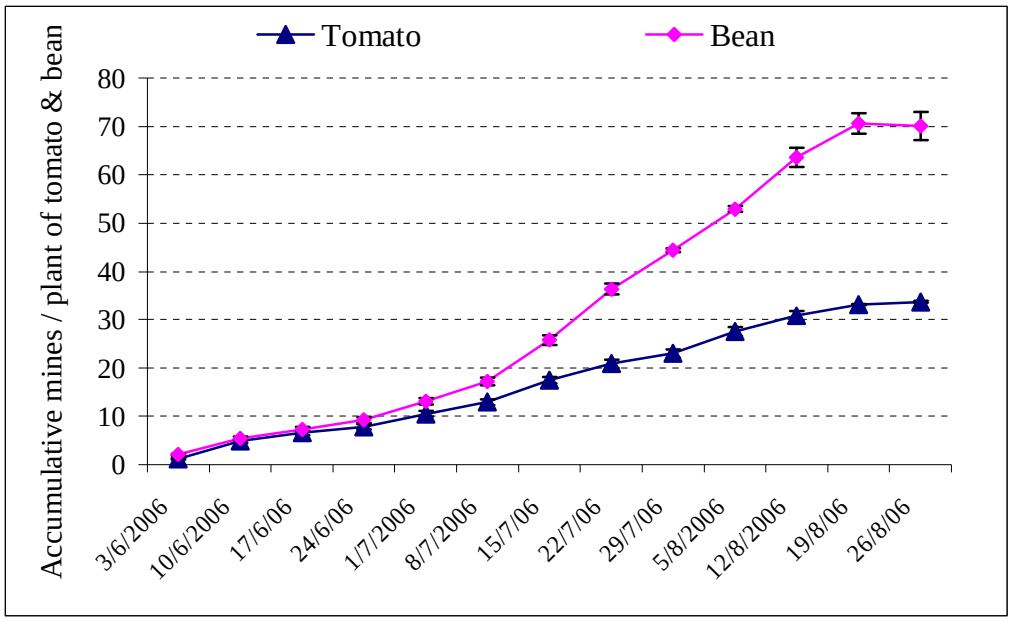

Fig. 3.11. Mean accumulated number of *L. trifolii* mines/plant of tomato and bean cultivars in open field

Results presented in Fig 3.11 shows the accumulated number of mines/plant that were recorded on tomato and bean plants in the open field throughout of the season (3rd`June till 19th`August 2006). Statistical analysis showed that throughout the season, the average accumulated numbers of mines/plant that were recorded on bean plants were significantly higher than that on tomato (at *P value* ≤ 0.05).

3.2.3.3. Mean umber of *L. trifolii* mines/leaf of tomato and bean in the open field.

Results presented in Table 3.11 Shows the mean number of mines that were recorded on tomato and bean cultivars in the open field throughout the season during (26th` June-18th`September 2006). Statistical analysis showed that at the end of the season the number of leaf miners recorded on bean plants were significantly higher than that on tomato plants (at *P value* ≤ 0.05).

Table 3.11. Mean number of *L. trifolii* mines/leaf of bean and tomato plant in the open field. (Mean* ± S.E)

Date	Tomato	Bean	P-value
3/6/2006	0.93±0.09	1.01±0.05	0.426NS
10/6/2006	1.65±0.18	1.57±0.13	0.742NS
17/6/2006	1.3±0.13	1.56±0.12	0.163NS
24/6/2006	1.24±0.12	1.52±0.14	0.119NS
1/7/2006	1.64±0.13	2.02±0.21	0.125NS
8/7/2006	1.22±0.14	2.14±0.22	0.109NS
15/7/2006	2.32±0.27	2.28±0.18	0.898NS
22/7/2006	1.91±0.17	2.48±0.27	0.082NS
29/7/2006	1.67^{b} ±0.13	2.46^{a} ±0.20	0.002
5/8/2006	1.94±0.19	2.41±0.23	0.114NS
12/8/2006	1.86^{b} ±0.16	2.54^{a} ±0.22	0.015
19/8/2006	1.8±0.15	2.17±0.21	0.157NS
26/8/2006	0.5^{b} ±0.08	0.86^{a} ±0.1	0.009

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons.

NS: No significant differences at P value ≤0.05.

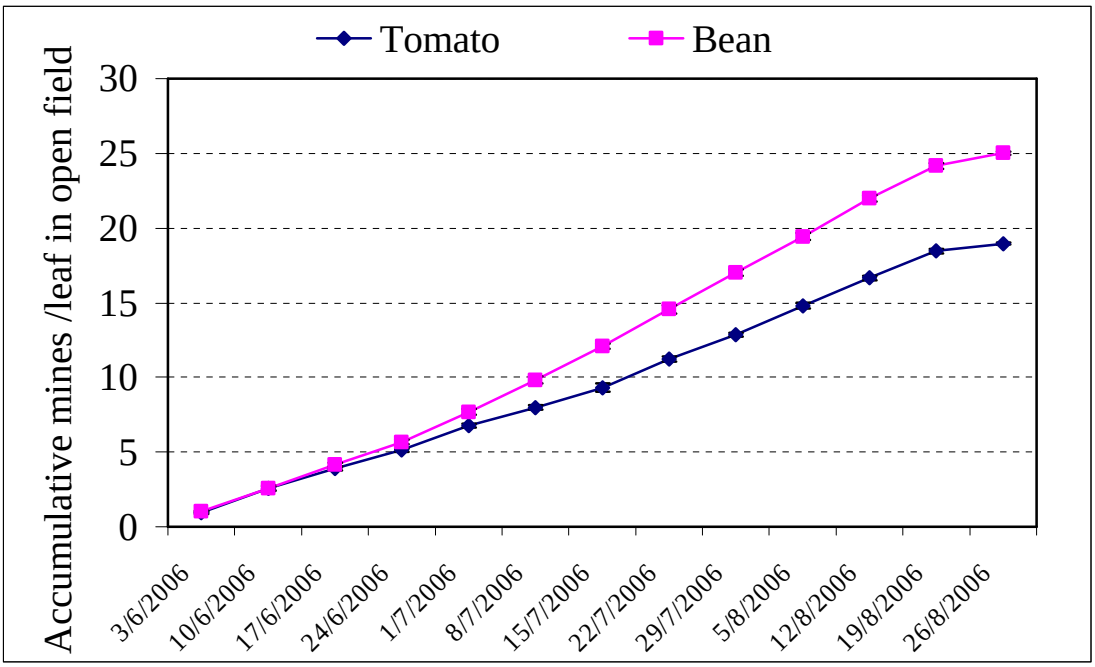

Fig. 3.12. Mean accumulated number of *L. trifolii* mines/leaf of tomato and bean plant in the open field

The results presented in Fig 3.12 Shows the accumulative number of mines/leave that was recorded on tomato and bean cultivars in the greenhouse throughout of the season (26th` June-18$^{th}$`September 2006). Statistical analysis showed that throughout the season, the accumulated number of mines/leave on tomato was significant higher than on bean in the greenhouse (at $p\ value \leq 0.05$).

3.2.3.4. Mean number of *L. trifolii* pupa/plant of tomato and bean in open field

Results presented in Table 3.12 shows the mean number of pupa/plant that were collected from tomato and bean plant throughout the season 10th`June -19$^{th}$` August 2006. Statistical analysis showed that throughout the season, the average numbers of pupa that were collected from bean plants were significant higher than that collected from tomato plant (at $p\ value \leq 0.05$).

Table 3.12. Mean number of *L. trifolii* pupa/plant of tomato and bean in open field. (Mean* ± S.E)

Date	Bean	Tomato	P value
10/6/2006	0.44±0.10	0.36±0.08	0.523 NS
17/6/06	0.8±0.15	1.19±0.20	0.13 NS
24/6/06	0.98±0.18	0.64±0.14	0.226 NS
1/7/2006	1.72±0.28	1.89±0.25	0.661 NS
8/7/2006	4.31 [a] ±0.51	1.33 [b] ±0.19	0.000
15/7/06	4.61 [a] ±0.30	2.44 [b] ±0.16	0.000
22/7/06	4.56 [a] ±0.26	3.17 [b] ±0.19	0.000
29/7/06	4.22 [a] ±0.30	3.17 [b] ±0.17	0.004
5/8/2006	7.06 [a] ±0.31	2.86 [b] ±0.14	0.000
12/8/2006	3.78 [a] ±0.22	1.81 [b] ±0.14	0.000
19/8/06	0.44 [a] ±0.08	0 [b] ±0.0	0.000
Total	32.86 [a] ±1.40	18.86 [b] ±0.69	0.000

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons.

NS: No significant differences at P value ≤0.05

3.3. Susceptibility of different tomato and bean cultivars to *L. trifolii* infestation in the greenhouse

3.3.1. Susceptibility of different tomato cultivars to *L. trifolii* infestation in the greenhouse

3.3.1.1. Mean number of *L. trifolii* infested leaves/plant of tomato cultivars in the greenhouse

Results presented in Table 3.13 shows the mean number of infested leaves/plant that were recorded on tomato cultivars (554, 144 and 259) in greenhouse throughout the season (26th`June till 21$^{st}$`Auguet 2006).

Statistical analysis showed that throughout the season, almost all records of infested leaves/plant were without significant differences between the three tomato cultivars in greenhouses (at *p value* ≤ 0.05).

Table 3.13. Mean number of *L. trifolii* infested leaves/plant of tomato cultivars in greenhouse (Mean *± S.E)

Date	554	144	259	*P value*
26/6/06	0.08 ± 0.08	0.17 ± 0.11	0.08 ± 0.08	0.771 NS
3/7/06	0.25 ± 0.13	0.25 ± 0.13	0.42 ± 0.15	0.614 NS
10/7/06	0.42 ± 0.19	0.25 ± 0.13	0.75 ± 0.25	0.205 NS
17/7/06	0.58 ± 0.19	0.47 ± 0.19	0.92 ± 0.23	0.231 NS
24/7/06	0.67^{b} ± 0.19	0.75^{b} ± 0.13	1.25^{a} ± 0.18	0.041
31/7/06	0.25 ± 0.13	0.33 ± 0.14	0.50 ± 0.15	0.453 NS
7/8/06	1.42^{a} ± 0.19	0.67^{b} ± 0.14	0.67^{b} ± 0.23	0.011
14/8/06	0.58 ± 0.15	0.42 ± 0.15	0.33 ± 0.14	0.478 NS
21/8/06	0.75 ± 0.22	0.58 ± 0.19	0.50 ± 0.15	0.640 NS

*: Figures within the same rows with different letters differ significantly at *p value* $\leq$ 0.05 using one way ANOVA, Fisher's pair wise comparisons.

NS: No significant differences at P value $\leq$0.05

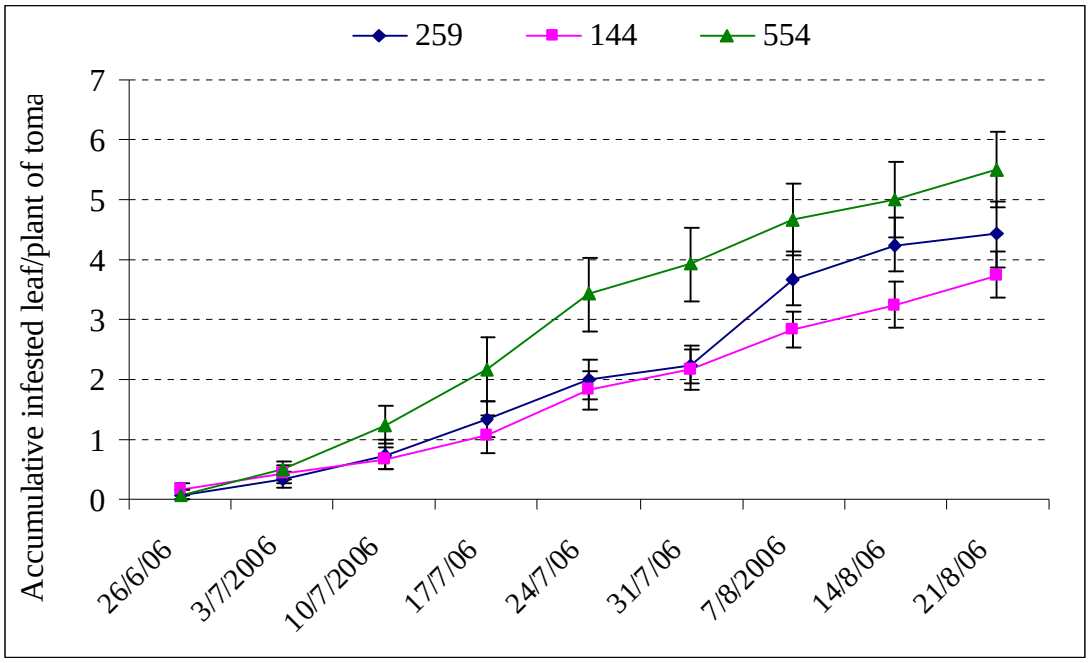

Fig. 3.13. Mean accumulated number of *L. trifolii* infested leaves/plant of tomato cultivars in the greenhouse

Results presented in Fig 3.13 shows the accumulation of infested leaves/plant that were recorded on tomato cultivars (554, 144 and 259) in the greenhouse throughout the season (26th`June till 21st`August 2006). Statistical analysis showed that throughout the season, the accumulated numbers of infested leaves/plant were significantly higher on tomato cultivar (554) that that on 259 and 144 cultivars (at $p\ value \leq 0.05$).

3.3.1.2. Mean number of *L. trifolii* mines/plant of tomato cultivars in the greenhouse.

The results presented in table 3.14 shows the mean number of mines /plant that were recorded on three tomato cultivars (554, 144 and 259) in the greenhouse throughout the season (26th`June till 21st`August 2006). Statistical analysis showed that throughout the season, no significant differences were found between the numbers of mines/plant that were recorded on the three tomato cultivars.

Table 3.14. Mean number of *L. trifolii* mines/plant of tomato cultivars in greenhouse. (Mean* ± S.E).

Date	554	144	259	*P value*
26/6/06	0.08 ± 0.08	0.17 ± 0.11	0.08 ± 0.08	0.771 NS
3/7/06	0.17 ± 0.11	0.25 ± 0.13	0.33 ± 0.14	0.662 NS
10/7/06	0.50 ± 0.29	0.25 ± 0.18	0.92 ± 0.45	0.356 NS
17/7/06	0.67 ± 0.28	0.42 ± 0.19	1.00 ± 0.44	0.451 NS
24/7/06	0.83 ± 0.17	1.08 ± 0.19	1.33 ± 0.19	0.170 NS
31/7/06	0.25 ± 0.13	0.33 ± 0.14	0.42 ± 0.15	0.707 NS
7/8/06	1.67^{a} ± 0.19	0.83^{b} ± 0.24	0.83^{b} ± 0.17	0.007
14/8/06	0.58 ± 0.15	0.50 ± 0.15	0.25 ± 0.13	0.247 NS
21/8/06	0.67 ± 0.14	0.67 ± 0.14	0.42 ± 0.15	0.379 NS
Total	5.33 ± 0.76	4.42 ± 0.68	5.58 ± 1.29	0.661 NS

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons

NS: No significant differences at P value ≤0.05

Results presented in Fig 3.14 shows the average accumulated number of miner / plant that were recorded on tomato cultivars (554, 144 and 259) in the greenhouse throughout the season (26^{th}`June till $21^{st}$`August 2006). Statistical analysis showed that the accumulated number of mines/plant recorded on tomato cultivar (259), was significantly higher than that on 554 and 144 cultivars.

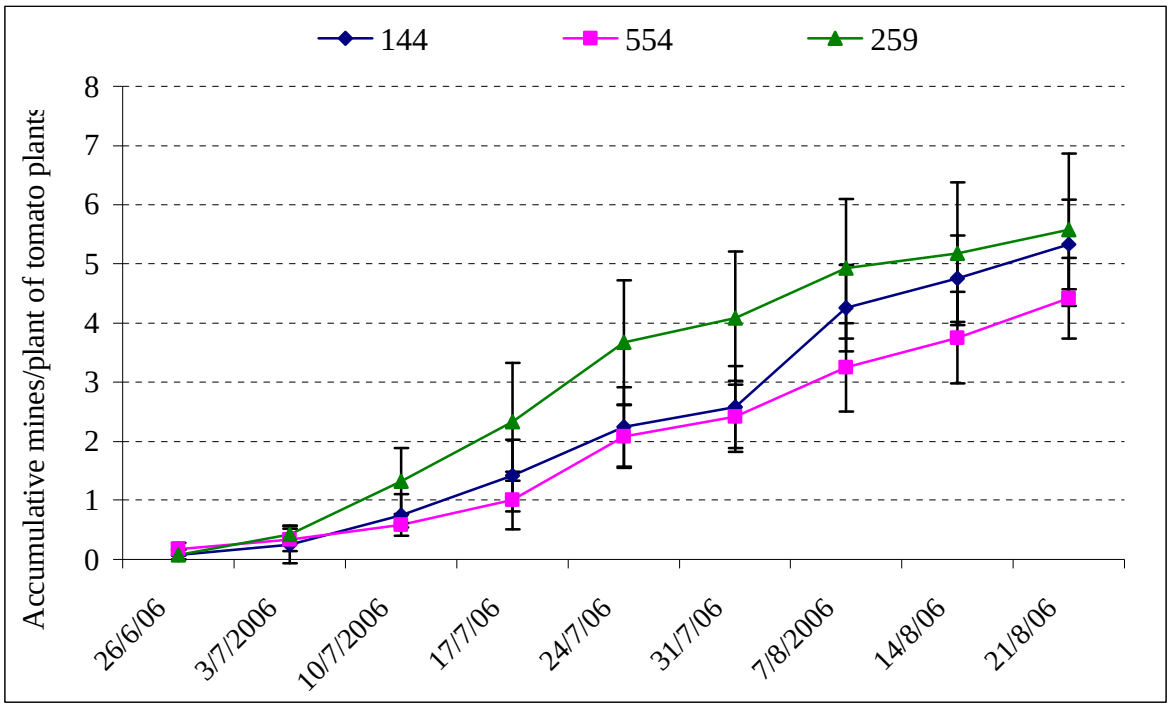

Fig. 3.14. Mean accumulated number of L. trifolii mines/plant of tomato cultivars in the greenhouse.

3.3.1.3. Mean number of *L. trifolii* mines/leaf of tomato cultivars in the greenhouse

The results presented in Table 3.15 Shows the mean number of mines /leaf that were recorded on three tomato cultivars (554,144 and 259) in the greenhouse throughout the season (26th`June till 21$^{st}$`August 2006). Statistical analysis showed that, at the beginning of the season (26th June – 31st July), no significant differences in number mines/leaf were recorded between the three tomato cultivars, and later on, number mines/leaf recorded on tomato cultivar (554) were significantly higher than that on 144 and 259 cultivars.

Table 3.15 Mean number of mines / leaf of tomato cultivars in the greenhouse. (Mean* ± S.E)

Date	554	144	259	P-value
26/6/2006	0.08 ± 0.06	0.08 ± 0.58	0.17 ± 0.78	0.581 NS
3/7/2006	0.08 ± 0.06	0.25 ± 0.09	.25 ± 0.09	0.23 NS
10/7/2006	0.25 ± 0.10	0.20 ± 0.09	0.30 ± 0.1	0.25 NS
17/7/2006	0.50 ± 0.20	0.25 ± 0.12	0.40 ± 0.23	0.568 NS
24/7/2006	0.79 ± 0.12	1.08 ± 0.13	1.04 ± 0.11	0.184 NS
31/7/2006	0.25 ± 0.09	0.33 ± 0.1	0.33 ± 0.1	0.777 NS
7/8/2006	1.25^{a} ± 0.12	0.83^{b} ± 0.17	0.54^{c} ± 0.1	0.001
14/8/2006	0.58^{a} ± 0.1	0.25^{b} ± 0.09	0.08^{c} ± 0.03	0.000
21/8/2006	0.63 ± 0.1	0.63 ± 0.1	0.33 ± 0.1	0.056 NS

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons.

NS: No significant differences at P value ≤0.05

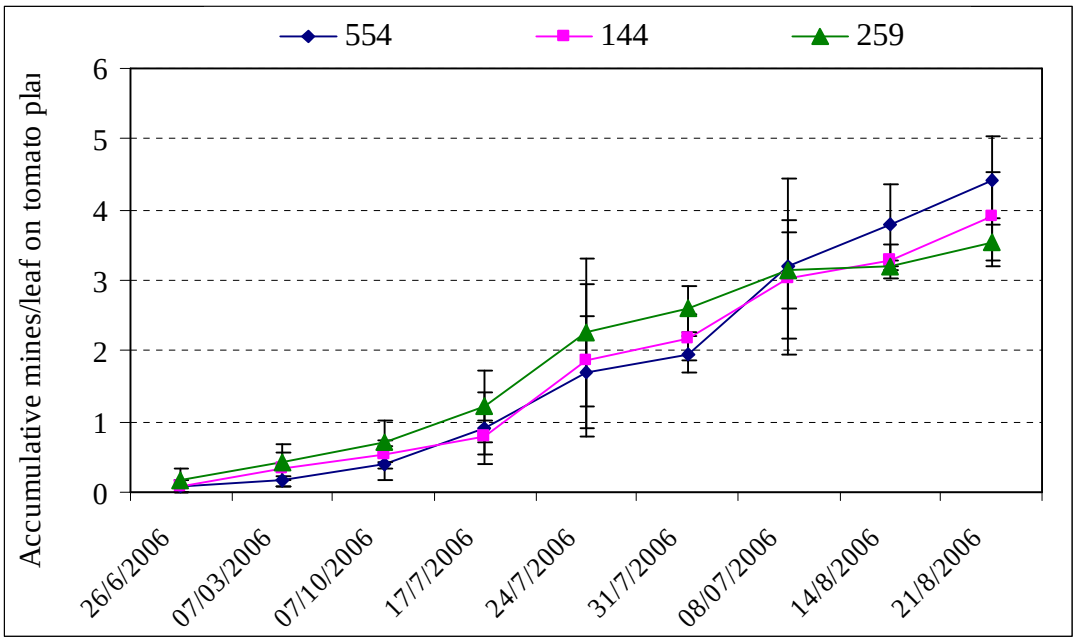

Fig. 3.15. Accumulative number of *L. trifolii* mines/leaf of tomato cultivars in the greenhouse

Results presented in Fig 3.15 shows the accumulated number of miner / leaf that were recorded on tomato cultivars (554, 144 and 259) in the greenhouse throughout the season (26th June till 21st` August 2006). Statistical analysis showed that there was no significantly in the accumulated number of mines / leaf between tomato cultivars.

3.3.1.4. Mean number of *L. trifolii* pupa/plant of tomato cultivars greenhouse

The results presented in Table 3.16 shows the mean number of pupa that were recorded on tomato cultivars in the greenhouse throughout the season (3rd` July till 21st` August 2006). The highest pupa number was recorded on 554 at 14th` August.

Table 4.16. Mean number of *L. trifolii* pupa/plant of tomato cultivars in greenhouse. (Mean* ± S.E)

Date	554	144	259	*P value*
3/7/06	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	-
10/7/06	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	-
17/7/06	0.33 ± 0.14	0.33 ± 0.19	0.58 ± 0.23	0.566 NS
24/7/06	0.83 ± 0.21	0.67 ± 0.19	1.08 ± 0.23	0.375 NS
31/7/06	0.75 ± 0.25	0.58 ± 0.23	0.83 ± 0.27	0.774 NS
7/8/06	1.92 ± 0.26	1.50 ± 0.29	1.08 ± 0.31	0.139 NS
14/8/06	2.17^{a} ± 0.42	1.17^{b} ± 0.27	0.83^{b} ± 0.27	0.020
21/8/06	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	-
Total	6.00^{a} ± 0.60	4.25^{b} ± 0.30	4.42^{b} ± 0.67	0.05

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons

NS: No significant differences at P value ≤0.05

Statistical analysis showed that there was no significant differences were found between the three tomatos cultivars in the number of pupa collected from infested tomato plants in the green house throughout the season.

3.3.2. Susceptibility of different bean cultivars to *L. trifolii* infestations in the greenhouse

3.3.2.1. Mean number of *L. trifolii* infested leaves/plant of bean cultivars in the greenhouse

Results presented in Table 3.17 shows the mean number of *L. trifolii* infested leaves/plant that were recorded on bean cultivars (Ascrow, Gesica and Local variety) in the greenhouse throughout the season (26th`June till 19$^{th}$`September 2006). Statistical analysis showed that there was no significant differences were recorded between the three bean cultivars to leaf miners of infestation in the greenhouses at $p\ value \leq 0.05$.

Results presented in Fig 3.16 shows the average accumulated number of infested leaves/ plant that were recorded on bean cultivars in the greenhouse throughout the season (26th`June till 18th``September 2006).
Statistical analysis showed that both Ascrow and Gesica with significantly higher accumulated number of infested leaves/plant that than local cultivar at $p\ value \leq 0.05$.

Table 3.17 Mean number of *L. trifolii* infested leaves/plant of bean cultivars in greenhouse. (Mean* ± S.E).

Date	Ascrow	Gesica	Local	*P value*
26/6/06	$1.92^{a} \pm 0.34$	$1.42^{a} \pm 0.19$	$0.50^{b} \pm 0.15$	0.001
3/7/06	$2.50^{a} \pm 0.44$	$2.75^{a} \pm 0.22$	$0.92^{b} \pm 0.15$	0.000
10/7/06	$3.25^{b} \pm 0.41$	$4.08^{a} \pm 0.56$	$2.08^{c} \pm 0.26$	0.008
17/7/06	3.25 ± 0.88	5.00 ± 0.62	2.00 ± 0.39	0.011
24/7/06	$6.67^{a} \pm 0.78$	$6.25^{a} \pm 0.65$	$4.00^{b} \pm 0.49$	0.015
31/7/06	$4.00^{a} \pm 0.54$	$3.33^{b} \pm 0.47$	$2.17^{c} \pm 0.17$	0.014
7/8/06	$5.67^{a} \pm 0.54$	$3.83^{b} \pm 0.56$	$5.17^{a} \pm 0.73$	0.009
14/8/06	$2.33^{b} \pm 0.25$	$1.67^{c} \pm 0.31$	$3.08^{a} \pm 0.40$	0.016
21/8/06	2.42 ± 0.29	2.08 ± 0.36	2.33 ± 0.19	0.696 NS
28/806	3.67 ± 0.26	2.92 ± 0.26	3.25 ± 0.31	0.169 NS
4/9/06	$2.58^{b} \pm 0.23$	$2.58^{b} \pm 0.34$	$4.08^{a} \pm 0.23$	0.000
11/9/06	1.08 ± 0.19	1.25 ± 0.13	1.50 ± 0.15	0.196 NS
18/9/06	1.08 ± 0.19	1.08 ± 0.15	1.25 ± 0.13	0.698 NS
Total	$40.42^{a} \pm 2.66$	$38.33^{b} \pm 2.38$	$32.33^{c} \pm 1.66$	0.045

*: Figures within the same rows with different letters differ significantly at *p value* $\leq$ 0.05 using one way ANOVA, Fisher's pair wise comparisons.

NS: No significant differences at P value $\leq$0.05.

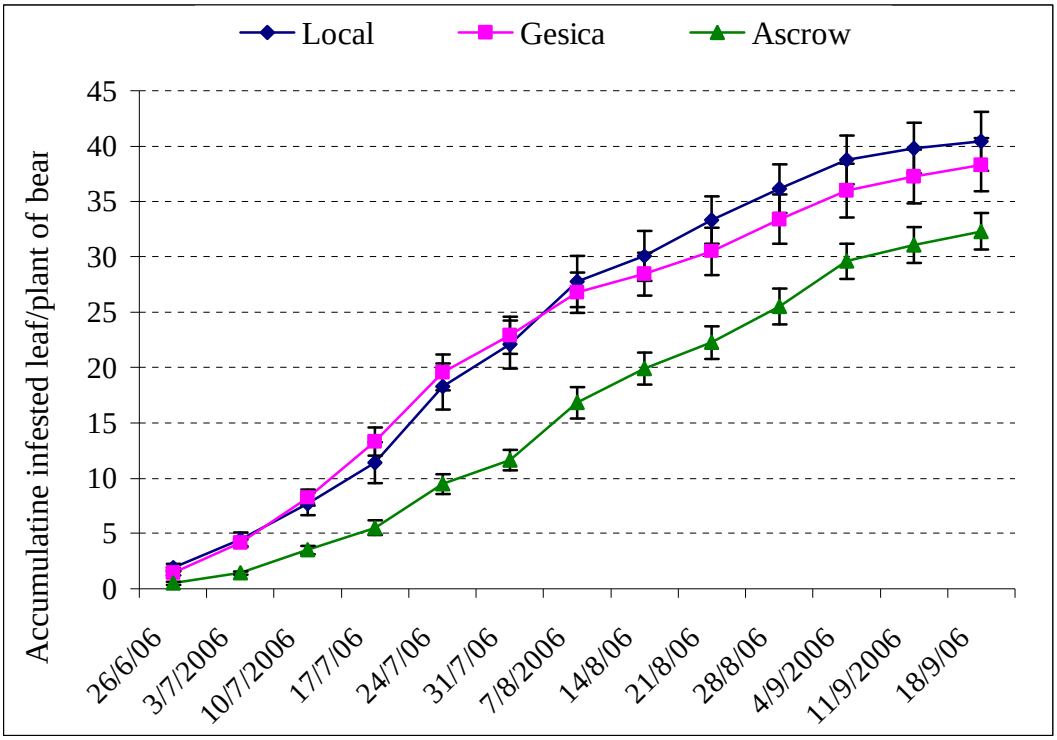

Fig. 3.16. Mean accumulated number of *L. trifolii* infested leaves/plant of bean cultivars in the greenhouse

3.3.2.2. Mean number of *L. trifolii* mines/plant of bean cultivars in the greenhouse

The results presented in Table 3.18 shows the mean number of mines that were recorded on three bean cultivars in the greenhouse throughout the season (26th`June till 18th``September2006). The highest numbers of mines were recorded on Ascrow at 24th` July 2006.

Statistical analysis shows that both Ascrow and Gesica cultivar were significant higher than the Local cultivar in number of mines/plant that were recorded at the beginning of the season (26th`June-14thAugust 2006) later on till the end of the season no significant differences were found between the three cultivar.

Table 3.18 Mean number of *L. trifolii* mines/plant of bean cultivars in greenhouse. (Mean* ± S.E).

Date	Ascrow	Gesica	Local	*P value*
26/6/06	$2.92^{a} \pm 0.31$	$2.83^{a} \pm 0.44$	$1.08^{b} \pm 0.29$	0.001
3/7/06	$3.92^{a} \pm 0.633$	$4.42^{a} \pm 0.40$	$1.50^{b} \pm 0.31$	0.000
10/7/06	5.25 ± 0.72	6.42 ± 0.76	4.08 ± 0.58	0.073 NS
17/7/06	$6.92^{a} \pm 1.40$	$9.17^{a} \pm 1.37$	$4.08^{b} \pm 0.67$	0.018
24/7/06	$11.50^{a} \pm 0.67$	$10.83^{a} \pm 0.82$	$8.92^{b} \pm 0.67$	0.043
31/7/06	$6.08^{a} \pm 0.38$	$5.75^{a} \pm 0.54$	$3.75^{b} \pm 0.37$	0.001
7/8/06	$10.00^{a} \pm 0.26$	$7.17^{b} \pm 0.60$	$10.00^{a} \pm 0.82$	0.013
14/8/06	$3.25^{b} \pm 0.31$	$3.08^{b} \pm 0.45$	$5.42^{a} \pm 0.53$	0.001
21/8/06	3.83 ± 0.37	3.17 ± 0.52	3.92 ± 0.34	0.386 NS
28/806	5.42 ± 0.60	4.67 ± 0.50	6.33 ± 0.66	0.148 NS
4/9/06	3.67 ± 0.40	4.25 ± 0.51	5.25 ± 0.58	0.093 NS
11/9/06	1.58 ± 0.29	1.75 ± 0.35	2.17 ± 0.30	0.408 NS
18/9/06	1.33 ± 0.28	1.42 ± 0.38	2.17 ± 0.35	0.174 NS

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons.

NS: No significant differences at P value ≤0.05

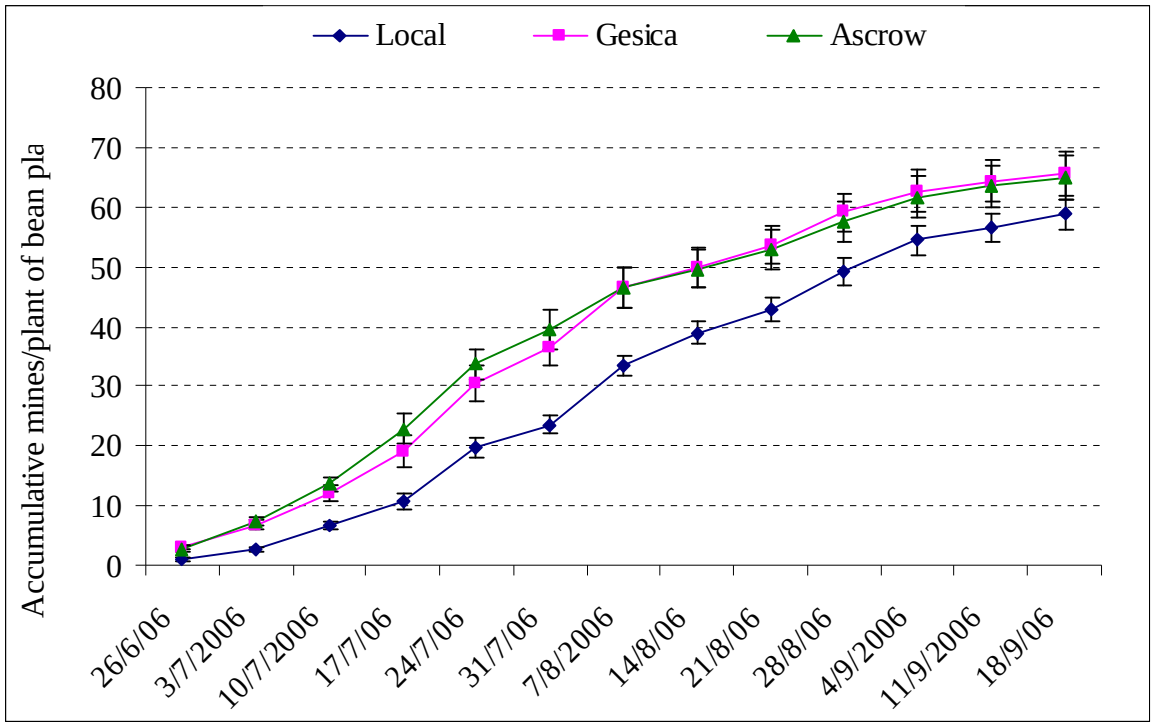

Fig. 3.17. Mean accumulated number of *L. trifolii* mines/plant of bean cultivars in the greenhouse

The results presented in Fig 3.17 shows the average accumulated number of mines/ plant that were recorded on three bean cultivars in the greenhouse throughout the season (26th`June till 18$^{th}$`September 2006).

Statistical analysis showed that both Ascrow and Gesica cultivar were with significantly higher value of accumulated number of mines/plant than that on the Local cultivar in the greenhouse throughout the season (at *p value* ≤ 0.05).

3.3.2.3. Mean number of *L. trifolii* mines/leaf of bean cultivars in the greenhouse

The results presented in Table 3.19 shows the mean number of mines that were recorded on three bean cultivars in the greenhouse throughout the season (26th`June till 18th``September2006)

Statistical analysis shows that there was no significant differences were found between the three cultivars.

Table 3.19. Mean number of *L. trifolii* mines/leaf of bean cultivars in the greenhouse. (Mean ± SE)

Date	Ascrow	Giseca	Local	P-value
26/6/2006	1.8±0.31	2.04±0.41	1.08±0.29	0.131 NS
3/7/2006	1.74±0.34	1.69±0.19	1.37±0.28	0.613 NS
10/7/2006	1.67±0.16	1.84±0.26	2.180.32	0.363 NS
17/7/2006	2.44±0.46	2.01±0.29	2.57±0.40	0.525 NS
24/7/2006	1.9±0.16	1.92±0.26	2.51±0.33	0.172 NS
31/7/2006	2.03±0.42	2.17±0.37	1.85±0.22	0.806 NS
7/8/2006	1.94±0.22	2.7±0.62	2.58±0.49	0.48 NS
14/8/2006	1.56±0.20	2.18±0.36	2.1±0.34	0.319 NS
21/8/2006	2.11±0.49	1.44±0.25	1.79±0.19	0.239 NS
28/8/2006	1.64±0.28	1.74±0.26	2.05±0.19	0.474 NS
4/9/2006	1.49±0.16	1.89±0.31	1.3±0.14	0.156 NS
11/9/2006	1.32±0.3	1.38±0.26	1.63±0.28	0.763 NS
18/9/2006	1.04±0.22	1.25±0.31	1.96±0.35	0.087 NS

NS: No significant differences at P value ≤0.05

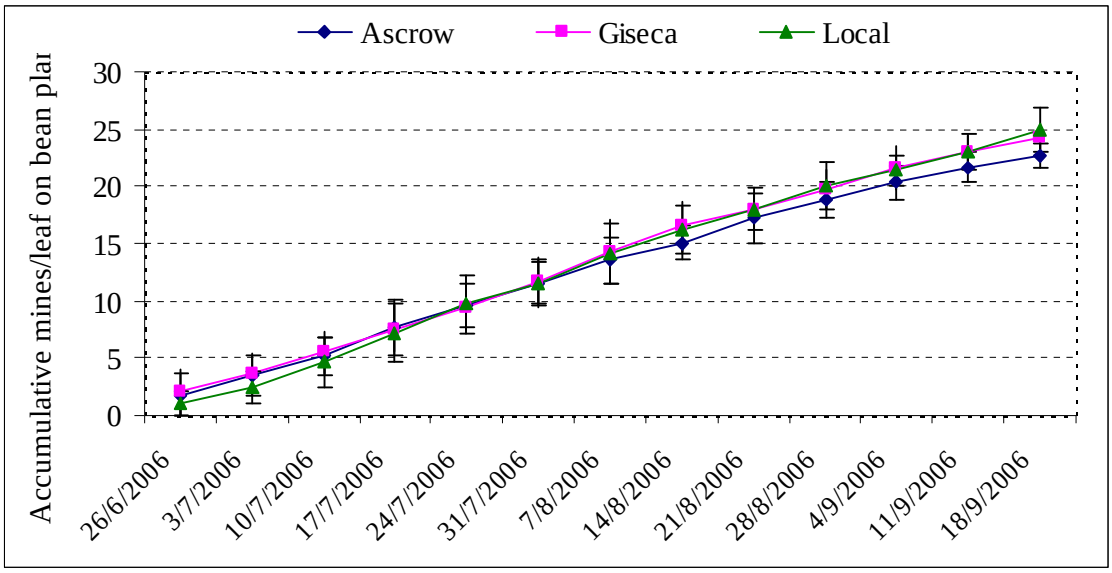

Fig. 3.18. Accumulative number of *L. trifolii* mines/leaf of bean cultivars in greenhouse

The results presented in Fig 3.18 shows accumulated number of mines/leaf that were recorded on three bean cultivars in the greenhouse throughout the season, (26th`June till 18th```September 2006).

Statistical analysis shows that there was no significant differences were found between the three bean cultivar in the greenhouse throughout the season (at *p value* ≤ 0.05).

3.3.2.4 Mean number of *L. trifolii* pupa/plant of bean cultivars in greenhouse

Results presented in Table 3.20 shows the mean number of pupa/pupa that were from bean plant in the greenhouse throughout the season collected (3rd`July till 21st`August 2006) at *P value* ≤0.05.

Table 3.20 Mean number of *L. trifolii* pupa/plant of Bean cultivars in greenhouse. (Mean* ± S.E).

Date	Ascrow	Gesica	Local	*P value*
3/7/06	$1.58^{a} \pm 0.23$	$1.25^{a} \pm 0.29$	$0.25^{b} \pm 0.131$	0.000
10/7/06	$5.25^{a} \pm 0.463$	$2.83^{b} \pm 0.42$	$1.25^{c} \pm 0.31$	0.000
17/7/06	$11.67^{a} \pm 1.45$	$8.25^{b} \pm 1.14$	$5.17^{c} \pm 0.52$	0.001
24/7/06	$16.92^{a} \pm 0.10$	$14.17^{b} \pm 1.31$	$4.00^{c} \pm 0.64$	0.000
31/7/06	15.17 ± 1.13	15.67 ± 1.14	12.33 ± 1.05	0.088 NS
7/8/06	$15.75^{a} \pm 0.90$	$13.33^{b} \pm 0.78$	$10.33^{c} \pm 0.58$	0.000
14/8/06	15.42 ± 1.25	13.33 ± 1.02	16.67 ± 0.95	0.105 NS
21/8/06	9.00 ± 0.61	8.75 ± 0.80	10.33 ± 0.93	0.328 NS
28/806	6.67 ± 0.55	6.50 ± 0.65	7.58 ± 0.71	0.409 NS
4/9/06	$6.50^{b} \pm 0.65$	$5.67^{b} \pm 0.67$	$9.00^{a} \pm 0.71$	0.004
11/9/06	3.25 ± 0.25	3.58 ± 0.38	3.58 ± 0.31	0.696 NS
18/9/06	1.33 ± 0.28	1.00 ± 0.17	1.50 ± 0.31	0.406 NS

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons.

NS: No significant differences at P value ≤0.05

The highest number of pupa was recorded on Ascrow at 24th` July followed by Local variety at 14th`August 2006. Statistical analysis showed the mean number of pupa throughout the season weekly collected / plant were most the time significantly higher on Ascrow than that on Gesica and the Local cultivar.

3.3.3. Comparison between susceptibility of different tomato and bean cultivars to *L. trifolii* infestation in the greenhouse.

3.3.3.1. Mean number of *L. trifolii* infested leaves/plant of tomato and bean in the greenhouse

Results presented in Table 3.21 shows the mean number of *L. trifolii* infested leaves that were recorded on in the greenhouse throughout the season (26th June-18th September 2006). The highest infested number was recorded on bean at 24th July. During the season significantly higher infestation was recorded on bean plants than that on tomato plants.

Table 3.21. Mean number of *L. trifolii* infested leaves/plant of tomato and bean cultivars in greenhouse. (Mean* ± S.E)

Date	Tomato	Bean	*P value*
26/6/06	$0.11^{b} \pm 0.05$	$1.28^{a} \pm 0.17$	0.00
3/7/06	$0.31^{b} \pm 0.07$	$2.06^{a} \pm 0.21$	0.00
10/7/06	$0.47^{b} \pm 0.12$	$3.14^{a} \pm 0.28$	0.00
17/7/06	$0.64^{b} \pm 0.12$	$3.59^{a} \pm 0.42$	0.00
24/7/06	$0.89^{b} \pm 0.10$	$5.64^{a} \pm 0.42$	0.00
31/7/06	$0.36^{b} \pm 0.08$	$3.17^{a} \pm 0.27$	0.00
7/8/06	$0.92^{b} \pm 0.12$	$4.89^{a} \pm 0.37$	0.00
14/8/06	$0.44^{b} \pm 0.08$	$2.36^{a} \pm 0.21$	0.00
21/8/06	$0.61^{b} \pm 0.11$	$2.28^{a} \pm 0.16$	0.00
28/8/06	$0.00^{b} \pm 0.00$	$3.28^{a} \pm 0.16$	0.00
4/9/06	$0.00^{b} \pm 0.00$	$3.08^{a} \pm 0.19$	0.00
11/9/06	$0.00^{b} \pm 0.00$	$1.28^{a} \pm 0.09$	0.00
18/9/06	$0.00^{b} \pm 0.00$	$1.14^{a} \pm 0.09$	0.00
Total	$4.56^{b} \pm 0.32$	$37.03^{a} \pm 1.4$	0.00

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using t-test analysis., Fisher's pair wise comparisons

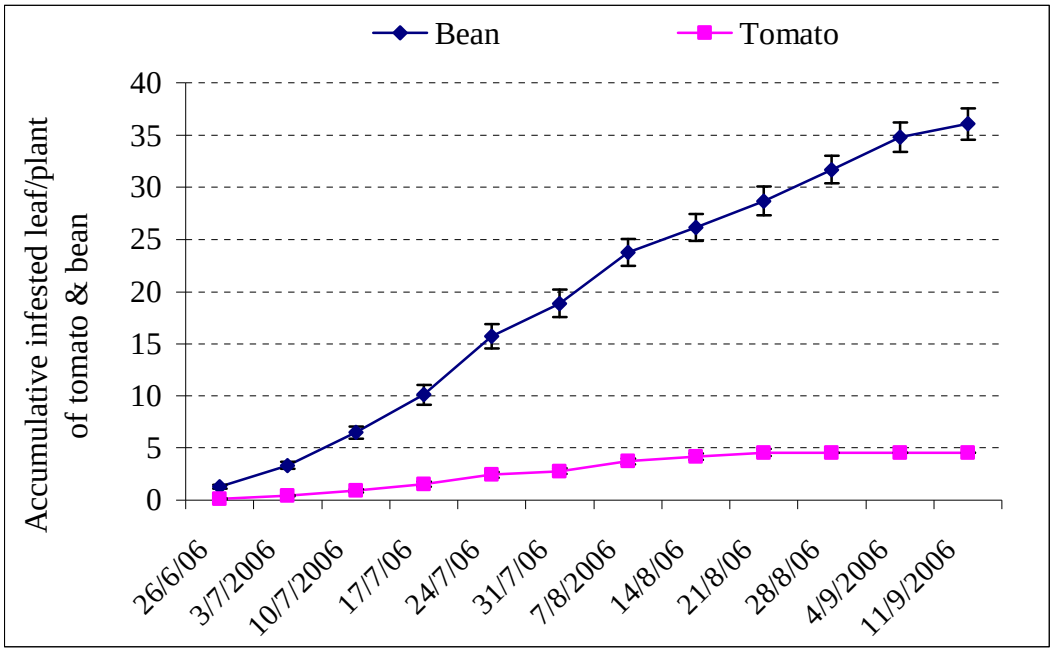

Fig. 3.19. Mean accumulated number of *L. trifolii* infested leaves/plant of tomato and bean cultivars in the greenhouse

Results presented in Fig 3.19 shows that the accumulative number of infested leaves/plant of tomato and bean cultivars in the greenhouse throughout of the season (26th` June-11th`September 2006).

Statistical analysis showed that significant differences in susceptibility of tomato and bean cultivar to leaf miner infestation were recorded throughout the season in the greenhouse at *p value* ≤ 0.05.

3.3.3.2. Mean number of *L. trifolii* mines/plant of tomato and bean in the greenhouse.

Results presented in Table 3.22 shows the mean number of mines that were recorded on tomato and bean cultivars in the greenhouse throughout the season during (26th` June-18th`September 2006).

Statistical analysis showed that throughout the season the number of leaf miners recorded on bean plants were significantly higher than that on tomato plants.

Table 3.22. Mean number of *L. trifolii* mines/plant of tomato and bean cultivars in greenhouse. (Mean* ± S.E)

Date	Tomato	Bean	*P-value*
26/6/06	0.11 [b] ± 0.05	2.28 [a] ± 0.24	0.000
3/7/06	0.33 [b] ± 0.09	5.56 [a] ± 0.50	0.000
10/7/06	0.89 [b] ± 0.24	10.81 [a] ± 0.82	0.000
17/7/06	1.58 [b] ± 0.42	17.56 [a] ± 1.5	0.000
24/7/06	2.67 [b] ± 0.45	28.0 [a] ± 1.8	0.000
31/7/06	3.03 [b] ± 0.49	33.2 [a] ± 2.0	0.000
7/8/06	4.14 [b] ± 0.52	42.2 [a] ± 1.9	0.000
14/8/06	4.56 [b] ± 0.53	46.1 [a] ± 1.8	0.000
21/8/06	5.11 [b] ± 0.54	49.8 [a] ± 1.8	0.000
28/8/06	5.11 [b] ± 0.54	55.25 [a] ± 1.83	0.000
4/9/06	5.11 [b] ± 0.54	59.64 [a] ± 1.88	0.000
11/9/06	5.11 [b] ± 0.54	61.47 [a] ± 1.87	0.000
18/9/06	5.11 [b] ± 0.54	63.11 [a] ± 1.92	0.000

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using t-test analysis., Fisher's pair wise comparisons

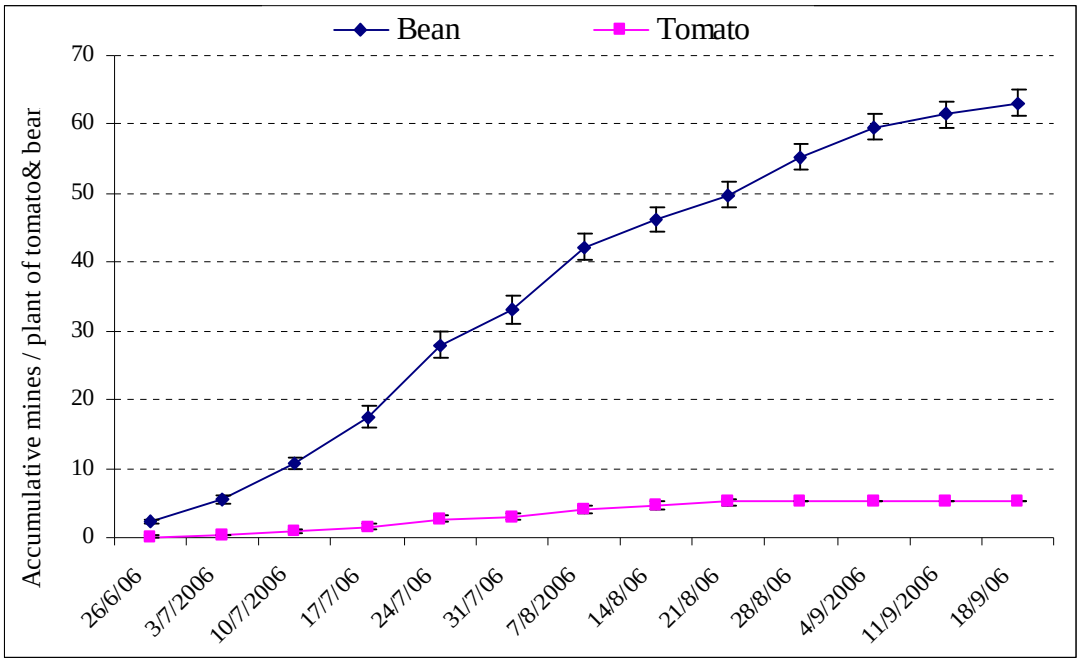

Fig. 3.20. Man accumulated number of *L. trifolii* mines/plant of tomato and bean cultivars in the greenhouse

The results presented in Fig 3.20 shows the accumulative number of mines/plant that was recorded on tomato and bean cultivars in the greenhouse throughout of the season (26th` June-18$^{th}$`September 2006).

Statistical analysis showed that the accumulated number of mines/plants was significant higher on bean than on tomato throughout the season in the greenhouse at *p value* ≤ 0.05.

3.3.3.3. Mean number of *L. trifolii* mines/leaf of tomato and bean in the greenhouse.

Results presented in Table 3.23 shows the mean number of mines that were recorded on tomato and bean cultivars in the greenhouse throughout the season during (26th` June-18$^{th}$`September 2006).

Statistical analysis showed that throughout the season the number of leaf miners recorded on bean plants were significantly higher than that on tomato plants.

Table 3.23. Mean number of *L. trifolii* mines/leaf of bean and tomato plant in the greenhouse. (Mean± SE)

Date	Tomato	Bean	P-value
26/6/2006	0.17 [b] ±0.06	1.6 [a] ±0.2	0.000
3/7/2006	0.33 [b] ±0.08	1.6 [a] ±0.15	0.000
10/7/2006	0.4 [b] ±0.12	1.9 [a] ±0.15	0.000
17/7/2006	0.67 [b] ±0.17	2.34 [a] ±0.22	0.000
24/7/2006	1.02 [b] ±0.09	2.11 [a] ±0.15	0.000
31/7/2006	0.5 [b] ±0.08	2.0 [a] ±0.2	0.000
7/8/2006	0.97 [b] ±0.11	2.4 [a] ±0.27	0.000
14/8/2006	0.56 [b] ±0.08	1.95 [a] ±0.18	0.000
21/8/2006	0.72 [b] ±0.08	1.81 [a] ±0.19	0.000
28/8/2006	0 [b] ±0.0	1.87 [a] ±0.14	0.000
4/9/2006	0 [b] ±0.0	1.56 [a] ±0.13	0.000
11/9/2006	0 [b] ±0.0	1.61 [a] ±0.13	0.000
18/9/2006	0 [b] ±0.0	1.42 [a] ±0.19	0.000

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using one way ANOVA, Fisher's pair wise comparisons.

The results presented in Fig 3.21 Shows the accumulative number of mines/leave that was recorded on tomato and bean cultivars in the greenhouse throughout of the season (26th` June-18$^{th}$`September 2006).

Statistical analysis showed that the accumulated number of mines/leave was significant higher on tomato than on bean throughout the season in the greenhouse at *p value* ≤ 0.05.

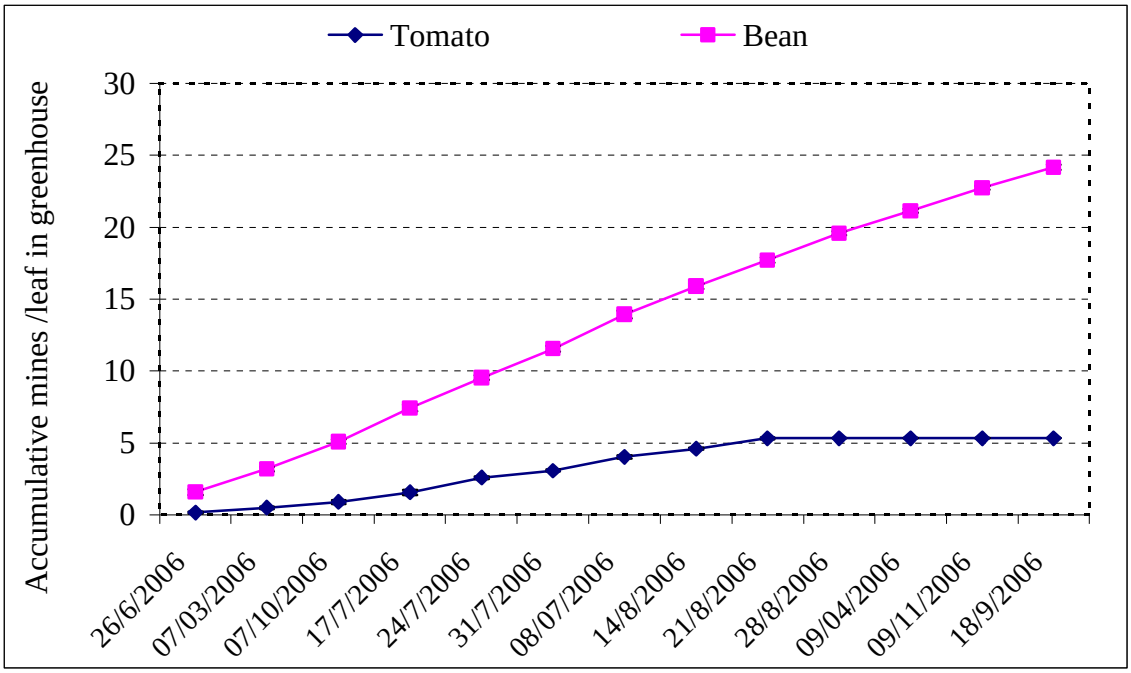

Fig. 3.21 Mean accumulated number of *L. trifolii* mines/leaf of tomato and bean plant in the greenhouse

3.3.3.4. Mean number of *L. trifolii* pupa/plant of tomato and bean in the greenhouse

Results presented in Table 3.24 shows the mean number of pupa that were recorded on tomato and bean cultivars in the greenhouse throughout the season (3rd`July till 18$^{st}$`August 200).

Statistical analysis showed that the total number of pupa that was collected was recorded 4.89 from bean plants was significantly higher than that from tomato plants.

Table 3.24. Mean number of *L. trifolii* pupa/plant of tomato and bean in greenhouse. (Mean* ± S.E)

Date	Tomato	Bean	*P value*
3/7/06	0.00 [b] ± 0.00	1.02 [a] ± 0.146	0.000
10/7/06	0.00 [b] ± 0.00	3.11 [a] ± 0.36	0.000
17/7/06	0.42 [b] ± 0.11	8.36 [a] ± 0.77	0.000
24/7/06	0.86 [b] ± 0.12	12.69 [a] ± 0.91	0.000
31/7/06	0.72 [b] ± 0.14	14.39 [a] ± 0.67	0.000
7/8/06	1.50 [b] ± 0.17	13.14 [a] ± 0.57	0.000
14/8/06	1.39 [b] ± 0. 21	15.14 [a] ± 0.65	0.000
21/8/06	0.00 [b] ± 0.00	9.36 [a] ± 0.46	0.000
28/8/06	0.00 [b] ± 0.00	6.89 [a] ± 0.37	0.000
4/9/06	0.00 [b] ± 0.00	7.01 [a] ± 0.45	0.000
11/9/06	0.00 [b] ± 0.00	3.47 [a] ± 0.18	0.000
18/9/06	0.00 [b] ± 0.00	1.28 [a] ± 0.15	0.000
Total	4.89 [b] ± 0.34	97.90 [a] ± 2.52	0.000

*: Figures within the same rows with different letters differ significantly at *p value* ≤ 0.05 using t-test analysis., Fisher's pair wise comparisons.

3.4. Susceptibility of different bean cultivar to *L. trifolii* infestation under laboratory conditions

3.4.1. Mean number of *L. trifolii* infested leaves/plant under laboratory conditions of 26ºC, 75%R.H, and continuous light

The result in Table 3.25 shows the mean number of infested leaves/plant that was recorded on three bean cultivars (Ascrow, Celena and platy) in laboratory throughout the season (5^{th} December till 17^{th} December 2006).

The first infestation was recorded on Celina cultivar after two days from release of a pair of insects within Perspex cage. Statistical analysis showed that throughout the experiment no significant differences to leaf miners infestation were recorded between the three beans under the laboratory condition.

Table 3.25. Mean number of *L. trifolii* infested leaves under laboratory conditions of 26ºC, 75%R.H, and continuous light (Mean* ± SE)

Date	Ascrow	Celena	Platy	*P-value*
Date of release	**3/12/06**	**3/12/06**	**3/12/06**	
5/12/06	0.00 ± 0.0	1.00 ± 0.0	0.00 ± 0.0	-
6/12/06	2.50 ± 0.50	1.50 ± 0.50	1.0 ± 1.0	0.422 NS
7/12/06	2.00 ± 0.0	1.50 ± 0.50	2.00 ± 1.0	0.829 NS
8/12/06	2.00 ± 1.0	0.50 ± 0.50	1.50 ± 0.50	0.422 NS
9/12/06	1.50 ± 0.50	1.50 ± 0.50	1.50 ± 1.0	0.854 NS
10/12/06	2.00 ± 0.0	1.50 ± 0.50	1.00 ± 1.0	0.604 NS
11/12/06	1.00 ± 1.0	1.50 ± 0.50	1.00 ± 0.0	0.829 NS
12/12/06	1.00 ± 0.0	1.00 ± 1.0	0.50 ± 0.50	0.829 NS
13/12/06	1.50 ± 0.50	1.50 ± 0.50	1.00 ± 1.0	0.854 NS
14/12/06	1.00 ± 1.0	1.50 ± 0.50	05.0 ± 0.50	0.650 NS
15/12/06	1.50 ± 0.50	1.50 ± 1.50	0.50 ± 0.50	0.722 NS
16/12/06	0.50 ± 0.50	1.50 ± 0.50	0.50 ± 0.50	0.385 NS
17/12/06	1.00 ± 0.0	0.00 ± 0.0	1.00 ± 0.0	-

NS: No significant differences at P value ≤0.05

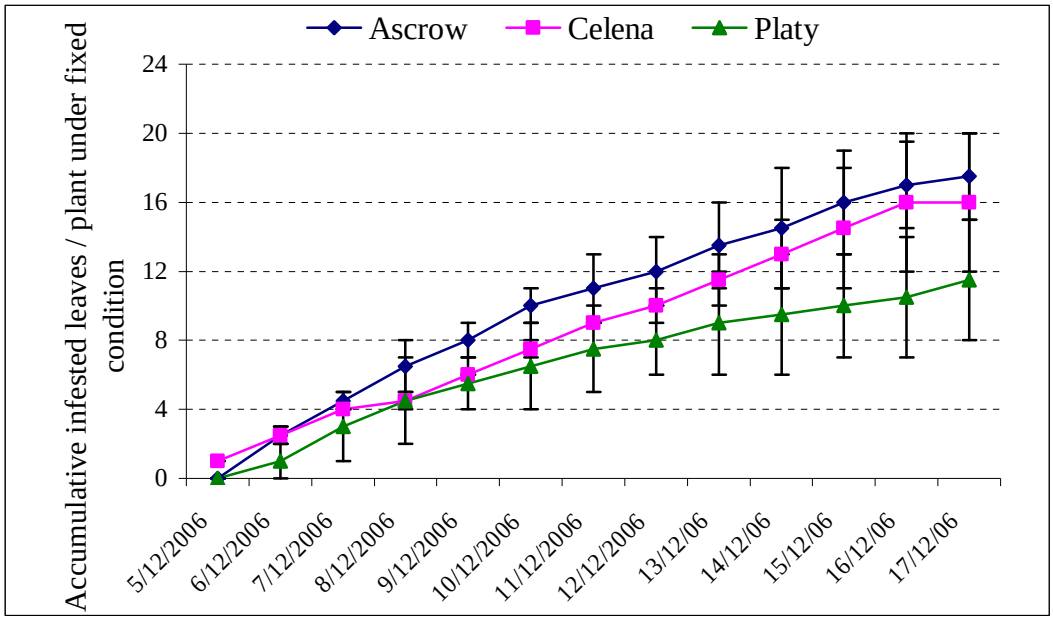

Fig. 3.22. Number of accumulated *L. trifolii* infested leaves/plant under laboratory condition of 26ºC, 75% R.H, and continuous light

Results presented in Fig 3.22 shows the accumulative number of infested leaves/plant that were recoded on three bean cultivars throughout the season under laboratory condition. The results showed that Ascrow cultivar was with significantly the highest number of cumulated infested leaves /plant, followed by Celina cultivar and platy cultivar.

3.4.2. Mean number of *L. trifolii* mines/plant under laboratory conditions of 26ºC, 75% R.H, and continuous light

Results presented in Table 3.26 shows that mean number of mines under standard condition was recorded on bean cultivars in laboratory 5th December till 17th December 2006

The mines was recorded on Celina cultivar after tow day of released of a pair of insects within Perspex cage

Statistical analysis showed that there was no significant differences of mines to leaf miners were recorded between three cultivar of bean in 5th December till 17th December 2006.

Table 3.26. Mean number of *L. trifolii* mines/plant under laboratory conditions of 26ºc, 75%R.H and continuous light (Mean* ± SE).

Date	Ascrow	Celena	Platy	*P-value*
5/12/06	0.00 ± 0.0	1.00 ± 1.0	0.00 ± 0.0	0.465 NS
6/12/06	4.50 ± 0.50	3.50 ± 1.5	2.50 ± 2.50	0.734 NS
7/12/06	7.50 ± 2.50	2.50 ± 0.50	3.00 ± 1.0	0.190 NS
8/12/06	4.50 ± 1.50	2.50 ± 1.50	3.00 ± 0.0	0.555 NS
9/12/06	5.00 ± 2.0	4.0 ± 2.0	2.00 ± 0.0	0.502 NS
10/12/06	3.00 ± 1.0	2.0 ± 1.0	3.0 ± 1.0	0.740 NS
11/12/06	3.50 ± 0.50	3.50 ± 1.50	1.50 ±0.50	0.362 NS
12/12/06	3.50 ± 0.50	2.00 ± 1.0	3.00 ± 1.0	0.534 NS
13/12/06	4.50 ± 1.50	2.00 ± 2.0	1.50 ± 1.50	0.490 NS
14/12/06	6.50 ± 2.50	4.00 ± 0.0	3.00 ± 0.0	0.343 NS
15/12/06	4.50 ± 1.50	5.50 ± 3.50	4.50 ± 1.50	0.943 NS
16/12/06	4.00 ± 0.0	3.50 ± 2.50	2.00 ± 1.0	0.676 NS
17/12/06	3.00 ± 1.0	4.00 ± 3.0	4.00 ± 2.0	0.933 NS
18/12/06	6.00 ± 5.0	3.50 ± 0.50	3.50 ± 0.5	0.797 NS
19/12/06	4.00 ± 0.0	5.00 ± 1.0	3.00 ± 1.0	0.354 NS
20/12/06	0.00 ± 0.0	0.00 ± 0.0	1.50 ± 1.50	0.465 NS

NS: No significant differences at P value ≤0.05

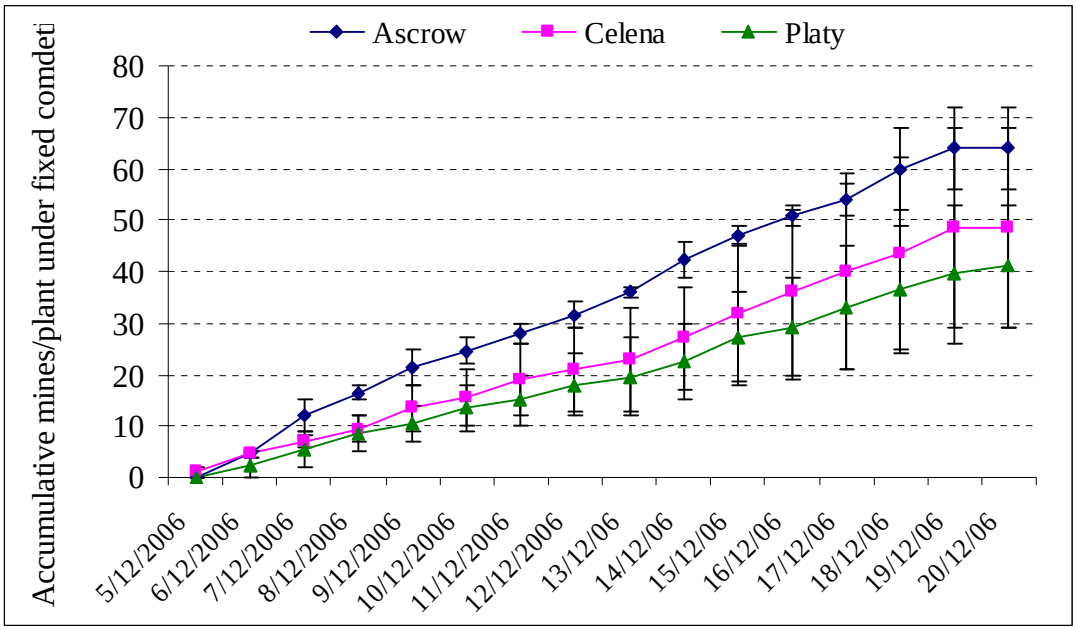

Fig.3.23. Number of accumulated *L. trifolii* mines under laboratory conditions of 26ºC, 75% R.H, and continuous light

Results presented in Fig 3.23 shows the mean number of accumulated mines/plant that were recorded on bean cultivars under laboratory condition.

The highest number of accumulated mines/plants was recorded on Ascrow cultivar followed by Celena and platy.

Statistical analysis showed that significant differences were not recorded between of three bean cultivar of mines throughout the experiment .but Ascrow showed with higher susceptibility to leaf miner infestation than Celina and Platy.

3.4.3. Mean number of *L. trifolii* pupa/plant under laboratory conditions of 26ºC, 75% R.H, and continuous light

Results presented in Table 3.27 shows the mean number of pupa/plant that was collected from three bean cultivar under laboratory condition.

Statistical analysis shows that there was no significant difference in number of pupa collected from the three bean cultivar throughout the experiment

Table 3.27. Mean number of *L. trifolii* pupa/plant under laboratory conditions of 26ºC, 75%R.H and continuous light (Mean* ± SE)

Date	Ascrow	Celena	Platy	P-value
11-Dec	1.50 ± 1.50	2.50 ± 1.50	0.50 ± 1.50	0.59 NS
12-Dec	2.0 ± 00	3.0 ± 0.0	2.50 ± 0.50	0.192 NS
13-Dec	3.00 ± 00	3.50 ± 1.50	3.00 ± 1.0	0.928 NS
14-Dec	4.50 ± 0.5	4.0 ± 2.0	1.00 ± 0.0	0.227 NS
15-Dec	3.5 ± 0.0	2.50 ± 0.50	4.50 ± 1.50	0.441 NS
16-Dec	1.50 ± 0.50	4.50 ± 2.50	2.0 ± 0.0	0.416 NS
17-Dec	3.50 ± 1.50	1.50 ± 0.50	3.00 ± 1.00	0.485 NS
18-Dec	3.50 ± 0.50	2.00 ± 1.00	3.0 ± 0.0	0.372 NS
19-Dec	3.0 ± 0.00	3.50 ± 0.50	1.50 ± 0.50	0.081 NS
20-Dec	2.50 ± 1.50	1.50±0.50	1.50 ± 0.50	0.722 NS
Total	34.50 ± 0.5	38.50 ± 0.5	28.50 ± 0.50	

NS: No significant differences at P value ≤0.05

3.5. Laboratory studies on life cycle of *L. trifolii* on bean cultivars under laboratory conditions of 26ºC, 75% R.H. and continuous light.

3.5.1. Life history parameters of *L. trifolii* under laboratory conditions of 26ºC, 75% R.H. and continuous light

The result in Table 3.28 shows the duration of development of the *L. trifolii* under the laboratory condition on three bean cultivars. Statistical analysis showed that duration of developments, adult's longevity and life span of *L. trifolii* were not significantly affected by the cultivar of the host plant.

Table 3.28. Duration of development of *L. trifolii* under laboratory conditions of 26ºC, 75% R.H. and continuous light.

Stages	Ascrow	Celina	Platy	*P-value*	Average
Egg	2.90 ± 0.10	2.80 ± 0.12	2.83 ± 0.11	0.819 NS	2.84 ± 0 .11
L1	1.80 ± 0.12	1.60 ± 0.10	1.67 ± 0.11	0.465 NS	1.69 ± 0.11
L2	2.40 ± 0.19	2.40 ± 0.19	2.42 ± 0.20	0.997 NS	2.41 ± 0.19
L3	1.70 ± 0.12	1.70 ± 0.12	1.75 ± 0.11	0.940 NS	1.72 ± 0.12
Pupa	7.50 ± 0.16	7.90 ± 0.10	7.50 ± 0.18	0.162 NS	7.59 ± 0.15
Total (Egg-Adult)	16.30 ± 0.30	16.40 ± 0.30	16.17± .21	0.097 NS	16.3 ± 0.24
Adult Longevity	11.40 ± 0.68	10.80 ± 1.02	8.17 ± 1.25	0.077 NS	10.12 ±0.75
Life Span	27.80 ± 0.86	27.40 ± 0.98	24.50±1.18	0.819 NS	26.56 ± 1.0

NS: No significant differences at P value ≤0.05

In conclusion, the average life history parameters of *Liriomyza trifolii* on bean plants under laboratory conditions at 26ºC, 75% R.H and continuous light were as the following:

1. Duration of development from egg to adult : 16.29 days
2. Adult longevity: 8-11 days
3. Life span: 24-28 days
4. Ovipositional period: 7-9 days
5. Total fecundity: 149-194 eggs

3.5.2: Number of *L. trifolii* eggs/female/day age under laboratory conditions of 26ºC, 75% R.H. and continuous light.

The highest average number of egg development in the 24 day was recorded 20.80 Egg / day, the highest total of egg placed on Ascrow cultivar reached to 194.1 eggs during the 13 day, the total of egg placed on Celina cultivar 149.7 eggs and 154.5 eggs on platy cultivar (Table 3.29).

Table. 3.29. Number of *L. trifolii* eggs/ female/day age under laboratory conditions of 26ºC, 75% R.H. and continuous light (Mean (Egg/Female) ± SE)

Age (Day)	Ascrow	Celina	Platy	*P-value*
17	15.10 ± 1.02	15.20 ± 0.87	15.00 ± 0.70	0.987 NS
18	17.40 ± 0.79	17.60 ± 0.52	15.70 ± 1.54	0.382 NS
19	17.60 ± 2.02	17.50 ± 1.97	19.70 ± 0.42	0.573 NS
20	19.40 ± 2.34	17.80 ± 3.0	19.70 ± 2.27	0.853 NS
21	18.80 ± 3.19	19.30 ± 3.25	18.60 ± 3.15	0.987 NS
22	19.70 ± 3.35	18.50 ± 4.07	20.10 ± 3.41	0.949 NS
23	20.10 ± 3.38	15.70 ± 4.30	18.30 ± 4.03	0.583 NS
24	20.80 ± 3.50	15.90 ± 4.41	15.30 ± 4.25	0.730 NS
25	19.30 ± 3.40	14.00 ± 4.07	14.20 ± 4.02	0.550 NS
26	15.50 ± 3.67	11.70 ± 4.17	9.70 ± 4.14	0.588 NS
27	5.50 ± 3.69	4.70 ± 3.20	2.40 ± 2.40	0.771 NS
28	2.60 ± 2.60	2.40 ± 2.40	2.40 ± 2.40	0.998 NS
29	2.30 ± 2.30	0.00 ± 0.0	2.20 ± 2.20	0.612 NS
Total Eggs/female	194.1 ± 25.4	149.7± 29.3	154.5 ± 23.2	0.429 NS
Oviposition Period (day)	9.00 ± 1.10	7.80 ± 1.11	8.10 ± 0.97	0.711 NS
Ave Eggs/Female/ Oviposition Day	21.32 ± 0.70	17.79 ± 1.81	18.78 ± 1.19	0.166 NS

NS: No significant differences at P value ≤0.05

3.5.3. Survival of adult *L. trifolii,* on bean plants under laboratory conditions of 26ºC, 75% R.H. and continuous light

The survival curves of *L. trifolii* fed on bean cultivar (Fig. 3.24) fit to type I that the mortality concentrated in the oldest age classes under laboratory conditions of 26 º C, 75% R.H, and continuous light.

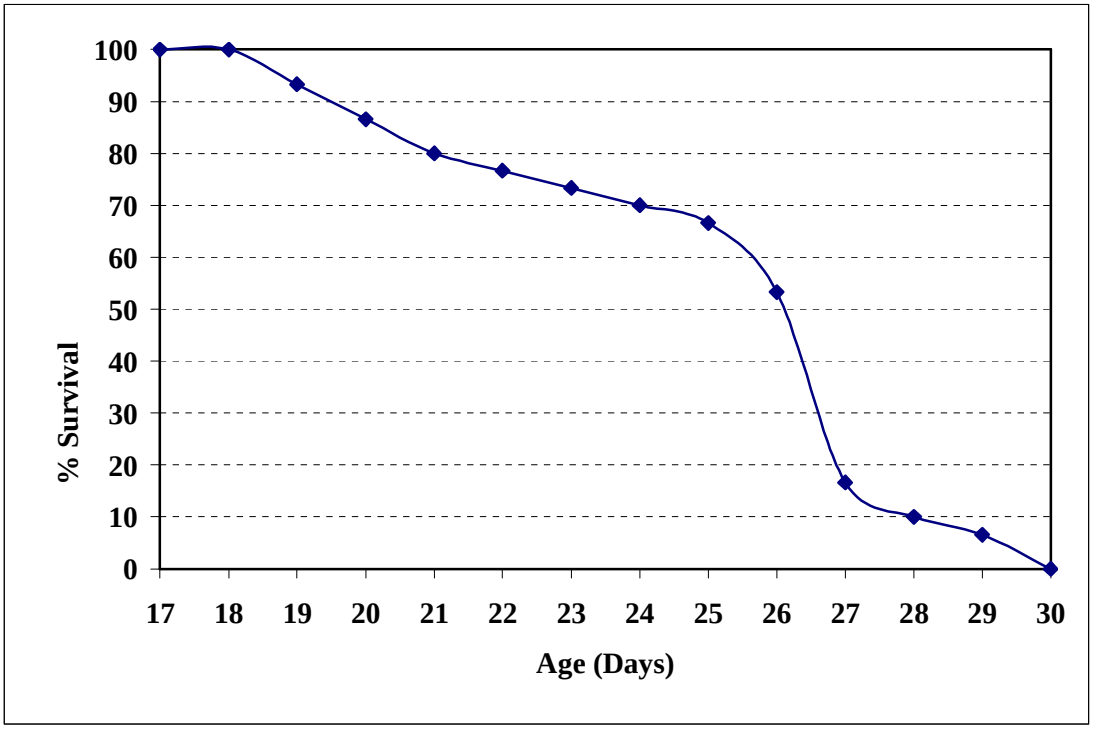

Fig. 3.24. Survival % of adult *L. trifolii,* under laboratory conditions of 26ºC, 75% R.H. and continuous light.

CHAPTER FOUR: DISCUSSION

CHAPTER FOUR: DISCUSSION

4.1. Flight activity of *L. trifolii* in open field and greenhouse

The results of this research showed that, the flight activity of *L. trifolii* started in May 2006 and stopped at the beginning of February 2007. The highest peak was recorded in the middle of June 2006. In addition, results showed that the flight activity of the *L. trifolii* was not recorded below 15ºC and above 30ºC, this result agrees with William *et al*., (1995); and Stegmaier, (1966)**.**

Furthermore, results showed that, yellow colored traps were significantly more efficient in monitoring the flight activity of *L. trifolii* than other colored traps (red, green and blue), This result agree with the result of previous studies that were conducted on monitoring of flight activity of *Liriomyza spp.* (Wolfenbarger1966; Musgrave, 1975; Johnson et al. 1980; Zehnder & Tumble 1984, 1985).

4.2. Susceptibility of tomato cultivars to *Liriomyza* infestation in the open field and in the greenhouse

Results showed that in the open field, the leaf miner infestation on bean plants started at the beginning of June and extended until the end of August, The highest number of leaf mines/plant were recorded during July and August. However, infestation in the greenhouse started three weeks later 26th، June 2006) and stopped at 21st August 2006.

Results of the accumulative total number of mines/plant showed that in the open field, the tomato cultivars Teba and 1370 were significantly more susceptible to *Liriomyza* infestation than that on 1415. Meanwhile, in the greenhouse, the tomato cultivar 259 was significantly more susceptible than 144 and 554.

4.3. Susceptibility of bean cultivars in the open field and in the greenhouse

Results showed that in the open field, the leaf miner infestation on tomato plants started at the beginning of June and extended until the end of August, and the highest number of leaf mines/plant were recorded during July and August. However, infestation in the greenhouse started on 26th of June and extended until the 18th December 2006, and the highest number of leaf mines/plant was recorded during July.

Results of the accumulative total number of mines/plant showed that in the open field, the susceptibility to *Liriomyza* infestation was significantly higher on the bean cultivars Venonica than that on Celena and Dali. Meanwhile, in the greenhouse Ascrow and Gesica were significantly more susceptible than Local variety.

Furthermore, under laboratory conditions of 26 ±1ºC, 75% R.H. and continuous light, results of the accumulative total number of mines/plant showed that Platy cultivar was significantly more susceptible to *Liriomyza* infestation than Celena and Ascrow.

4.4. Comparison between Susceptibility of tomato and bean in open field and greenhouse

Results showed that in the open field as well as in the greenhouse plantation, bean was significantly more susceptible to leaf miner infestation than tomato.

This might be due to the differences in the morphological and physiological characteristics of bean and tomato plants including color, thickness, and number of trichomes. Bean leaves are wider and thicker than tomato leaves meanwhile, the number of trichomes on tomato leaves are more densely than that on bean leaves (Johnson et al, 1980). In

addition, the yellowish color of bean leaves might be more attractive to the leaf miner flies than the greenish color of tomato. These results might be supported by the conclusions of several authors whom reported that attraction to yellow color was significantly higher than that to green color. (Wolfenbarger1966; Musgrave, 1975; Johnson *et al.*, 1980; Zehnder &Tumble, 1984, 1985).

4.5. Life cycle under standard laboratory condition on bean cultivar

4.5.1. Duration of Development, adult longevity and life span

Under the standardized conditions of 26 ±1ºC, 75% R.H. and continuous light photoperiod, life history of *L. trifolii* observed passing through 5 developmental stages (egg +3 larval instars + pupa), and the total duration of development from egg to adult was found to be 16 days. Results also showed that, the host plant cultivar have not shown significant effect on the duration of development, adult longevity and life span of *L. trifolii*. Those results were in agreement with that recorded by previous studies on bean and chrysanthemums (Leibee, 1984; Minkenberg, 1988; William *et al.*, 1995)

4.5.2. Fecundity

Results showed that the oviposition period of *L. trifolii* was 7 - 9 days; the average daily number of *L. trifolii* larva hatched/female was 17 – 21 in bean cultivars and the fecundity of *L. trifolii* on bean cultivars were 149 - 194 eggs/female. This result was in agreement with Leibee (1984) who reported that, at 25ºC, the average fecundity *L. trifolii* on bean plants was 200.

4.5.3. Mortality and Survival Curve

Results showed that the analysis of the percentage mortality distribution of *L. trifolii* during its life time showed that when reared on three bean cultivars, the survival curve of adult *L. trifolii* fit to type I that the mortality concentrated in the oldest age, according to Jervis and Copland categories (1996).

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بسم الله الرحمن الرحيم

الملخص بالعربية ARABIC ABSTRACT

دراسة بيولوجية وبيئية لذبابة صانعة الأنفاق [Diptera: Agromyzidae] *Liriomyza trifolii* في محطة العروب للابحاث الزراعية, فلسطين

تعتبر ذبابة الأنفاق *Liriomyza trifolii* من الآفات التي تهاجم ما يقارب 25 عائلة نباتية إذ تتغذى على الانسجة النباتية الواقعة بين السطح العلوي والسطح السفلي للأوراق النباتية

لقد انتشرت هذه الذبابة بسرعة كبيرة و على مدى واسع لتدرج ضمن الآفات الخطيرة للعديد من نباتات الزينة والخضار سواء في المناطق الباردة أو الاستوائية ،حيث تتبع ذبابة الإنفاق *Liromiza spp.* رتبة ثنائية الأجنحة وهي من أكثر الآفات صعوبة في المكافحة وخصوصا على نبات الزينة والعديد من المحاصيل الهامة الأخرى كالبندورة والفاصوليا .

يكمن الضرر الذي تسببه ذبابة الإنفاق في تغذية يرقاتها على أنسجة الأوراق مسببة ضعف عام للنبات و انخفاض في كفاءة البناء الضوئي للنبات المصاب.

لقد تم تصميم هذا البحث للتحقق من عدد من الخواص البيولوجيه والبيئية لذبابة الإنفاق والتي تشمل نشاط الطيران الموسمي لذبابة الأنفاق على محصولي البندورة والفاصوليا في الحقل المفتوح والبيت البلاستيكية .كذلك صمم هذا البحث لدراسة حساسية أصناف البندورة والفاصوليا المختلفة للإصابة وذلك ضمن ظروف الحقل وأيضا ضمن ظروف المختبر (26±1ºC, 75±5%R.H) و الإضاءة المستمرة بالاضافه إلى دراسة دورة حياة ذبابة الإنفاق على أصناف الفاصوليا ضمن ظروف المختبر(26±1ºC, 75±5 % R.H).

أشارت النتائج إلى أن بداية نشاط الطيران لذبابة الإنفاق يكون في نهاية نيسان ويستمر حتى نهاية كانون الثاني.كما أظهرت الدراسة أن المصائد المائية الصفراء أكثر كفاءة في جذب لذبابة الإنفاق مقارنة بالمصائد المائية الملونة الأخرى مثل اللون الأخضر والأزرق والأحمر. فيما يتعلق بدورة الحياة اثبتت التجارب المخبرية أن الزمن اللازم لتطور الذبابة من بيضة إلى حشره بالغة كان 16 يوم على أصناف الفاصوليا وكان معدل وضع البيض حوالي 149-194 بيضة/أنثى على نبات الفاصوليا ،بالإضافة لذلك وجدت فروق معنوية في حساسية أصناف

البندورة والفاصوليا لذبابة الإنفاق كما أن الحشرة كانت أكثر ميلا لنبات الفاصوليا منها إلى نبات البندورة تحت ظروف الحقل المفتوح و البيت البلاستيكي.