

**HORMOLIGOSIS OF INSECTICIDAL SPRAYS IN
Bemisia tabaci (GENN.) ON COTTON**

Dissertation

**Submitted to the Punjab Agricultural University
in partial fulfilment of the requirements
for the degree of**

**DOCTOR OF PHILOSOPHY
in
ENTOMOLOGY**

(Minor Subject : Biochemistry)

By

Abdallh Nasher Morshed Mokbal

(L-1999-A-61-D)

**Department of Entomology
College of Agriculture
PUNJAB AGRICULTURAL UNIVERSITY
LUDHIANA - 141 004
2002**

CERTIFICATE I

This is to certify that the dissertation entitled, "**Hormoligosis of insecticidal sprays in *Bemisia tabaci* (Genn.) on cotton**" submitted for the degree of **Doctor of Philosophy**, in the subject of **Entomology** (Minor subject: **Biochemistry**) to the Punjab Agricultural University, Ludhiana, is a bonafide research work carried out by **Mr. Abdallh Nasher Morshed Mokbal (L-1999-A-61-D)** under my supervision and that no part of this dissertation has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

Joginder Singh 24/12/02

Major Advisor

(Dr. Joginder Singh)

Professor and Head,

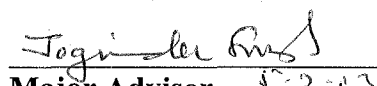
Department of Entomology

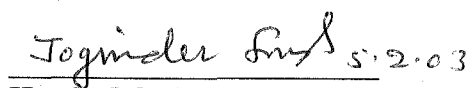
Punjab Agricultural University

Ludhiana 141 004

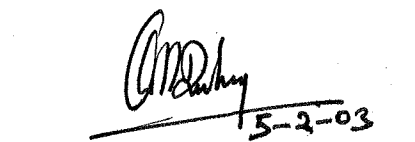
CERTIFICATE II

This is to certify that the thesis entitled, "**Hormologosis of insecticidal sprays in *Bemisia tabaci* (Genn.) on cotton**" submitted by **Mr. Abdallh Nasher Morshed Mokbal (L-1999-A-61-D)** to the Punjab Agricultural University, Ludhiana, in partial fulfillment of the requirements for the degree of **Doctor of Philosophy**, in the subject of **Entomology** (Minor subject: **Biochemistry**) has been approved by the Student's Advisory Committee after an oral examination on the same, in collaboration with an External Examiner.


Major Advisor 5-2-03
(Dr. Joginder Singh)


Head of the Department
(Dr. Joginder Singh)


Dean Post-Graduate Studies
(Dr. K.S. Sekhon)


External Examiner
Dr O.P. Dubey
Assistant Director General (PP)
Indian Council of Agril. Research
Krishi Bhavan,
New Delhi-110 001

Title of dissertation : Hormoligosis of insecticidal sprays in *Bemisia tabaci* (Genn.) on cotton
Name of the student and Admission number : Abdallh Nasher Morshed Mokbal (L-1999-A-61-D)
Major subject : Entomology
Minor subject : Biochemistry
Name and Designation of Major Advisor : Dr. Joginder Singh, Professor and Head, Dept. of Entomology
Degree to be awarded : Doctor of Philosophy
Year of award of degree : 2002
Total pages in dissertation : 127
Name of the University : Punjab Agricultural University
Ludhiana -141 004
Punjab, India

ABSTRACT

The studies on insecticidal hormoligosis in cotton whitefly, *Bemisia tabaci*, has been carried out at Punjab Agricultural University, Ludhiana, Punjab, India, during 2001 and 2002 crop seasons. The repeated application of quinalphos (250, 375 and 500 g ai/ha), carbaryl (625, 938 and 1250 g ai/ha), acephate (750, 1125 and 1500 g ai/ha), endosulfan (438, 656 and 875 g ai/ha) and fenvalerate (25, 38 and 50 g ai/ha) were evaluated for hormoligosis in terms of effect on whitefly fecundity, duration and survival of immature stages, longevity and in attractiveness of adults to treated plants for feeding and oviposition preference, and in host plant nutrition. The results revealed that fenvalerate resulted in significant increase in fecundity followed by acephate. Fenvalerate recorded minimum incubation period and maximum egg viability. Endosulfan resulted in prolongation of the nymphal duration, total life cycle, maximum reduction in nymphal and total survival of *B. tabaci*. Similarly, endosulfan resulted in maximum reduction in nymphal growth index and immature stages growth index. Fenvalerate did not prolong this life cycle nor affected growth index and it was at par with control. None of the tested insecticides showed significant effect on sex ratio. All insecticides have shown significant reduction on male and female longevity individually and both sexes together with maximum reduction being in endosulfan and high doses of carbaryl and quinalphos, whereas minimum reduction in fenvalerate and acephate. Fenvalerate attracted significantly more number of whitefly adults followed by acephate. Fenvalerate treated plants were more preferred by whitefly for oviposition. Higher dose of fenvalerate recorded significant increase in total sugars of treated cotton leaves. All insecticides significantly increased free amino acids and decreased pH of treated cotton leaves. Total phenols in treated plants also varied significantly among different treatments. The overall results confirmed hormoligosis of fenvalerate and acephate in *B. tabaci*.

Key words: Hormoligosis, *Bemisia tabaci*, insecticides, cotton


Signature of Major Advisor


Signature of Student

ACKNOWLEDGEMENTS

With all humility and sincerity I bow before the Almighty Allah for his benevolence and blessings.

Words cannot express the feelings of gratitude and indebtedness that I wish to evince for my Major Advisor Dr. Joginder Singh, Professor and Head, Department of Entomology, for his intellectual guidance, unceasing encouragement, personal interest and useful suggestions that led to the completion of present research. I feel proud to be his student.

Sincere thanks are extended to the members of my Advisory Committee, Dr. A.S. Sohi, Sr. Entomologist, Dr. B.S. Sohal, Professor of Biochemistry, Dr. R. K. Bhatia, Plant Physiologist and Dr. B.S. Joia, Sr. Entomologist for providing necessary guidance and critically going through the manuscript.

I also thank Dr. K.S. Brar, Sr. Entomologist, Dr. V.K. Dilawari, Professor of Ecology, Dr. M.S. Sultan, Sr. Plant Pathologist, and Dr. Maninder S. and other staff of the Entomology Department for their help at various stages of the work.

I owe all my success to my beloved parents, my wife, my children, sisters, brothers and other relatives for their affection, encouragement and support during my study.

I express my sincere thanks to all my friends, Sethi A., Jaspal Singh, Kamaldeep Singh, Dr. Shabih Alhasan, Mansoor Althobhani, Jacob, Firos, Rahol, Roy and other friends for their close association, jovial company, everwilling cooperation and help throughout the study.

Also I acknowledge the ungrudging help rendered by Harbans and other members of the field staff in my day to day work.

I also keep on record my gratitude to all those who might have raised hand of help at any stage of my study.



Abdallh Nasher M. M.

Date: 23 - 12 - 2002

P.A.U., Ludhiana

CONTENTS

CHAPTER	TITLE	PAGE NO.
I	INTRODUCTION	1-3
II	REVIEW OF LITERATURE	4-25
III	MATERIALS AND METHODS	26-36
IV	RESULTS AND DISCUSSION	37-103
V	SUMMARY	104-110
	REFERENCES	111-127

CHAPTER I

INTRODUCTION

Whitefly, *Bemisia tabaci* (Genn.) is widespread in the tropics and subtropics and is on the move, having been recorded in recent years from many areas outside the previous known range of its distribution. It is highly polyphagous with remarkable ability to adapt to new host plants, having been reported to attack more than 600 host plant species (De Barro, 1995; Gerling and Kravchenko, 1995; Markham *et al*, 1994; Secker *et al*, 1998), belonging to 77 families (Basu, 1995). Cotton, *Gossypium* spp an important cash crop of many countries, has suffered from its attack. About 1200 species of whitefly have been recorded in the world so far (Campbell *et al*, 1995; Markham *et al*, 1994; Mound and Hasley, 1978). Out of these, 265 species have been reported in India (Megathan and David, 1994). Among them *B. tabaci* has become a colossal problem in Indian farming system. *B. tabaci* acts as major pest of cotton in 16 out of 27 cotton producing countries (Butler and Henneyberry, 1994) including India in which it is grown over an area of 81.2 lac hectares with annual production of 114.8 lac bales (Anonymous, 2001). Earlier, it was a minor pest on cotton and it emerged as a major pest from 1984-1985 onwards (Katiyar, 1987; Patil *et al* 1990; Regu *et al*, 1990). Economic damage to cotton may result from its direct feeding (Husain and Trehan, 1933) or from contamination of lint by honeydew and sooty moulds that cause serious problems during ginning and spinning process, which is considered as the most serious economic damage caused to cotton by whitefly (Horowitz *et al*, 1984; Hendrix *et al*, 1995; Naranjo *et al*, 1995; Drost *et al*, 1998). Its honeydew secretion also affects the photosynthesis of the plant, finally affecting the quality and quantity of cotton fibers, and leads to reducing the yield (Mound, 1965; Sakalbale *et al*, 1991). The importance of this pest has further increased

due to its being a vector of more than 70 viral diseases in cultivated and weed plants (Duffus, 1987). It invades cotton crop at cotyledonary stage from its winter hosts, and transmit the cotton leaf curl viral disease during vegetative and other phases of crop growth (Dikson *et al*, 1954; Duffus and Flock, 1982; Brown and Nelson, 1984; Butler *et al*, 1985; Singh *et al*, 1994; Denholm, 1998; Athar, 2001). It causes loss of 10.56 to 92.20 per cent in seed-cotton yield in Punjab (India) by spreading cotton leaf curl virus disease (Singh *et al*, 1994).

B. tabaci has been reported to be responsible for loss of cotton crop in many cotton growing areas of the country (Pawar and Prasad, 1985; Singh *et al*, 1995). In Punjab, in which cotton is grown over an area of 4.74 lac hectares, with annual production of 11.99 lac bales (Anonymous, 2001), the pest remains active throughout the year and completes 14 to 15 overlapping generation in a year (Aneja, 2000). The cotton growers in the state have been making indiscriminate use of insecticides or their mixtures on cotton crop for controlling bollworm complex (Singh *et al*, 1998). Besides, the pest has developed resistance to various insecticides (Dhawan *et al*, 1999; Singh *et al*, 1999; Elbert and Nauen, 2000). The repeated use of insecticides, especially pyrethroids has induced resurgence of whitefly in Thailand (Wanghonkong, 1981), South California (Johnson *et al*, 1982) and Zimbabwe (Musuna, 1983). In Punjab due to also excessive use of insecticides on cotton crop whitefly population is showing increasing trend since 1990 (Singh *et al* 1999). Therefore, resurgence induced by insecticidal sprays has emerged as one of the important factor in increasing the severity of *B. tabaci* on cotton and many other crops. Many studies have been conducted on the biology of whitefly on cotton (Azab *et al*, 1971; Husain and Trehan, 1933; Kurhatkar, 1988; Khodke, 1989; Bethke *et al*, 1991; Aneja, 2000), but the information on the effects of insecticides on the physiology and behaviour of whitefly remains either scanty or lacking. Some

information on insecticide induced resurgence in whitefly is available in case of synthetic pyrethroids, but these are lacking for the other groups of insecticides. Moreover, the mechanism by which these chemicals favour the whitefly is not well known. Insecticidal hormoligosis means favourable changes in insect physiology/behaviour or its host plants that lead to its resurgence. Keeping these in view, the studies were conducted with the following objectives:

- (i) To study the physiological hormoligosis of insecticides, through their effects on the biology of whitefly.
- (ii) To study the behavioural hormoligosis of insecticides, through their effects on oviposition and host selection by whitefly.

CHAPTER II

REVIEW OF LITERATURE

Since 1889, when Gennadius described *Bemisia tabaci* as *Aleurodes tabaci* on tobacco in Greece, it has received more attention from entomologists, particularly in recent years as it became among the most serious insect pests facing world of agriculture. India being the third largest cotton grower in the world (Dandale *et al*, 2001) produce only 11.48 million bales, over an area of 8.12 million hectares in 2000-2001, which is very low as compared to world average (Anonymous, 2001). Bollworms and sucking pests are the major constraints in the cotton production. Among the sucking pests, whitefly is considered as the most notorious. It has been reported to cause 8-13% loss in seed-cotton yield in north India (Punjab) (Sukhija *et al*, 1986). However, at the peak levels of infestation leading to sooty-mould development, the losses were 21.7 and 31.8% in boll numbers, 10.3 and 23.7% in boll weight, 25.9 and 48.9% in seed cotton yield, 12.4 and 15.3% in seed oil and 29.4 and 66.5% in seed germination in promising new cultivars tested (LK861, LPS141, L389) and in commonly cultivated varieties (JKHY1, MCU5 and ADB10050), respectively. Fibre qualities such as length, strength, fineness and maturity were also adversely affected by high infestation of the pest (Rao *et al*, 1989). Cotton growers are heavily dependent on various insecticides to check the pest problems. Indiscriminate use of insecticides on cotton, particularly pyrethroids to control bollworms resulted in resurgence of sucking pests, including whitefly, although these insecticides are not that effective against it (Katiyar, 1987). The real reasons that are responsible for insecticide resurgence of whitefly are not well understood, but generally it is attributed to destruction of its natural enemies and to the

hormoligosis of these insecticides in whitefly. The pertinent literature has been reviewed under the following heads:

2.1. BIOLOGY OF WHITEFLY

2.2. EFFECTS OF INSECTICIDES ON WHITEFLY

2.2.1. Efficacy of Insecticides

2.2.2. Insecticide Resistance

2.2.3. Insecticide Resurgence

2.2.3.1. Resurgence due to destruction of natural enemies

2.2.3.2. Resurgence due to hormoligosis

2.2.3.2.1. Hormoligosis due to physiological and behavioural changes

2.2.3.2.2. Hormoligosis due to changes in host plant

2.2.3.3. resurgence due to removing of competitors

2.1. BIOLOGY OF WHITEFLY

Many studies have been conducted on the biology of whitefly on cotton, under different environmental conditions. Basic information is required for better understanding the impact of insecticides on the biology of whitefly. However, the different studies conducted on the biology of whitefly as a hemimetabolous insect indicated the presence of four immature stages between the egg and emergence of adult.

2.1.1. Egg Stage

Eggs of *B. tabaci* are usually laid indiscriminately on the lower surface of leaves, singly and sometimes in small circular or semi-circular groups, due to rotation of female, anchored by the labium which remains inserted into leaf surface. The female usually lays a few eggs on the leaf upon which they emerge as adults and then move to newer growth

(Byrne and Bellows, 1991). The eggs are generally spindle shaped, possessing a pedicel or stalk which is inserted into leaf tissue of host plant (Rao and Reddy, 1989; Deotale *et al*, 1992). It has been suggested that, the pedicel in whitefly eggs serve as a means of absorbing water into eggs (Byrne and Bellows, 1991). Female secrete a glue-like substance around the pedicel which helps egg to get glued to the leaf surface (Gameel, 1974). The size of the eggs ranged between 0.134 mm to 0.255 mm with an average of 0.194 mm in length and 0.108 mm in breadth (Deotale *et al*, 1992). Freshly laid eggs are creamy white, turn pale brown, and then dark brown before hatching (Pimpale and Summanwar, 1984; Basu, 1995). At the time of hatching, the egg cracks at the apical end along a longitudinal line of dehiscence (Byrne and Bellows, 1991). The nymph then walks away from the empty eggshell, which retains its shape and upright position. The incubation period of the eggs depends on various factors, especially temperature (Basu, 1995). Husain and Trehan (1933) reported that incubation period ranged from 2 to 5 days (April-September) to 33 days (December to January) under Punjab condition. However, recent studies under Punjab conditions indicate that duration of eggs ranged between 3 to 8 days (Aneja, 2000). The incubation period at 19 to 26°C and 53 to 84 per cent RH, ranged from 2 to 8 days (Deotale *et al*, 1992). Incubation period vary from 5.0 to 22.5 days at 32.5°C and 16.7°C, respectively and the eggs failed to hatch at 36.0°C (Butler *et al*, 1983). In South India, Natarajan *et al* (1986) reported that incubation period ranged between 2 to 18 days. In North India on different genotypes of cotton the incubation period ranged between 4 to 5 days during September-October (weekly temperature 25.5 to 30.4°C with 81.0 to 93.6 per cent RH) (Butter and Vir, 1991). However, incubation period on cotton as reported by Mohanty and Basu (1987) varied from 2 to 4 days during March-October and 7-8 days during November and February.

2.1.2. Immature Stages

Various workers have recognized four immature stages of *B. tabaci* between the egg and emergence of adult. The first three stages are generally referred to as nymphal instar and the fourth as the pupal stage. Since the metamorphosis of whitefly is incomplete, the term nymph seems to be more appropriate than larva (Byrne and Bellows, 1991; Basu, 1995). Similarly, the use of the term pupa for the fourth nymphal instar is not strictly applicable since what takes place during this stage in whiteflies is, in fact distinct from what occurs in holometabolous insects. However the term has been used universally for so many years, that its replacement would only cause confusion (Byrne and Bellows, 1991; Basu, 1995).

First-instar nymph: After emergence, it crawls actively in search of suitable site. First instar nymph is the only nymphal instar that has functional legs while the other instars are not movable and they remain attached to the leaf surface until adult emergence. That is why the first instar nymph is usually named as crawler. After reaching to a suitable site, legs are laid and it inserts its mouthparts into phloem tissue and begins extracting sap. First-instar nymphs are elliptical in shape, transparent to yellowish in colour (Rao and Reddy, 1989). The eyes are represented by two small inconspicuous crimson spots on each side of the cephalic region. The duration of the first instar nymph has been reported to be 2 to 5 days on cotton during March-October and 8 to 11 days during November-February (Mohanty and Basu, 1987) and 3 to 9 days under Punjab conditions (Aneja, 2000).

Second instar nymph: It is bigger in size than first instar, but the eyes are still inconspicuous and look like two red spots. The duration of this instar on cotton varies from 2 to 11 days (Mohanty and Basu, 1987; Aneja, 2000).

Third instar nymph: It is having more elongated body than the earlier instar. Immediately after moulting it appears whitish and transparent and after feeding it turns to

yellowish (Deotale *et al*, 1992). The eyes are visible, but not so conspicuous (Aneja, 2000). The duration period varies from 2 to 10 days (Mohanty and Basu, 1987; Aneja, 2000).

Fourth instar Nymph: The eyes are still small, but they appear as two conspicuous spots. For the reasons stated earlier, the description furnished here corresponds to those given by various workers for the early, or freshly formed pupa (Byrne and Bellows, 1991). Almost all of the workers consider this stage is a pupa but according to Gill (1990) this form feeds and therefore cannot be termed as pupa.

Pupa: Pupa having two very distinctive characters: the eyes and the caudal furrow. For the first time the eyes are truly distinguishable, resembling two red spots constricted in the middle. Likewise the caudal furrow (the median longitudinal depression along the posterior abdominal dorsum between the distal portion of the vasiform orifice and the tip of the abdomen) appears only in the pupa (Byrne and Bellows, 1991). It is deep yellow in colour, slightly convex in body shape and comparatively bigger in size than that of third nymphal instar (Aneja, 2000). The duration of pupa has been reported to be 3 to 11 days by Mohanty and Basu (1987) and 3 to 9 days by Aneja (2000). The entire period of immature stages is reported to be 29 to 47 days (Deotale *et al*, 1992). Mortality of *B. tabaci* is highest during the crawler and young nymphal stages, mainly due to climatic factors. An average of 17 per cent and maximum of 40 per cent of eggs reach the adult stages in cotton field in Israel (Horowitz *et al*, 1984). Borad and Puri (1991) reported that an average 20.14 per cent of eggs reached the adult stage. They reported that the rate of survival of *B. tabaci* was high during October. Powell and Bellows (1992a) reported approximately 50 per cent survival of immature stages of *B. tabaci* on cotton. Adult emergence ranged between 56.14 to 96.51 per cent on different cotton genotypes under Punjab conditions during August-

September (Butter and Vir, 1991). However, recent study under Punjab conditions indicated that maximum mortality was 66.66 per cent during 8th generation (October 14th to November 14th) and 20 per cent during 6th generation (September 4th to September 27th). The mean mortality in different stages was 5.2 to 18.1 per cent (Aneja, 2000).

The total life cycle found to be correlated with the seasonal factors, rather than the different hosts (Mohanty and Basu, 1987). They reported that, life cycle was longest (47 days) during December-January as compared to 14 days during September. The total life cycle was completed in 12 to 17 days in August-September (Misra and Lamba, 1929), 14 to 107 days in different months of the year (Husain and Trehan, 1933), 39 to 62 days (Deotale *et al*, 1992), 11 to 83 days during May-December (Pimpale and Summanwar, 1984), 15 to 21 days (Zalom *et al*, 1985) and 14 to 20 days during summer (Natarajan *et al*, 1986). The total life cycle was found to vary with the change in temperature, which was 68.0 days at 12 to 20°C, 36.0 days at 18 to 24°C and 24.2 days at 25°C (Coikesen and Sekeroglu, 1987). In South India, the shortest life cycle (13 days) occurred in September and it increased to 20.5 days in December (Rao and Reddy, 1989). Butler *et al*, (1983) reported that the total life cycle was 16.60 and 65.10 days at 30.0°C and 14.9°C, respectively. Powell and Bellow (1992b) reported mean developmental period to be 17.7 and 38.2 days at 25.5°C and 20°C, respectively. Total life cycle of *B. tabaci* under Punjab conditions varied from 24 to 44 days during different months (Aneja, 2000). The number of overlapping generations of *B. tabaci* per year seemed to range between 10 to 15 at different places. *B. tabaci* has 10 to 12 overlapping generations (Husain and Trehan, 1933; Pruthi and Samuel, 1942; Azab *et al*, 1971), while 15 were reported by Pimpale and Summanwar (1984) and Aneja (2000). The length of a generation varied from 14 to 21 days during August-September and 50 to 105

days during November-February (Husain and Trehan, 1933). Aneja (2000) reported that the generation period was 17 days during September-October and 39 days during January-February.

2.1.3. Adult

The newly emerged adult is soft, pale yellow changing to white within a few hours due to deposition of wax on the body and wings. The males are generally more slender and smaller than females. The female can be distinguished from the male by bigger size and broader abdomen, having blunt tip, which is different from male abdominal tip that is tapering in shape. The adult emerges out of the pupal case through a 'T' shaped suture (Pimpale and Summanwar, 1984; Rao and Reddy, 1989). Maximum adult emergence occurs between 6.00 to 9.30 am (Butler *et al*, 1983; Hoffman and Byrne, 1986) and between 8.00 to 11.00 am (Husain and Trehan, 1933). Azab *et al* (1971) observed that, most of adult emergence occurred during 7.00 am to 12.00 noon, but the emergence was reduced significantly during night. Under Punjab conditions, the maximum adult emergence was observed during 5.00 am to 11.00 am in all seasons with peak between 5.00 am to 7.00 am during monsoon and 7.00 am to 9.00 am during post-monsoon and pre-monsoon periods (Aneja, 2000). Generally male emerges a little earlier than female (Gerling *et al*, 1986). Adult of *B. tabaci* took 5 to 15 minutes to emerge and that was followed by wing expansion, which occurred near pupal case and the mating process was initiated 6 to 8 hours after emergence (Azab *et al*, 1971). Butler *et al* (1983) reported the pre-oviposition period in field ranging from 1 to 8 days at temperature above 20°C. In general, the period between final ecdysis and first flight for *B. tabaci* is approximately 4 hours and 10 minutes at 27°C (Byrne and Bretzel, 1987).

2.1.3.1. Adult Longevity

Under captivity, longevity of adult ranged between 2 to 5 days in summer and 24 days during November (Husain and Trehan, 1933). Adult longevity was longer in females than in males (Azab *et al*, 1971). Longevity of females was 8.0 to 60 days and that of males 2 to 17 days at various temperatures. Deotale *et al* (1992) reported that male longevity in confined cages was 4 to 7 days as compared to 9 to 18 days in females. Adult longevity of *B. tabaci* was 10 to 15 days during summer and 30 to 60 days during winter (Gerling *et al*, 1986). Under Punjab conditions adult longevity ranged between 1 to 21 days (Aneja, 2000). Male longevity was 7.6 and 11.7 days, while that of females was 8.0 to 14.4 days at 32°C and 26.6°C, respectively (Butler *et al*, 1983).

2.1.3.2. Fecundity

The pre-oviposition period of *B. tabaci* is reported to be 3.6 days at 25°C and 4.9 days at 14°C (Sharaf and Batta, 1985) and 1 to 8 days at temperature above 20°C (Butler *et al*, 1983). Lopez-Avila (1986) found pre-oviposition period to be within 24 hours of emergence. In *B. tabaci* female is attracted to male, but it allows the male to initiate courtship only after 10 hours from pupal eclosion (Li *et al*, 1989). The number of eggs laid by a single female was variable under different environmental conditions. However, under captivity, the fecundity was found to be over 50 (Basu, 1995). Husain and Trehan (1933) found that the maximum number of eggs laid by a single female in captivity on cotton was 119 over a period of 18 days. The average number of eggs laid during 24 hours was 6 and 8 in two different years, with the maximum being 16 (Basu, 1995). Under South Indian conditions, the maximum fecundity was found to be 200 eggs (Natarajan, 1990). An average of 22.5 to 86.0 eggs per female was observed by Butter and Vir (1991) on different

genotypes of cotton. Fecundity on cotton ranged between 75 to 180 eggs per female (Deotale *et al*, 1992). Under Punjab condition, fecundity ranged between 18.1 to 26.8 eggs per female (Aneja, 2000). Number of eggs laid were also affected by environmental factors, particularly temperature. The mean number of eggs laid per female was 60.47, 88.24 and 41.95 at 20, 25 and 30°C, respectively (Zamora and Gallardo, 1999). However, the fecundity reported by different workers in India is considerably lower than those reported by workers from Egypt, Sudan and Israel (Basu, 1995). The mean number of eggs laid by a female on cotton during September-November was 160.4 (Gameel, 1974). However, Sudanese strain of *B. tabaci* appeared to be much more prolific than strains from other parts of the world (Gerling *et al*, 1986). This was confirmed by the results obtained by Dittrich *et al* (1985) when he reported that Sudanese whiteflies have fecundity on cotton of 344 eggs per female. However, the number of eggs laid by female is also host and biotype dependent and ranged from 7 to 514 eggs (Patel *et al*, 1992; Powell and Bellows, 1992b). Unmated *B. tabaci* females were capable of laying unfertilized eggs which developed into males only (Azab *et al*, 1971; Basu, 1995; Byrne and Bellows, 1991; Husain and Trehan, 1933; Mound, 1983; Sharaf and Batta, 1985). Horowitz and Gerling (1992) reported that the young females laid proportionately more female producing eggs than older females. The oviposition period ranged between 2 to 18 days (Husain and Trehan, 1933; Aneja, 2000).

2.1.3.3. Sex Ratio

The ratio of male to female whitefly adults changed throughout the year (Byrne and Bellows, 1991). Sex ratio of *B. tabaci* on cotton is usually 1:1 (Gameel, 1978). Adult field population had sex ratio of 2 female : 1 male (Gondim and Sales, 1983). This may follow a 1:1 primary sex ratio, because females live longer in the population as adults (Azab *et al*,

1971; Mound, 1983; Van Lenteren and Noldus, 1990). Sex ratio has been observed in favour of females during early season of summer, but it became in favour of males at the end of summer (Horowitz and Gerling, 1992). Change in temperature is found to affect the sex ratio. When the temperature decreased from 25°C to 14°C, the number of females observed to increase from 1:1 to 1:3.4 males to females (Sharaf and Batta, 1985). Aneja (2000) observed that the overall mean of sex ratio was towards the female 1:1.36.

2.2. Effect of insecticides on whitefly

2.2.1. Efficacy of insecticides against whitefly

A number of insecticides are recommended against whitefly on cotton crop in India, viz., triazophos, ethion, endosulfan, dimethoate, oxydemeton-methyl, formothion, phosphamidon and monocrotophos (Dhawan, 1998) and neem oil (Basu, 1995). Methyl demeton, phosalone, fish oil, resin soap and neem oil with teepol (Sundaramurthy and Chitra, 1992). However, whitefly has developed resistance against a number of insecticides (Singh *et al*, 1999). Monocrotophos and dimethoate reduce *B. tabaci* population more effectively than quinalphos and fenvalerate (Singh *et al*, 1973; Shalaby *et al*, 1990). Hassan *et al* (1974) observed high effectiveness of monocrotophos, dimethoate, methamidophos and malathion against *B. tabaci*. Deltaphos (a mixture of deltamethrin and triazophos) was found to be highly effective against whitefly and it was at par with triazophos (Rao *et al*, 1990). Monocrotophos (0.04%), dimethoate (0.03%) and chlorpyrifos (0.05%) significantly reduced whitefly population over untreated check and the dimethoate was superior to monocrotophos and chlorpyrifos (Chander and Singh, 1991). Triazophos (0.05%) and amitraz (0.05%) effectively controlled *B. tabaci* on cotton (Sudhakar and Paul, 1991). Similarly triazophos, acephate and monocrotophos reduced whitefly population significantly

over control even after seven days of application (Sakalbale *et al*, 1991). Acephate and endosulfan were found to be effective against nymphal stage of whitefly (Dominick and Sundaram, 1992). Polytrin, cypermethrin and profenophos were found to be effective against whitefly on cotton (Dhawan and Simwat, 1993; 1994; Rao *et al*, 1996). Triazophos was more effective in reducing whitefly population, followed by deltapos, quinalphos, monocrotophos and endosulfan (Singh and Gupta, 1993). Triazophos, endosulfan and acephate were found to be effective in reducing whitefly nymphs and adults (Reddy *et al*, 1985; Rao *et al*, 1991; Tanweer and Rao, 1997). Endosulfan registered low population of whitefly as compared to deltamethrin and Decidan (mixture of endosulfan with deltamethrin) (Dhawan *et al*, 1999). According to Horowitz *et al* (1997), a mixture of abamectin with paraffinic oil was found to be highly effective in suppressing whitefly population on cotton. Mariam and Chandramohan (2000) reported high level of ovicidal action of dichlorovos (89.38%), malathion (88.06%) and phosphalone (82.96%) on whitefly eggs. Bifenthrin (0.01%) reported highest reduction of whitefly over untreated control than malathion (0.1%) (Sudhakar *et al*, 1998a). Kandil *et al* (1991) reported high effectiveness of diafenthiuron, carbosulfan, buprofezin and imidacloprid against whitefly.

Imidacloprid as a new nicotinoid insecticide, being recommended against sucking pests has been reported to be effective against whitefly by many researchers (Mote *et al*, 1993; Jarande and Dethé, 1994; Walunj and Mote, 1995; Stansly *et al*, 1998; Brar *et al*, 1999; Patil *et al*, 1999; Phadke and Phadke, 2000; Iersel *et al*, 2001; Kumar and Dikshit, 2001; Dandale *et al*, 2001). However, Mohan and Katiyar (2000) reported that, continuous use of imidacloprid resulted in greater whitefly population. Neem products are Also reported to be effective against whitefly by many workers (Jayaraj *et al*, 1987; Phadke *et al*, 1988; Flint and

Parks, 1989; Prabhakar *et al*, 1989; Natarajan and Sundaramurthy, 1990; Rao *et al*, 1990; Dhawan and Simwat, 1992; Muthukrishnan *et al*, 1992; Raman *et al*, 1993; Ahmed *et al*, 1995; Gupta *et al*, 1998; Murthy and Ram, 2000). Verma *et al* (1989) observed that neem oil (3 l/ha) in combination with teepol in ratio of 5:1 reduced whitefly by 98.76 per cent as against 96.72, 96.42 and 66.42 per cent by quinalphos, amitraz and triazophos, respectively. Neemark (0.05%), Neem oil (3%) and NSKE (5%) were as effective as fenvalerate and triazophos in controlling *B. tabaci* (Raju *et al*, 1992). Neemark (5 ml along with 0.2 ml Teepol/l water) was found to be significantly superior in reducing whitefly population. It was at par with phosphamidon, quinalphos, cypermethrin and phosphamidon. However, it was inferior to triazophos (0.05%) and acephate (0.05%) (Dhanorkar *et al*, 1990). Neem-seed extract sprays @ 1 kg/40 l water at 14 days interval starting at the beginning of infestation, significantly reduced the population of *B. tabaci* to less than 50 per cent of control (Siddiq, 1991). Neem oil (0.5%) and Kernal extract from seed (5%) were also as effective as conventional insecticides: monocrotophos (0.5 l/ha) and endosulfan (0.75 l/ha) against whitefly (Yadav and Patel, 1990). Similarly, Nimbalkar *et al* (1993) observed neem oil and neem seed extract to be as effective as dimethoate, phosphamidon, monocrotophos, acephate, phosalone and fenvalerate. Neem oil recorded 90-95 per cent mortality of whitefly, which was at par with triazophos (Natarajan and Shanthi, 1994). Nimbecidine (2%) caused 69.6 per cent nymphal mortality against 41 and 60 per cent in neem oil (0.5%) and phosalone (0.02%) 15 days after spray, respectively (Udaiyan and Ramarathinan, 1994). Neemark at 0.5 and 1.0 per cent was equally effective as fentropathrin (0.05%) against both adults and nymphs of *B. tabaci* (Puri *et al*, 1994). Azatin was effective in suppression of oviposition as well as in inducing larval mortality of whitefly (Prabhakar *et al*, 1999). Neem products,

Limnol and NSKE @ 5.0 l per hectare were more effective than endosulfan in reducing the population of whitefly on cotton after 7 days (Sreenivas and Patil, 2001).

2.2.2. Insecticide resistance in whitefly

B. tabaci, has developed a high degree of resistance against several chemical classes of insecticides including chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids, neonicotinoids and insect growth regulators (Cahill *et al*, 1996; Elbert and Nauen, 2000). Populations of *B. tabaci* collected from different areas in Punjab have shown high levels of resistance to organophosphates (acephate, chlorpyrifos, dimethoate, monocrotophos, oxydemeton methyl and quinalphos) and synthetic pyrethroids (cypermethrin, deltamethrin and fenvalerate) insecticides. However, the population was found to be sensitive to widely used insecticides against bollworms like endosulfan, ethion and triazophos (Singh *et al*, 1998). *B. tabaci* showed 757, 1.8 and 0.7 fold of resistance to pyriproxyfen, buprofezin and diafenthiuron, respectively (Ishaaya and Horowitz, 1995). Populations of whitefly from Turkey, Guatemala and Nicaragua have been reported to have developed resistance against monocrotophos, cypermethrin and carbofuran (Dittrich *et al*, 1990). Populations of *B. tabaci* collected from fields in Andhra Pradesh were found to be resistant to BHC (HCH), endosulfan, dimethoate, phosalone, acephate, monocrotophos, quinalphos and carbaryl (Prasad *et al*, 1993). *B. tabaci* was found to be resistant to monocrotophos, profenophos and chlorpyrifos (Byrne *et al*, 1994). Also *B. tabaci* developed resistance against the new insecticides with novel mode of action, such as insect growth regulators. About 47 fold of resistance was reported against Buprofezin in Netherlands (Cahill *et al*, 1996), 75 fold in glasshouse strain (Cahill and Denholm, 1993). Four fold against Buprofezin and 10 fold against pyriproxyfen was reported by Horowitz *et*

al (1994). *B. tabaci* showed 5 fold and 8 fold of resistance for methomyl and bifenthrin, respectively (Horowitz *et al*, 1994). Whitefly subjected to imidacloprid selection pressure, developed 82 fold of resistance after 32 generations (Prabhakar *et al*, 1997). Similarly, *B. tabaci* collected from cotton field subjected to selection pressure by methidathion led to increase in the LC_{50} to 7-8 folds in 8 generations in the selected line (Bloch and Wool, 1994). A field population of cotton whitefly, subjected to selection pressure with bifenthrin, resulted in early development of resistance, which steadily increased under continuous selection to 750 fold after 27 generations (Prabhakar *et al*, 1998).

2.2.3. Insecticide resurgence in whitefly

Different factors are responsible for whitefly resurgence like low rainfall coupled with high temperature (Singh and Butter, 1985; Simwat and Gill, 1992; Bishnoi *et al*, 1996; Gupta *et al*, 1998), monocropping system (Reddy *et al*, 1989), growing of susceptible varieties (Butler *et al*, 1986b; Thakare *et al*, 1986, Jayaraj *et al*, 1987), nutritional imbalance (Balaji and Veeravel, 1995; Bentz *et al*, 1995; Butler *et al*, 1986a Sudhakar *et al*, 1998b) and indiscriminate and excessive use of broad spectrum insecticides (Jayaraj *et al*, 1987; Regu *et al*, 1990; Bhathal *et al*, 1991; Gupta and Katiyar, 1991; Butter and Kular, 1999; Rao and Reddy, 1999; Bharpoda *et al*, 2000; David *et al*, 2000). Repeated application of synthetic pyrethroids against bollworms on cotton caused resurgence of *B. tabaci* in Thailand (Wanghoonkong, 1981), California (Johnson *et al*, 1982), Zimbabwe (Musuna, 1983), Sudan (Eveleens, 1983; Abdurrahman *et al*, 1990), Egypt, Syria, Israel, China, Pakistan and India (Ishaaya and Ascher, 1984; Reddy *et al*, 1986; Jayaraj *et al*, 1987; Saini, 1997; Gupta *et al*, 1999; Kaler, 1999; Mohan and Katiyar, 2000). Similarly, indiscriminate use of organophosphates resurged whitefly in India (Singh *et al*, 1994; Kaler 1999; Aneja, 2000).

Repeated application of fenopropathrin, fenvalerate, cypermethrin, deltamethrin and fluvalinate also caused resurgence of whitefly (Reddy *et al*, 1987). Jayaraj *et al* (1987) observed outbreak of whitefly with twelve round of application of organophosphate and synthetic pyrethroids. Heavy build-up of whitefly on cotton has been reported in alternate spray schedule using sprays of synthetic pyrethroids (cypermethrin, deltamethrin and fenvalerate) and monocrotophos (Natarajan *et al*, 1987) and heavy spray schedules of synthetic pyrethroids (Jayaswal and Singh, 1987; Thakare *et al*, 1986). Four sprays of cypermethrin alternating with monocrotophos, significantly reduced bollworm damage, but increased population of *B. tabaci* (Shelke *et al*, 1987). Cotton plants sprayed with tank mixture of chlorpyrifos with cypermethrin and fenvalerate resulted in heavy build-up of whitefly population, and the build-up increased with increase in number of sprays (Regu *et al*, 1990). Plants sprayed with deltamethrin and fenvalerate registered high nymphal population of whitefly compared with Padan (cartap hydrochloride) treated plants which was at par with control, however, the build-up was found to increase with increase in the number of sprays (David *et al*, 1987). Patil *et al* (1990) found that repeated application of decamethrin (deltamethrin), cypermethrin, fenvalerate and fluvalinate increased the whitefly population after 5 days of 3rd, 4th and 5th spray. However, the application of sub-lethal doses of these compounds induced higher degree of resurgence of cotton whitefly. The maximum population of whitefly was observed in deltamethrin than cypermethrin treated plots, while the population was lower in the plots treated with tank mixture of these compounds with monocrotophos (Gupta and Katiyar, 1991). Singh and Gupta (1993) observed high population build-up of whitefly in those plots treated with synthetic pyrethroids and the maximum build-up was noted in fenvalerate, deltamethrin, cypermethrin then cyhalothrin-

treated plots. They further reported that the two neem products, namely, margocide OK (80% EC 10 ml/l) and margocide CK (20% EC 5 ml/l) not only failed to combat the population of whitefly, but rather revealed an increase in their population 2 days after application.

In Punjab also, heavy build-up of whitefly was observed with repeated use of cypermethrin, fenvalerate and deltamethrin (Butter *et al*, 1994; Dhawan and Simwat, 1997; Butter and Kular, 1999). Similar results were obtained in field study by Saini (1997), when the population build-up was significantly higher in cypermethrin, deltamethrin and fenvalerate. Kaler (1999) observed that repeated application of cypermethrin, monocrotophos and acephate caused resurgence of whitefly. The resurgence of pests due to insecticides is the result of different reasons, such as, insecticide hormoligosis, destruction of natural enemies and/or reduced competition. These factors may operate individually or in combination to determine the level of resurgence (Dhawan *et al*, 2000).

2.2.3.1. Resurgence due to destruction of natural enemies

Indiscriminate and excessive use of broad-spectrum insecticides lead to destruction of natural enemies of some pests, and thereby relieved those pests from a biotic suppression, resulting in their resurgence.. Triazophos, deltapos and acephate were most toxic to natural enemies of whitefly on cotton followed by cypermethrin, deltamethrin, dimethoate and endosulfan (Rao *et al*, 1990). Similarly, triazophos, monocrotophos and methamidiphos were more toxic than endosulfan and phosalone (Natarajan, 1990). Beevi and Balasubramanian (1992) reported high toxicity of triazophos, monocrotophos and endosulfan to *Encarsia shafeei* than Buprofezin and diflubenzuron. Similarly, Kandil *et al* (1991) observed that, dimethoate, cyanophos + diflubenzuron and quinalphos were toxic to the

predators of *B. tabaci* than tested insect growth regulators. Ethiofencarb, diafenthrin and chlorpyrifos-methyl significantly reduced the emergence of *Eretmocerus mundus* and *Ecarsia lutea* from pupae of *B. tabaci* (El-Sayad and El-Ghar, 1992). Chlorpyrifos and chlorpyrifos-methyl resulted in higher reduction in population of predatory spiders on cotton followed by quinalphos, compared with commonly used insecticides, cypermethrin, endosulfan and deltamethrin that were less lethal to natural enemy complex of cotton ecosystem (Dhawan, 2000). Acephate, deltapos and triazophos were more toxic to natural enemies of whitefly, followed by cypermethrin, deltamethrin, endosulfan and dimethoate (Kaler and Simwat, 2001). Kaler (1999) reported detrimental effect of cypermethrin, acephate, monocrotophos, triazophos and chlorpyrifos on natural enemies of *B. tabaci* on cotton. However, natural products, particularly neem, were found to be less toxic to whitefly natural enemies than synthetic insecticides (Mansour *et al*, 1993; Stansley and Liu, 1997; Raguraman and Singh, 1999; Singh, 2000).

2.2.3.2. Resurgence due to hormoligosis

In some instances, pest upsets cannot be explained on the basis of natural enemy destruction, rather, they are caused by direct favourable influences on arthropod physiology and/or behaviour or nutritional changes in host plants. This phenomenon is called hormoligosis (hormo = excite and oligo = small quantities). Basically it was confined to sub-lethal quantities of stressful agent which increase an organism's sensitivity/response to environmental factors. In several instances, this response has increased reproduction (Pedigo, 1999). Lucky (1968) explained the resurgence phenomenon through hormoligosis concept. "Hormoligosis is a term applied to the phenomenon in which sub-lethal quantities of many stress agents may be helpful when presented to organisms in sub-optimal environments". In

another words hormoligosis can be defined as the favourable changes in physiology and behaviour of the pest or its host plants in response to exposure to sub lethal doses that ultimately lead to population build-up of the pest. Roan and Hopkins (1961) suggested that sub-lethal doses might stimulate the neural activity to bring favourable neurohormonal influence on reproduction. The sub-lethal doses of insecticides induce several insects to feed and reproduce more.

2.2.3.2.1. Hormoligosis due to physiological and behavioural changes in whitefly

The hormoligosis phenomenon has been reported in case of *Plutella xylostella* (Sota *et al*, 1998), planthopper (BPH) (Chelliah, 1979; Krishnaiah and Kalode, 1985) and cotton aphid, *A. gossypii* (Gajendran, 1985; Gajendran *et al*, 1987; Nandihali *et al*, 1992), western corn rootworm, *Diabrotica virgivira*, two spotted spider mite, *Tetranychus urticae*, granary weevil, *Sitophilus granarius*, and elongated hemlock scale, *Fiorinia externa*, (Pedigo, 1999) but such information on whitefly is scanty. Some studies were conducted to study the effect of insecticides on the biology of whitefly, using only high or recommended doses. However, hormoligosis of sub-lethal/sub-optimal doses on the biology on the behaviour of *B. tabaci* is not available. Dittrich *et al* (1985) observed increase in sex ratio (1:3 to 1:6), fecundity (97.5 to 116.5 eggs/ female) and decrease in incubation period when synthetic pyrethroids (cypermethrin, deltamethrin and fenvalerate) were used to control bollworms on cotton as compared with other insecticides. In another study, Dittrich *et al* (1986) also reported stimulation of whitefly fertility by DDT. In a study in Andhra Pradesh to investigate the effect of 8 insecticides on bionomics of whitefly showed that synthetic pyrethroids (cypermethrin, fenvalerate and deltamethrin) registered highest fecundity (96.5 to 116.7 eggs/female) as compared to conventional insecticides (52.0 to 71.2 eggs) with shortened

incubation period (2.75 to 3.5 days) against 4.25 to 5.25 days in other chemicals. Synthetic pyrethroids also cause increased proportion of females in the resultant population (1.3 to 1.6), unlike in case of other insecticides (1.1 to 1.2). All these factors ultimately lead to resurgence of whitefly (Anonymous, 1989).

The growth regulators, diflubenzuron and triflunuron at 50 to 800 ppm suppressed the survival, development and fecundity of whitefly (Radwan *et al*, 1982). Similarly, Ishaaya *et al* (1988) reported that application of buprofezin at 62.5 and 125 mg/litre resulted in 50 per cent inhibition of egg hatching and more than 95% suppression of progeny formation in whitefly. Natarajan and Sundaramurthy (1990) observed that growth and development of nymphs was suppressed by neem oil but was unaffected by monocrotophos. Fenpropathrin (0.02%) reduced egg hatching by 10 per cent and at 0.01 per cent, caused 68 per cent mortality of late nymphal and pupal stage (Rao *et al*, 1990). Tamilselvan *et al* (1990) observed high fecundity on plants that received repeated sprays of deltamethrin, with reduction in nymphal period of whitefly. Beevi and Balasubramanian (1991) observed extension in oviposition period with a considerable increase in mean fecundity on cotton seedling treated with buprofezin at 50 to 500 ppm. Saini, (1997) in a study conducted on the effect of synthetic pyrethroids (fenvalerate and cypermethrin, both at 50 and 100 g/ha, deltamethrin at 10 and 20 g/ha and alphasmethrin 25 to 50 g/ha) on biology of whitefly of cotton, found that all synthetic pyrethroid compounds except alphasmethrin increased fecundity and survival and reduced the duration of immature stages after 2, 4 and 6 sprays, and resulted in heavy build-up of whitefly. These studies revealed that hormoligosis could occur even at optimal and higher doses of insecticides. In another study, acephate, monocrotophos and cypermethrin caused significant increase in fecundity, longevity, sex

ratio and nymphal population with reduction in duration of egg, nymphal and pupal stages, total survival and nymphal growth index as compared with control which resulted in high build-up of whitefly (Kaler, 1999). Effect of sub-lethal doses on honeydew excretion in different strains of whitefly studied by Nauen *et al* (1998) indicated that effect of sub-lethal doses of imidacloprid seems to be minor.

Information on the effect of insecticides on the behaviour of whitefly remains scanty. However, Uk and Dittrich (1986) observed that endosulfan application caused mass emigration of adult whitefly from treated plots without detectable mortality.

2.2.3.2.2. Hormoligosis in host plant of whitefly

Insecticides are routinely used all over the world to suppress the detrimental activity of pests. These chemicals are not always a biotic stress to plants. Instead, often they make plants large, faster growing, and in some cases higher yielding. The ultimate effect of a particular insecticide on a crop plant may largely depend on the plant species and insecticide molecules (Heinrichs, 1988). In some studies, it was observed that the insecticide-applied plants, after an initial period of efficacy, began to harbour a greater population of a particular pest, in contrast with a distinctly lower population in untreated control plants (Pradhan *et al*, 1960; Jotwani *et al*, 1966; Shanks, 1966; Sithanantham *et al*, 1973) particularly due to the use of sub-lethal doses of insecticides (Pedigo, 1999). Researchers hypothesized that the insecticides may cause changes in the growth rate, fruiting rate, and physiology of the plants and make them more attractive. This sort of resurgence is attributed to the phenomenon that is known as hormoligosis (Pedigo, 1999). The application of some insecticides found to have effect on the growth, composition and physiology of the plant (Dale and Heinrichs, 1999), that ultimately may favour the pest build-up fast (Dhawan, 2000). However, the information

on the effect of insecticides on plant physiology or its characters to the advantage or disadvantage of pests have generally been ignored by Entomologists responsible for developing insecticide recommendations (Jones *et al*, 1986). Leaves of cotton plants treated with disulfotam, phorate, dimethoate and lindane showed higher quantities of amino acids (cystine, asparagines and tryptophan) and lower content of carbohydrates as compared with untreated ones. These changes were responsible for increase in the fecundity of cotton aphid, *Aphis gossypii* (Sithanantham *et al*, 1973). Similarly, Ravindhran and Anne Xavier (1997) reported high sugar and low phenol content in cypermethrin, deltamethrin and fenvalerate treated cotton plants, which were responsible for high population of *A. gossypii*. Repeated use of endosulfan on cotton plants lead to increase in phenolic content that was associated with low level of whitefly population, suggesting that high content of phenols provide the resistance against whitefly (Dominick and Sundaram, 1992). They also observed that, plants treated with cypermethrin and deltamethrin showed high content of proteins with higher total sugar that was associated with high population of whitefly, but that was not so with fenvalerate. Similarly, Tamilselvan *et al* (1990) observed that with increased application of deltamethrin, there was increase in levels of reducing sugar, free amino acids, protein and chlorophyll, whereas the level of phenol decreased. This trend was well collaborated with increased fecundity, survival, growth index and decreased developmental period of whitefly. Butter *et al* (1992) reported that total phenols, O-dihydroxy phenols, tannins, flavonol and gossypol content were found to be negatively correlated with the population density of *B. tabaci* in different genotypes of cotton. Similar results were obtained by Kaler (1999) in which acephate, monocrotophos and cypermethrin registered higher percentage of total sugars and lower percentage of total phenols, O-dihydroxy phenols and tannins that were associated with high population of whitefly, whereas chlorpyrifos and triazophos treatments

had low total sugars, but higher total phenols, O-dihydroxy phenols and tannins which were associated with low level of whitefly population. High nitrogen and chlorophyll content, and high pH of leaves were positively correlated with resistance to *B. tabaci* in cotton (Ilyas *et al*, 1991). High doses of nitrogen coupled with use of cypermethrin and monocrotophos caused resurgence of whitefly (Purohit and Deshpande, 1991). Effect of insecticide application on the level of pH in plant leaves may play important role in resurgence of whitefly. Whitefly could differentiate between pH values of the level of 0.25 and showed clear preference for pH values of 6.0-7.25 offered in vitro (Basu, 1995).

2.2.3.3. Resurgence due to removing Competitors of whitefly

One of the results of using the broad spectrum insecticides is lowering of diversity of non-target pests, that alters the biological balance and results in resurgence of minor pests due to lack of competition. In cotton ecosystem, the synthetic pyrethroids have led to displacement of one species by other (David *et al*, 2000; Dhawan *et al*, 2000). In South India the low population of whitefly, *B. tabaci* and high population of cotton aphid, *A. gossypii* were observed when pyrethroids alone were used as compared to alternate sprays of pyrethroids and monocrotophos (Natarajan *et al*, 1987). Similarly, Surulivelu (1991) reported that triazophos and fenvalerate application on cotton registered higher population of aphid, which precluded the incidence of *B. tabaci*, and on the other hand elimination of aphid by monocrotophos and methyl demeton provide a better habitat for *B. tabaci*.

The review warrants the need to carryout detailed investigations regarding both physiological and behavioural hormoligosis of insecticides through their effects on biology and host plant selection by *B. tabaci* in cotton. These will help in better understanding of the upsets in the insect pest populations caused by the use of insecticides in cotton.

CHAPTER III

MATERIAL AND METHODS

The studies were carried out on *Gossypium hirsutum* Cotton var. LH. 1556 under greenhouse conditions at Entomological Research Farm, Punjab Agricultural University, Ludhiana, during crop season 2001 and 2002.

Preparation of pots

The soil used in various experiments was prepared by mixing of soil and FYM (Farm Yard Manure) in ratio of 1:1 which was later on sieved. The mixture was analysis for physico-chemical properties mainly; texture, pH, electrical conductivity, organic carbon, available phosphorous and potash. The results of soil analysis are given in (Table 1). The pots were then filled with equal quantity of this soil to ensures the all pots contained soil possessing uniform properties.

Table 1: Physico-chemical properties of the soil used in various experiments.

Property	Result
Texture	Loamy sand
PH	8.3
Electrical Conductivity (EC)	0.20 Millie mhos/cm
Organic Carbon(OC)	% 0.870
Available phosphorous(P)	28.8 kg/hectare
Available potassium(K)	> 300 kg/hectare

Raising of test plants

The seeds of cotton variety LH-1556 were obtained from Senior Cotton Breeder, Department of Plant Breeding, Punjab Agricultural University, Ludhiana. They were soaked in ordinary tap water for 6 hours prior to sowing to facilitate germination. Three seeds were sown in each pot (30 x 23 cm). After germination only single healthy seedling was retained in each pot. These pots were kept in whitefly-free screenhouses. The plants in screenhouse were protected from outside infestation of whitefly, by spraying the walls, ceiling and floor of the screenhouse with triazophos (Hostathion 40 EC) @ 0.6 ml per litre of water. The door of screenhouse also was covered with muslin to prevent entry of whitefly into screenhouse. Further, yellow sticky trap (12 x 12 cm) using card board and grease as sticky material were placed in screenhouse one meter apart (Plate I). All these measures made for making screenhouse free from any invasion of whitefly from outside.

The plants of each experiment (50 day old) were split into five sets, in which the first set was given one spray, second two sprays, third three sprays, fourth four sprays and fifth five sprays after an interval of 7 days. The sprayed plants were taken for study in each experiment. Similar procedures were followed to raise the test plants required for each experiment.

Raising of colonies of *B. tabaci*

The colonies of *B. tabaci* were maintained on unsprayed plants of *hirsutum* var. LH 1556 in a separate screenhouse. For initiating the culture, whitefly adults were collected from the field, using aspirator (30 cm). Thereafter whitefly adults were released on untreated cotton plants kept inside the screenhouse for raising the colonies. For maintaining good colonies of whitefly the old plants were replaced with new ones when ever needed. Due to



Plate I: Yellow sticky traps

emergence of biotype issue in *B. tabaci*, the population used in these studies has been characterized by Kumar *et al* (2002) (Fig 1).

Leaf cages

The leaf cage developed by Kaler (1999) was used for confining the adults. The cylindrical leaf cage (3.1 cm in diameter and 2.0 cm in height) was made from cylindrical semi-transparent plastic can (empty photographic film cover) by cutting its bottom with sharp edge blade. Six circular holes (0.75 cm in diameter) were made on sides of tube at equal distance from each other, with the help of electrical soldering rod. Five holes were covered with muslin using Fevicol to facilitate ventilation, while one hole was kept uncovered for releasing the whitefly adults into the cage which was later plugged with the cotton swab. On the cut end the tube, transparent sheet was glued with fevicol which helped inspection of caged insects. In the bottom of leaf cage, cotton leaf was inserted. A sheet of sun mica (4 cm²) was used for giving support to leaf cage and cotton leaf in which the smooth surface of it was covered with thin sponge piece (10 mm thickness) measuring 4 cm² using fevicol. The other end of the tube was fastened on the lower surface of the cotton leaf which was supported from upper side of the leaf by sunmica piece (described above) with the help of simple lady's hair clip which was modified manually for proper fastening of the cage. One end of the hair clip was placed on sunmica sheet, while the other end was placed above the end of leaf cage having transparent sheet, sandwiching the leaf between the leaf cage and sunmica sheet (Plate II). The soft sponge piece on the upper leaf surface provided cushioning softness effect to leaf surface, while the sunmica piece supported the leaf cage firmly on leaf surface with least injury to the leaf. The plants having leaf cages were provided support with wooden sticks.

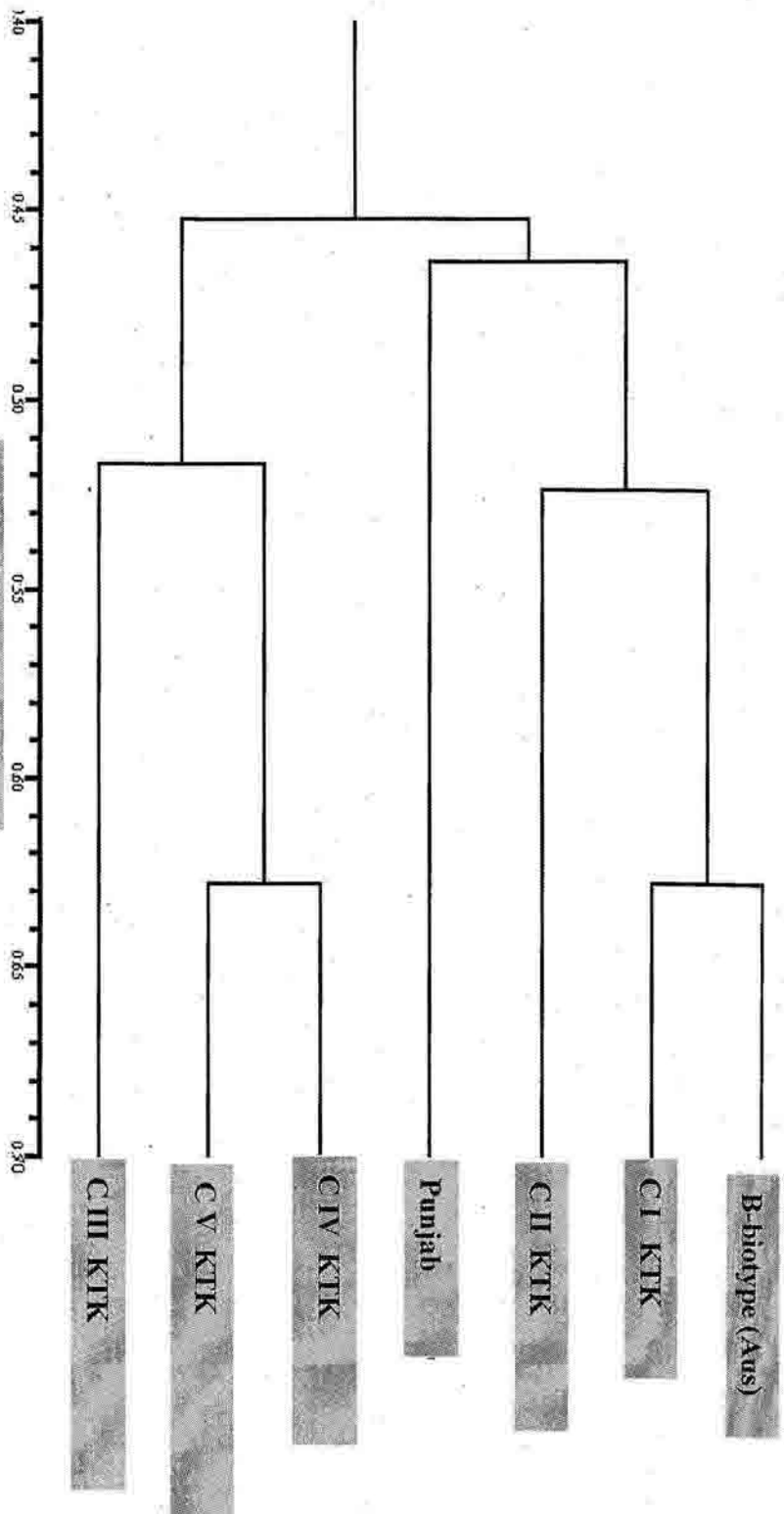


Fig. 1. Dendrogramme depicting genetic relatedness amongst whitefly populations in and around Kolar region of Karnataka and their comparison with standard B-biotype and Punjab population (After *Dikavari et al.*, 2002)

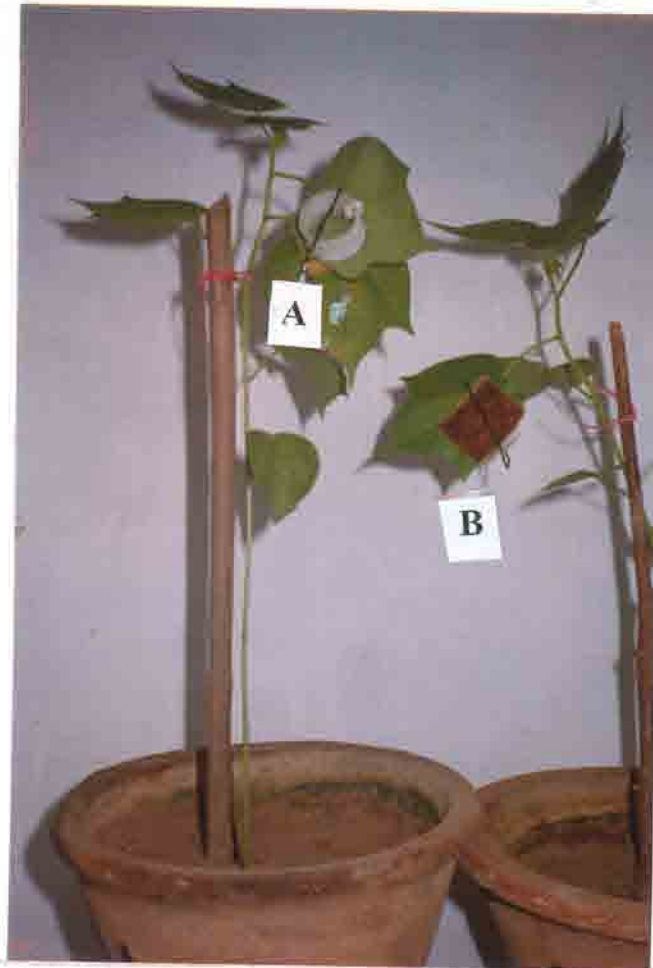


Plate II: Leaf cages attached to cotton leaves (A= front view; B= back view)

Collection of newly emerged adults

Plants having abundant pupae of whitefly were taken from main colony. All whitefly adults were removed from these plants and kept in a separate screenhouse over night. The newly emerged adults were collected next morning and were sexed by examining the tip of the abdomen which is tapering in males and blunt in females (Plates III and IV) with help of stereomicroscope-binocular (25X). These whitefly were used in different experiments. The different experiments conducted in these studies are under the following parameters:

3.1. HORMOLIGOSIS OF INSECTICIDAL SPRAYS ON BIOLOGY OF WHITEFLY

3.2.1. Hormoligosis in fecundity

3.3.2. Hormoligosis in duration and survival of different immature stages

3.3.3. Hormoligosis in sex ratio

3.3.4. Hormoligosis in longevity

3.2 HORMOLIGOSIS OF INSECTICIDAL SPRAYS IN BEHAVIOUR OF WHITEFLY

3.2.1. Hormoligosis in attractiveness of adults

3.2.2. Hormoligosis in oviposition preference

3.3. HORMOLIGOSIS IN BIOCHEMICAL COMPONENTS OF HOST PLANT (COTTON LEAVES)

3.3.1 Total sugars

3.3.2 Total free amino acids

3.3.3 Total phenols

3.3.4 pH of cotton leaves

3.1 HORMOLIGOSIS OF INSECTICIDAL SPRAYS ON BIOLOGY OF WHITEFLY

The studies on the impact of insecticidal sprays on the biology of whitefly were conducted during August to December 2001. Different Insecticides used in different

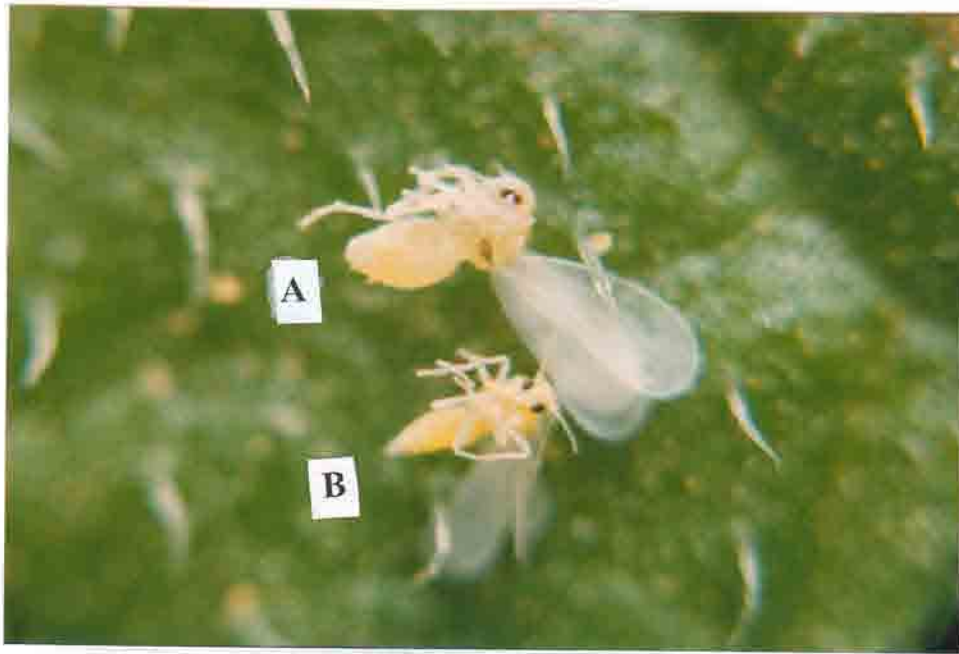


Plate III: (A) female and (B) male of *B. tabaci*



Plate IV: (A) Female and (B) male of *B. tabaci* in courtship

experiments are given in Table 2. The insecticides sprayed with the help of simple manual sprayer. The First spray was given on 50 days old plants then repeated at one week interval. These plants were used for studying the impact of insecticidal sprays on the biology of whitefly. These studies were repeated during (May-October) 2002 crop season.

3.1.1 Hormoligosis in fecundity

The experiment for studying the hormoligosis of insecticidal sprays in *B. tabaci* was conducted during November and December (2001) and repeated during June (2002).

Two male and two female of newly emerged whitefly were collected using single tube aspirator and released inside a leaf cage which was attached to top fully opened cotton leaves after 72 hours of I, II, III, IV and V spray. Three replications per treatment were kept for recording oviposition. The number of eggs (Plates V and VI) was counted after adults died. The newly hatched nymphs were counted as eggs using stereomicroscope-binocular (25X). The data were analyzed using CRD.

3.1.2. Hormoligosis in duration and survival of different immature stages

The duration of various developmental stages namely, egg, nymph, pupa and adult, was recorded and their weighted means were calculated. In each experiment, leaf cages were attached to the lower leaf surface of fully opened top leaves (3 leaf cages per treatment) of the sprayed plants. Five pairs of freshly emerged *B. tabaci* adults from the colonies were confined to the leaf cages for egg laying. After 24 hours, adults were removed along with leaf cages. The leaf portion under each leaf cage was marked and observed under stereomicroscope binocular using 25X for number of eggs laid. Only 20 eggs were kept and remaining were removed carefully with the help of needle and fine brush. Again the leaf cages were attached to the leaves on marked area to prevent oviposition by *B. tabaci* from



Plate V: Freshly laid eggs of *B. tabaci*



Plate VI: Old eggs of *B. tabaci*

Table 2. Insecticides use in various experiments

Insecticidal treatments	Dose (g a.i / ha)
Quinalphos (Ekalux 25 EC)	250
	375
	500
Carbaryl (Sevin 50 WP)	625
	938
	1250
Acephate (Asataf 75 SP)	750
	1125
	1500
Endosulfan (Thiodan 35 EC)	438
	656
	875
Fenvalerate (Tatafen 20 EC)	25
	38
	50
Untreated control	Water spray

outside, and moving of crawlers outside the marked area. Each leaf having known number of eggs was tagged using jewel tags indicating its treatment and date of egg lying. The marked area was observed daily under stereo-microscope binocular (25X) (Plate VII). The time period between laying of eggs and appearance of the crawlers (Plate VIII) was taken as incubation period. Similarly, the time period between crawlers stage and appearance of red-eyed nymphs (Plates IX, X and XI) was considered as nymphal period. The time between appearance of pupae and adult emergence was taken as pupal period. The period from egg laying to appearance of adult was considered as the total life cycle. Besides, survival of eggs, nymphs, pupae and overall survival of immature stages was also recorded.

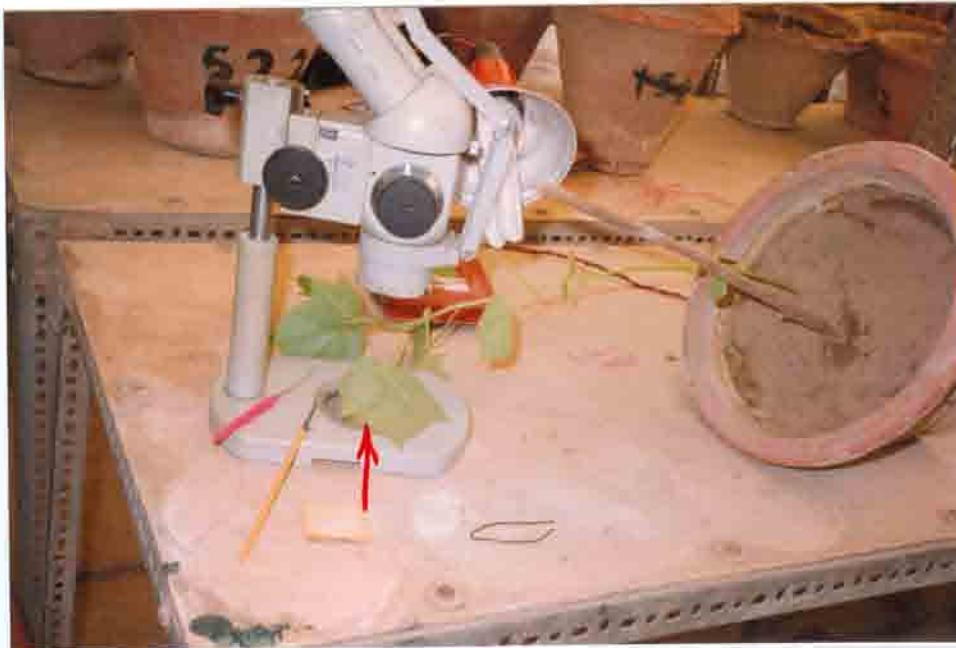


Plate VII: Marked leaf area being examined under stereomicroscope-binocular



Plate IIX: 1st instar nymphs (crawlers) of *B. tabaci*



Plate IX: 2nd instar nymph of *B. tabaci*



Plate X: 3rd instar nymph of *B. tabaci*



Plate XI: Red eyed nymphs (pupae) of *B. tabaci*

3.1.3 Hormoligosis in sex ratio

The emerged adults from the pupae (as mentioned in 3.1.3) were collected and sexed under stereo-microscope binocular for recording the effect of different treatments on sex ratio of *B. tabaci*.

3.1.4. Hormoligosis in longevity

The newly emerged ten female, ten male and five pairs of both male and female were released in separate leaf cage for each repeat which were attached to top fully opened cotton leaves after 72 hours of I, II, III, IV and V spray. The mortality of adults in each cage was counted daily and the weighted mean of longevity of each was calculated and the data were analyzed using CRD.

3.2 HORMOLIGOSIS OF INSECTICIDAL SPRAYS ON BEHAVIOUR OF WHITEFLY

3.2.1 Effect on attractiveness of adults

To study the impact of different treatments on the attractive behaviour of whitefly adults, a multiple choice-test was conducted during August 2001 and repeated during September of the same year for conformation of the results. For the experiment conducted during August 2001, plants sown on May 16, 23, 30, June 6 and 13 were given 5, 4, 3, 2 and 1 spray, respectively. First spray was given when the plants of each set reached 50 days old. It started from July 6 and continued at weekly interval up to 3 August. After 72 hours of I, II, III, IV and V spray, the total of 240 plants of all treatments (3 repeat per treatment) were distributed randomly outside the screenhouse in 12 rows each having 20 plants keeping 67.5 cm and 30 cm distance between rows and plants, respectively (Plate XII). One border row of untreated plants of variety LH-1556 was kept around the experimental plants (Fig. 2). All the leaves of all plants were removed keeping only the uppermost two fully formed leaves.



Plate XII: Cotton plants with different insecticidal treatments randomly distributed for behavioural hormoligosis studies



Plate XIII: Releasing of whitefly adults between cotton plants treated with different insecticides for behavioural hormoligosis studies

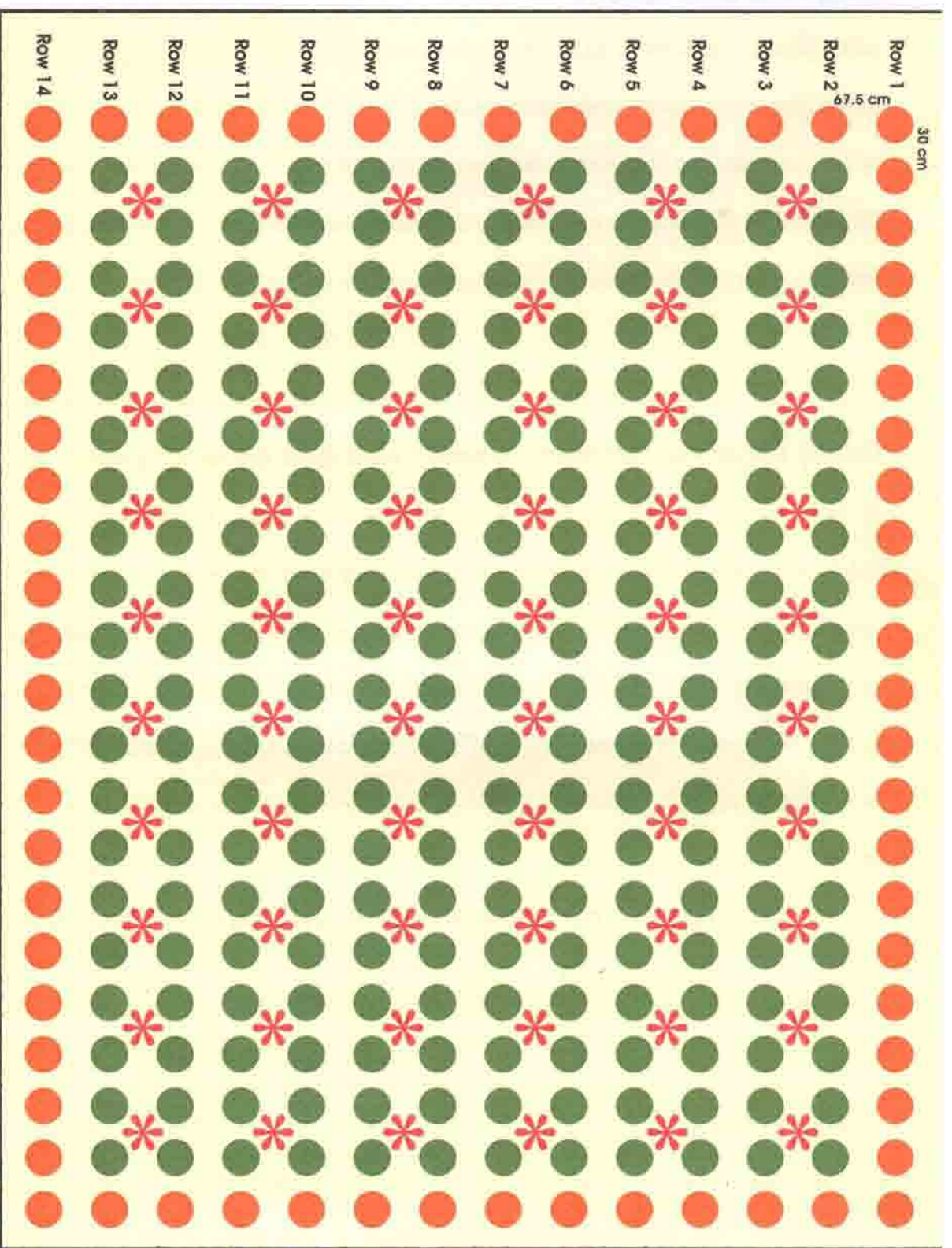


Fig. 1. Layout for studying the behavior hormoligosis in *Bemisia tabaci*

Total of 40 whitefly adults (20 males and 20 females) were collected from the main colony using single tube aspirator and were released at equidistant at the center of the each 4 plants (Plate XIII) (10 adults/plant). Number of whitefly adults settled on lower surface of each leaf was counted before 8.00 am daily for 7 days by taking visual observations as per procedures given by Singh and Gupta (1993) as the adults were less active and easy to count. The experiment was repeated during September 2001, in which the sowing started from June 19 and continued till July 17. The first sprays started on August 9 and continued till September 6. The data collected were analyzed using CRD.

3.2.2 Effect on oviposition preference

For studying the impact of different insecticidal treatments on attraction of adult whitefly for oviposition, the multiple choice-test was conducted during August 2001 as described in 3.5.1. The two leaves of each plants were removed after 10 days of releasing whitefly adults (oviposition period under Punjab condition 4-10 days as reported by Aneja, 2000) and the total leaf area was scanned under microscope using 40X magnification as described by Mariam and Chandramohan (2000). The newly hatched nymphs were counted as eggs. The same experiment was also repeated during September 2001 as mentioned at 3.5.1. The data collected were analysed using CRD.

3.3 HORMOLIGOSIS IN BIOCHEMICAL COMPONENTS OF HOST PLANT (COTTON LEAVES)

Chemical analysis of treated cotton leaves was carried out in Department of Biochemistry and Chemistry, PAU, Ludhiana.

Third fully formed leaf from the top of the plant of each treatment (repeated thrice) was excised and kept immediately in oven at $65 \pm 1^\circ\text{C}$ for three days. Later, each dried leaf was powdered and kept in small air tight plastic vial till further analysis.

3.3.1 Total sugars

Extraction: To 20 mg dried leaf samples, 3 ml of 80% hot ethanol was added and contents were refluxed for 10 min and centrifuged at 5000 r.p.m. for 15 min. Supernatant was collected, the residue left over was given washing twice with 80% aqueous ethanol and process was repeated. Supernatants collected were pooled and volume was made to 5 ml.

Estimation: Ethanolic extract (3 ml) was evaporated to dryness. Then 1.0 ml saturated lead acetate was added and volume of the extract was made to 9 ml with distilled water. This was kept overnight till all proteins in the extract got precipitated. To this, a pinch of sodium oxalate was added to remove lead ions from the extract. It was again kept overnight. Thereafter the extract was filtered through Watman No. 1 filter paper. The clear extract thus obtained was used for sugar estimation as per method given by Dubois *et al* (1956).

(a) Reagents: 95% H_2SO_4

5% phenol (w/v) redistilled

(b) Procedure: To 0.1 ml of sugar extract, 1 ml of 5% phenol was added followed by addition of 5 ml of conc. H_2SO_4 . The H_2SO_4 was poured directly in the centre of test tube to ensure proper mixing. After 10 min, tubes were cooled to room temperature with running water. After another 20 min the absorbance was measured at 490 nm against reagent blank. The concentration of total sugars was calculated from the standard curve prepared by using glucose in the range of 10-60 μg .

3.3.2 Total free amino acids

The same ethanolic extract used for soluble sugars was used for estimation of free amino acids following methods described by Lee and Takahashi (1966).

(a) Reagents:

- A. 1% ninhydrin in 0.5M citrate buffer (pH 5.5)
- B. Pure glycerol
- C. 0.5 M citrate buffer pH 5.5
- D. A:B:C (5:12:2)

(b) Procedure: One ml of ethanolic extract was evaporated to dryness and the residue left behind was dissolved in 1 ml of distilled water. To this 5.0 ml of reagent D was added and contents were shaken thoroughly. The reaction mixture was refluxed for 10 min in boiling water bath using condenser and then cooled to room temperature under tap water. Absorbance was recorded at 570 nm within 1 hour. The blank was prepared by distilled water and reagent D. The concentration of amino acids was read from the standard curve prepared by using glycine in the range of 5-25 µg

3.3.3 Total phenols

The phenol content of cotton leaves was estimated as per procedure given by Swain and Hillis (1959) with some modification. The same ethanolic extract as taken for soluble sugar was used for total phenol estimation. To 0.5 ml ethanolic extract, 5 ml of distilled water was added and mixed thoroughly. To it was added 0.5 ml of Folin phenol reagent and mixed thoroughly. After three minutes, 1 ml saturated sodium carbonate solution was added and kept undisturbed for one hour. Absorbance of colour developed was recorded at 725 nm using spectrophotometer. Standard curve was prepared using 5-60 µg gallic acid as the standard.

3.3.4 pH of cotton leaves

Second fully open leaf from the top of the plant of each replication for each treatment was excised and brought under cold conditions to the laboratory for analysis. Each leaf was

ground thoroughly in pestle and mortar with 100 ml of distilled water. The water extract was directly taken for pH estimation using calibrated pH-meter.

STATISTICAL ANALYSIS

The data obtained in all the experiments were analyzed using CRD.

CHAPTER IV

RESULTS AND DISCUSSION

The results of investigations on the 'Hormoligosis of Insecticidal Sprays in *B. tabaci* (Genn.) on cotton' have been presented and discussed as below:

4.1. HORMOLIGOSIS OF INSECTICIDAL SPRAYS IN BIOLOGY OF WHITEFLY

4.1.1. Hormoligosis in fecundity

4.1.2. Hormoligosis in furation and survival of different immature stages

4.1.2.1. Egg stage

4.1.2.2. Nymphal stage

4.1.2.3. Pupal stage

4.1.2.4 Total life cycle

4.1.3. Hormoligosis in sex ratio

4.1.4. Hormoligosis in longevity

4.1.4.1 Male longevity

4.1.4.2. Female longevity

4.1.4.3. Longevity of both sexes together

4.2 HORMOLIGOSIS OF INSECTICIDAL SPRAYS IN BEHAVIOUR OF WHITEFLY

4.2.1. Hormoligosis in attractiveness of adults

4.2.2. Hormoligosis in oviposition preference

4.3 HORMOLIGOSIS IN BIOCHEMICAL COMPONENTS OF HOST PLANT (COTTON LEAVES)

4.3.1 Total sugars

4.3.2 Total free amino acids

4.3.3 Total phenols

4.3.4 pH of cotton leaves

4.1. HORMOLIGOSIS OF INSECTICIDAL SPRAYS ON BIOLOGY OF WHITEFLY

The effect of different insecticidal treatments on the biology of whitefly on American cotton (var. LH-1556) was studied by releasing of adult whitefly on sprayed plants in leaf cages after 72 hours of 1st, 2nd, 3rd, 4th and 5th spray under screen house conditions. The results obtained are given below.

4.1.1. Hormoligosis in fecundity

The effect of different insecticidal treatments on the fecundity of *B. tabaci* during 2001 and 2002 crop season is presented in table 4.1.1(a) and 4.1.1 (b).

(a) Crop season of 2001

The data summarized in Table 4.1.1a revealed that all insecticidal treatments resulted in significant effect on fecundity. The maximum fecundity after first spray was recorded in fenvalerate 25 g/ha (73.0 eggs/2 pairs) and was at par with acephate (750 and 1125 g/ha) and fenvalerate (38 and 50 g/ha) and was significantly higher than control. The fecundity in all the doses of endosulfan (22.7 to 24.3 eggs/2 pairs), quinalphos (28.0 to 46.3 eggs/2 pairs) and carbaryl (37.0 and 38.7 eggs/2 pairs) was significantly lower than untreated control. After 2nd spray, maximum fecundity was recorded in fenvalerate (81.3 eggs/2 pairs), followed by other doses of fenvalerate (78.3 and 69.3 eggs/2pairs at 38 and 50 g/ha), acephate (62.3, 61.3 and 58.3 eggs) and it was significantly higher than control. Lowest fecundity was recorded in different doses of endosulfan (32.0, 34.0 and 38.0 eggs) and carbaryl 1250 g/ha (39.7 eggs/2 pairs). Almost similar trend with minor changes was observed after 3rd, 4th and 5th spray. The pooled analysis of the data of all the sprays revealed that all the doses of

Table. 4.1.1a. Fecundity of *B. tabaci* on American cotton (Var. LH 1556) in different insecticidal treatments (October – November 2001)

Insecticide	Dose (g a.i./ha)	Number of eggs/ 2 pairs after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	46.3	53.3	65.3	61.3	63.3	57.9
	375	43.0	56.0	54.7	59.0	59.3	54.4
	500	28.0	42.0	53.0	56.0	44.7	44.7
Carbaryl	625	55.3	52.3	61.0	60.0	61.0	57.9
	938	38.7	45.3	55.0	55.0	57.7	50.3
	1250	37.0	39.7	49.0	47.3	42.7	43.2
Acephate	750	68.3	62.3	72.0	75.0	96.3	69.4
	1125	70.3	61.3	74.3	69.7	68.7	68.9
	1500	57.3	58.3	67.3	64.7	65.7	62.7
Endosulfan	438	24.3	34.0	47.7	42.7	43.0	38.3
	656	22.7	38.0	41.3	39.0	39.0	36.0
	875	24.3	32.0	36.3	31.7	21.3	29.1
Fenvalerate	25	73.0	81.3	87.7	81.0	89.3	82.5
	38	69.3	78.3	85.3	77.0	80.7	78.1
	50	65.3	69.3	82.0	75.3	77.7	73.9
Untreated control	Water spray	60.3	48.7	55.3	56.7	48.7	53.9
CD (P=0.05)		9.0	9.3	10.4	8.3	8.4	4.0

fenvalerate, acephate and lower dose of quinalphos and carbaryl resulted in significant increase in fecundity of *B. tabaci*, whereas endosulfan at all doses caused significant decrease as compared with untreated control.

(b) Crop season of 2002

In the experiment conducted during June 2002, the effect of different insecticides in fecundity of *B. tabaci* (Table 4.1.1b) was, in general, similar to that obtained during November-December 2001 except in 5th spray, when significantly higher fecundity was recorded in all the doses of fenvalerate (81.0, 75.0 and 64.3 eggs). Similarly, lowest doses of quinalphos (250 g/ha) and carbaryl (625 g/ha) recorded significantly higher fecundity (49.7 and 48.0 eggs/2 pairs, respectively) as compared with untreated control (37.0 eggs/2 pairs). The minimum fecundity was recorded in all doses of endosulfan (21.7, 24.0 and 25.0 eggs/2 pairs) ranking from highest to lowest dose, respectively. The pooled analysis of the data revealed that all the doses of fenvalerate, acephate and lower dose of quinalphos (250 g/ha) increased the fecundity significantly. Whereas the fecundity observed in all the doses of endosulfan and higher dose of carbaryl was significantly lower than control.

The pooled data in both experiments also revealed that fenvalerate and acephate at different doses increased the fecundity whereas endosulfan in all the doses caused reduction in fecundity of *B. tabaci* (Fig. 4.1.1).

The data obtained from both of the experiments conducted during the two crop seasons revealed that, fecundity of *B. tabaci* on untreated plants ranged between 21.15 to 26.95 eggs per female (42.30 to 53.90 eggs/2 pairs). Earlier, the average fecundity of *B. tabaci* under Punjab climatic condition has been reported to be 43.0 eggs/female (Misra and

Table 4.1.1b. Fecundity of *B. tabaci* on American cotton (Var. LH 1556) in different insecticidal treatments (June 2002)

Insecticide	Dose (g a.i./ha)	Number of eggs/ 2 pairs after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	49.0	49.0	44.3	46.0	49.7	47.6
	375	43.7	39.7	39.7	39.7	40.0	40.5
	500	31.7	36.0	34.7	35.7	36.7	34.9
Carbaryl	625	45.3	42.3	47.0	44.0	48.0	45.3
	938	36.7	40.7	37.7	45.7	45.3	41.2
	1250	34.3	32.0	31.7	34.0	35.7	33.5
Acephate	750	58.7	53.0	51.7	54.7	58.7	55.3
	1125	54.3	49.0	52.7	53.7	47.0	51.3
	1500	54.0	58.7	51.3	50.3	50.3	52.9
Endosulfan	438	24.7	29.7	25.7	26.7	25.0	26.3
	656	24.0	21.0	24.0	25.3	24.0	23.7
	875	20.7	22.0	21.3	20.7	21.7	21.3
Fenvalerate	25	67.0	65.7	62.3	61.3	81.0	67.5
	38	61.7	61.3	61.3	60.7	75.0	64.1
	50	61.3	56.3	57.0	59.3	64.3	59.7
Untreated control	Water spray	53.3	42.3	37.3	41.7	37.0	42.3
CD (P=0.05)		8.4	8.2	7.2	9.1	7.6	3.5

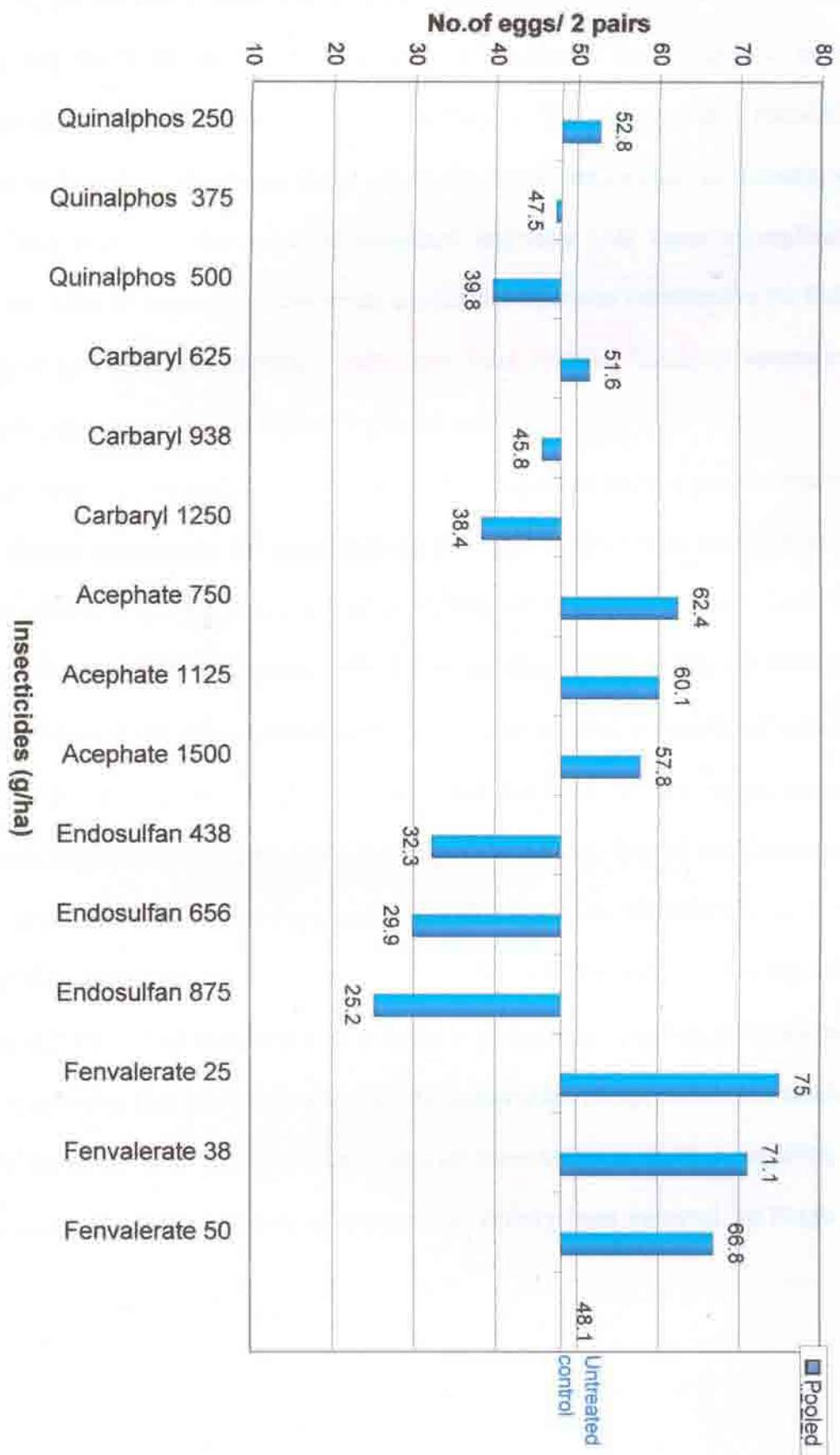


Fig. 4.1.1. Increase and decrease of fecundity of *B. tabaci* over untreated control on American cotton (Var. LH 1556) in different insecticidal treatments (Pooled data of the two crop seasons)

Lamba, 1929; Husain and Trehan, 1933). However, the results of the present studies are in agreement with the recent studies of Aneja (2000) who reported the fecundity of *B. tabaci* varied from 18.1 to 26.8 eggs/female at Ludhiana, Punjab. The present studies revealed that fenvalerate and acephate at different doses resulted in significant increase in fecundity of *B. tabaci*. These results further revealed increased fecundity with repeated applications. Increased fecundity in response to fenvalerate application on cotton corroborates the findings of Dittrich *et al* (1985), Anonymous (1989) and Saini (1997). Similarly acephate was reported to increase fecundity of *B. tabaci* by Kaler (1999).

The increase in fecundity by fenvalerate and acephate treatments may be one of the important factors responsible for resurgence of *B. tabaci* in the cotton treated with these insecticides (David *et al*, 1987; Jayaraj *et al*, 1987; Regu *et al*, 1990; Singh and Gupta, 1993; Dhawan and Simwat, 1997; Patil *et al*, 1990; Butter and Kular, 1999; Kaler, 1999 and Aneja, 2000). The lowest doses of quinalphos and carbaryl also resulted in significant increase in fecundity of *B. tabaci* over untreated control which seems to be new report. Roan and Hopkins (1961) have cited examples of insects from Coleoptera, Diptera and Orthoptera, in which enhanced production following exposure to sub-lethal doses of toxicants was observed suggesting that such amounts might excite the nerve activity and could bring about a favourable neurohormonal influence on the insect reproduction. The results of the present studies also revealed that the low doses of all the insecticides except endosulfan resulted in increase of fecundity of *B. tabaci* as compared with untreated control. The sensitivity of *B. tabaci* to endosulfan under Punjab conditions has already been reported by Singh *et al* (1998).

4.1.2.Hormoligosis in duration and survival of different immature stages

4.1.2.1 Egg stage

(a) Duration

The results on effect of different insecticides on duration of eggs are presented in Table 4.1.2.1a. The data revealed that in all the sprays, there was no significant differences between different treatments except in pooled data of all the sprays.

The pooled analysis of the data revealed that duration of eggs significantly increased in carbaryl (1250 g) as compared with untreated control whereas all other treatments were at par with control.

Incubation period has earlier been reported to range from 2 to 5 days during April-September and 33 days in December-January (Husain and Trehan, 1933). Mohanty and Basu (1987) also reported incubation period to range from 2 to 4 days during March-October and 7 to 8 days during November and February. Under Punjab conditions incubation period on cotton plants has been reported to be 6.20 days (Kaler, 1999), 5.03 days (Singh, 2000), 8.94 days (Saini, 1997) and 3 to 8 days (Aneja, 2000). These results support the present findings in which incubation period ranged from 5.5 to 8.8 days.

(b) Egg survival

The data obtained on the egg survival revealed non-significant differences in different treatments in all the sprays (Table 4.1.2.1b). However, the analysis pooled of the data showed significant differences. The egg survival varied from 70.0 to 91.7 per cent. Decrease in egg survival was observed in quinalphos (250 g/ha), carbaryl (938 g/ha) and endosulfan (438 and 656 g/ha) as compared with untreated control. The egg survival on acephate treated plants varied from 79 to 84 per cent in the present studies which is in agreement with that

Table 4.1.2.1a. Duration of eggs of *B. tabaci* on American cotton (Var. LH 1556) in different insecticidal treatments.

Insecticide	Dose (g a.i./ha)	Duration of eggs (days) after different Sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	7.5	6.4	7.0	7.4	7.0	7.1
	375	7.9	7.5	6.3	6.9	7.1	7.1
	500	7.9	7.3	6.6	6.7	7.0	7.1
Carbaryl	625	7.2	6.8	7.0	7.7	7.0	7.1
	938	6.6	7.1	5.9	6.9	7.0	6.9
	1250	8.8	6.9	6.2	7.5	7.0	7.2
Acephate	750	6.1	7.0	6.2	6.8	7.0	6.6
	1125	6.6	6.5	5.8	7.0	7.3	6.6
	1500	7.3	7.1	6.3	7.1	7.4	7.1
Endosulfan	438	7.7	6.9	5.8	6.8	7.1	6.9
	656	5.6	7.1	5.9	6.8	7.0	6.5
	875	6.8	7.0	5.7	6.9	7.0	6.7
Fenvalerate	25	7.1	7.1	6.3	6.8	7.2	6.9
	38	6.6	6.5	5.8	7.0	7.6	6.7
	50	7.5	5.9	5.5	6.5	7.3	6.5
Untreated Control	Water spray	6.3	6.6	6.0	7.0	7.0	6.6
CD (P=0.05)		NS	NS	NS	NS	NS	0.5

NS = Non significant

Table 4.1.2.1b. Egg viability of *B. tabaci* on American cotton (Var. LH 1556) in different insecticidal treatments.

Insecticide	Dose (g a.i./ha)	Per cent viability after different Sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	80.0	90.0	46.7	88.3	71.7	75.3 (63.73)
	375	81.7	76.7	90.0	91.7	73.3	82.7 (69.34)
	500	80.0	68.3	83.3	81.7	70.0	76.7 (65.16)
Carbaryl	625	100.0	93.3	76.7	88.3	80.0	87.7 (78.61)
	938	68.3	75.0	60.0	71.7	76.7	70.0 (58.47)
	1250	73.3	75.0	56.7	93.3	60.0	71.7 (60.07)
Acephate	750	96.7	83.3	68.3	91.7	55.0	79.0 (66.93)
	1125	98.3	75.0	90.0	96.7	70.0	86.0 (73.03)
	1500	75.0	96.7	81.7	93.3	73.3	84.0 (72.09)
Endosulfan	438	73.0	73.3	93.3	78.3	51.7	74.0 (63.71)
	656	70.0	78.3	68.3	85.0	65.0	73.3 (61.45)
	875	91.7	95.0	53.3	88.3	66.7	79.0 (67.08)
Fenvalerate	25	95.0	90.0	96.7	85.0	91.7	91.7 (77.82)
	38	96.7	90.0	96.7	98.3	63.3	89.0 (76.61)
	50	75.0	96.7	91.7	95.0	78.3	87.3 (73.56)
Untreated Control	Water spray	100.0	83.3	85.0	95.0	78.3	88.3 (74.81)
CD (P=0.05)		NS	NS	NS	NS	NS	(10.82)

NS = Non significant

Figures in parentheses are arc sine transformed values.

recorded by Kaler (1999) who reported 79.6 per cent of egg survival on acephate treated plants. The egg survival 88.7 to 91.7 per cent in fenvalerate treatments in the present studies is in agreement with that of Saini (1997) who reported 73.0 to 92.5 per cent egg survival on fenvalerate treated plants. Non-significant differences observed in egg survival in different insecticidal treated plants and untreated plants in the present studies might be attributed to the fact that as the eggs were laid by female on treated plants after spray in which the chance of contact between eggs and insecticides was comparatively less.

4.1.2.2. Nymphal stage

(a) Duration

Different insecticides have shown significant effect on the duration of nymphs (Table 4.1.2.2a).

After 1st spray, the nymphal duration varied from 9.3 days in carbaryl at 1250 g/ha to 12.4 days in carbaryl at 938 g/ha but there was non-significant differences between various treatments. After 2nd spray the minimum nymphal period on insecticidal treatments was observed in fenvalerate 38 and 50 g/ha (9.9 and 10.0 days, respectively), which were at par with untreated control (9.7 days). Maximum nymphal period was recorded in all the treatments of endosulfan, followed by carbaryl at 1250g/ha, quinalphos at 375 and 500 g/ ha and acephate at 750 g/ha. Rest of the treatments was at par with untreated control. Almost similar trend of results was observed after 3rd, 4th and 5th spray with minor changes. The pooled data revealed that all the dose of endosulfan and carbaryl at 938 and 1250 g/ha, quinalphos at 375 g and 500 g/ha and acephate at 1500 g/ha significantly prolonged the duration of nymphal stage as compared with untreated control. The prolongation of nymphal duration in all above insecticideal treatments confirmed their adverse effects. Saini, (1997) has reported

Table 4.1.2.2a. Duration of nymphs of *B. tabaci* on American cotton (Var. LH 1556) in different insecticidal treatments.

Insecticide	Dose (g a.i./ha)	Duration of nymphs (days) after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	11.5	10.9	11.9	13.0	11.2	11.7
	375	10.6	11.1	12.7	13.3	11.7	11.9
	500	11.1	11.1	13.2	13.3	11.7	12.1
Carbaryl	625	10.8	10.1	12.7	12.3	11.3	11.5
	938	12.4	10.9	12.8	12.8	11.0	12.0
	1250	9.3	11.4	13.5	13.5	11.8	11.9
Acephate	750	11.1	11.0	12.7	12.8	10.7	11.7
	1125	11.0	10.0	13.4	12.3	11.0	11.6
	1500	11.3	10.6	12.7	13.3	11.6	11.9
Endosulfan	438	11.0	11.3	12.9	12.6	11.9	11.9
	656	11.9	11.9	13.5	13.1	12.6	12.6
	875	11.2	11.5	13.5	14.4	13.4	12.8
Fenvalerate	25	10.9	10.5	12.5	11.8	10.0	11.1
	38	10.8	9.9	12.2	10.9	9.3	10.6
	50	10.5	10.0	12.0	12.2	10.1	11.0
Untreated Control	Water spray	11.7	9.7	12.4	11.6	10.2	11.1
CD (P=0.05)		NS	1.2	0.7	1.3	1.3	0.6

NS = Non significant

similar results in case of fenvalerate 50 g/ha and Kaler (1999) in case of acephate 1500 g/ha. However, similar trend of the results observed in both higher and lower doses of different insecticides in the present studies seems to be a new finding.

(b) Survival

The data presented in Table 4.1.2.2b revealed that different treatments have shown significant differences on the nymphal survival. After 1st spray per cent nymphal survival ranged between 41.1 to 88.3 per cent, with maximum being in untreated control and minimum in endosulfan at 656 g/ha with non-significant differences. Per cent nymphal survival did not vary significantly in different treatments after 2nd spray except significant reduction observed in higher dose of carbaryl and endosulfan. The significant increase in nymphal survival was observed only in lower dose of quinalphos (250 g/ha) and acephate (750 g/ha) after 3rd spray. The trend in nymphal survival again changed after 4th spray. It indicated significant reduction in nymphal survival in endosulfan treatments (656 and 875 g/ha). The trend in per cent nymphal survival became clear after the 5th spray. All the doses of endosulfan and higher doses of quinalphos and carbaryl significantly reduced the nymphal survival.

The pooled analysis of the data revealed that nymphal survival was at par with untreated control in all the doses of fenvalerate, lower doses of acephate, quinalphos (250 g/ha). This clearly indicates the absence of adverse effect from these treatments on survival of the nymphal instars being as normal as untreated control. Saini (1997) compared the nymphal survival in fenvalerate (50 and 100 g/ha) with untreated control, observing non-significant differences in all the treatments. However, the present studies have revealed that fenvalerate (38 and 50 g/ha), acephate (750 and 1125 g/ha), quinalphos (250 g/ha) and

Table 4.1.2.2b. Survival of nymphs of *B. tabaci* on American cotton (Var. LH 1556) in different insecticidal treatments.

Insecticide	Dose (g a.i./ha)	Per cent survival after different Sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	60.3	61.0	54.8	80.0	75.8	66.4
		(51.40)	(51.49)	(47.79)	(68.04)	(61.66)	(56.08)
	375	49.2	70.0	35.7	68.5	60.0	56.7
		(44.89)	(56.82)	(36.26)	(56.51)	(51.66)	(49.23)
	500	61.9	72.1	35.0	72.7	53.9	59.1
		(51.89)	(58.29)	(36.26)	(58.60)	(47.25)	(50.48)
Carbaryl	625	45.0	66.7	30.6	75.8	55.0	54.6
		(42.01)	(54.86)	(33.49)	(61.44)	(47.89)	(47.94)
	938	62.1	63.6	41.1	78.1	72.2	63.4
		(53.13)	(53.00)	(39.82)	(63.40)	(58.44)	(53.55)
	1250	43.3	47.1	28.5	56.7	63.7	47.8
		(40.92)	(43.29)	(32.05)	(48.82)	(52.97)	(43.61)
Acephate	750	61.8	74.7	51.5	74.4	94.1	71.3
		(52.11)	(60.27)	(45.85)	(60.38)	(78.48)	(59.42)
	1125	61.1	80.0	28.3	71.7	74.8	63.2
		(51.81)	(63.52)	(32.13)	(57.84)	(64.67)	(53.99)
	1500	51.0	55.0	26.3	70.8	77.6	56.2
		(45.55)	(48.06)	(30.84)	(57.70)	(62.67)	(48.97)
Endosulfan	438	44.5	88.3	21.2	81.6	50.5	57.2
		(41.87)	(70.09)	(27.16)	(64.62)	(45.37)	(49.82)
	656	41.1	58.3	27.2	45.5	52.2	44.9
		(39.23)	(50.46)	(31.38)	(42.49)	(46.29)	(41.97)
	875	61.9	44.3	23.4	48.1	54.4	46.4
		(51.99)	(41.65)	(28.66)	(43.83)	(47.87)	(42.80)
Fenvalerate	25	70.2	72.1	31.8	90.8	68.5	66.7
		(57.10)	(58.16)	(34.11)	(75.56)	(56.51)	(56.29)
	38	59.9	72.4	39.4	81.6	77.6	66.2
		(51.35)	(58.63)	(38.85)	(65.61)	(66.40)	(56.17)
	50	80.4	70.0	36.7	72.9	78.0	67.6
		(68.26)	(56.82)	(37.13)	(58.96)	(63.30)	(56.89)
Untreated Control	Water spray	88.3	71.6	33.4	77.4	91.2	72.4
		(70.47)	(58.45)	(35.10)	(62.22)	(79.68)	(61.19)
CD (P=0.05)		NS	(12.64)	(8.49)	(16.02)	(21.03)	(7.26)

NS = Non significant

Figures in parentheses are arc sine transformed values.

carbaryl (625 g/ha) did not adversely affect the nymphal survival. This is new information pertaining to the effect of these insecticides on nymphal survival. Furthermore, *B. tabaci* is reported to be susceptible to endosulfan under Punjab condition (Singh *et al*, 1999).

(c) Nymphal growth index

The data presented in Table 4.1.2.2c revealed that significant effects of different insecticidal treatments started appearing after the second spray, with significant reduction of growth index in carbaryl (1250 g/ha) and endosulfan (656 and 875 g/ha) as compared with untreated control. These changes were rather inconsistent for both the 3rd and 4th sprays. However, significant reduction in growth index over untreated control was observed in all the doses of endosulfan, higher doses of quinalphos (357 and 500 g/ha) and carbaryl (625 and 1250 g/ha) after 5th spray. The pooled analysis of the data revealed that all doses of endosulfan, carbaryl, higher doses of quinalphos (375 and 500 g/ha) and acephate (1500 g/ha) resulted in significant reduction in nymphal growth index, whereas all doses of fenvalerate and low doses of acephate (750 and 1125 g/ha) and quinalphos (250 g/ha) were at par with untreated control. The similarity in the growth index values on all the doses of the fenvalerate, lower doses of acephate (750 and 1125 g/ha) and low dose of quinalphos (250 g/ha) with untreated control further indicated non-adverse effect on nymphal stage of *B. tabaci*.

4.1.2.3. Pupal stage

(a) Duration

The data on effect of different insecticidal treatments on the pupal duration are presented in Table 4.1.2.3a. Pupal duration varied from 1.5 to 3.4 days with minimum being in acephate 1125 g and 1500 g/ha and maximum in quinalphos 250 g/ha but without

Table 4.1.2.2c. Nymphal growth index of *B. tabaci* cotton (Var. LH 1556) in different insecticidal treatments.

Insecticide	Dose (g a.i./ha)	Growth index* after different Sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	5.2	5.7	4.6	6.2	6.8	5.7
	375	4.7	6.3	2.8	5.2	5.3	4.8
	500	5.9	6.5	2.7	5.5	4.7	5.0
Carbaryl	625	4.1	6.6	2.4	6.2	4.8	4.8
	938	5.3	5.9	3.2	6.2	6.6	5.4
	1250	4.9	4.2	2.1	4.2	5.4	4.2
Acephate	750	5.5	6.8	4.1	5.9	9.0	6.2
	1125	5.6	8.0	2.1	5.9	6.8	5.7
	1500	4.5	5.2	2.1	5.3	6.7	4.8
Endosulfan	438	4.1	7.8	1.7	6.5	4.3	4.9
	656	3.5	4.9	2.1	3.5	4.2	3.6
	875	5.7	3.8	1.7	3.4	4.1	3.8
Fenvalerate	25	6.5	6.9	2.6	7.7	6.9	6.1
	38	5.6	7.4	3.2	7.6	8.6	6.5
	50	7.7	7.2	3.1	6.0	7.7	6.3
Untreated Control	Water spray	7.6	7.4	2.7	6.8	9.1	6.7
CD (P=0.05)		NS	2.2	1.1	1.8	2.8	1.1

NS= Non significant

* Nymphal growth index = $\frac{\text{Percent survival of nymphs}}{\text{Duration of nymph}}$

Table 4.1.2.3a. Pupal duration of *B. tabaci* on American cotton (Var. LH 1556) in different insecticidal treatments.

Insecticide	Dose (g a.i./ha)	Duration of pupa (days) after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	2.0	3.4	2.3	2.1	2.7	2.5
	375	1.8	3.3	2.1	2.1	2.3	2.3
	500	2.8	3.3	2.2	1.9	2.0	2.4
Carbaryl	625	2.0	2.8	2.0	2.1	2.4	2.3
	938	2.3	3.0	1.7	1.9	2.2	2.2
	1250	2.5	2.9	1.8	1.8	2.0	2.2
Acephate	750	2.6	2.5	2.3	2.1	2.8	2.5
	1125	2.8	3.1	1.5	2.0	2.9	2.4
	1500	1.5	2.5	2.4	1.9	2.7	2.2
Endosulfan	438	2.3	3.3	2.1	1.8	2.3	2.4
	656	2.5	3.3	1.9	1.7	2.3	2.4
	875	3.1	3.3	2.1	2.1	2.4	2.6
Fenvalerate	25	2.7	2.3	1.9	1.8	2.4	2.2
	38	2.2	3.3	2.0	1.8	2.5	2.4
	50	2.8	2.8	1.8	1.9	3.4	2.5
Untreated Control	Water spray	2.5	3.1	1.7	2.2	2.2	2.3
CD (P=0.05)		NS	NS	NS	NS	NS	NS

NS = Non significant

significant differences between different treatments. These results revealed that none of the insecticides at the tested doses has adverse effect on the pupal duration. Similarly, Saini (1997) recorded non-significant effect of cypermethrin, fenvalerate at 50 and 100 g/ha for both and deltamethrin at 10 and 20 g/ha on the duration of pupa of *B. tabaci* on cotton, and the duration varied from 1.52 to 4.95 days. Similarly, Kaler (1999) reported non-significant differences in pupal duration between acephate treated plants at 1500 g/ha with untreated control. However, the effect of sub-optimal (below recommended) doses was also studied in the present investigations.

(b) Survival

The data presented in Table 4.1.2.3b revealed that survival of pupa ranged between 56.2 to 100 per cent in different treatments and these differences were non-significant. This may be attributed to the fact that pupal stage is non-feeding and immovable that reduces the contact with insecticide residues that remained on the leaves of the sprayed plants. Similar results were also obtained by Saini (1977) using synthetic pyrethroids at recommended and higher doses.

4.1.2.4 Life cycle

(a) Duration

The data presented in Table 4.1.2.4a revealed that different insecticidal treatments have shown significant effect on duration of life cycle. After 1st spray total duration of immature stages after one spray varied from 19.5 to 21.8, with maximum being in quinalphos 500 g/ha and minimum in fenvalerate 38 g/ha, but there were non-significant differences among different treatments. After 2nd spray minimum duration of life cycle was recorded in highest dose of fenvalerate (18.7 days) and it was at par with untreated control (19.3 days).

Table 4.1.2.3b. Survival of pupa of *B. tabaci* on American cotton (Var. LH 1556) in different insecticidal treatments.

Insecticide	Dose (g a.i./ha)	Per cent survival after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	97.6	91.7	100.0	86.7	92.5	93.7
	375	97.4	79.1	68.7	94.6	91.0	86.2
	500	80.0	97.4	57.1	91.3	92.6	83.7
Carbaryl	625	100.0	84.9	88.6	97.2	97.4	93.6
	938	89.8	88.9	75.0	94.4	91.7	88.0
	1250	100.0	81.0	88.9	97.2	84.1	90.3
Acephate	750	94.5	87.1	67.9	87.6	81.0	83.6
	1125	80.7	83.3	81.7	81.1	97.4	84.7
	1500	88.9	90.4	96.7	89.6	76.5	88.4
Endosulfan	438	83.3	77.8	88.9	81.8	88.9	84.2
	656	90.0	56.2	83.4	96.3	96.3	84.5
	875	77.8	85.4	91.7	80.4	58.3	78.7
Fenvalerate	25	97.9	100.0	90.3	80.4	81.9	90.1
	38	96.7	75.0	94.4	90.5	94.4	90.2
	50	91.1	88.5	83.3	100.0	93.8	91.3
Untreated Control	Water spray	91.0	90.4	100.0	100.0	84.0	93.1
CD (P=0.05)		NS	NS	NS	NS	NS	NS

NS = Non significant

Table 4.1.2.4a. Total duration of life cycle of *B. tabaci* on American cotton (Var. LH-1556) in different insecticidal treatments.

Insecticide	Dose (g a.i./ha)	Total duration of life cycle (days)* after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	21.0	20.8	21.2	22.5	20.9	21.3
	375	20.3	21.9	21.0	22.3	21.0	21.3
	500	21.8	21.7	21.9	21.9	20.7	21.6
Carbaryl	625	20.0	19.7	21.7	22.1	20.7	20.8
	938	21.3	21.0	20.4	21.6	20.1	20.9
	1250	20.5	21.1	21.5	22.7	20.8	21.3
Acephate	750	19.8	20.5	21.1	21.7	20.5	20.7
	1125	20.4	19.6	20.7	21.3	21.1	20.6
	1500	20.2	20.3	21.4	22.2	21.7	21.2
Endosulfan	438	21.0	21.5	20.8	21.2	21.3	21.2
	656	20.0	22.3	21.3	21.6	21.8	21.4
	875	21.1	21.8	21.4	23.5	22.8	22.1
Fenvalerate	25	20.7	19.9	20.6	20.4	19.5	20.2
	38	19.5	19.7	20.0	19.7	19.3	19.6
	50	20.8	18.7	19.2	20.6	20.7	20.0
Untreated Control	Water spray	20.5	19.3	20.1	20.7	19.4	20.0
CD (P=0.05)		NS	2.0	1.4	1.5	1.8	0.8

NS = Non significant

* Duration of all immature stages

Maximum duration of life cycle was recorded in endosulfan at 656 g/ha (22.3 days) and it was at par with endosulfan at 875 and 438 g/ha (21.8 and 21.5 days, respectively), all doses of quinalphos, carbaryl (938 and 1250 g/ha) and acephate (750 g/ha). After 3rd spray minimum duration was recorded in fenvalerate at 50 g/ha (19.2 days) and it was at par with carbaryl at 938 g/ha, fenvalerate at 25 and 38 g/ha and untreated control. Maximum duration was observed in highest dose of quinalphos (21.9 days) and it was significantly higher than untreated control (20.1 days). Almost same trend was observed in 4th and 5th sprays.

The pooled analysis of the data of all the sprays revealed that among all insecticidal treatments, fenvalerate and lowest doses of acephate recorded minimum duration of life cycle which was at par with untreated control (Fig. 4.1.2.4a). However, all the doses of endosulfan, quinalphos and higher doses of carbaryl (938 and 1250 g/ha) and acephate (1500 g/ha) caused significant prolongation in the life cycle of *B. tabaci* which inturn indicated the absence of hormoligosis by these insecticides also. Shortest life cycle of *B. tabaci* was also observed on the plants treated with deltamethrin (Tamilselvan *et al*, 1990; Saini, 1997), cypermethrin, fenvalerate and alphamethrin (Saini, 1997) and acephate, cypermethrin and monocrotophos (Kaler, 1999) as compared to untreated control. Similarly, Neemazal, Rakshakgold and ICIPE neem prolonged the life cycle of *B. tabaci* on cotton plants as compared with untreated control (Singh, 2000).

(b) Total survival of *B. tabaci*

The data obtained on the total survival of *B. tabaci* have been presented in Table 4.1.2.4b. Different insecticidal treatments have shown significant differences on the total survival of whitefly. After 1st spray, total survival in all the treatments varied from 23.3 to 80.0 per cent being maximum in untreated control and minimum in endosulfan 656 g/ha, but

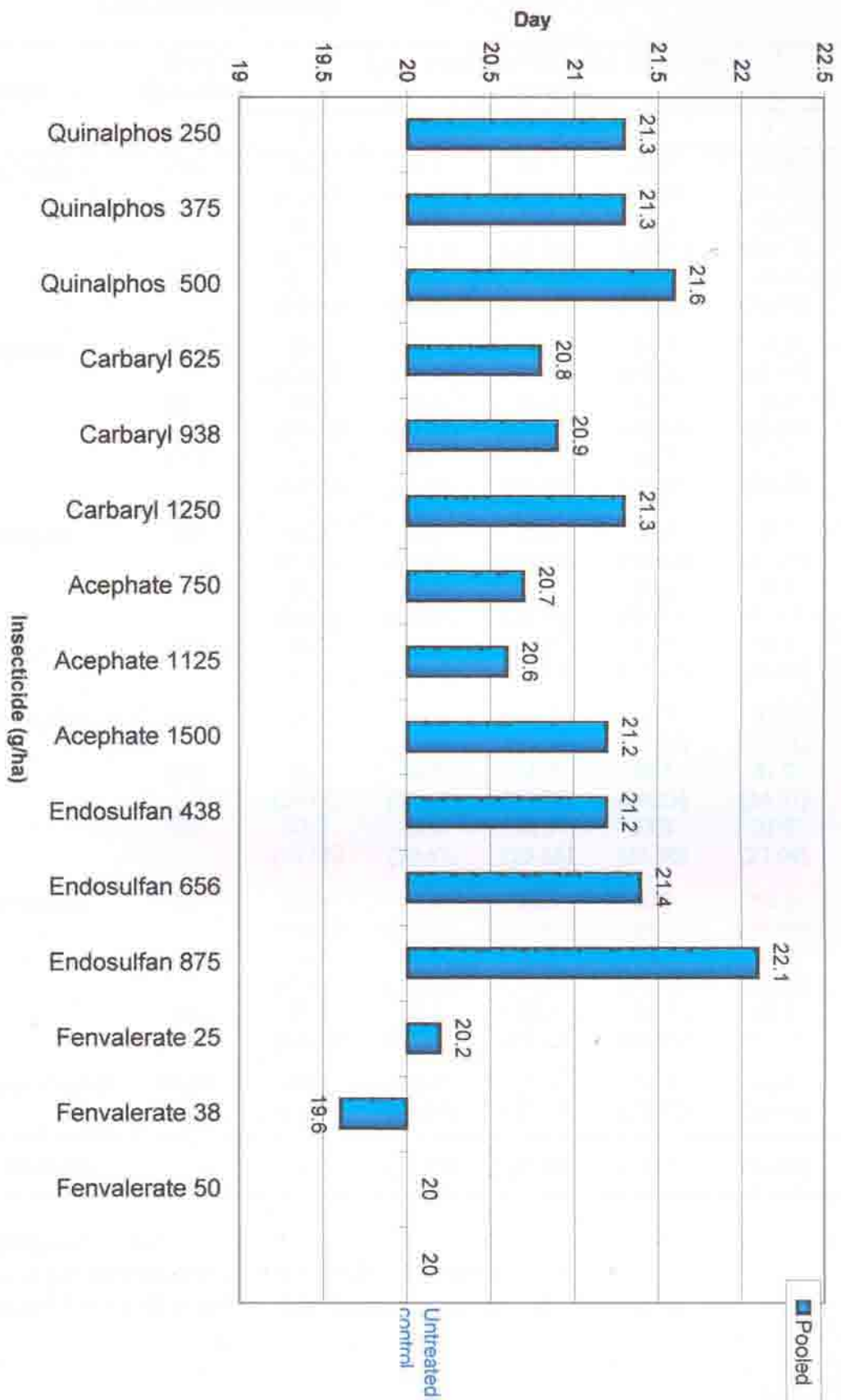


Fig 4.1.2.4(a). Increase and decrease of total duration of life cycle of *B. tabaci* over untreated control on American cotton (Var. LH 1556) in different insecticidal treatments

Table 4.1.2.4b. Total survival of *B. tabaci* on American cotton (Var. LH 1556) in different insecticidal treatments.

Insecticide	Dose (g a.i./ha)	Total survival (%)* after different Sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	46.7	53.3	26.7	61.7	50.0	47.7
		(43.06)	(46.89)	(30.66)	(51.67)	(45.10)	(43.49)
	375	38.3	43.3	21.7	58.3	41.7	40.7
		(37.98)	(41.11)	(27.27)	(49.81)	(40.18)	(39.27)
	500	41.7	40.0	18.3	55.0	35.0	38.0
		(39.98)	(39.20)	(25.30)	(48.06)	(36.12)	(37.73)
Carbaryl	625	45.0	51.7	23.3	61.7	43.3	45.0
		(42.01)	(45.94)	(28.77)	(51.76)	(41.14)	(41.92)
	938	38.0	43.3	18.3	51.7	35.0	37.3
		(38.07)	(40.94)	(24.80)	(45.94)	(36.06)	(37.16)
	1250	30.0	28.3	13.3	46.7	31.7	30.0
		(32.99)	(31.63)	(21.33)	(43.04)	(34.22)	(32.64)
Acephate	750	46.7	50.0	25.0	60.0	43.3	45.0
		(43.06)	(44.97)	(29.91)	(50.83)	(41.00)	(41.96)
	1125	58.3	50.0	21.7	60.0	43.3	46.7
		(50.06)	(44.98)	(27.70)	(50.94)	(41.15)	(42.96)
	1500	35.0	48.3	20.0	60.0	41.7	41.0
		(35.96)	(44.08)	(26.44)	(51.12)	(40.07)	(39.53)
Endosulfan	438	28.3	31.7	16.7	51.7	25.0	30.7
		(31.13)	(33.84)	(24.04)	(45.94)	(29.91)	(32.97)
	656	23.3	36.7	16.7	38.3	31.7	29.3
		(28.07)	(37.13)	(23.73)	(38.23)	(34.01)	(32.23)
	875	43.3	25.0	11.7	33.3	21.7	27.0
		(40.76)	(29.67)	(19.88)	(35.20)	(27.08)	(30.52)
Fenvalerate	25	65.0	65.0	28.3	80.0	50.0	57.7
		(53.82)	(53.85)	(32.08)	(64.72)	(44.98)	(49.89)
	38	56.7	53.3	36.7	73.3	51.7	54.3
		(49.48)	(46.82)	(37.21)	(59.98)	(46.53)	(48.00)
	50	53.3	63.3	28.3	66.7	63.3	55.7
		(46.99)	(52.89)	(32.13)	(55.05)	(52.72)	(47.96)
Untreated Control	Water spray	80.0	56.7	28.3	71.7	60.0	59.3
		(63.52)	(48.91)	(32.13)	(58.72)	(50.94)	(50.84)
CD (P=0.05)		NS	(12.89)	(7.40)	(13.39)	(13.91)	(5.97)

NS = Non significant

Figures in parentheses are arc sine transformed values.

* Total survival of all immature stages

there were no significant differences among different treatments. After 2nd spray, maximum survival was observed in fenvalerate at 25 g/ha (65.0%) and it was at par with all other treatments except quinalphos at 500 g/ha, carbaryl at 938 and 1250 g/ha and all doses of endosulfan. Minimum survival was recorded in endosulfan at 875 g/ha (25.0%) and it was at par with quinalphos at 375 and 500 g/ha, carbaryl at 938 and 1250 g/ha and endosulfan at 438 and 656 g/ha. After 3rd spray maximum survival was registered in fenvalerate at 38 g/ha (36.8%) and it was at par with quinalphos at 250 g, acephate at 750 g, fenvalerate at 25 and 50 g/ha and untreated control. Minimum survival was observed on endosulfan at 875 g/ha (11.7%) and it was at par with quinalphos at 375 and 500 g/ha, carbaryl at 938 and 1250 g/ha, acephate at 1500 g and endosulfan at 438 and 656 g/ha. Almost same trend was observed after 4th and 5th sprays.

The analysis of the pooled data revealed that total survival of *B. tabaci* in all the doses of fenvalerate was at par with untreated control. All other treatments caused reduction in the total survival of whitefly (Fig. 4.1.2.4b). The present studies revealed that total survival of *B. tabaci* in fenvalerate was as normal as in untreated control. On the other hand endosulfan caused significant reduction in total survival of *B. tabaci* which was followed by highest doses of carbaryl and quinalphos. Endosulfan caused reduction in survival of all immature stages, which ultimately adversely affected the total life cycle. Decrease in total survival observed in 3rd spray as compared to other sprays is attributed to the sudden rainfall (Appendix I). Among all immature stages, nymphal stage was the most susceptible stage (Table 4.1.2.4). According to Horowitz *et al* (1984), mortality of *B. tabaci* is highest during the crawlers and young nymphal stage, with an average of 17 to 40 per cent of eggs reached the adult stage. The increase in total survival of *B. tabaci* on cotton plants treated with

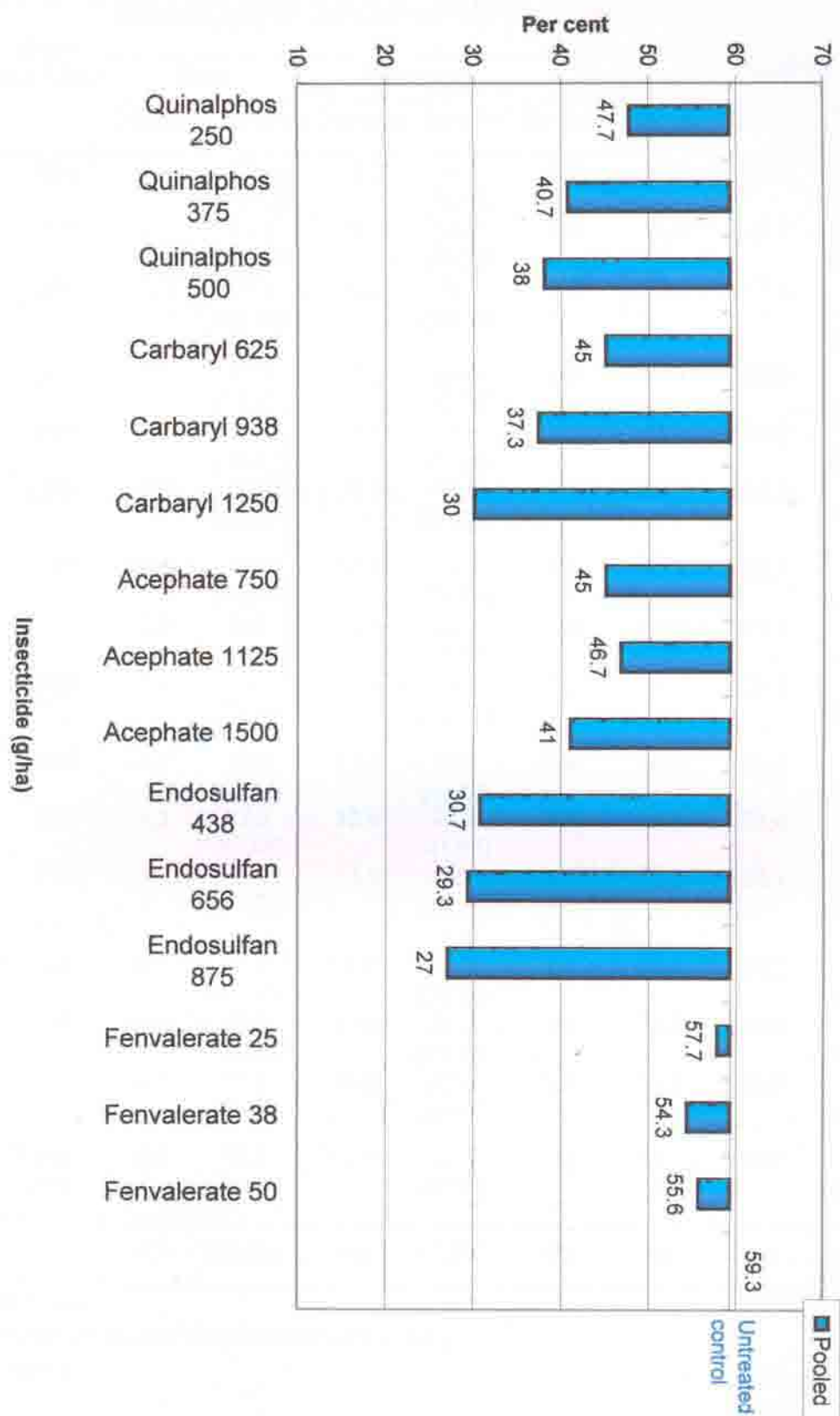


Fig 4.1.2.4(b). Decrease of total survival of *B. tabaci* over untreated control on American cotton (Var. LH 1556) in different insecticidal treatments

Table 4.1.2.4. Duration and survival of different immature stages of *B. tabaci* on American cotton (Var. LH 1556) in different insecticidal treatments.

Insecticide	Dose (g a.i./ha)	Duration (days) *and survival (%)* of different stages							
		Eggs		Nymphs		Pupae		Total life cycle	
		Duration	Survival	Duration	Survival	Duration	Survival	Duration	Survival
Quinalphos	250	7.1	75.3 (63.73)	11.7	66.7 (56.08)	2.5	93.7	21.3	47.7 (43.49)
	375	7.1	82.7 (69.34)	11.9	56.7 (49.23)	2.3	86.2	21.3	40.7 (39.27)
	500	7.1	76.7 (65.16)	12.1	59.1 (50.48)	2.4	83.7	21.6	38.0 (37.73)
Carbaryl	625	7.1	87.7 (78.61)	11.5	54.6 (47.94)	2.3	93.6	20.8	45.0 (41.92)
	938	6.7	70.3 (58.47)	12.0	63.4 (53.56)	2.2	88.0	20.9	37.3 (37.16)
	1250	7.2	71.7 (60.07)	11.9	47.8 (43.61)	2.2	90.3	21.3	30.0 (32.64)
Acephate	750	6.6	79.0 (66.93)	11.7	71.3 (59.42)	2.5	83.6	20.7	45.0 (41.96)
	1125	6.6	86.0 (73.03)	11.6	63.2 (53.99)	2.4	84.7	20.6	46.7 (42.96)
	1500	7.1	84.0 (72.09)	11.9	56.2 (48.97)	2.2	88.4	21.2	41.0 (39.54)
Endosulfan	438	6.9	74.0 (63.71)	11.9	57.3 (49.82)	2.4	84.2	21.2	30.7 (32.97)
	656	6.5	73.3 (61.48)	12.6	44.9 (41.97)	2.4	84.4	21.4	29.3 (32.23)
	875	6.7	79.0 (67.08)	12.8	46.4 (42.80)	2.6	78.7	22.1	27.0 (30.52)
Fenvalerate	25	6.9	91.7 (77.82)	11.13	66.7 (56.29)	2.2	90.1	20.2	57.7 (49.89)
	38	6.7	89.0 (76.61)	10.6	66.2 (56.17)	2.4	90.2	19.6	54.3 (48.00)
	50	6.5	87.3 (73.56)	11.0	67.6 (56.89)	2.5	91.3	20.0	55.0 (47.96)
Untreated Control	Water spray	6.6	88.3 (74.81)	11.1	72.4 (61.19)	2.3	93.1	20.0	59.3 (50.84)
CD (P=0.05)		0.5	(10.82)	0.6	(7.26)	NS	NS	0.8	(5.97)

NS = Non significant

Figures in parentheses are arc sine transformed values.

* Pooled of all sprays

deltamethrin and fenvalerate was at par with untreated control (Saini, 1997). Acephate at 1500 g/ha, monocrotophos at 500 g/ha and cypermethrin at 50 g/ha increased the total survival of *B. tabaci* significantly over untreated control, whereas at triazophos 600 g/ha and chlorpyrifos at 1000 g/ha caused reduction in the total survival (Kaler, 1999).

(c) Growth index of immature stages

The data on the effect of different treatments on growth index of immature stages are presented in Table 4.1.2.4c. The differences in growth index of immature stages after 1st spray were non-significant. However, it varied from 1.2 to 3.9, maximum being in untreated control and minimum in endosulfan at 656 g/ha. After 2nd spray significant reduction in growth index was observed in all dosages of endosulfan and carbaryl at 1250 g/ha in comparison with untreated control. After the 3rd spray significant reduction in growth index was in carbaryl at 1250 g/ha, quinalphos at 500 g/ha and in all dosages of endosulfan. Similar results were observed after 4th and 5th spray. Growth index was more in all dosages of fenvalerate from 1st to 5th spray as compared with all other treatments.

The pooled data showed similar trend of the results (Fig. 4.1.2.4c). These findings are corroborated by results of Saini (1997) who also reported increased growth index in fenvalerate at 50 and 100 g/ha.

4.1.3. Hormoligosis in sex ratio

The results obtained on the effect of different insecticidal treatments on sex ratio (male: female) have been presented in Table 4.1.3. In general, sex ratio was in favour of females. The pooled data showed that sex ratio in all the treatments varied from 1.12 to 2.57 with no significant differences recorded between different treatments.

Table 4.1.2.4c. Immature stages growth index* of *B. tabaci* on cotton (Var. LH 1556) in different insecticidal treatments

Insecticide	Dose (g a.i./ha)	Growth index after different Sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	2.2	2.6	1.2	2.8	2.4	2.2
	375	1.9	2.0	1.0	2.6	2.0	1.9
	500	2.0	1.8	0.8	2.5	1.7	1.8
Carbaryl	625	2.2	2.5	1.1	2.8	2.1	2.2
	938	1.8	2.1	0.9	2.4	1.8	1.8
	1250	1.5	1.4	0.6	2.1	1.5	1.4
Acephate	750	2.4	2.4	1.2	2.8	2.2	2.2
	1125	2.9	2.6	1.1	2.8	2.1	2.3
	1500	1.7	2.4	0.9	2.7	1.9	1.9
Endosulfan	438	1.4	1.5	0.8	2.4	1.2	1.5
	656	1.2	1.7	0.8	1.8	1.5	1.4
	875	2.1	1.1	0.6	1.4	1.0	1.2
Fenvalerate	25	3.1	3.3	1.4	3.9	2.6	2.9
	38	2.9	2.7	1.8	3.8	2.8	2.8
	50	2.6	3.4	1.5	3.2	3.1	2.8
Untreated Control	Water spray	3.9	2.9	1.4	3.5	3.1	3.0
CD (P=0.05)		NS	1.1	0.5	1.0	1.3	0.5

NS = Non significant

* Immature stages growth index = $\frac{\text{Per cent survival of immature stages}}{\text{Duration of immature stages}}$

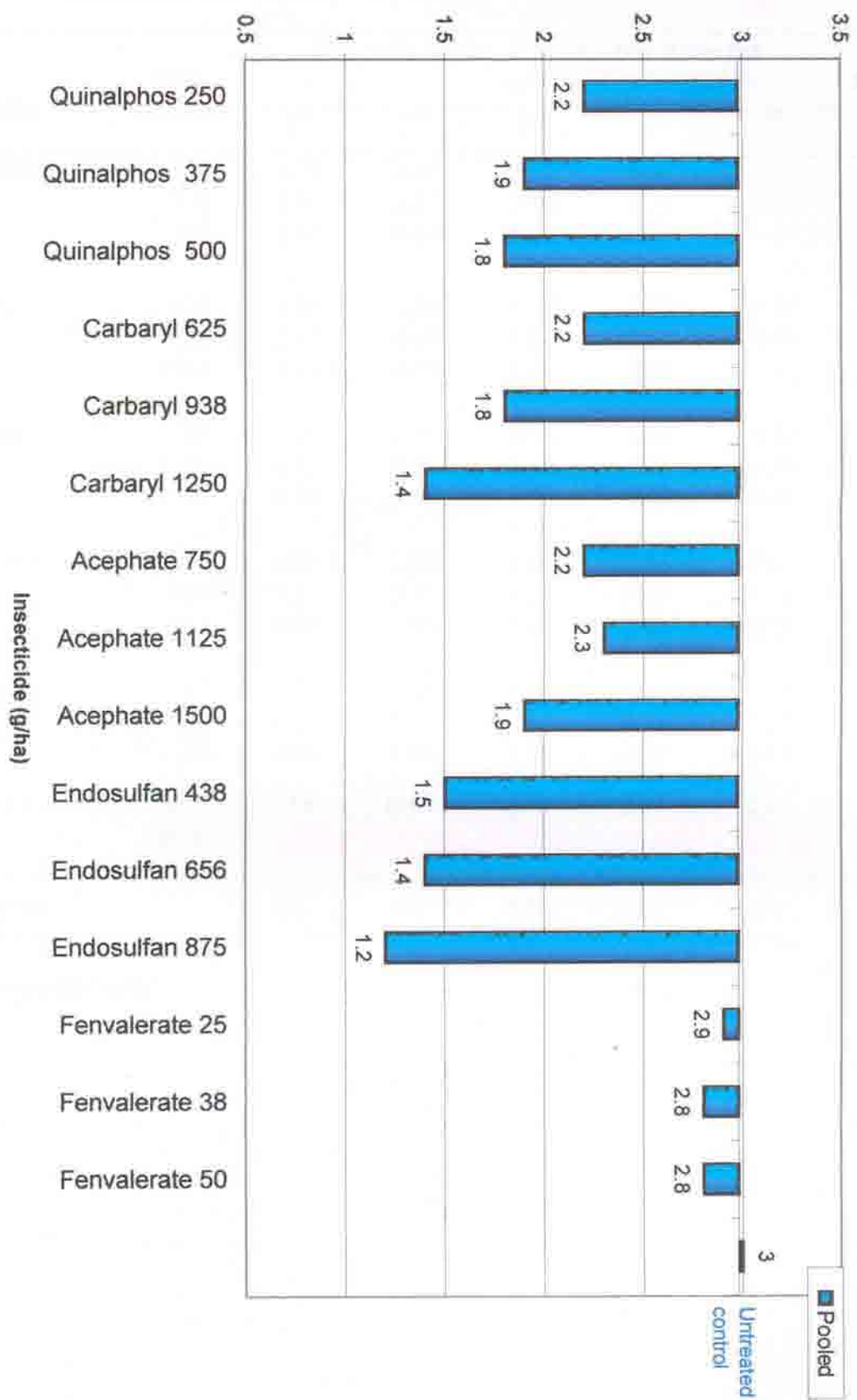


Fig 4.1.2.4(c). Decrease of immature stages growth index of *B. tabaci* over untreated control on cotton (Var. LH 1556) in different insecticidal treatments.

Table 4.1.3. Sex ratio of *B. tabaci* on American cotton (Var. LH 1556) in different insecticidal treatments.

Insecticide	Dose (g a.i./ha)	Sex ratio (male : female) after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	1.71	1.36	1.00	0.96	1.07	1.22
	375	2.07	1.57	3.00	1.72	1.11	1.90
	500	1.35	0.64	1.83	2.39	1.35	1.51
Carbaryl	625	1.38	2.80	4.33	2.20	1.14	2.37
	938	2.11	0.60	1.50	2.31	4.09	2.12
	1250	3.11	1.53	1.11	2.33	1.37	1.89
Acephate	750	1.60	0.56	0.93	4.69	0.53	1.66
	1125	0.87	0.76	1.00	1.75	1.99	1.27
	1500	0.92	2.57	4.00	2.44	0.88	2.16
Endosulfan	438	1.81	1.08	2.60	1.53	2.67	1.94
	656	1.53	2.17	1.25	0.97	1.28	1.44
	875	1.22	1.00	2.00	0.88	4.08	1.84
Fenvalerate	25	1.00	1.44	1.50	2.50	0.98	1.48
	38	4.13	2.28	2.38	1.78	1.33	2.38
	50	0.63	1.56	1.00	1.29	1.11	1.12
Untreated Control	Water spray	1.08	0.48	5.33	2.75	2.83	2.57
CD (P=0.05)		NS	NS	NS	NS	NS	NS

NS = Non significant

4.1.4. Hormoligosis in longevity

4.1.4.1 Hormoligosis in male longevity

Different insecticidal treatments have shown significant differences on male longevity.

a) Crop season of 2001

The data presented in table 4.1.4.1a revealed that single spray of any insecticide at any dose did not significantly influence the male longevity. In general male longevity was significantly reduced in all doses of endosulfan, higher doses of carbaryl (1250 g/ha) and quinalphos (500 g/ha) after 2nd to 5th spray excepting quinalphos at 500 g/ha after 2nd spray. However, the male longevity was at par with untreated control in all the doses of fenvalerate which inturn was significantly more as compared with the remaining treatments except acephate.

The results of pooled analysis of the data further indicated that male longevity was significantly reduced in all the doses of endosulfan which inturn was at par with carbaryl (938 and 1250 g/ha) and quinalphos (375 and 500 g/ha). Only lower dose of fenvalerate (25 g/ha) did not influence the male longevity adversely as compared with untreated control.

b) Crop season of 2002

The data presented in Table 4.1.4.1b showed same trend of the results obtained during 2001 crop season in which fenvalerate and acephate at the lower dosage did not influence the male longevity adversely being at par with untreated control. However, almost all the doses of endosulfan, higher doses of carbaryl (1250 g/ha) and quinalphos (500 g/ha) caused significant reduction in male longevity.

Table 4.1.4.1a. Longevity of male of *B. tabaci* on American cotton leaves (var. LH-1556) in different insecticidal treatments (Nov-Dec 2001)

Insecticide	Dose (g a.i./ha)	Longevity (days) after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	12.9	12.3	12.6	13.4	8.9	12.0
	375	11.4	9.0	10.9	11.2	7.8	10.1
	500	8.8	9.7	8.4	9.1	7.3	8.7
Carbaryl	625	11.9	12.1	12.0	13.1	9.9	11.8
	938	10.6	11.9	9.5	11.9	7.7	10.3
	1250	9.5	7.8	7.6	7.8	6.9	7.9
Acephate	750	12.4	12.2	12.4	16.3	15.7	13.8
	1125	13.0	13.0	11.9	15.4	11.4	12.9
	1500	12.2	11.4	11.0	11.5	8.1	10.8
Endosulfan	438	9.7	8.9	9.2	9.1	8.0	9.0
	656	11.8	7.4	7.9	8.9	6.1	8.4
	875	8.0	6.9	5.3	7.0	5.3	6.5
Fenvalerate	25	13.5	14.1	14.7	16.9	17.6	15.4
	38	12.6	12.2	13.1	15.8	12.9	13.3
	50	12.1	11.8	11.7	11.7	8.2	11.1
Untreated control	Water spray	13.9	13.8	15.2	16.5	16.9	15.3
CD (P = 0.5)		NS	2.6	4.0	3.0	2.1	1.4

NS = Non significant

Table 4.1.4.1b. Longevity of male of *B. tabaci* on American cotton leaves (var. LH-1556) in different insecticidal treatments (June 2002)

Insecticide	Dose (g a.i./ha)	Longevity (days) after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	4.8	6.4	4.6	3.8	5.3	5.0
	375	3.5	3.8	3.4	3.4	3.5	3.5
	500	2.5	3.0	3.0	3.1	3.1	2.9
Carbaryl	625	4.3	5.0	4.6	3.7	4.4	4.4
	938	3.5	2.9	3.4	3.5	4.1	3.5
	1250	2.7	2.8	2.8	1.8	2.6	2.5
Acephate	750	6.9	6.2	5.1	4.0	6.1	5.6
	1125	4.6	4.5	4.2	4.1	5.5	4.6
	1500	4.2	3.1	3.5	3.5	4.1	3.7
Endosulfan	438	3.4	3.1	2.9	3.1	3.4	3.2
	656	3.1	2.9	2.6	2.9	2.1	2.7
	875	2.2	2.0	2.3	1.7	2.1	2.1
Fenvalerate	25	6.4	6.6	5.6	4.4	5.9	5.8
	38	5.4	4.6	4.7	4.0	5.7	4.9
	50	5.7	3.5	5.6	3.6	4.1	4.5
Untreated control	Water spray	7.1	7.5	5.6	4.4	7.4	6.4
CD (P = 0.5)		NS	2.0	0.9	1.3	1.9	1.0

NS = Non significant

The pooled analysis also revealed that lower doses of both fenvalerate (25 g/ha) and acephate (250 g/ha) did not reduce the male longevity significantly as these were at par with untreated control.

4.1.4.2. Hormoligosis in female longevity

The data presented in Table 4.1.4.2a and 4.1.4.2b have shown significant effect of different insecticidal treatments on female longevity.

a) Crop season of 2001

Data in Table 4.1.4.2a showed that after 1st spray maximum female longevity (20.1 days) was recorded in untreated plants followed by fenvalerate (17.5 and 17.4 days at 38 and 25 g/ha, respectively) and acephate (17.3 and 17.0 days at 750 and 1125 g/ha, respectively). However, untreated control remained superior over all other treatments which in turn was at par with fenvalerate (38 g/ha). Minimum female longevity was recorded on plants treated with endosulfan doses being 12.3, 14.3 and 14.4 days at 875, 438 and 656 g/ha, respectively, and highest dose of quinalphos and carbaryl (13.1 and 14.5, respectively).

After 2nd spray, untreated control also recorded maximum longevity (19.3 days) followed by all the doses of fenvalerate and acephate. Minimum longevity was recorded on plants treated with all the doses of endosulfan, quinalphos (375 and 500 g/ha) and highest dose of carbaryl (1250 g/ha). Almost similar trend was observed after 3rd, 4th and 5th sprays with slight variations.

The pooled data of all these sprays indicated that significantly more longevity was observed in untreated control and the lower dose of fenvalerate (25 g/ha) and they were at par with each other, whereas longevity was significantly reduced in all other treatments being minimum in endosulfan.

**Table 4.1.4.2a. Longevity of female of *B. tabaci* on American cotton leaves
(var. LH-1556) in different insecticidal treatments (Nov – Dec 2001)**

Insecticide	Dose (g a.i./ha)	Longevity (days) after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	16.7	16.2	15.2	16.3	12.7	15.4
	375	15.9	12.8	14.1	14.8	11.2	13.8
	500	13.1	14.2	9.6	11.9	9.8	11.7
Carbaryl	625	16.8	16.8	16.1	15.9	13.4	15.8
	938	15.5	16.0	12.7	14.1	11.1	13.9
	1250	14.5	12.3	11.4	11.4	9.0	11.7
Acephate	750	17.3	17.3	17.2	19.8	18.5	18.0
	1125	17.0	16.6	16.5	18.2	14.2	16.5
	1500	16.5	16.4	13.9	14.8	11.7	14.7
Endosulfan	438	14.3	13.2	12.8	12.7	9.9	12.6
	656	14.4	12.4	9.9	11.5	8.2	11.3
	875	12.3	11.3	7.8	9.9	6.9	9.6
Fenvalerate	25	17.4	18.7	20.8	20.8	19.8	19.5
	38	17.5	16.9	19.8	19.5	15.6	17.9
	50	15.1	16.3	15.2	15.3	10.9	14.6
Untreated control	Water spray	20.1	19.3	21.6	20.7	20.3	20.4
CD (P = 0.5)		2.6	3.8	3.9	3.1	2.8	1.4

b) Crop season of 2002

The data in Table 4.1.4.2b showed that, all the insecticidal treatments have significant affect on female longevity in all the sprays except after 2nd spray. The general trend revealed that female longevity was reduced numerically in all the insecticidal treatments.

4.1.4.3. Hormoligosis in longevity of both sexes

a) Crop season of 2001

The data in Table 4.1.4.3a revealed that different insecticidal treatments have significant effect on both the sexes.

No significant differences appeared between different treatments after 1st spray. The data for the remaining sprays revealed that lower doses of fenvalerate (25 g/ha) and acephate (750 g/ha) were consistent in their trend and had no adverse effect on adult longevity as these were at par with untreated control. Endosulfan doses reduced adult longevity and its higher doses exhibited its consistency in its trend in all the sprays. The overall analysis of the data also revealed similar trend.

b) Crop season of 2002

The overall adult longevity varied from 3 to 7.2 days in different treatments after different sprays. Numerically all the insecticidal treatments reduced the adult longevity as compared to untreated control (Table 4.1.4.3b). However, the reduction was significant in all the doses of endosulfan after all the sprays. Similar trend was observed in doses of carbaryl (938 and 1250 g/ha) and quinalphos doses (375 and 500 g/ha). Whereas lower doses of fenvalerate (25 g/ha) and acephate (750 g/ha) exhibited the consistent pattern after every spray as observed in untreated control. Besides lower dose of each insecticide registered slightly higher longevity as compared with the higher doses in almost all the insecticides.

Table 4.1.4.2b. Longevity of female of *B. tabaci* on American cotton leaves (var. LH-1556) in different insecticidal treatments (June 2002)

Insecticide	Dose (g a.i./ha)	Longevity (days) after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	6.5	6.4	6.4	5.6	6.9	6.4
	375	4.6	4.5	5.5	4.5	5.1	4.8
	500	3.5	3.4	4.2	4.2	3.7	3.8
Carbaryl	625	5.5	6.3	4.9	4.6	6.1	5.5
	938	4.8	4.5	4.3	4.6	5.8	4.8
	1250	3.9	4.3	3.9	4.2	2.6	3.8
Acephate	750	8.1	8.0	7.1	5.8	7.6	7.3
	1125	6.0	6.5	6.1	5.8	7.1	6.3
	1500	3.7	5.8	5.7	5.0	5.9	5.2
Endosulfan	438	4.4	4.4	4.1	4.5	4.7	4.4
	656	3.5	4.2	3.6	3.1	3.2	3.6
	875	2.8	4.1	3.4	2.9	2.4	3.1
Fenvalerate	25	7.8	8.5	7.5	6.0	8.1	7.6
	38	7.0	8.1	6.8	5.8	7.3	7.0
	50	6.3	5.1	4.8	5.2	5.8	5.5
Untreated control	Water spray	9.7	9.4	7.2	8.5	10.1	9.0
CD (P = 0.5)		4.0	NS	2.7	2.4	4.1	1.6

NS = Non significant

Table 4.1.4.3a. Longevity of male and female of *B. tabaci* on American cotton leaves (var. LH-1556) in different insecticidal treatments. (Nov – Dec 2001)

Insecticide	Dose (g a.i./ha)	Longevity (days) after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	16.8	16.0	14.9	14.1	11.9	14.7
	375	15.5	12.9	14.2	14.1	10.6	13.5
	500	12.9	13.5	9.3	12.0	9.1	11.4
Carbaryl	625	15.6	15.9	15.8	16.2	12.8	15.3
	938	14.2	15.8	13.6	14.6	10.7	13.8
	1250	13.5	11.3	10.5	10.7	8.2	10.8
Acephate	750	16.9	15.9	16.5	20.1	18.3	17.5
	1125	16.1	16.9	16.1	18.6	14.0	16.3
	1500	16.0	15.9	14.2	14.6	11.2	14.4
Endosulfan	438	13.5	12.7	12.6	12.0	10.1	12.2
	656	15.5	11.3	9.3	11.8	7.7	11.1
	875	11.8	10.2	5.0	9.4	6.0	8.5
Fenvalerate	25	17.3	18.0	20.3	21.6	21.6	19.8
	38	16.3	16.4	16.7	18.7	15.0	16.6
	50	16.0	15.5	14.9	15.6	11.1	14.6
Untreated control	Water spray	18.1	18.7	18.6	20.2	22.0	19.5
CD (P = 0.5)		NS	4.0	3.4	5.1	5.6	2.1

NS = Non significant

Table 4.1.4.3b. Longevity of male and female of *B. tabaci* on American cotton leaves (var. LH-1556) in different insecticidal treatments (June 2002)

Insecticide	Dose (g a.i./ha)	Longevity (days) after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	5.4	5.1	5.5	4.9	5.6	5.3
	375	3.3	4.0	4.2	3.8	3.9	3.9
	500	4.0	3.0	3.8	3.8	3.6	3.6
Carbaryl	625	4.6	5.2	5.7	4.7	4.3	4.9
	938	4.2	4.3	4.4	3.8	3.6	4.1
	1250	3.0	3.0	3.4	3.4	3.5	3.3
Acephate	750	6.2	5.8	6.2	6.4	5.7	6.1
	1125	4.3	5.4	5.9	4.9	5.3	5.2
	1500	5.6	4.8	5.2	4.3	4.7	4.9
Endosulfan	438	3.9	4.0	4.2	3.9	4.2	4.1
	656	3.4	3.3	4.1	3.4	3.3	3.5
	875	3.3	2.8	3.8	3.2	3.2	3.3
Fenvalerate	25	6.5	5.9	6.2	5.3	6.2	6.0
	38	6.2	5.5	5.8	6.1	5.9	5.9
	50	4.2	4.3	4.7	4.0	4.2	4.3
Untreated control	Water spray	6.9	5.7	7.2	6.3	6.6	6.5
CD (P = 0.5)		2.5	1.9	2.2	1.9	2.2	0.9

The pooled analysis exhibited non-significant differences in adult longevity in fenvalerate (25 and 38 g/ha), acephate (750 g/ha) and untreated control. Also the mean of pooled data of both crop seasons showed similar trend of results (Fig. 4.1.4.3). Earlier studies on biology of whitefly indicated longer longevity for female than male (Aneja, 2000; Azab *et al*, 1971; Butler *et al*, 1983; Butter and Vir, 1991 and Deotale *et al*, 1992) under unsprayed conditions.

4.2 HORMOLIGOSIS OF INSECTICIDAL SPRAYS IN BEHAVIOUR OF WHITEFLY:

4.2.1. Hormoligosis in Attractiveness of Adults:

a) August 2001 experiment

After 1st spray (Table 4.2.1.1a) no significant differences were recorded between different treatments except after 7th day from releasing adult whitefly in which the significant differences appeared between different treatments with each other, but none of them was significantly different from untreated control. Attraction of whitefly adults was more in fenvalerate treatments as compared with quinalphos treatments.

The pooled analysis of the data after 1st spray revealed that acephate and fenvalerate treatments numerically were more attractive for *B. tabaci*, but there were non-significant differences as compared with untreated control. After 2nd spray (Table 4.2.1.2a), different treatments showed significant differences between themselves started from 3rd day of releasing adult whitefly, with maximum number being attracted to fenvalerate doses followed by acephate, whereas minimum number was recorded on quinalphos. Although, all the treatments showed significant differences among themselves, but none of them was significantly different from untreated control. Same trend of results with minor changes was observed after 4th, 5th, 6th and 7th day after releasing whitefly adults in which fenvalerate

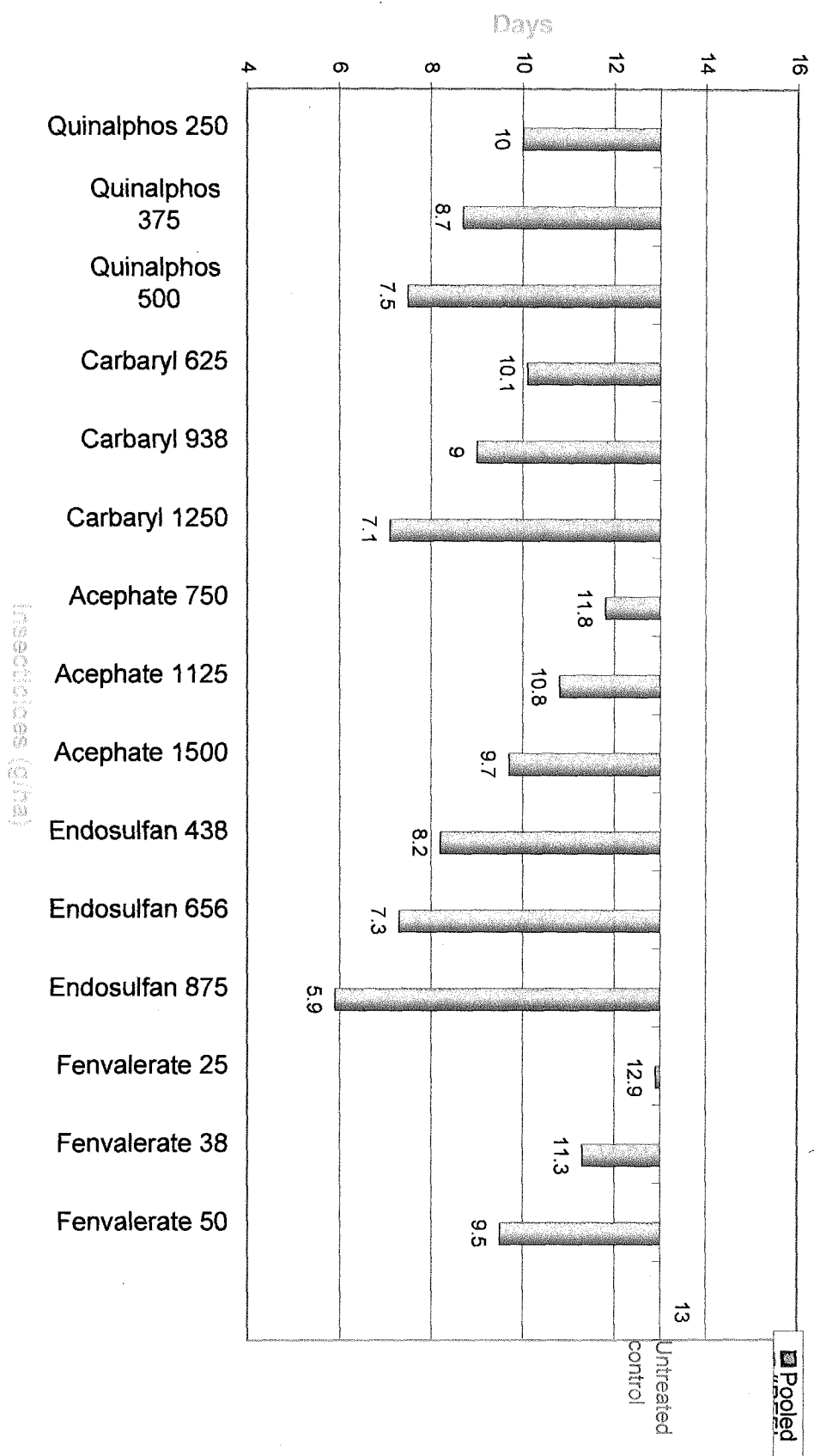


Fig 4.1.4.3 Decrease of male and female longevity of *B. tabaci* over untreated control on American cotton leaves (var. LH-1556) in different insecticidal treatments. (Pooled data of the two crop seasons)

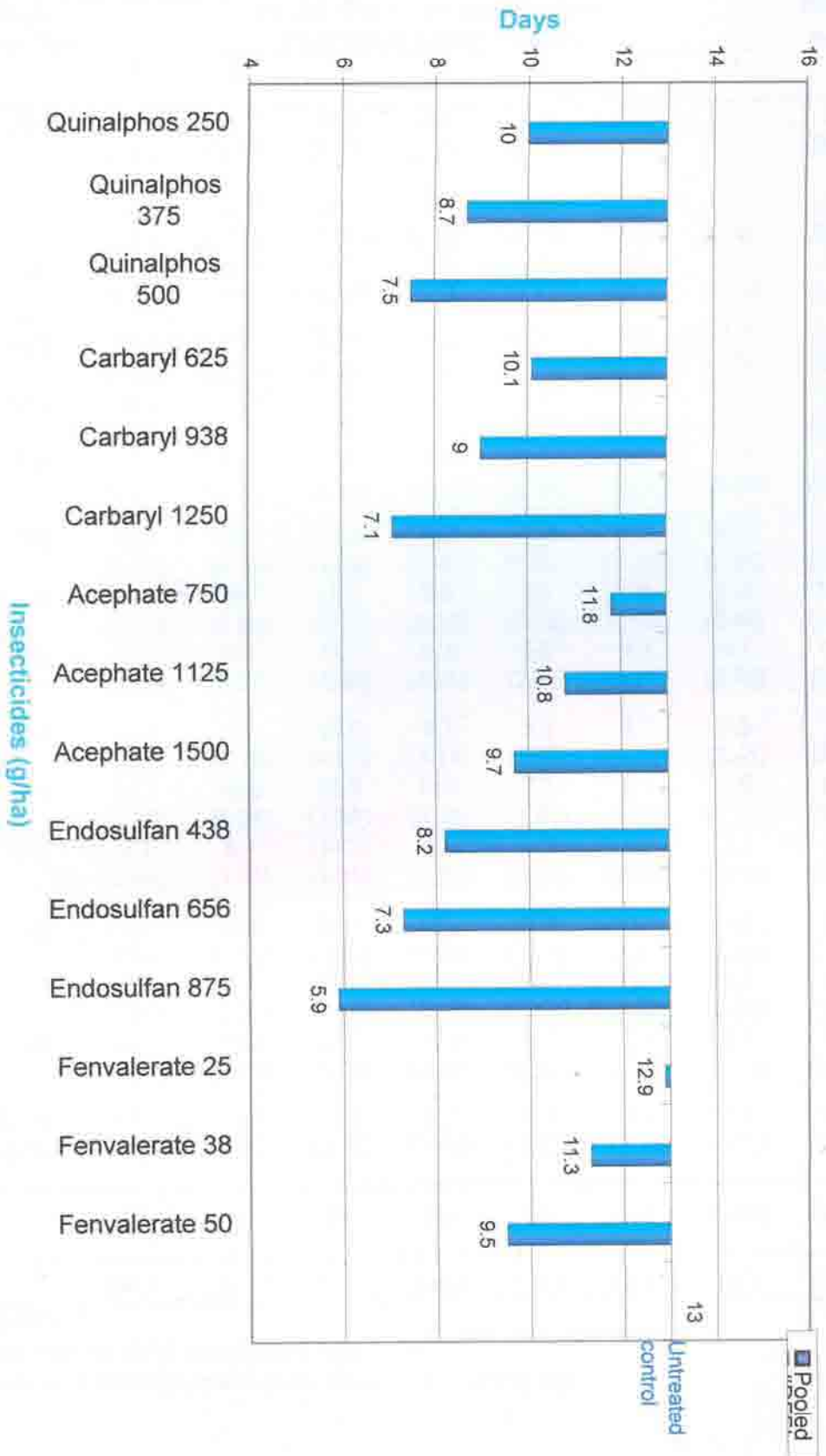


Fig 4.1.4.3 Decrease of male and female longevity of *B. tabaci* over untreated control on American cotton leaves (var. LH-1556) in different insecticidal treatments. (Pooled data of the two crop seasons)

Table 4.2.1.1a. Attraction of adult whitefly to different insecticidal treatments under multiple choice conditions after one spray (August 2001)

Insecticide	Dose (g a.i./ha)	Period after insect release (days) (Number of adults/ 2 leaves)							Pooled mean
		1	2	3	4	5	6	7	
Quinalphos	250	13.3 (3.54)	12.7 (3.61)	13.3 (3.77)	5.3 (2.36)	5.3 (2.33)	7.3 (2.88)	3.3 (2.03)	8.7 (2.93)
	375	11.3 (3.50)	4.7 (2.34)	10.7 (3.21)	6.0 (2.62)	6.0 (2.37)	6.0 (2.36)	2.7 (1.90)	6.8 (2.62)
	500	8.0 (2.92)	14.7 (3.8)	14.0 (3.85)	8.0 (2.94)	5.3 (2.49)	8.0 (2.95)	4.0 (2.20)	8.9 (3.02)
Carbaryl	625	20.7 (4.62)	3.3 (1.91)	12.7 (3.55)	8.7 (3.03)	4.7 (2.32)	8.0 (2.98)	2.7 (1.90)	8.7 (2.90)
	938	10.0 (3.24)	18.7 (4.17)	15.3 (4.02)	10.0 (3.19)	6.0 (2.60)	7.3 (2.88)	4.7 (2.32)	10.3 (3.21)
	1250	10.7 (3.10)	10.0 (3.15)	12.0 (3.43)	7.3 (2.88)	4.7 (2.32)	6.7 (2.73)	4.0 (2.20)	7.9 (2.83)
Acephate	750	11.3 (3.28)	16.7 (4.10)	17.3 (4.14)	11.3 (3.44)	7.3 (2.53)	9.3 (3.18)	6.0 (2.62)	11.3 (3.33)
	1125	14.0 (3.63)	14.7 (3.86)	16.7 (4.13)	9.3 (3.18)	9.3 (3.08)	8.0 (2.96)	5.3 (2.49)	11.1 (3.33)
	1500	22.7 (4.81)	28.0 (5.34)	18.7 (4.06)	10.0 (3.31)	6.0 (2.44)	9.3 (3.21)	6.7 (2.76)	14.5 (3.71)
Endosulfan	438	13.3 (3.77)	8.7 (3.10)	15.3 (4.02)	9.3 (3.14)	5.3 (2.49)	8.7 (3.08)	5.3 (2.45)	9.4 (3.15)
	656	16.7 (4.18)	10.0 (3.28)	16.0 (4.05)	10.0 (3.19)	7.3 (2.87)	8.7 (3.10)	4.0 (2.20)	10.4 (3.27)
	875	7.3 (2.64)	8.7 (3.06)	14.7 (3.96)	8.0 (2.73)	4.0 (2.20)	8.0 (2.99)	3.3 (2.03)	7.7 (2.80)
Fenvalerate	25	7.3 (2.83)	12.0 (3.57)	19.3 (4.49)	11.3 (3.50)	9.3 (3.08)	11.3 (3.47)	8.0 (2.94)	11.2 (3.41)
	38	3.3 (2.07)	6.3 (2.61)	20.0 (4.57)	12.7 (3.68)	13.3 (3.63)	13.3 (3.78)	8.7 (3.08)	11.1 (3.35)
	50	13.3 (3.71)	18.0 (4.19)	21.3 (4.69)	12.0 (3.60)	11.3 (3.22)	12.0 (3.60)	8.7 (3.10)	13.8 (3.73)
Untreated control	Water spray	17.3 (4.19)	15.3 (3.97)	15.3 (3.84)	8.7 (3.03)	6.7 (2.53)	7.3 (2.87)	4.7 (2.32)	10.8 (3.25)
CD (P=0.05)		NS	NS	NS	NS	NS	NS	(0.80)	(0.56)
Total Number*		200.5	202.5	252.6	147.9	111.8	139.2	82.1	162.6

NS = Non significant

Figures in parentheses are $\sqrt{N+1}$ transformed values.

* Total number of adult whitefly settled on all plants of the same spray.

Table 4.2.1.2a. Attraction of adult whitefly to different insecticidal treatments under multiple choice conditions after two sprays (August 2001)

Insecticide	Dose (g a.i./ha)	Period after insect release (days) (Number of adults/ 2 leaves)							Pooled mean
		1	2	3	4	5	6	7	
Quinalphos	250	11.3	18.7	11.3	5.3	3.3	2.7	4.0	8.2
		(3.40)	(4.30)	(3.46)	(2.50)	(2.03)	(1.90)	(2.20)	(2.85)
	375	12.7	18.7	8.7	4.7	1.3	3.3	2.0	7.3
		(3.56)	(4.42)	(3.80)	(2.34)	(1.48)	(1.96)	(1.73)	(2.66)
	500	8.0	4.7	7.3	7.3	4.0	3.3	2.7	5.3
		(2.86)	(2.34)	(2.86)	(2.85)	(2.20)	(2.03)	(1.82)	(2.43)
Carbaryl	625	22.7	12.7	12.7	7.3	2.0	3.3	3.3	9.1
		(4.80)	(3.68)	(3.65)	(2.88)	(1.65)	(2.03)	(2.03)	(2.97)
	938	11.3	11.3	11.3	5.3	4.0	4.0	5.3	7.5
		(3.45)	(3.32)	(3.49)	(2.50)	(2.20)	(2.20)	(2.45)	(2.81)
	1250	11.3	8.0	11.3	6.0	3.3	4.7	2.7	6.8
		(3.28)	(2.60)	(3.50)	(2.62)	(1.96)	(2.37)	(1.79)	(2.59)
Acephate	750	15.3	21.3	18.7	10.0	6.0	6.7	5.3	11.9
		(3.86)	(4.58)	(4.41)	(3.30)	(2.62)	(2.76)	(2.50)	(3.44)
	1125	15.3	16.0	16.0	9.3	6.7	4.7	4.7	10.4
		(4.01)	(4.09)	(4.03)	(3.20)	(2.73)	(2.34)	(2.34)	(3.25)
	1500	9.3	6.7	18.7	8.7	7.3	4.7	5.3	8.7
		(3.14)	(2.66)	(4.42)	(3.03)	(2.85)	(2.34)	(2.50)	(3.00)
Endosulfan	438	8.0	6.0	15.3	8.7	4.0	4.7	4.0	7.2
		(2.94)	(2.44)	(4.02)	(3.09)	(2.20)	(2.37)	(2.20)	(2.76)
	656	14.0	20.0	12.7	8.0	4.7	4.7	3.3	9.6
		(3.77)	(4.45)	(3.65)	(2.98)	(2.37)	(2.37)	(1.96)	(3.08)
	875	5.3	8.0	14.0	7.3	4.7	4.0	3.3	6.7
		(2.46)	(2.85)	(3.82)	(2.88)	(2.37)	(2.20)	(2.03)	(2.66)
Fenvalerate	25	11.3	6.0	21.3	12.7	11.3	7.3	8.0	11.1
		(3.34)	(2.25)	(4.72)	(3.69)	(3.49)	(2.88)	(2.98)	(3.34)
	38	7.3	8.0	24.0	10.7	12.0	8.0	8.7	11.1
		(2.53)	(2.73)	(4.94)	(3.41)	(3.59)	(2.98)	(3.10)	(3.32)
	50	2.7	7.3	22.0	11.3	11.3	7.3	8.7	10.1
		(1.82)	(2.85)	(4.75)	(3.50)	(3.49)	(2.85)	(3.08)	(3.20)
Untreated control	Water spray	10.0	12.7	14.7	7.3	5.3	5.3	3.3	8.4
		(3.21)	(3.56)	(3.90)	(2.88)	(2.50)	(2.50)	(2.03)	(2.95)
CD (P=0.05)		NS	NS	(1.05)	(0.61)	(0.79)	NS	(0.87)	(0.45)
Total Number*		175.8	186.1	240.0	129.9	91.2	78.7	74.6	139.4

NS = Non significant

Figures in parentheses are $\sqrt{N+1}$ transformed values.

*Total number of adult whitefly settled on all plants of the same spray.

treated plants attracted significantly higher number of whitefly adults as compared with all other treatments.

The pooled analysis of the data of 2nd spray revealed that plants treated with acephate at 750 g/ha were significantly more attractive for *B. tabaci* (11.9 adults/2 leaves) as compared with untreated control (8.4 adults/2 leaves). Numerically more whitefly adults were attracted towards plants treated with all doses of fenvalerate although the differences were non-significant as compared with untreated control. After 3rd spray (Table 4.2.1.3a) the pooled analysis of the data revealed that all fenvalerate doses were significantly superior in their attractiveness (15.4, 12.1 and 9.4 adults/2 leaves) over untreated control (5.1 adults/2 leaves) whereas all other treatments remained at par with untreated control excepting low dose of quinalphos at 250 g/ha (3.2 adults/2 leaves) which was significantly less than untreated control.

The pooled analysis of the data after 4th spray (Table 4.2.1.4a) revealed that plants treated with fenvalerate 50 g/ha was significantly more attractive for whitefly adults (9.3 adults/2 leaves) as compared with untreated control (6.4 adults/2 leaves). Also fenvalerate at 25 and 38 g/ha was numerically more attractive to whitefly adults than untreated control, but statistically differences were non-significant. However, all the plants treated with quinalphos and carbaryl doses received significantly less number of adults of whitefly, whereas all the remaining treatments remained at par with untreated control. After 5th spray (Table 4.2.1.5a) the pooled analysis of the data revealed that plants treated with fenvalerate doses (14.2, 12.2 and 11.6 adults/2 leaves) and acephate at 1500 and 1125 g/ha (6.8 and 6.2 adults/2 leaves, respectively) were significantly more attractive for *B. tabaci* as compared with untreated control (4.2 adults/2 leaves). Remaining treatments were at par with untreated control.

Table 4.2.1.3a. Attraction of adult whitefly to different insecticidal treatments under multiple choice conditions after three sprays (August 2001)

Insecticide	Dose (g a.i./ha)	Period after insect release (days) (Number of adults/ 2 leaves)							Pooled mean
		1	2	3	4	5	6	7	
Quinalphos	250	4.7 (2.32)	0.7 (1.24)	7.3 (2.85)	4.0 (2.23)	1.3 (1.48)	2.7 (1.82)	2.0 (1.65)	3.2 (1.95)
	375	8.0 (2.91)	8.7 (3.10)	8.0 (2.91)	2.7 (1.90)	2.7 (1.80)	3.3 (2.03)	0.7 (1.24)	4.9 (2.27)
	500	4.7 (2.37)	6.7 (2.68)	5.3 (2.45)	4.7 (2.34)	2.7 (1.90)	3.3 (2.06)	2.0 (1.65)	4.2 (2.21)
Carbaryl	625	12.7 (3.59)	4.7 (2.37)	4.7 (2.21)	2.7 (1.82)	2.7 (1.90)	2.7 (1.79)	1.3 (1.48)	4.5 (2.17)
	938	8.0 (2.96)	4.0 (2.09)	4.0 (2.20)	5.3 (2.49)	1.3 (1.48)	4.0 (2.20)	2.0 (1.73)	4.1 (2.17)
	1250	19.3 (4.50)	6.7 (2.52)	7.3 (2.85)	3.3 (2.06)	2.0 (1.73)	3.3 (2.03)	2.7 (1.90)	6.4 (2.52)
Acephate	750	8.7 (3.08)	6.7 (2.53)	9.3 (3.18)	7.3 (2.87)	6.7 (2.73)	6.7 (2.73)	4.0 (2.20)	7.3 (2.80)
	1125	10.0 (3.15)	6.0 (2.62)	10.0 (3.27)	6.0 (2.62)	6.0 (2.57)	5.3 (2.49)	5.3 (2.42)	7.0 (2.74)
	1500	7.3 (2.82)	8.7 (2.94)	11.3 (3.44)	7.3 (2.87)	6.0 (2.62)	6.7 (2.73)	4.7 (2.37)	7.1 (2.78)
Endosulfan	438	11.3 (3.50)	8.7 (3.03)	10.0 (3.27)	4.7 (2.32)	4.0 (2.23)	4.7 (2.3)	3.3 (1.96)	6.7 (2.66)
	656	6.7 (2.76)	6.7 (2.74)	8.7 (3.00)	6.0 (2.62)	4.7 (2.34)	5.3 (2.42)	4.7 (2.34)	6.1 (2.61)
	875	8.7 (3.01)	10.7 (3.20)	6.7 (2.69)	4.0 (2.20)	4.0 (2.20)	4.7 (2.37)	2.7 (1.90)	5.9 (2.51)
Fenvalerate	25	14.7 (3.69)	18.0 (4.35)	30.0 (5.54)	22.0 (4.77)	10.0 (3.30)	7.3 (2.82)	6.0 (2.52)	15.4 (3.86)
	38	5.3 (2.50)	11.3 (3.45)	13.3 (3.70)	10.7 (3.36)	9.3 (3.20)	8.0 (2.98)	8.0 (2.96)	9.4 (3.17)
	50	10.0 (3.30)	14.0 (3.77)	20.0 (4.55)	15.3 (3.97)	10.7 (3.41)	7.3 (2.86)	7.3 (2.83)	12.1 (3.53)
Untreated control	Water spray	7.3 (2.85)	3.3 (1.96)	7.3 (2.85)	4.7 (2.37)	3.3 (2.03)	4.7 (2.32)	4.7 (2.34)	5.1 (2.39)
CD (P=0.05)		NS	NS	(1.22)	(0.82)	(0.74)	NS	(0.95)	(0.41)
Total Number*		147.4	125.6	163.2	110.7	77.4	80.0	61.4	109.4

NS = Non significant

Figures in parentheses are $\sqrt{N+1}$ transformed values.

* Total number of adult whitefly settled on all plants of the same spray.

Table 4.2.1.4a. Attraction of adult whitefly to different insecticidal treatments under multiple choice conditions after four sprays (August 2001)

Insecticide	Dose (g a.i./ha)	Period after insect release (days) (Number of adults/ 2 leaves)							Pooled mean
		1	2	3	4	5	6	7	
Quinalphos	250	11.3	4.7	2.7	2.7	2.7	1.3	3.3	4.1
		(3.40)	(2.11)	(1.82)	(1.90)	(1.79)	(1.41)	(1.96)	(2.06)
	375	5.3	0.7	2.0	0.7	0.7	2.0	2.0	1.9
		(2.50)	(1.24)	(1.73)	(1.24)	(1.24)	(1.65)	(1.65)	(1.61)
	500	12.0	3.3	2.7	4.0	2.0	2.7	2.0	4.1
		(3.59)	(2.03)	(1.82)	(2.20)	(1.73)	(1.90)	(1.65)	(2.14)
Carbaryl	625	8.7	2.7	3.3	2.7	1.3	1.3	3.3	3.3
		(3.08)	(1.82)	2.06	(1.82)	(1.48)	(1.48)	(2.06)	(1.98)
	938	11.3	2.7	2.7	2.7	0.7	3.3	2.0	3.6
		(3.50)	(1.90)	(1.90)	(1.90)	(1.24)	(2.03)	(1.65)	(2.02)
	1250	4.7	2.7	4.0	2.0	1.3	2.7	1.3	2.7
		(2.32)	(1.90)	(2.20)	(1.65)	(1.48)	(1.90)	(1.41)	(1.84)
Acephate	750	10.0	6.0	8.0	4.7	5.3	4.0	5.3	6.2
		(3.30)	(2.56)	(2.98)	(2.37)	(2.50)	(2.20)	(2.49)	(2.63)
	1125	8.7	2.0	7.3	5.3	4.0	4.7	4.7	5.2
		(2.82)	(1.73)	(2.82)	(2.49)	(2.20)	(2.37)	(2.37)	(2.40)
	1500	4.7	8.0	8.0	5.3	5.3	4.0	4.0	5.6
		(2.18)	(2.77)	(2.98)	(2.42)	(2.50)	(2.23)	(2.23)	(2.48)
Endosulfan	438	14.0	5.3	7.3	4.7	3.3	2.7	3.3	5.8
		(3.81)	(2.33)	(2.86)	(2.37)	(2.06)	(1.79)	(2.06)	(2.47)
	656	12.0	1.3	6.7	3.3	2.7	3.3	2.7	4.6
		(3.57)	(1.41)	(2.73)	(2.03)	(1.90)	(1.96)	(1.90)	(2.22)
	875	9.3	9.3	6.0	3.3	2.7	3.3	2.7	5.2
		(3.17)	(3.14)	(2.64)	(2.06)	(1.90)	(2.06)	(1.82)	(2.40)
Fenvalerate	25	5.3	8.7	14.0	6.7	6.0	6.7	6.7	7.7
		(2.50)	(3.08)	(3.85)	(2.73)	(2.62)	(2.74)	(2.76)	(2.90)
	38	3.3	14.0	9.3	6.0	6.0	10.0	6.0	7.8
		(1.77)	(3.85)	(3.20)	(2.62)	(2.64)	(3.15)	(2.64)	(2.84)
	50	8.0	9.3	14.0	14.7	6.7	6.7	6.0	9.3
		(2.96)	(3.05)	(3.84)	(3.90)	(2.73)	(2.76)	(2.62)	(3.13)
Untreated control	Water spray	14.7	14.0	6.0	2.7	2.0	2.7	2.7	6.4
		(3.83)	(3.86)	(2.62)	(1.90)	(1.65)	(1.90)	(1.90)	(2.53)
CD (P=0.05)		NS	NS	(0.76)	(0.820)	(0.700)	(0.95)	(0.80)	(0.37)
Total Number*		143.3	94.7	104.0	71.5	52.7	61.4	58.0	83.47

NS = Non significant

Figures in parentheses are $\sqrt{N+1}$ transformed values.

*Total number of adult whitefly settled on all plants of the same spray.

Table 4.2.1.5a. Attraction of adult whitefly to different insecticidal treatments under multiple choice conditions after five sprays (August 2001)

Insecticide	Dose (g a.i./ha)	Period after insect release (days) (Number of adults/ 2 leaves)							Pooled mean
		1	2	3	4	5	6	7	
Quinalphos	250	7.3	6.7	4.0	3.3	2.7	2.7	3.3	4.3
		(2.85)	(2.68)	(2.20)	(2.06)	(1.90)	(1.90)	(2.06)	(2.24)
	375	7.3	4.0	4.7	3.3	3.3	3.3	3.3	4.3
		(2.85)	(2.20)	(2.37)	(2.06)	(2.06)	(2.06)	(2.03)	(2.26)
	500	6.7	6.0	3.3	2.7	2.0	1.3	2.0	3.4
		(2.73)	(2.62)	(2.06)	(1.82)	(1.65)	(1.41)	(1.65)	(2.00)
Carbaryl	625	7.3	9.3	6.0	2.7	5.3	4.0	4.0	5.5
		(2.69)	(3.14)	(2.62)	(1.90)	(2.50)	(2.23)	(2.23)	(2.48)
	938	6.0	4.7	4.7	2.0	4.0	3.3	3.3	4.0
		(2.62)	(2.34)	(2.34)	(1.73)	(2.20)	(2.06)	(2.66)	(2.20)
	1250	8.0	4.7	5.3	4.7	3.3	2.0	4.0	4.6
		(2.91)	(2.18)	(2.49)	(2.37)	(1.96)	(1.73)	(2.20)	(2.27)
Acephate	750	7.3	2.0	8.0	6.0	6.7	4.7	4.7	5.6
		(2.82)	(1.65)	(2.98)	(2.62)	(2.74)	(2.32)	(2.32)	(2.50)
	1125	5.3	6.0	9.3	6.7	6.0	4.7	5.3	6.2
		(2.28)	(2.43)	(3.17)	(2.73)	(2.62)	(2.37)	(2.50)	(2.59)
	1500	7.3	7.3	8.0	6.0	7.3	5.3	6.0	6.8
		(2.79)	(2.86)	(2.99)	(2.62)	(2.82)	(2.50)	(2.62)	(2.75)
Endosulfan	438	5.3	14.0	6.7	4.0	6.0	4.0	4.0	6.3
		(2.32)	(3.84)	(2.76)	(2.23)	(2.62)	(2.15)	(2.20)	(2.59)
	656	7.3	2.0	6.0	4.7	5.3	3.3	3.3	4.6
		(2.60)	(1.65)	(2.64)	(2.37)	(2.49)	(2.03)	(2.03)	(2.26)
	875	8.7	3.3	7.3	4.7	5.3	2.7	4.0	5.1
		(3.00)	(2.06)	(2.88)	(2.37)	(2.49)	(1.79)	(2.20)	(2.40)
Fenvalerate	25	12.7	10.0	29.3	10.0	8.0	6.0	9.3	12.2
		(3.68)	(3.30)	(5.49)	(3.30)	(2.95)	(2.62)	(3.18)	(3.51)
	38	12.7	11.3	29.3	21.3	7.3	8.7	8.7	14.2
		(3.68)	(3.47)	(5.49)	(4.71)	(2.88)	(3.03)	(3.08)	(3.77)
	50	13.3	18.7	14.0	12.7	9.3	6.7	7.3	11.6
		(3.77)	(4.34)	(3.83)	(3.68)	(3.17)	(2.76)	(2.85)	(3.49)
Untreated control	Water spray	6.7	3.3	6.0	3.3	4.7	2.7	2.7	4.2
		(2.73)	(2.03)	(2.62)	(2.06)	(2.32)	(1.90)	(1.90)	(2.23)
CD (P=0.05)		NS	NS	(0.680)	(0.58)	(0.84)	(0.80)	(0.75)	(0.34)
Total Number*		129.2	113.3	151.9	86.5	86.5	65.4	75.2	102.9

NS = Non significant

Figures in parentheses are $\sqrt{N+1}$ transformed values.

* Total number of adult whitefly settled on all plants of the same spray.

b) September 2001 experiment

Non-significant differences were observed between different treatments after one spray (Table 4.2.1.1b). After 2nd spray (Table 4.2.1.2b) different treatments showed significant differences from 3rd day after releasing adult whitefly being maximum in fenvalerate treated plants (22.7, 20.0 and 16.0 adults) ranking from low dose to higher, respectively, followed by acephate treated plants which recorded (14.0 and 13.3 and 12.3 adults at 750, 1125 and 1500 g/ha, respectively), but these were at par with untreated control (8.7 adult).

Same trend of results was observed after 3, 5, 6 and 7 days after release with no significant differences appeared after 4 days. Similar trend was observed after 3rd (Table 4.2.1.3b), 4th (Table 4.2.1.4b) and 5th spray (Table 4.2.1.5b) in which fenvalerate treated plants attracted maximum number of adult whitefly, followed by acephate. Minimum number of whitefly adults were observed on plants treated with quinalphos and carbaryl.

The pooled analysis of the data for both experiments (Fig. 4.2.1c) revealed that fenvalerate doses attracted more number of whitefly (13.4, 13.1 and 12.6 adults/2 leaves at 38, 50 and 25 g/ha, respectively) followed by acephate doses (9.7 and 8.8 adults/2 leaves at 1500, 1125 and 750 g/ha, respectively) compared with untreated control (6.1 adults/2 leaves). Minimum number of whitefly attracted to quinalphos doses (5.0 and 5.7 adults/2 leaves at 375 and 250 g/ha, respectively).

The data in the above Tables revealed that non-significant differences were observed in whitefly attraction after 1st and 2nd day from releasing whitefly. It may be attributed to the time taken by whitefly to select the suitable plants. However, the settlement trend of whitefly adults on treated plants became apparent after 3rd day and afterwards. The change

Table 4.2.1.1b. Attraction of adult whitefly to different insecticidal treatments under multiple choice conditions after one spray (September 2001)

Insecticide	Dose (g a.i./ha)	Period after insect release (days) (Number of adults/ 2 leaves)							Pooled mean
		1	2	3	4	5	6	7	
Quinalphos	250	7.3	5.3	11.3	4.0	4.0	10.0	6.0	6.9
		(2.26)	(2.04)	(3.01)	(2.01)	(2.01)	(3.21)	(2.62)	(2.46)
	375	2.0	8.7	9.3	7.3	6.0	7.3	6.7	6.8
		(1.65)	(2.78)	(3.20)	(2.43)	(2.52)	(2.85)	(2.76)	(2.60)
	500	3.3	4.7	12.0	2.7	4.7	8.0	5.3	5.8
		(1.77)	(2.11)	(3.07)	(1.82)	(2.32)	(2.99)	(2.45)	(2.36)
Carbaryl	625	4.7	6.7	12.0	2.7	4.7	10.7	6.7	6.9
		(2.21)	(2.73)	(3.56)	(1.82)	(2.18)	(3.36)	(2.74)	(2.66)
	938	3.3	4.7	11.3	8.0	4.0	9.3	6.7	6.8
		(1.96)	(2.18)	(3.41)	(2.99)	(2.20)	(3.17)	(2.76)	(2.67)
	1250	6.7	6.0	10.0	3.3	5.3	8.7	4.7	6.4
		(2.61)	(2.41)	(3.20)	(2.03)	(2.49)	(3.08)	(2.37)	(2.60)
Acephate	750	4.0	11.3	16.0	3.3	8.0	13.3	9.3	9.3
		(2.09)	(3.16)	(4.10)	(1.96)	(2.60)	(3.63)	(3.18)	(2.96)
	1125	6.0	10.7	17.3	10.7	10.0	14.7	8.7	11.1
		(2.41)	(3.00)	(4.14)	(3.21)	(3.19)	(3.95)	(3.03)	(3.28)
	1500	5.3	3.3	15.3	4.7	8.7	14.0	8.0	8.5
		(2.45)	(1.91)	(3.80)	(2.34)	(3.10)	(3.86)	(2.99)	(2.92)
Endosulfan	438	3.3	1.3	12.7	3.3	6.0	11.3	7.3	6.5
		(1.77)	(1.49)	(3.58)	(1.91)	(2.60)	(3.44)	(2.85)	(2.52)
	656	10.7	10.7	14.0	5.3	6.7	13.3	8.0	9.8
		(3.41)	(3.13)	(3.87)	(2.42)	(2.69)	(3.77)	(2.96)	(3.18)
	875	6.0	2.7	13.3	2.0	8.0	10.7	6.7	7.1
		(2.44)	(1.67)	(3.79)	(1.65)	(2.94)	(3.63)	(2.74)	(2.66)
Fenvalerate	25	6.0	15.3	19.3	5.3	16.7	15.3	11.3	12.8
		(2.63)	(3.99)	(4.46)	(2.45)	(4.12)	(4.04)	(3.49)	(3.60)
	38	12.0	18.0	21.3	5.3	12.0	18.0	12.7	14.2
		(3.57)	(4.30)	(4.66)	(2.35)	(3.54)	(4.32)	(3.69)	(3.78)
	50	8.0	28.0	18.0	6.7	11.3	16.7	10.7	14.2
		(2.83)	(5.20)	(4.20)	(2.53)	(3.34)	(4.17)	(3.37)	(3.67)
Untreated control	Water spray	1.3	6.0	14.0	3.3	7.3	11.3	6.7	7.1
		(1.48)	(2.36)	(3.75)	(1.77)	(2.87)	(3.47)	(2.76)	(2.64)
CD (P=0.05)		NS	NS	NS	NS	NS	NS	NS	(0.62)
Total Number*		89.9	143.4	227.1	77.9	123.4	192.6	125.5	140.2

NS = Non significant

Figures in parentheses are $\sqrt{N+1}$ transformed values.

* Total number of adult whitefly settled on all plants of the same spray.

Table 4.2.1.2b. Attraction of adult whitefly to different insecticidal treatments under multiple choice conditions after two sprays (September 2001)

Insecticide	Dose (g a.i./ha)	Period after insect release (days) (Number of adults/ 2 leaves)							Pooled mean
		1	2	3	4	5	6	7	
Quinalphos	250	5.3	5.3	5.3	4.0	2.7	6.0	5.3	4.9
		(2.36)	(2.46)	(2.49)	(2.16)	(1.90)	(2.62)	(2.51)	(2.36)
	375	0.7	2.7	4.7	2.7	2.0	6.7	4.7	3.4
		(1.24)	(1.79)	(2.37)	(1.79)	(1.66)	(2.76)	(2.39)	(2.00)
	500	5.3	12.0	10.7	8.7	6.7	8.7	4.7	8.1
		(2.28)	(3.38)	(3.36)	(2.95)	(2.75)	(3.09)	(2.37)	(2.88)
Carbaryl	625	8.0	6.0	8.0	2.7	4.0	7.3	4.7	5.8
		(2.88)	(2.37)	(2.99)	(1.79)	(2.24)	(2.88)	(2.37)	(2.50)
	938	6.0	4.7	7.3	Nil	0.7	8.0	4.7	4.5
		(2.44)	(2.22)	(2.83)	(1.00)	(1.24)	(2.96)	(2.37)	(2.15)
	1250	6.0	8.7	10.0	3.3	3.3	8.7	6.0	6.6
		(2.63)	(2.83)	(3.23)	(1.91)	(2.04)	(3.11)	(2.63)	(2.62)
Acephate	750	10.0	14.7	14.0	3.3	6.7	18.0	9.3	10.9
		(3.29)	(3.92)	(3.85)	(2.07)	(2.73)	(4.33)	(3.17)	(3.34)
	1125	6.0	2.7	13.3	10.7	4.7	13.3	8.0	8.4
		(2.29)	(1.79)	(3.78)	(3.87)	(2.22)	(3.74)	(2.97)	(2.88)
	1500	10.0	11.3	12.0	10.0	5.3	14.7	8.7	10.3
		(3.16)	(3.24)	(3.55)	(3.28)	(2.46)	(3.93)	(3.11)	(3.25)
Endosulfan	438	2.7	6.0	11.3	3.3	3.3	12.0	8.0	6.7
		(1.7)	(2.12)	(3.50)	(1.77)	(2.07)	(3.58)	(2.99)	(2.53)
	656	3.3	4.0	11.3	3.3	4.0	10.0	6.7	6.1
		(1.96)	(2.21)	(3.49)	(1.96)	(2.21)	(3.31)	(2.93)	(2.55)
	875	6.0	10.0	9.3	4.7	3.3	9.3	7.3	7.1
		(2.42)	(3.29)	(3.19)	(2.04)	(2.04)	(3.21)	(2.85)	(2.76)
Fenvalerate	25	10.7	10.7	22.7	4.7	10.7	14.0	8.7	11.7
		(3.40)	(3.37)	(4.81)	(2.11)	(3.36)	(3.82)	(3.11)	(3.43)
	38	11.3	22.0	20.0	5.3	12.0	20.0	12.3	14.8
		(3.41)	(4.77)	(4.57)	(2.51)	(3.58)	(4.55)	(3.63)	(3.86)
	50	12.0	14.7	16.0	2.7	10.7	16.7	10.7	11.9
		(3.60)	(3.92)	(4.09)	(1.82)	(3.40)	(4.18)	(3.41)	(3.49)
Untreated control	Water spray	4.7	0.7	8.7	2.0	2.7	10.0	8.0	5.2
		(2.11)	(1.24)	(3.08)	(1.55)	(1.90)	(3.31)	(2.99)	(2.31)
CD (P=0.05)		NS	NS	(0.96)	NS	(0.89)	(0.81)	(0.70)	(0.46)
Total Number*		108.0	136.2	184.6	71.4	82.8	183.4	117.8	126.4

NS = Non significant

Figures in parentheses are $\sqrt{N+1}$ transformed values.

* Total number of adult whitefly settled on all plants of the same spray.

Table 4.2.1.3b. Attraction of adult whitefly to different insecticidal treatments under multiple choice conditions after three sprays (September 2001)

Insecticide	Dose (g a.i./ha)	Period after insect release (days) (Number of adults/ 2 leaves)							Pooled mean
		1	2	3	4	5	6	7	
Quinalphos	250	8.0	6.0	6.0	7.3	6.7	12.0	3.3	7.1
		(2.70)	(2.52)	(2.62)	(2.43)	(2.74)	(3.57)	(2.03)	(2.67)
	375	9.3	5.3	8.0	0.0	3.3	9.3	3.3	5.5
		(2.90)	(2.45)	(2.91)	(1.00)	(2.06)	(3.21)	(2.06)	(2.38)
	500	5.3	4.0	7.3	6.7	4.7	12.0	4.7	6.5
		(2.45)	(2.01)	(2.58)	(2.53)	(2.37)	(3.59)	(2.34)	(2.58)
Carbaryl	625	5.3	7.3	7.3	5.3	4.0	14.0	4.7	7.1
		(2.42)	(2.53)	(2.98)	(2.20)	(2.09)	(3.86)	(2.37)	(2.64)
	938	2.0	11.3	7.3	1.3	6.0	13.3	4.0	6.5
		(1.54)	(3.44)	(2.64)	(1.48)	(2.62)	(3.77)	(2.20)	(2.53)
	1250	17.3	11.3	8.0	4.0	5.3	13.3	6.7	9.4
		(4.22)	(3.40)	(2.98)	(2.01)	(2.45)	(3.77)	(2.73)	(3.09)
Acephate	750	3.3	10.0	12.7	3.3	10.7	18.7	8.0	9.5
		(2.06)	(2.98)	(3.66)	(1.96)	(3.39)	(4.39)	(2.98)	(3.07)
	1125	6.0	7.3	12.0	2.7	9.3	22.0	9.3	9.8
		(2.56)	(2.85)	(3.59)	(1.82)	(3.21)	(4.79)	(3.17)	(3.14)
	1500	12.0	10.7	14.7	22.0	10.0	20.7	10.0	14.3
		(3.34)	(2.94)	(3.90)	(4.49)	(3.25)	(4.61)	(3.29)	(3.69)
Endosulfan	438	2.7	6.0	12.0	1.3	7.3	16.7	7.3	7.6
		(1.79)	(2.62)	(3.58)	(1.41)	(2.86)	(4.18)	(2.85)	(2.76)
	656	6.0	16.0	8.7	4.0	8.7	14.7	6.7	9.2
		(2.56)	(4.10)	(3.09)	(2.07)	(3.10)	(3.13)	(2.73)	(3.09)
	875	2.7	1.3	7.3	3.3	7.3	15.3	6.7	6.3
		(1.79)	(1.41)	(2.64)	(1.96)	(2.85)	(4.02)	(2.66)	(2.47)
Fenvalerate	25	14.7	19.3	27.3	6.7	13.3	25.3	12.0	17.0
		(3.94)	(4.45)	(5.26)	(2.45)	(3.78)	(5.12)	(3.57)	(4.09)
	38	12.7	22.7	28.0	19.3	14.0	27.3	16.0	20.0
		(3.61)	(4.85)	(5.35)	(4.15)	(3.86)	(5.30)	(4.09)	(4.47)
	50	14.7	16.7	34.7	18.0	16.7	29.3	14.7	20.6
		(3.95)	(4.15)	(5.87)	(3.84)	(4.19)	(5.48)	(3.93)	(4.49)
Untreated control	Water spray	2.7	10.7	8.0	0.7	8.7	14.0	6.0	7.2
		(1.66)	(2.77)	(2.98)	(1.24)	(3.08)	(3.84)	(2.62)	(2.60)
CD (P=0.05)		NS	NS	(1.42)	NS	(0.79)	(0.82)	(0.98)	(0.56)
Total Number*		124.7	165.9	209.3	105.9	136.0	277.9	123.4	163.6

NS = Non significant

Figures in parentheses are $\sqrt{N+1}$ transformed values.

* Total number of adult whitefly settled on all plants of the same spray.

Table 4.2.1.4b. Attraction of adult whitefly to different insecticidal treatments under multiple choice conditions after four sprays (September 2001)

Insecticide	Dose (g a.i./ha)	Period after insect release (days) (Number of adults/ 2 leaves)							Pooled mean
		1	2	3	4	5	6	7	
Quinalphos	250	5.3	9.3	6.7	2.0	2.0	10.0	5.3	5.8
		(2.28)	(3.14)	(2.76)	(1.54)	(1.65)	(3.27)	(2.45)	(2.45)
	375	2.7	3.3	6.7	2.7	3.3	8.0	4.0	4.4
		(1.90)	(1.96)	(2.73)	(1.82)	(1.96)	(2.96)	(2.20)	(2.22)
	500	5.3	6.7	9.3	5.3	4.0	7.3	4.7	6.1
		(2.33)	(2.66)	(3.18)	(2.37)	(2.20)	(2.88)	(2.37)	(2.57)
Carbaryl	625	5.3	7.3	8.7	7.3	3.3	8.7	6.0	6.7
		(2.35)	(2.64)	(2.82)	(2.62)	(2.06)	(3.08)	(2.62)	(2.60)
	938	2.0	3.3	9.3	1.3	4.7	10.0	5.3	5.1
		(1.54)	(1.96)	(3.14)	(1.48)	(2.21)	(3.27)	(2.49)	(2.30)
	1250	10.0	15.3	10.7	3.3	4.7	12.0	4.0	8.6
		(2.96)	(4.02)	(3.36)	(1.91)	(2.32)	(3.57)	(2.20)	(2.91)
Acephate	750	4.0	4.7	16.7	3.3	8.0	16.7	9.3	9.0
		(2.09)	(2.21)	(4.10)	(1.96)	(2.99)	(4.15)	(3.21)	(2.96)
	1125	9.3	14.0	17.3	6.0	7.3	18.0	8.0	11.4
		(3.14)	(3.75)	(4.25)	(2.62)	(2.85)	(4.33)	(2.96)	(3.42)
	1500	4.0	6.7	16.7	6.7	9.3	17.3	10.0	10.1
		(2.01)	(2.73)	(4.15)	(2.45)	(3.20)	(4.27)	(3.30)	(3.16)
Endosulfan	438	6.7	2.7	12.7	4.7	4.7	13.3	7.3	7.4
		(2.66)	(1.90)	(3.65)	(2.32)	(2.37)	(3.73)	(2.85)	(2.79)
	656	6.0	3.3	12.7	6.7	6.0	11.3	6.0	7.4
		(2.44)	(1.96)	(3.68)	(2.66)	(2.59)	(3.45)	(2.62)	(2.78)
	875	11.3	5.3	11.3	10.0	7.3	12.0	6.7	9.1
		(3.32)	(2.32)	(3.49)	(3.29)	(2.85)	(3.57)	(2.73)	(3.08)
Fenvalerate	25	7.3	16.0	21.3	11.3	14.0	20.0	11.3	14.5
		(2.69)	(4.07)	(4.66)	(3.44)	(3.83)	(4.55)	(3.49)	(3.82)
	38	15.3	15.3	31.3	12.0	16.7	22.0	14.0	18.1
		(3.90)	(4.00)	(5.65)	(3.47)	(4.17)	(4.78)	(3.82)	(4.26)
	50	7.3	9.3	26.7	6.0	11.3	22.7	11.3	13.5
		(2.64)	(3.20)	(5.19)	(2.56)	(3.44)	(4.83)	(3.46)	(3.62)
Untreated control	Water spray	5.3	1.3	10.7	0.7	4.0	12.7	5.3	5.7
		(2.35)	(1.41)	(3.36)	(1.24)	(2.09)	(3.67)	(2.50)	(2.38)
CD (P=0.05)		NS	NS	(1.33)	NS	(1.08)	(0.98)	(0.81)	(0.50)
Total Number*		107.1	123.8	228.8	89.3	110.6	222.0	118.5	142.9

NS = Non significant

Figures in parentheses are $\sqrt{N+1}$ transformed values.

* Total number of adult whitefly settled on all plants of the same spray.

Table 4.2.1.5b. Attraction of adult whitefly to different insecticidal treatments under multiple choice conditions after five sprays (September 2001)

Insecticide	Dose (g a.i./ha)	Period after insect release (days) (Number of adults/ 2 leaves)							Pooled mean
		1	2	3	4	5	6	7	
Quinalphos	250	2.7	4.7	6.0	2.0	1.3	8.0	4.0	4.1
		(1.79)	(2.21)	(2.62)	(1.65)	(1.48)	(2.98)	(2.20)	(2.14)
	375	4.0	4.0	6.0	4.7	2.7	9.3	5.3	5.1
		(2.09)	(2.01)	(2.62)	(2.32)	(1.82)	(3.18)	(2.49)	(2.37)
	500	6.7	12.0	8.7	4.0	1.3	11.3	3.3	6.8
		(2.45)	(3.17)	(2.81)	(2.20)	(1.40)	(3.47)	(2.06)	(2.53)
Carbaryl	625	5.3	10.0	10.7	0.7	2.7	6.0	6.0	5.8
		(2.42)	(3.30)	(3.30)	(1.24)	(1.82)	(2.62)	(2.62)	(2.48)
	938	5.3	3.3	8.7	2.7	4.7	7.3	4.7	5.3
		(2.42)	(2.03)	(3.08)	(1.82)	(2.37)	(2.88)	(2.34)	(2.44)
	1250	3.3	8.0	10.0	4.7	2.0	10.7	4.0	6.1
		(2.03)	(2.83)	(3.29)	(2.34)	(1.65)	(3.39)	(2.20)	(2.54)
Acephate	750	3.3	3.3	11.3	2.0	4.7	16.0	8.7	7.1
		(1.77)	(1.91)	(3.46)	(1.65)	(2.37)	(4.11)	(3.08)	(2.63)
	1125	2.7	1.3	13.3	2.7	4.7	16.7	8.0	7.1
		(1.90)	(1.41)	(3.76)	(1.90)	(2.37)	(4.20)	(2.98)	(2.65)
	1500	8.7	15.3	16.0	4.0	5.3	19.3	10.7	11.4
		(3.05)	(4.02)	(4.11)	(2.22)	(2.50)	(4.48)	(3.37)	(3.42)
Endosulfan	438	10.7	8.0	10.7	5.3	1.3	14.7	8.7	8.5
		(3.06)	(2.66)	(3.37)	(2.45)	(1.48)	(3.95)	(3.08)	(2.87)
	656	7.3	10.0	8.7	2.0	1.3	12.7	6.0	6.9
		(2.60)	(2.81)	(2.82)	(1.65)	(1.41)	(3.68)	(2.62)	(2.52)
	875	14.0	10.7	8.0	6.0	3.3	11.3	6.0	8.5
		(3.67)	(3.03)	(2.98)	(2.62)	(1.96)	(3.49)	(2.62)	(2.92)
Fenvalerate	25	6.7	15.3	17.3	2.7	7.3	26.7	10.7	12.4
		(2.53)	(4.03)	(4.26)	(1.82)	(2.88)	(5.24)	(3.37)	(3.45)
	38	7.3	20.7	18.7	8.0	7.3	20.0	12.7	13.6
		(2.82)	(4.63)	(4.39)	(2.98)	(2.86)	(4.53)	(3.68)	(3.72)
	50	12.0	12.7	18.7	5.3	9.3	24.0	12.0	13.4
		(3.60)	(3.68)	(4.41)	(2.49)	(3.17)	(4.97)	(3.57)	(3.70)
Untreated control	Water spray	1.3	2.0	7.3	1.3	0.7	10.0	5.3	4.0
		(1.48)	(1.65)	(2.85)	(1.41)	(1.24)	(3.27)	(2.49)	(2.06)
CD (P=0.05)		NS	NS	(1.230)	NS	(0.85)	(0.78)	(0.78)	(0.47)
Total Number*		101.3	141.3	180.1	57.8	59.9	224.0	116.1	126.1

NS = Non significant

Figures in parentheses are $\sqrt{N+1}$ transformed values.

* Total number of adult whitefly settled on all plants of the same spray.

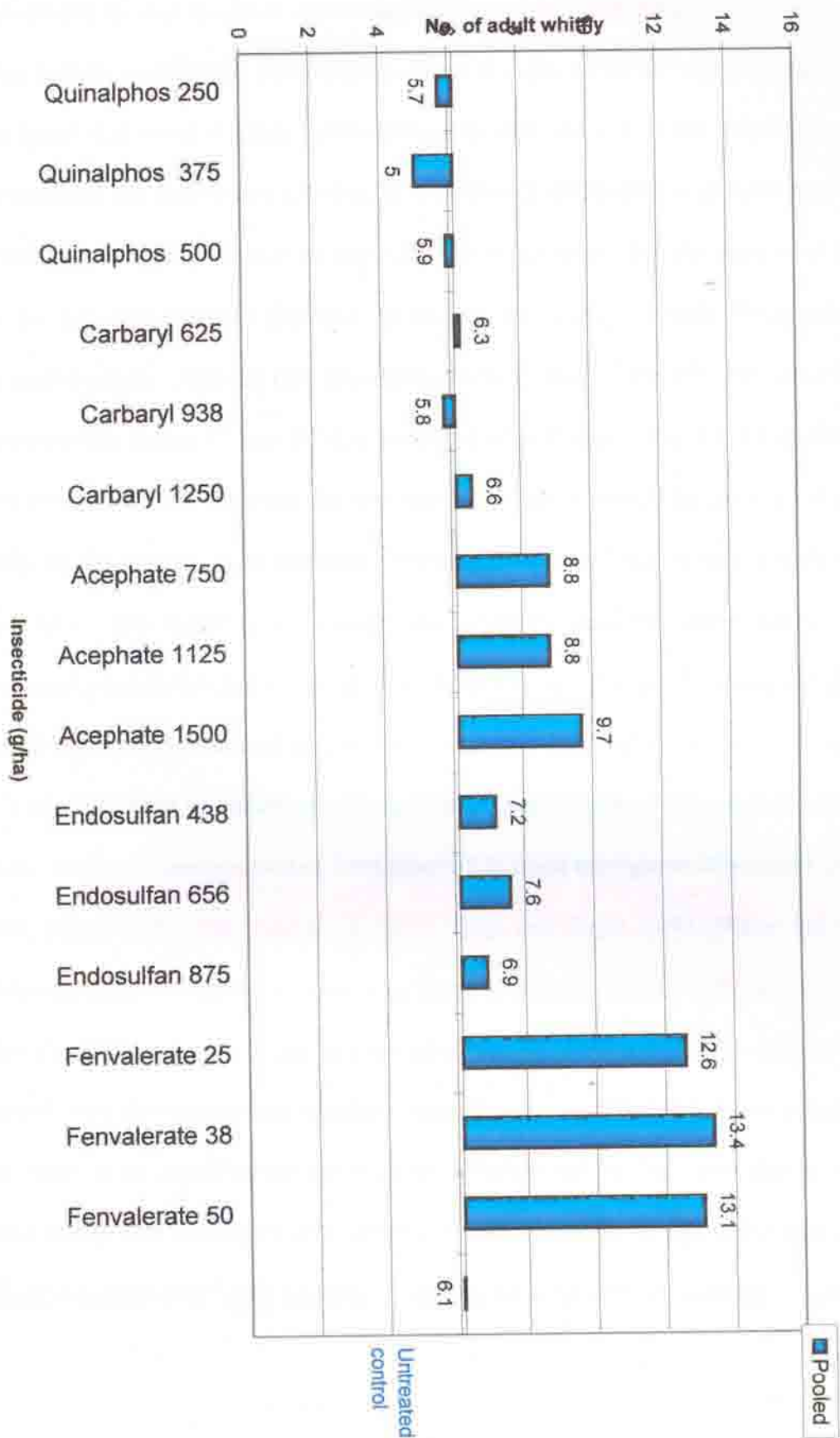


Fig. 4.2.1. Attraction pattern of whitefly adults to the plants treated with different insecticidal treatments under multiple choice conditions (Mean of the Pooled data of both experiments)

of this trend after 4th day in all the sprays during September experiment was because of the weathering factors, particularly wind that appeared at night of the 3rd day (Appendix I) in which its speed was about 6 km/h, followed by rain with average of 8.4 mm which might have redistributed the population of whitefly on different treatments with large number of them settled on weeds that covered the ground of the experiment. But the population started again to be attracted towards different treatments favourably towards fenvalerate and acephate treated plants. Also the data showed that less number of whitefly were recorded on different treatments during 1st then 2nd day compared with 3rd day. This may be attributed to the movement of whitefly between the treatment in which some of the population settled temporarily on the ground or on the stem of cotton plants and became uncountable during those two days. The important conclusion can be drawn from the above results is that, fenvalerate and acephate treated plants attracted more number of whitefly adults which were significantly higher than untreated control, indicating that these two compounds are causing changes in the behaviour of whitefly resulting in more attraction to plants treated with these compounds. However, fenvalerate has been reported to cause resurgence of whitefly (Jayaraj *et al*, 1987; Regu *et al*, 1990; Patil *et al*, 1990; Singh and Gupta, 1993; Butter and Kular, 1999). Also acephate is reported to cause resurgence of whitefly (Kaler, 1999; Aneja, 2000).

From the above results it can be concluded that the attractiveness of whitefly to the plants treated with fenvalerate and acephate may play an important role in its resurgence. However, there is no report about the changes in behaviour of the insect due to use of insecticides except that of Dittrich *et al* (1985) in which he reported that endosulfan sprays caused mass emigration of adult whitefly from treated plots without detectable mortality.

Therefore, the increased attraction of whitefly adults to the fenvalerate and acephate treated cotton plants are the new findings in literature.

4.2.2. Hormoligosis in oviposition preference:

Different insecticides at different doses had shown significant effect on oviposition preference by *B. tabaci* in both of the experiments (Table 4.2.2a and 4.2.2b).

a) August 2001 experiment

During August 2001 experiment all the treatments showed significant differences except after 1st spray (Table 4.2.2a). After 2nd spray, maximum oviposition was recorded in fenvalerate (48.0, 46.3 and 39.3 eggs) ranking from highest to lowest dose respectively. These were followed by acephate at highest dose (37.3 eggs), quinalphos and carbaryl at lowest doses (33.0 and 29.7 eggs). Minimum eggs were recorded in endosulfan (13.3 and 14.0 eggs) at lowest and highest doses, respectively. These were followed by untreated plants (15.3 eggs), then by quinalphos at highest dose and endosulfan at 656 g/ha (15.3 and 16.0 eggs, respectively). Rest of the treatments recorded more number of eggs but these were at par with untreated control. After 3rd spray also plants treated with doses of fenvalerate recorded more number of eggs (40.3, 38.7 and 37.3 eggs) ranking from highest dose to lowest dose, respectively. These treatments were at par with acephate at 1500 and 1125 g/ha (37.3 and 29.7 eggs, respectively), endosulfan at 656.5 g/ha and carbaryl at highest dose (35.0 and 33.3 eggs, respectively) then quinalphos at lowest dose (24.0 eggs). Minimum number of eggs was recorded in endosulfan and quinalphos at highest dose (9.7 and 11.0 eggs, respectively), followed by untreated control (13.0 eggs). Rest of the treatments were at par with untreated control. After 4th spray, plants treated with fenvalerate at 38 g/ha recorded maximum number of eggs (24.0 eggs) followed by fenvalerate (50 g/ha)

Table 4.2.2a. Oviposition preference by *B. tabaci* attracted to different treatments after different sprays (August 2001)

Insecticide	Dose (g a.i./ha)	Number of eggs/ one leave after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	27.3	33.0	24.0	5.7	12.3	20.5
	375	26.7	25.3	19.3	10.3	9.7	18.3
	500	17.0	15.3	11.0	15.0	23.0	16.3
Carbaryl	625	25.3	29.7	17.3	13.0	17.7	20.6
	938	23.7	24.3	13.3	10.7	19.0	18.2
	1250	17.3	21.7	33.3	13.3	18.7	20.9
Acephate	750	23.7	23.7	13.0	13.0	20.3	18.7
	1125	21.7	25.0	29.7	11.3	13.3	20.2
	1500	32.3	37.3	37.3	14.3	13.0	26.9
Endosulfan	438	9.0	13.3	16.7	4.7	5.0	9.7
	656	20.7	16.0	35.0	11.0	5.0	17.5
	875	14.0	14.0	9.7	12.3	9.0	11.8
Fenvalerate	25	24.7	39.3	37.3	12.0	58.0	36.1
	38	34.3	46.3	38.7	24.0	53.3	39.3
	50	35.3	48.0	40.3	21.3	41.3	37.3
Untreated Control	Water spray	18.0	15.3	13.0	12.0	12.3	14.1
CD (P=0.05)		NS	16.1	16.7	9.6	14.4	6.7

NS = Non significant

and quinalphos (500 g/ha), whereas all other treatments remained at par with untreated plants (12.0 eggs). After 5th spray, plants treated with different doses of fenvalerate received maximum number of eggs (58.0, 53.3 and 41.3 eggs) ranking from lowest dose to highest dose, respectively. All the other treatments remained at par with untreated control (12.3 eggs).

The pooled data of this experiment also revealed that fenvalerate doses recorded maximum number of eggs (39.3, 37.3 and 36.1 eggs at 38, 25 and 50 g/ha, respectively) followed by high dose of acephate (26.9 eggs), carbaryl at lowest and higher doses (20.6 and 20.9 eggs, respectively) and quinalphos at 250 g/ha (20.5 eggs). Remaining treatments were at par with untreated plants (14.1 eggs).

b) September 2001 experiment

Almost similar trend was observed in the experiment conducted during September 2001 (Table 4.2.2b) in which plants treated with different doses of fenvalerate received significantly more number of eggs. Plants treated with acephate at 1500 g/ha also exhibited comparatively higher oviposition, whereas rest of the treatments remained at par with untreated control. The analysis of the pooled data for both crop seasons revealed that all the treatments of fenvalerate were more preferred for oviposition by the whitefly adults which were followed by acephate as compared with other treatments (Fig. 4.2.2). The above data also revealed that number of eggs laid by females of *B. tabaci* on different treatments during September were comparatively more than the eggs laid during August. This may be attributed to the suitability of weather conditions during September than in August. The preference of fenvalerate and acephate treated cotton plants by adults of *B. tabaci* for oviposition has not so far been reported in the literature which seems to be the new findings.

Table 4.2.2b. Oviposition preference by *B. tabaci* attracted to different treatments after different sprays (September 2001)

Insecticide	Dose (g a.i./ha)	Number of eggs/ one leave after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	76.3	70.7	66.3	44.7	58.7	63.3
	375	74.7	66.0	64.7	45.7	55.7	61.3
	500	48.3	40.7	45.0	85.0	68.3	57.5
Carbaryl	625	71.7	70.3	61.0	79.3	62.0	68.9
	938	63.7	39.7	57.0	51.0	59.7	54.2
	1250	59.7	60.0	70.3	85.7	62.0	67.5
Acephate	750	61.0	35.3	49.0	82.3	62.7	58.1
	1125	58.7	65.3	63.7	76.7	60.3	64.9
	1500	83.7	70.7	92.3	86.0	61.0	78.7
Endosulfan	438	40.0	44.0	60.0	41.7	48.0	46.7
	656	57.7	37.0	68.7	76.7	50.7	58.1
	875	45.0	48.0	3.3	78.0	53.7	52.6
Fenvalerate	25	70.3	74.0	74.3	79.3	92.3	81.7
	38	97.0	81.0	104.0	96.7	94.3	94.6
	50	113.0	80.7	102.3	89.0	85.3	94.1
Untreated Control	Water spray	56.3	36.3	45.0	69.7	59.0	53.3
CD (P=0.05)		NS	33.0	36.6	34.7	24.7	14.9

NS = Non significant

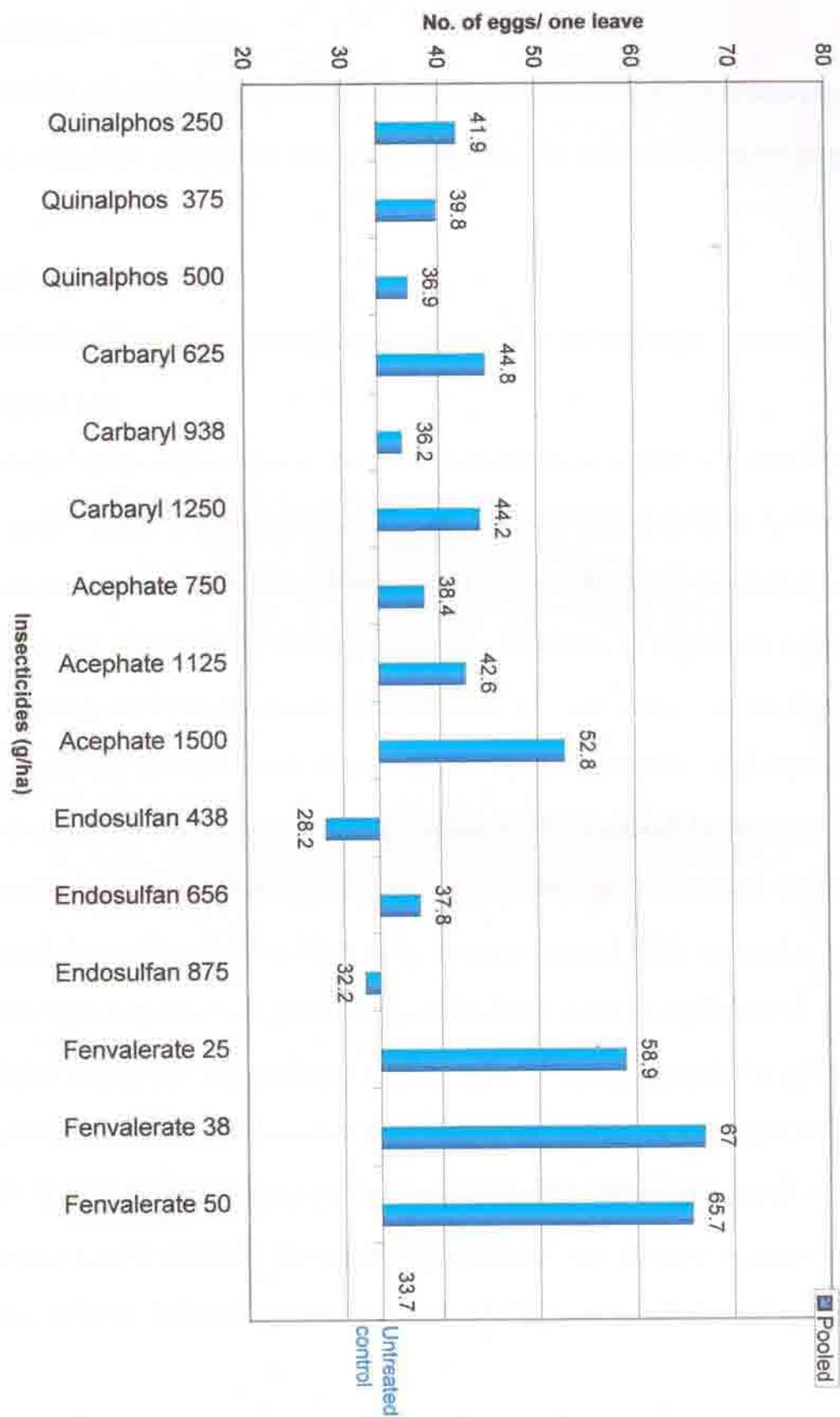


Fig 4.2.2. Increase and decrease of oviposition preference of *B. tabaci* over untreated control in different insecticidal treatments (Pooled data of the both experiments)

4.3. HORMOLIGOSIS IN BIOCHEMICAL COMPONENTS OF HOST PLANT (COTTON LEAVES):

Biochemical components of treated cotton leaves were analyzed for total sugar, total free amino acids, total phenols and changes in pH value. The results obtained are presented below.

4.3.1 Total sugars

Different doses of insecticides had significant effect on total sugar content of cotton leaves (Table 4.3.1).

After 1st spray higher sugar content was recorded in quinalphos 250 g/ha (2.67%), followed by fenvalerate at highest dose (2.63%) and untreated control (2.43%). Lower sugar content was recorded in endosulfan at lowest dose (1.91%) followed by carbaryl at highest dose (1.91%) and endosulfan at 656 g/ha (1.93%). However, no significant differences appeared between different treatments. Similarly after 2nd spray there were no significant differences between different treatments. After 3rd spray, maximum sugar content was recorded in fenvalerate at 38 and 50 g/ha (3.14 and 3.10%) followed by untreated check (3.05%) and quinalphos at lowest dose (3.01%). Minimum sugar content was recorded in endosulfan at highest dose (2.09%) followed by its lowest dose (2.13%), carbaryl at highest dose (2.20%) then acephate 1125 g/ha (2.25%) and carbaryl at lowest dose (2.38%). Rest of the treatments were at par with untreated control. After 4th spray, maximum sugar content was recorded in quinalphos at lowest dose (2.93%) followed by fenvalerate doses (2.87, 2.80 and 2.76% 38, 50 and 25 g/ha, respectively). However, the fenvalerate doses remained at par with untreated control (2.48%). Minimum sugar content was recorded in endosulfan at highest dose (2.04%) followed by its lowest dose (2.17%) and quinalphos at highest dose

Table 4.3.1. Total sugar contents of American Cotton leaves (var. LH-1556) in different insecticidal treatments.

Insecticide	Dose (g a.i./ha)	Total sugar contents (%age on dry wt. basis) after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	2.67	2.66	3.01	2.93	2.22	2.70
	375	2.19	2.32	2.87	2.37	1.88	2.32
	500	2.38	2.68	2.48	2.20	1.73	2.29
Carbaryl	625	2.20	2.38	2.38	2.44	1.82	2.24
	938	2.19	1.87	2.25	2.38	1.90	2.12
	1250	1.91	2.43	2.20	2.43	2.07	2.21
Acephate	750	2.20	2.22	2.51	2.36	1.79	2.22
	1125	1.99	2.36	2.25	2.44	1.86	2.18
	1500	2.10	2.14	2.55	2.45	2.18	2.28
Endosulfan	438	1.91	2.60	2.13	2.17	1.89	2.14
	656	1.93	2.29	2.55	2.21	2.11	2.22
	875	2.03	2.39	2.09	2.04	2.06	2.12
Fenvalerate	25	2.01	2.25	2.95	2.76	2.69	2.53
	38	2.31	2.56	3.14	2.87	3.06	2.79
	50	2.63	2.40	3.10	2.80	3.66	2.92
Untreated control	Water pray	2.43	2.62	3.05	2.48	3.00	2.72
CD (P=0.05)		NS	NS	0.63	0.41	0.53	0.23

NS = Non significant

(2.20%), but the latter two remained at par with untreated control. Rest of the treatments were at par with untreated control. Similarly, after 5th spray, maximum sugar content was recorded in fenvalerate doses (3.66 and 3.06%) 50 and 38 g/ha, respectively, followed by untreated control (3.00%) and fenvalerate at lowest dose (2.69%). Minimum sugar content was recorded in quinalphos at highest dose (1.73%), acephate at lowest dose (1.79%), carbaryl at lowest dose (1.82%) and acephate at 1125 g/ha (1.86%). The remaining treatments also were significantly less than untreated control.

The pooled analysis of the data showed that numerically higher sugar content was recorded in all the fenvalerate treatments (2.92 and 2.79%) at 50 and 38 g/ha, respectively. Also other treatments except lower doses of quinalphos had significantly less sugar content than untreated control being minimum at endosulfan. (Fig. 4.3.1).

The results of present studies revealed that the repeated applications of insecticides caused reduction in the sugar content in cotton leaves except fenvalerate which was at par with untreated control. These results are in agreement with that obtained by Tamilselvan *et al* (1990). They observed that the sugar content in cotton plant treated with pyrethroid (deltamethrin) decrease with increase in the number of spray, but statistically there were no significant differences with untreated control. Among all the insecticides, fenvalerate recorded maximum sugar content. However, Sithanantham *et al* (1973) reported that the content of total sugars found to be highest in untreated control plants as compared with treated plants. Dominick and Sundaram (1992) recorded higher content of sugars in cotton leaves treated with fenvalerate 75 g/ha (1.8%) than in untreated control (0.75%), but their data were not subjected to the statistical analysis. In the present studies, the insecticide

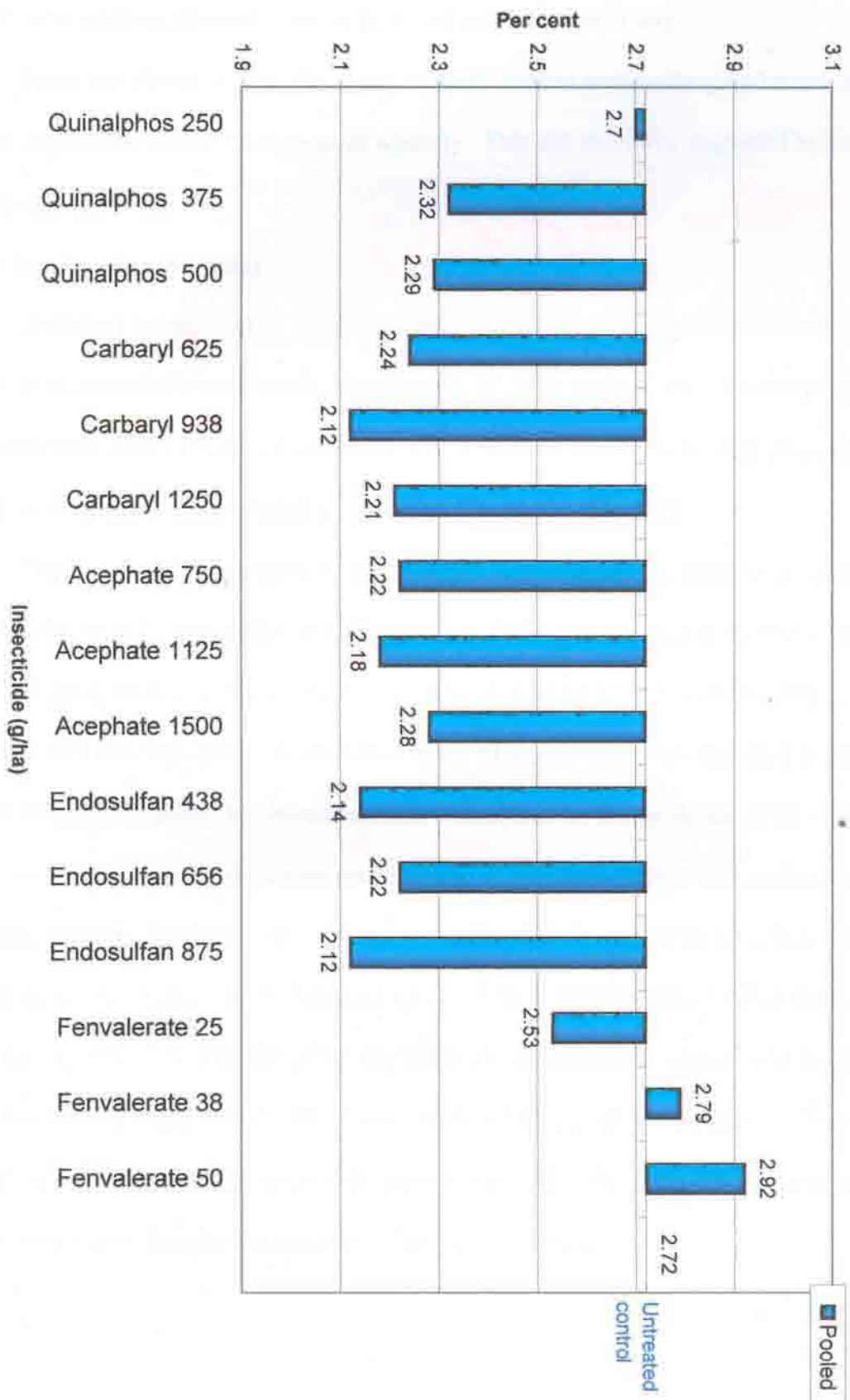


Fig 4.3.1 Increase and decrease of total sugars of American cotton leaves (var. LH-1556) treated with different insecticides over untreated control

doses that recorded highest sugar content also recorded maximum adult longevity, high number of whiteflies attracted towards them and maximum fecundity.

From the above results, the sugar content in these treatments may be one of those factors responsible for the resurgence of whitefly. This has also been suggested by Dominick and Sundaram (1992)

4.3.2 Total free amino acids

Different insecticides at different doses showed significant differences on the total amino acid content of cotton leaves. Total amino acids, in general, were comparatively more in insecticidal treated plants as compared with untreated control excepting quinalphos 500 g/ha after 4th spray and fenvalerate 38 g/ha after 5th spray (Table 4.3.2).

After 1st spray maximum content of amino acids was recorded in carbaryl at lowest dose (1.63%), followed by endosulfan at highest dose (1.35%) and acephate (1.33 and 1.32% 1500 and 1125 g/ha, respectively), quinalphos (1.30% at highest dose and endosulfan (1.25 and 1.24% at 438 and 656 g/ha). Minimum content of amino acids was recorded in untreated control (0.68%) followed by fenvalerate and quinalphos at lowest doses (0.98 and 1.00%, respectively). The rest of the treatments recorded significantly higher free amino acids than untreated control. Similarly after 2nd spray carbaryl at lowest dose recorded maximum content of amino acids (1.43%) followed by acephate at lowest dose (1.39%) then carbaryl (1.32 and 1.22% 1250 and 938 g/ha, respectively), endosulfan at highest and lowest dose (1.27 and 1.22%, respectively). Minimum content of amino acids was recorded in untreated control (0.70%). Rest of the treatments were at par with untreated control. Same trend of results with minor changes was observed after 3rd 4th 5th spray.

Table 4.3.2. Total amino acid contents of American cotton leaves (var. LH-1556) in different insecticidal treatments.

Insecticide	Dose (g a.i./ha)	Total amino acid contents (%age on dry wt. basis) after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	1.00	1.01	0.79	0.72	1.06	0.91
	375	1.07	0.93	1.33	0.85	1.38	1.11
	500	1.30	1.16	1.33	0.51	1.37	1.13
Carbaryl	625	1.63	1.43	1.20	0.67	1.23	1.23
	938	1.07	1.22	1.13	1.02	1.24	1.13
	1250	1.07	1.32	1.62	1.27	1.25	1.30
Acephate	750	1.01	1.39	1.20	0.91	1.10	1.12
	1125	1.32	0.80	1.61	0.85	1.17	1.15
	1500	1.33	0.89	1.15	1.18	0.78	1.06
Endosulfan	438	1.25	1.22	1.43	1.05	1.40	1.27
	656	1.24	0.87	1.39	1.06	1.41	1.19
	875	1.35	1.27	1.30	1.28	1.51	1.34
Fenvalerate	25	0.98	1.07	1.17	0.91	1.04	1.03
	38	1.12	0.84	1.14	0.85	0.88	0.96
	50	1.01	0.90	0.80	0.71	0.99	0.88
Untreated (Water spray)	-	0.68	0.70	0.74	0.68	0.97	0.75
CD (P = 0.5)		0.24	0.38	0.30	0.21	0.26	0.12

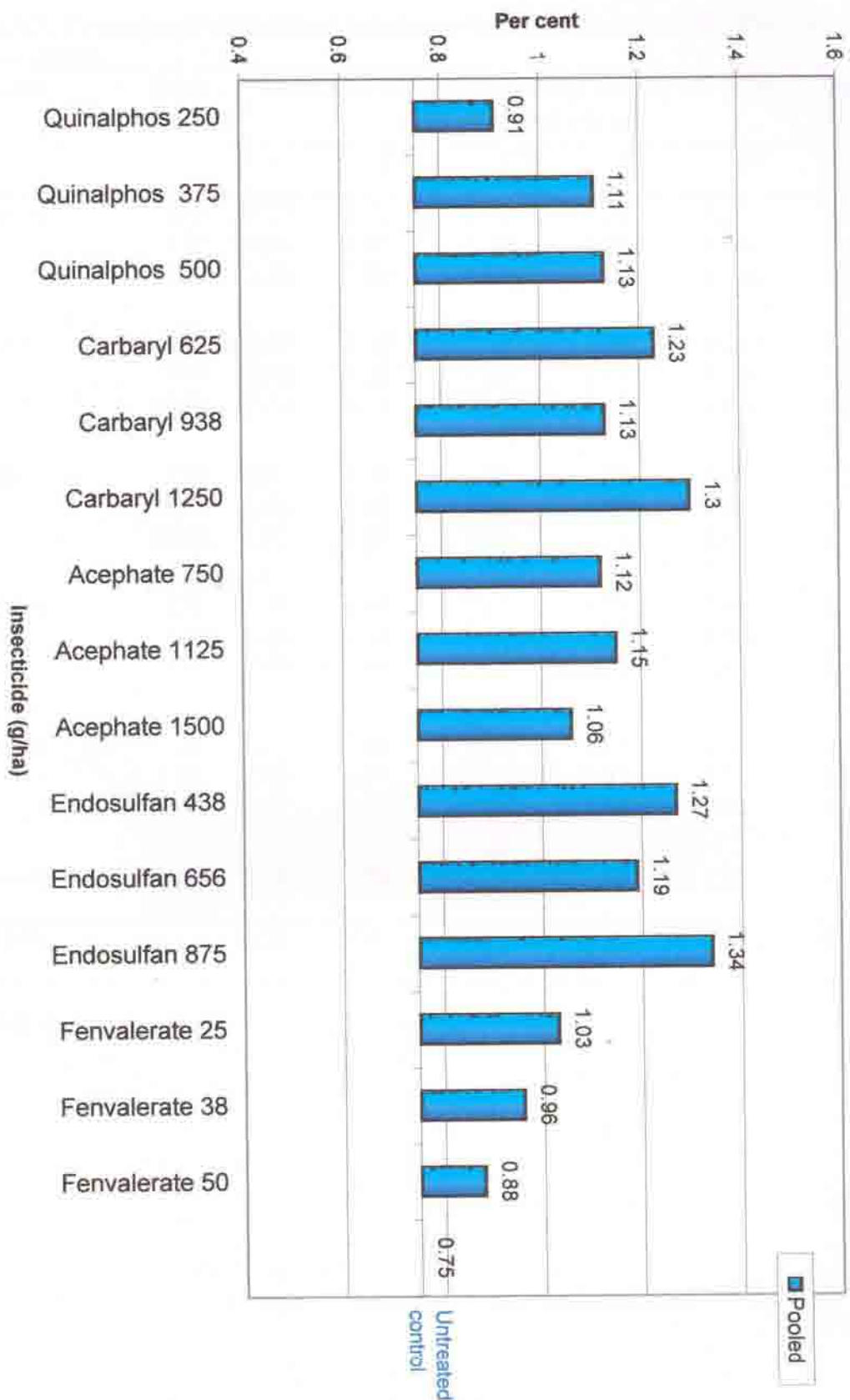


Fig 4.3.2. Increase of total free amino acids of American cotton leaves (Var. LH-1556) treated with different insecticides over untreated control

The pooled data of all the sprays also revealed that maximum content of amino acids was recorded in all the treatments of endosulfan (1.34, 1.27, 1.19%), whereas fenvalerate recorded minimum content (0.88, 0.96 and 1.03%) along with the lowest dose of quinalphos (0.91%). Total free amino acids in all the insecticidal treatments were significantly higher than untreated control (0.75%) (Fig. 4.3.2).

The above data revealed that the repeated applications of all the test insecticides resulted in increased amino acid content of cotton leaves, except fenvalerate and lowest dose of quinalphos in which the contents remained mostly at par with untreated control. On the other hand, endosulfan doses recorded the highest content of amino acids as compared with other treatments. Sithanantham *et al* (1973) also found that the quantity of amino acids was low in untreated plants than in insecticidal treated plants. In the present studies, cotton plants treated with fenvalerate doses were found to attract more number of whitefly and recorded maximum fecundity and longevity. The level of amino acid content in these treatments was also mostly at par with untreated plants. It might have favoured the different biological parameters of *B. tabaci*. On the other hand, increased amino acids contained in endosulfan treatments might be having adverse effect on the biological parameters of the pest which however needs further investigations.

4.3.3 Total phenols

The effect of different doses of insecticides on the total phenol content is presented in Table 4.3.3.

After 1st spray, maximum phenol content was recorded in carbaryl at highest dose (2.54%) followed by fenvalerate at lowest dose (2.20%), quinalphos at lowest dose (2.15%) and untreated plants (2.14%). However, all these treatments remained at par with each other.

Table 4.3.3. Total phenol contents of American cotton leaves (var. LH-1556) after different sprays

Insecticide	Dose (g a.i./ha)	Total phenol contents (%age on dry wt. basis) after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	2.15	2.20	2.11	1.58	1.36	1.88
	375	2.06	1.80	2.22	1.89	1.58	1.91
	500	1.89	1.84	1.66	1.84	1.40	1.74
Carbaryl	625	1.61	1.66	1.69	1.79	1.30	1.61
	938	2.02	1.72	1.89	1.86	1.43	1.78
	1250	2.54	1.88	2.07	1.60	1.52	1.92
Acephate	750	1.97	1.71	1.91	1.74	1.47	1.76
	1125	1.80	1.88	1.97	1.61	1.61	1.77
	1500	1.82	1.64	2.16	1.91	1.48	1.80
Endosulfan	438	1.75	1.98	2.07	1.71	1.43	1.79
	656	1.74	1.54	1.85	1.89	1.50	1.70
	875	2.09	1.58	1.84	1.74	1.47	1.74
Fenvalerate	25	2.20	1.63	1.89	1.83	1.53	1.81
	38	2.02	1.87	1.72	1.97	2.11	1.94
	50	2.08	1.85	1.75	1.84	2.01	1.90
Untreated control	Water spray	2.14	1.98	1.78	1.69	1.53	1.84
CD (P = 0.5)		0.33	NS	0.31	NS	0.25	0.13

NS = Non significant

Minimum phenol content was recorded in carbaryl at lowest dose (1.61%), endosulfan (1.74 and 1.75 656 and 438 g/ha, respectively) and acephate at 1125 g/ha (1.80%). After 2nd spray, maximum content of phenols was recorded in lowest dose of quinalphos (2.20%), endosulfan at lowest dose also (1.98%) and untreated plants (1.98%). Minimum content also recorded in endosulfan doses (1.54 and 1.58% 656 and 875 g/ha, respectively). However, statistically there were no significant differences among the treatment after 2nd spray. After 3rd spray, maximum phenol content was recorded in quinalphos (2.22% at 375 g/ha) then acephate at highest dose (2.16%) and quinalphos at lowest dose (2.11%). Minimum phenol content was recorded in quinalphos at highest dose (1.66%) which was at par with carbaryl at lowest dose (1.69%), fenvalerate (1.72 and 1.75% 38 and 50 g/ha, respectively) and untreated plants (1.78%). All the treatments became at par with each other after 4th spray. After 5th spray maximum phenol content was recorded in fenvalerate (2.11 and 2.01% 38 and 50 g/ha, respectively) followed by untreated plants (1.53%). Minimum phenol content was recorded in lowest doses of carbaryl, quinalphos and endosulfan (1.30, 1.36 and 1.43%, respectively). Same trend of the results appeared in the pooled data of all the sprays, in which fenvalerate at 38 g/ha recorded maximum phenol content (1.94%). This was at par with carbaryl at highest dose (1.92%), quinalphos (1.91% at 375 g/ha) then fenvalerate at highest dose (1.90%) and quinalphos at lowest dose (1.88%) and untreated control (1.84%). Similarly endosulfan recorded minimum content of phenol (1.70 and 1.74% at 656 and 875 g/ha, respectively). Dominick and Sundaram (1992) reported that the phenol content in cotton leaves repeatedly treated with fenvalerate and endosulfan did not vary as compared with untreated control. However, in the present studies total phenol contents were significantly less in the plants

treated with carbaryl 625 g/ha and endosulfan 656 g/ha. Besides Dominick and Sundaram (1992) did not subject their data to statistical analysis as in the case in the present studies.

From the data of biochemical analysis in the present studies it can be concluded that repeated applications of test insecticides had considerable influence on the levels of various biochemical parameters of cotton plant. These changes might have contributed either positively or negatively to the hormoligosis in *B. tabaci*. Further studies are required to evaluate these interactions critically.

4.3.4 pH of cotton leaves

Different treatments showed significant differences in pH value of treated cotton leaves (Table 4.3.4).

After 1st spray, quinalphos at lowest dose (250 g/ha) showed slightly high pH value (6.89) followed by endosulfan (6.71) at its lowest dose (438 g/ha). This inturn was at par with different doses of acephate (6.58, 6.65 and 6.55) ranking from lowest to highest dose, respectively then quinalphos (6.62 at 375 g/ha) and different doses of carbaryl (6.55, 6.62 and 6.59) ranking from lowest to highest dose, respectively. Minimum pH value was recorded in endosulfan (6.23 at 875 g/ha) followed by fenvalerate at lowest doses (6.30). Rest of fenvalerate doses were at par with untreated control. After 2nd spray, untreated control recorded significantly high pH (6.60), which was at par with fenvalerate at its highest dose (6.48). These were followed by endosulfan 875 and 656 g/ha doses (6.41 and 6.37, respectively), carbaryl (6.30 at 625 g/ha), quinalphos at 500 g/ha (6.29) and fenvalerate at lowest dose (6.27). All these treatments were at par with each other but significantly less than untreated control. Minimum pH value was recorded in carbaryl 938 g/ha (6.19), followed by endosulfan at lowest dose (6.20) then acephate (6.20 and 6.21 1125 and 1500

Table 4.3.4. Effect of different insecticidal treatments on pH of American cotton leave extract (var. LH-1556) after different sprays

Insecticide	Dose (g a.i./ha)	pH values of leaf extract after different sprays					Pooled mean
		1 st	2 nd	3 rd	4 th	5 th	
Quinalphos	250	6.89	6.21	6.57	6.10	6.47	6.45
	375	6.62	6.23	6.62	6.06	6.25	6.35
	500	6.48	6.29	6.65	6.35	6.51	6.45
Carbaryl	625	6.55	6.30	6.66	6.43	6.49	6.48
	938	6.62	6.19	6.68	6.36	6.36	6.44
	1250	6.59	6.23	6.55	6.42	6.50	6.46
Acephate	750	6.58	6.38	6.58	6.04	6.31	6.38
	1125	6.65	6.20	6.41	6.22	6.42	6.38
	1500	6.55	6.21	6.62	6.41	6.50	6.45
Endosulfan	438	6.71	6.20	6.65	6.18	6.21	6.39
	656	6.58	6.37	6.73	6.16	6.29	6.42
	875	6.23	6.41	6.65	6.48	6.53	6.46
Fenvalerate	25	6.30	6.27	6.79	6.32	6.18	6.37
	38	6.44	6.37	6.63	6.38	6.17	6.40
	50	6.42	6.48	6.62	6.52	6.23	6.45
Untreated control	Water spray	6.53	6.60	6.86	6.53	6.47	6.60
CD (P=0.05)		0.18	0.15	NS	0.12	0.11	0.07

NS = Non significant

g/ha, respectively). However, after 3rd spray all the treatments were statistically not significant from each other. After 4th spray, highest pH value(6.53), was observed in untreated control which inturn was at par with higher doses of fenvalerate (6.52), endosulfan (6.48) and carbaryl at lowest and highest doses (6.43 and 6.42, respectively). However, minimum pH values were recorded in acephate at 750 g/ha (6.04) and quinalphos (6.06 and 6.10) at 375 and 250 g/ha, respectively. The differences among these values were non-significant. Same trend of results with minor changes was observed after 5th spray.

The pooled analysis of the data showed that all insecticidal treatments resulted in significant reduction of pH value, as compared with the untreated control (6.6) with maximum reduction observed in quinalphos 375 g/ha (6.35) which was at par with acephate 750 and 1125 g/ha (6.38), endosulfan 438 and 656 g/ha (6.39 and 6.42, respectively) and fenvalerate 25 and 38 g/ha (6.37 and 6.40, respectively).

The above data indicated that all the test insecticides have variable ability to reduce the pH value of leaf extract. *B. tabaci* is known to differentiate between pH values of the level of 0.25 but with clear preference for pH values between 6.0 and 7.25 offered in vitro (Berlinger *et al*, 1983). Husain *et al* (1936) suggested that the relative incidence of the whitefly corresponded with the trend of the pH curve, indicating partiality towards high pH. However, the pH value observed in different treatments in the present studies varied between 6.35 and 6.60 (pooled data) which very well fall in the most preferred range.

OVERALL CONCLUSIONS:

The overall conclusions emerging out from the present investigations (Table 5) indicated that fecundity, total life cycle and total survival seem to be the most important biological parameters contributing towards hormoligosis in *B. tabaci*.

Table 5. Conclusive table

Insecticide	Dose g.a.i./ha	Effect of different treatments on									
		Fecundity	Total life cycle	Total survival	Longevity	Attraction	Oviposition	Total sugars	Total amino acids	Total phenols	pH
Quinalphos	250	+	+	NS	-	NS	+	NS	+	NS	-
	375	NS	+	NS	-	NS	NS	-	+	NS	-
	500	-	+	-	-	NS	NS	-	+	NS	-
Carbaryl	625	+	+	NS	-	NS	+	-	+	-	-
	938	NS	+	-	-	NS	NS	-	+	NS	-
	1250	-	+	-	-	NS	NS	-	+	NS	-
Acephate	750	+	NS	NS	NS	+	NS	-	+	NS	-
	1125	+	NS	NS	-	+	NS	-	+	NS	-
	1500	+	+	NS	-	+	+	-	+	NS	-
Endosulfan	438	-	+	-	-	NS	NS	-	+	NS	-
	656	-	+	-	-	NS	NS	-	+	-	-
	875	-	+	-	-	NS	NS	-	+	NS	-
Fenvalerate	25	+	NS	NS	NS	+	+	NS	+	NS	-
	38	+	NS	NS	-	+	+	NS	+	NS	-
	50	+	NS	NS	-	+	+	+	+	NS	-
Untreated control	Water spray										

+ = Increase over control, - = Decrease over control, NS = Non-significantly different from control

Significant increase in fecundity of adult whitefly was observed in all the treatments of fenvalerate and acephate. Besides, lower doses of quinalphos and carbaryl also, increased fecundity significantly. However, endosulfan treatments along with high doses of quinalphos (50 g/ha) and carbaryl (1250 g/ha) reduced the fecundity significantly as compared to untreated control.

The duration of total life cycle in all the doses of fenvalerate and sub-optimal doses of acephate (750 and 1125 g/ha) was same as in case of untreated control plants. Therefore, these treatments can help the pest to complete its life cycle in the same fashion as in case of untreated control, whereas, all the remaining insecticides exerted their negative influence in the form of prolonged life cycle. Total survival of the pest was as normal as in untreated control in case of all the doses of fenvalerate and acephate along with sub-optimal doses of quinalphos and carbaryl. However, the adult longevity was decreased by all the insecticidal treatments except in case of sub-optimal doses of fenvalerate and acephate.

The present studies have further revealed that significant influence of insecticidal treatments on the selection of suitable niches by the adult of *B. tabaci*. The experiments conducted under multiple choice conditions have indicated that cotton plants treated with different doses of fenvalerate and acephate became significantly more attractive to whitefly. None of the insecticidal treatments repelled the whitefly adults as compared with untreated control. Whitefly laid significantly more number of eggs on the cotton plants treated with fenvalerate, higher dose of acephate (1500 g/ha), sub-optimal doses of carbaryl (625 g/ha) and quinalphos (250 g/ha). Comparison of different biological parameters indicated the operation of hormoligosis of all the doses of fenvalerate, acephate, both (optimal and sub-optimal) and sub-optimal doses (lower than optimal doses) of quinalphos and carbaryl.

The results obtained from biochemical studies revealed that all the insecticidal treatments caused reduction in total sugars as compared with untreated control excepting fenvalerate and low dose of quinalphos. However, the higher dose of fenvalerate (50 g/ha) resulted in significant increase in total sugars. All the insecticidal treatments caused significant increase in total amino acids. Whereas pH of cotton leaf extract reduced by all the insecticidal treatments. Total phenols did not vary significantly in the treated and untreated plants except in case of sub-optimal doses of carbaryl (625 g/ha) and endosulfan (656 g/ha). However, further studies are required to investigate the changes occurring in host plants viz a viz their favourable influence on whitefly. Further studies are also needed to understand how the changes occur in the host plant due to application of insecticides and how they are going to influence the suitability of the cotton hosts for feeding, breeding and shelter niches for *B. tabaci*.

CHAPTER V

SUMMARY

Studies on the hormoligosis of insecticidal sprays in *Bemisia tabaci* (Gennadius) on cotton were carried out at Entomological Research Farm and Laboratory of Department of Biochemistry and Chemistry, Punjab Agricultural University, Ludhiana during 2001 and 2002 crop seasons. The studies were conducted on American Cotton (var. LH-1556). The test insecticides were quinalphos 250, 375 and 500 g, carbaryl 625, 938 and 1250 g, acephate 750, 1125 and 1500 g, endosulfan 438, 656 and 875 g, fenvalerate 25, 38 and 50 g a.i./ha. The hormoligosis has been evaluated in terms of effect on whitefly fecundity, duration and survival of immature stages, longevity and in attractiveness of adult to treated plants for feeding and oviposition preferences, and changes in the host plant nutrition. The plants used in each experiment were divided into 5 sets. Out of these first set received only one spray whereas, second, third, fourth and fifth sets received 2, 3, 4 and 5 sprays, respectively. Test plants in all the experiments were used only after 72 hours of the spray. The test insects used in all the experiments were obtained from the same culture which was raised on untreated plants of variety LH-1556.

The effect of test insecticides on biology of whitefly was observed by confining the adults in leaf cages. These cages were fixed on the fully formed leaves of upper plant canopy. The adult whiteflies were released into the leaf cages 72 hours after each spray.

Different insecticidal treatments have significantly influenced the fecundity of whitefly. Fecundity was significantly more on the plants, treated with different doses of fenvalerate and acephate during both the years as compared with untreated control. The treatments were followed by lower doses of quinalphos (250 g/ha) and carbaryl (625 g/ha).

The number of eggs observed in different treatments of fenvalerate and acephate varied from 73.9 to 82.5 and 62.7 to 69.4 eggs/2 pairs during October-November 2001 crop season, respectively. The corresponding figures in June 2002 crop season varied from 59.7 to 67.5 and 51.3 to 55.3 eggs/2 pairs, respectively. Significantly low fecundity was observed in all the doses of endosulfan during both the seasons and it varied from 29.1 to 38.3 and 21.3 to 26.3 eggs/2 pairs during 2001 and 2002 experiments, respectively. Significant decrease in fecundity was also observed at higher doses of quinalphos (500 g/ha) and carbaryl (1250 g/ha) as compared to untreated control. However, lower doses of quinalphos (250 g/ha) and carbaryl (625 g/ha) significantly increased the fecundity as compared to untreated control.

The incubation period varied between 5.5 and 8.78 days, but with no significant differences between different treatments. However, the statistical analysis of pooled data showed significant differences between the treatments. Minimum egg duration was observed on endosulfan and fenvalerate treated plants (6.5 days for both 656 and 50 g/ha, respectively). Maximum egg duration was observed in carbaryl (7.2 and 7.1 days 1250 and 625 g/ha, respectively) and all doses of quinalphos (7.1 days). Rest of the treatments remained at par with control (6.6 days). Similarly, survival of eggs varied from 46.7 to 100 % but with no significant differences between different treatments in all the sprays. The analysis of the pooled data of all the sprays have shown significant differences between different treatments. Maximum survival was recorded on plants treated with fenvalerate doses (91.7, 89.0 and 87.3% at 25, 38 and 50 g/ha, respectively), but with no significant differences over untreated control (88.3%). Minimum survival of eggs was observed on the plant treated with carbaryl (70.3 and 71.7% at 938 and 1250 g/ha, respectively), endosulfan

(73.3 and 74.0% at 656 and 438 g/ha, respectively) and quinalphos (75.3% at 250 g/ha) as compared with untreated control.

Different insecticides have shown significant effect on the duration of nymphs. The pooled data revealed that all the doses of endosulfan, carbaryl 938 and 1250 g/ha, quinalphos 375, 500 g/ha and acephate 1500 g/ha have prolonged the duration of nymphal stage significantly as compared with untreated control. However, the nymphal duration was completed in 10.6 to 11.1 days in case of different fenvalerate treatments which was at par with untreated control (11.1 days). The data revealed that nymphal survival was at par with untreated control in all the doses of fenvalerate, lower doses of acephate, quinalphos and carbaryl. This clearly indicated that all these treatments favoured the survival of the nymphal instars as in case of untreated control. Pooled mean of the nymphal growth index indicated that growth index varied from 3.6 to 6.7 in different treatments. The similarity in the growth index values in all the doses of fenvalerate, lower doses of acephate (750 and 1125 g/ha) and low dose of quinalphos (250 g/ha) with untreated control further highlighted the absence of adverse effect of these doses on nymphal stage of *B. tabaci*.

The duration of pupal stage varied from 2.2 to 2.6 days, but with no significant differences between different treatments. Likewise pupal survival ranged between 83.6 to 93.7 but it did not vary significantly in different treatments.

Total life cycle of *B. tabaci* was completed in the minimum period of 19.6 days on the plants treated with fenvalerate 38 g/ha followed by doses of fenvalerate, such optimal doses of acephate (750 and 1125 g/ha) and lower dose of carbaryl (625 g/ha). However all these treatments remained at par with untreated control. All the doses of endosulfan, quinalphos and higher dose of acephate (1500 g/ha) caused significant prolongation in the

life cycle of *B. tabaci* which in turn indicated the absence of hormoligosis by these treatments. The pooled data of total survival revealed that total survival was more in all the treatments of fenvalerate as compared with other treatments and it was at par with untreated control and varied from 54.3 to 59.3 per cent. It was followed by sub-optimal doses of acephate (750 and 1125 g/ha and lower dose of quinalphos (250 g/ha).

The pooled data on immature stages growth index have shown that all insecticidal treatments resulted in significant reduction in immature stages growth index except fenvalerate doses in which they varied from 2.8 to 2.9 and remained at par with untreated control (3.0).

The sex ratio usually favoured the females, but the differences between different treatments were non-significant.

The data obtained on the effect of different insecticidal treatments on longevity of male, female and both sexes together of adult whitefly have shown significant differences between different treatments in both of the experiments (November-December 2001 and June 2002). The pooled analysis of the data for November-December 2001 revealed that all insecticidal treatments caused reduction in male longevity except fenvalerate 25 g/ha (15.4 days) which was at par with untreated control. In June 2002 experiment the results were in the same trend, with maximum longevity being in untreated control, followed by the low doses of different insecticides, with maximum reduction in endosulfan at higher dose.

All the insecticidal treatments caused significant reduction in female longevity as compared with untreated control (20.4 days) except fenvalerate 25 g/ha (19.5 days) during November-December 2001. Maximum reduction recorded on plants treated with endosulfan (9.6 and 11.3 days at 875 and 656 g/ha) followed by higher dose of carbaryl and quinalphos

being 11.7 days for both 1250 and 500 g/ha . Minimum reduction was observed on plants treated with fenvalerate and acephate at low dose (19.5 and 18.0 days 25 and 750 g/ha, respectively), followed by fenvalerate 38 g/ha (17.9 days), acephate, carbaryl and quinalphos (16.5, 15.8 and 15.4 days 1125, 625 and 250 g/ha). Similar trend of results was observed in the pooled data of June 2002 experiment.

The pooled analysis of the data for effect of different treatments on the mixed sexes showed that all insecticidal treatments resulted in significant reduction in longevity of both sexes together except low dose of fenvalerate and acephate (19.8 and 17.5 days at 25 and 750 g/ha, respectively) during November-December 2001 crop season. Almost the same trend of results obtained during June 2002 crop season.

The experiments pertaining the attraction of adult whitefly to the plants treated with different doses of insecticides during August 2001 revealed that significant differences in whitefly settled appeared only after 3rd day from releasing of whitefly. Maximum attraction in all the cases was recorded in fenvalerate doses followed by acephate doses and minimum settling of adult was recorded in all the doses of quinalphos. Same trend of results with minor changes was observed in the repeated experiment (September 2001).

The pooled data on oviposition preference (August 2001) revealed that fenvalerate treated plants were significantly more preferred by whitefly. Maximum oviposition was recorded in fenvalerate (39.3, 37.3 and 36.1 eggs/leaf at 38, 50 and 25 g/ha, respectively) followed by acephate (26.9 eggs/leaf at 1500 g/ha) and carbaryl (20.9 eggs/leaf at 1250 g/ha). All other treatments were at par with untreated control (14.1 eggs/leaf) with minimum number of eggs observed on plants treated with endosulfan (9.7 and 11.8 eggs/leaf at 438 and 875 g/ha) followed by quinalphos (16.3 eggs/leaf at 500 g/ha). Almost same trend was

observed in the experiment conducted during September 2001. Maximum number of oviposition was recorded on plants treated with fenvalerate (94.6, 94.1 and 81.7 eggs/leaf at 38, 50 and 25 g/ha, respectively), followed by acephate and carbaryl (78.7 and 68.9 eggs/leaf at 1500 and 625 g/ha, respectively). All these treatments were significantly higher than untreated control (53.3 eggs/leaf), whereas all other treatments were at par with untreated control, with minimum number recorded on endosulfan (46.7 and 52.6 eggs/leaf @ 438 and 875 g/ha).

The results obtained from biochemical studies revealed that all the insecticidal treatments caused reduction in total sugars as compared with untreated control excepting fenvalerate and low dose of quinalphos. However, the higher dose of fenvalerate (50 g/ha) resulted in significant increase in total sugars. All the insecticidal treatments caused significant increase in total amino acids. Whereas pH of cotton leaf extract was reduced by all the insecticidal treatments. Total phenols did not vary significantly in the treated and untreated plants except in case of sub-optimal doses of carbaryl (625 g/ha) and endosulfan (656 g/ha). The forgoing results revealed that fecundity was significantly increased in all doses of fenvalerate, acephate and low dose of carbaryl and quinalphos. The total life cycle and survival of different stages were not adversely affected in these treatments. Besides the cotton plants treated with different doses of fenvalerate and acephate resulted in significant increase in attraction of whitefly adults. Plants treated with fenvalerate, high dose of acephate and low dose of quinalphos and carbaryl were more preferred by adult whitefly for oviposition. The results obtaining from these different biological parameters indicated presence of hormoligosis at both optimal and sub-optimal doses of fenvalerate and acephate and sub-optimal doses of quinalphos and carbaryl besides in the present studies total sugars,

amino acids, phenols and pH of leaf extract was also significantly influenced which indicated that necessity for investigating the changes occurring in host plants viz a viz their favourable influence on whitefly. Further studies are also needed to understand how the changes occur in the host plant due to application of insecticides and how they are going to influence the suitability of the cotton host for feeding, breeding and shelter niches for *B. tabaci*.

REFERENCES

- Abdurrahman A A, Munir B and Stam P A (1990) Recent advances in the integrated pest management in cotton in the Gezira and Rahad schemes in Sudan. *Proc Integrated Pest Management in Tropical and Subtropical Cropping Systems 1989*, 8-15 February 1987. No. 2, pp. 435-44. Frankfurt, Germany, Deutsche Landwirtschafts Gesellschaft.
- *Ahmed F, Khan F R and Khan M R (1995) Comparative efficacy of some traditional and non-traditional insecticides against sucking pests of cotton. *Sarhad J Agric* **11**: 733-39.
- Aneja A K (2000) *Studies on the biology of cotton whitefly Bemisia tabaci (Gennadius) on American cotton, Gossypium hirsutum (Linnaeus)*. M.Sc. thesis, Punjab Agricultural University, Ludhiana, India.
- Anonymous (1989) Management of whitefly, *Bemisia tabaci* Genn. on cotton. pp 27-28 Publication of Andhra Pradesh Agricultural University.
- Anonymous (2001) *Report of Directorate of Economics and Statistics*, pp. 57, Ministry of Agriculture, Government of India, Krishi Bhavan, New Delhi. pp. 57
- Athar (2001) *Symptom variability of Cotton Leaf Curl Virus in Punjab*. M.Sc. Thesis, Punjab Agricultural University, Ludhiana, India.
- Azab A K Megahed M M and El-Mirsawi D H (1971) On the biology of *Bemisia tabaci* Genn. *Bull ent Soc Egypt* **55**: 395-15.
- Balaji K and Veeravel R (1995) Effect of different levels of nitrogen on the incidence of whitefly, *Bemisia tabaci* (Genn.) in four varieties of brinjal. *Indian J Ent* **57**: 356-61.
- Basu A N (1995) *Bemisia tabaci* (Gennadius): *Crop Pest and Principle Whitefly Vector of Plant Viruses*. Oxford and IBH Publishing, New Delhi, pp.183.
- Beevi S P and Balasubramanian M (1991) Effect of Buprofezin on adult life span, oviposition, egg hatch and progeny of cotton whitefly *Bemisia tabaci*. *Phytoparasitica* **19**: 33-47.
- Beevi S P and Balasubramanian M (1992) Relative safety of Buprofezin and insecticides to *Encarsia Shafeei*, a parasite of cotton whitefly *Bemisia tabaci* (Genn.) *J Biol Control* **6**(2): 59-63.
- Bentz J, Reeves J, Barbosa P and Francis B (1995) Effect of nitrogen fertilize source and level on ovipositional choice of poinsettia by *Bemisia argentifolii* (Homoptera: Aleyrodidae) *J econ Ent* **88**: 1388-92.

- Berlinger M J, Mayal Z and Benzioni A (1983) The importance of pH in food selection by tobacco whitefly, *Bemisia tabaci*. *Phytoparasitica* **11**: 151-60.
- Bethke J A, Paine T D and Nuessly G S (1991) Comparative biology, morphometrics and development of two populations of *Bemisia tabaci* (Homoptera: Aleyrodidae) on cotton and poinsettia. *A Ent Soc Am* **84**: 407-11.
- Bharpoda T M, Patel H P, Patel U P, Patel G P, Patel J J and Patel J R (2000) Integrated Pest Management (IPM) in cotton H-6 cultivated in middle Gujarat. *Indian J Ent* **62**: 327-331.
- Bhathal J S, Dhillon G S and Dhaliwal G S (1991) Insecticide-induced resurgence in insect pests of agricultural crops. *Indian J Ent* **53**: 381-92.
- Bishnoi O P, Singh M, Rao V U M, Niwas R and Sharma P D (1996) Population dynamic of cotton pests in relation to weather parameters. *Indian J Ent* **58**: 103-107.
- Bloch G and Wool D (1994) Methidathian resistance in the sweet potato whitefly (Aleyrodidae: Homoptera) in Israel: Selection, heritability and correlated changes of esterase activity. *J econ Ent* **87**: 1147-56.
- Borad V K and Puri S N (1991) Life table studies of *Bemisia tabaci* (Gennadius) on cotton and brinjal under field conditions by artificial infestation. *Indian J Ecol* **18**: 186-89.
- Brar D S, Sohi A S, Singh J and Singh J (1999) Efficacy of insecticides against *Amrasca biguttula* (Ishida) and *Bemisia tabaci* (Genn.) on *Hirsutum* cotton. *Insect Enviro* **5**: 83.
- Brown J K and Nelson M R (1984) Geminat particles associated with Cotton Leaf Crumple disease in Arizona. *Phytopathology* **74**: 987-990.
- Butler G D and Henneberry T J (1994) *Bemisia* and *Trialeurodes* (Homoptera: Aleyrodidae) In: Mathews G A and Tunstall J P (eds.) *Insect pests of cotton*, , pp. 170-97, CAB International Wallingford, U K.
- Butler G D, Henneberry T J and Clayton T E (1983) *Bemisia tabaci* (Genn.) (Homoptera: Aleyrodidae): Development, oviposition and longevity in relation to temperature. *Ann ent Soc Am* **76**: 310-13.
- Butler G D, Henneberry T J and Hutchinson W D (1986a) Biology, sampling and population dynamics of *Bemisia tabaci*. *Agric Zool Rev* **1**: 167-95
- Butler G D Jr, Henneberry T J and Wilson F D (1986b) *Bemisia tabaci* (Genn.) (Homoptera: Aleyrodidae) on cotton: Adult longevity and cultivar oviposition preference. *J econ Ent* **79**: 350-54.
- Butler G D Jr, Wilson F D and Henneberry T J (1985) Cotton Leaf Crumple disease in Okra-leaf and normal leaf cotton. *J econ Ent* **78**: 1500-1502.

- Butter N S and Kular J S (1999) Resurgence of whitefly in cotton and its management. *Indian J Ent* **61**: 85-90.
- Butter N S, Kular J S and Singh T H (1994) Management of cotton pest with humic acid. In: *National Seminar on cotton production; Challenges in 21st Century*, pp. 69-70, April 18-20, 1994, Haryana Agricultural university, Hissar.
- Butter N S and Vir B K (1991) Response of whitefly, *Bemisia tabaci* Genn. to different cotton genotypes under glasshouse conditions. *Indian J Eng* **53**: 115-19.
- Butter N S, Vir B K, Gurdeepm Kaur, Singh T H, Raheja R K and Kaur G (1992) Biochemical basis of resistance to whitefly, *Bemisia tabaci* Genn. (Aleyrodidae: Hemiptera) in cotton. *Trop Agric* **69**: 119-22.
- Byrne D N and Bellows T S (1991) Whitefly biology. *A Rev Ent* **36**: 431-57.
- Byrne D N and Bretzel P K (1987) Similarity in flight activity rhythms in coexisting species of Aleyrodidae, *Bemisia tabaci* and *Trialeurodes abutilonea*. *Entomol Exp Appl* **43**: 215-19.
- Byrne F J, Cahill, Denholm I and Devonshire A L (1994) A biochemical and toxicological study of the role of insensitive acetyl cholinesterase in organophosphorus resistant *Bemisia tabaci* (Homoptera: Aleyrodidae) from Israel. *Bull ent Res* **84**: 179-84.
- Cahill M and Denholm I (1993) Detection of resistance to buprofezin in the whitefly *Bemisia tabaci*. *Resistane Pest Mgmt Newsl* **5**(1): 42.
- Cahill M, German K, Day S, Denholm I, Elbert A and Naven R (1996) Baseline determination and detection of resistance to imidacloprid in *Bemisia tabaci* (Homoptera: Aleyrodidae). *Bull ent Res* **86**: 343-49.
- Campbell B C, Campbell S J D and Gill R J (1995) Origin and radiation of whitefly: an initial molecular phylogenetic assessment. In: Gerling D and Mayer R T (eds.) *Bemisia 1995, Taxonomy, Biology, Damage, Control and Management*. pp. 29-51 Intercept Ltd., UK, pp. 29-51.
- Chander S and Singh Y (1991) Effect of insecticides on whitefly *Bemisia tabaci* (Gennadius) and yellow mosaic virus in green gram, *Vigna radiata* (L) Wilczek. *Indian J Ent* **53**: 348-51.
- Chelliah S (1979) Insecticide application and brown plant hopper *Nilaparvata lugens* (Stal.) resurgence in rice. A report of research conducted from July 8, 1977 to July 7, 1979, Department of Entomology, International Rice Institute, Philippines.
- *Coikesen T and Sekeroglu E (1987) Effect of changes in temperature on the development of the cotton whitefly, *Bemisia tabaci* (Genn.) (Homoptera: Aleyrodidae). *Turkiy Ent Dergisi*, **11**(3): 163-68.

- Dale D and Heinrichs E A (1999) Plant Stress induced by insecticides. In: Dhaliwal G S and Arora R (eds.) *Environmental Stress in Crop Plants*, pp. 121-148, Commonwealth, New Delhi.
- Dandale H G, Thakare A Y, Tikar S N, Rao N G V and Nimbalkar S A (2001) Effect of seed treatment on sucking pests of cotton and yield of seed cotton. *Pestology* 25(3): 20-23.
- David B V, Jesudasan R W A and Winston A A (1987) Effect of insecticides on the population build-up of *Bemisia tabaci* (Genn.) on cotton. In: Jayaraj S (ed.) *Resurgence of sucking pests*, pp. 125-128, Tamil Nadu Agricultural University, Coimbatore, India.
- David V B, Dived M M P and Selvakumaran S (2000) Status, distribution and bioecology of three whitefly pests and their management. In: Upadhyay R K, Mukerji K G and Dubey O P. *IPM system in Agriculture*, pp. 77-104, Aditya Book, New Delhi, India.
- De Barro P J (1995) *Bemisia tabaci* biotype B: a review of its biology, distribution and control 36, 1-58. Council of Scientific and Industrial Research Organization (CSIRO) , Division of Entomology, Technical paper.
- Denholm I (1998) Challenges with combating insecticide resistance in cotton pests in India. In: Bakhetia D R C, Dilawari V K, Singh J and Joia B S (Eds.) *Proc Critical Issues of IPM in the Changing Agricultural Scenario in India*, pp. 21-25, Dept. of Entomology, PAU, Ludhiana, 141004, India.
- Deotale R O, Nimbalkar S A and Jude Y S (1992) Biology of whitefly *Bemisia tabaci* (Genn.) on cotton. *J Soil Crops* 2: 30-32.
- Dhanorkar B K, Puri S N and Thakur B S (1990) Efficacy of neem against cotton whitefly, *Bemisia tabaci* (Gannadius). *Neem News* 8: 18-19.
- Dhawan A K (1998) Integrated pest management in cotton: Status of different management options and future perspectives. *Pestology* 22(12); 1998.
- Dhawan A K (2000) Impact of some new insecticides on natural enemy complex of cotton ecosystem. *Pestology* 24: 8-14.
- Dhawan A K and Dhaliwal G S and Chelliah S (2000) Insecticide-induced resurgence of insect pests in crop plants. In: Dhaliwal G S and Singh B (eds.) *Pesticides and Environment*, pp. 86-127. Commonwealth, New Delhi, India.
- Dhawan A K and Simwat G S (1992) Management of sucking pests of cotton with natural plant products. In: Tauro P and Narwal S S (eds) *1st Natl Symp on Allelopathy in Agroecosystem , Agric and Forestry*, pp. 154-55. Indian Society of Allelopathy, HAU, Hissar, India.
- Dhawan A K and Simwat G S (1993) Evaluation of some insecticidal mixtures against insect pests infesting cotton crop during flowering phase. *Pestology* 13-17.

- Dhawan A K and Simwat G S (1994) Field evaluation of profenophos alone and in comparison with cypermethrin for the control of insect pest during flowering phase. *Pestology* **18**(5): 40-43.
- Dhawan A K and Simwat G S (1997) Insecticide induced resurgence in sucking pests in upland cotton Punjab, India. *Proc 3rd Int Congr of Entomological Sciences*, p.12, March 18-20, National Agricultural Research Centre, Islamabad.
- Dhawan A K and Simwat G S and Prakash R (1999) Evaluation of decidan for the control of bollworm complex on upland cotton. *Pestology* **23**(4): 55-62.
- Dikson R C, Johnson M, McD and Laird E F (1954) Leaf Crumple, a virus disease of cotton. *Phytopathology* **44**: 479-480.
- Dittrich V, Ernst G H, Ruesch O and Solank U K (1990) Resistance mechanisms in sweet potato whitefly (Homoptera: Aleyrodidae) populations from Sudan, Turkey, Gautemala and Nicaragua. *J econ Ent* **83**: 1665-70.
- Dittrich V, Hassan S O and Ernst G H (1985) Development of a new primary pest of cotton in the Sudan: *Bemisia tabaci* (Gennadius) in cotton fields in Israel. *Ecol Appl* **5**: 221-33.
- Dittrich V, Hassan S O and Ernst G H (1986) Development of a new primary pest of cotton in the Sudan: *Bemisia tabaci*, the whitefly. *Agric econ Enviro* **17**: 137-42.
- Dominick J S and Sundaram M M (1992) Susceptibility of *Bemisia tabaci* (Genn.) (Hom.: Aleyrodidae) to insecticides. *Pestology* **16**(2): 5-7.
- Drost Y C, Lenteren V J C and Roermund V H J W (1998) Life-history parameters of different biotypes of *Bemisia tabaci* (Hemiptera: Aleyrodidae) in relation to temperature and host plant: a selective review. *Bull ent Res* **88**: 219-229.
- Dubois M, Miller A, Robert P A and Smith F (1956) Colorimetric method of determination of sugar and related substances. *Anal Chem* **25**: 350-56.
- Duffus J E (1987) Whitefly transmission of plant viruses. In: Harris K F (ed.) *Current Topics in Vector Research*, pp 4: 73-91. Springer Verlag, New York.
- Duffus J E and Flock R A (1982) Whitefly-transmitted disease complex of the desert Southwest. *Calif Agric* **36**: 4-6.
- Elbert A and Naven R (2000) Resistance of *Bemisia tabaci* (Homoptera: Aleyrodidae) to insecticides in Southern Spain with special reference to neonicotinoids. *Pest Mgmt Sci* **56**: 60-64.

- *El-Sayad A E G M and El-Ghar G E S A (1992) The influence of normal and low rate of application of insecticides on population of the cotton whitefly and melon aphid and associated parasites and predators on cucumber. *Anzeiger fur Schadlingskunde Pflanzenschutz* 65: 54-57.
- Eveleens K G (1983) Cotton insect control in the South Gezira: Analysis of a crisis. *Crop Prot* 2: 273-87.
- Flint H M and Parks N J (1989) Effect of Aza from the neem tree on immature Sweetpotato whitefly *Bemisia tabaci* (Homoptera: Aleyrodidae) and other selected species of cotton. *J agric Ent* 6: 211-15.
- Gajendran G (1985) *Effet of sub-lethal doses of insecticides on cotton aphid, Aphis gossypii G. and red cotton bug, Dysdercus cingulatus F.* Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore.
- Gajendran G, Chelliah S and Balasubramanian M (1987) Sub-lethal doses effects of certain insecticides on the cotton aphid, *Aphis gossypii* G. (Homoptera: Aphididae) In: Jayaraj S (ed.) *Resurgence of sucking pests*. pp.160-67. Tamil Nadu Agricultural University, Coimbatore, India.
- *Gameel O I (1974) Some aspects of the mating and oviposition behaviour of the cotton whitefly, *Bemisia tabaci* (Genn.) *R Zool Africane* 88: 784-88.
- Gameel O Z (1978) The cotton whitefly, *Bemisia tabaci* (Genn.) in the Sudan Gezira. *Third CIBA-Geigy Seminar on the Strategy for Cotton Pest Control in the Sudan (Baste)*, 8-10 May 1978, pp. 111-31 (Abstr.).
- Gerling D, Horowitz A R and Baumgartner J (1986) Autoecology of *Bemisia tabaci*. *Agric Ecosyst Environ* 17: 5-19.
- Gerling D and Kravchenko V (1995) Pest management of *Bemisia* out of doors. In: Gerling D and Mayer T (eds.) *Bemisia: 1995, Taxonomy, Biology, Damage, control and management*. pp. 667-80. Intercept U K.
- Gill R J (1990) The morphology of whiteflies. In: Gerling D (ed.) *Whiteflies: Their Bionomics, Pest Status and Management*, pp. 13-46. Wimborne, U K: Intercept.
- *Gondim M T P and Sales F J M (1983) Ciclo Biologico da mosca branca do cajueiro. *Nota Previa. Fitossanidade* 5: 38.
- Gupta G P and Katiyar K N (1991) Bioefficacy of tank-mix insecticides for control of bollworm complex (*Earias spp* and *pectinophora gossypiella*) and whitefly (*Bemisia tabaci*) in upland cotton (*Gossypium hirsutum*) *Indian J. agric. Sci.* 61: 531-34.
- Gupta G P, Katiyar K N, Kirti-Sharma, Sharma K and Singh R P (1999) Neem in the management strategies of insect pests of cotton. In: Saxena R C (ed.) *Azadirachta indica* pp. 177-89.

- Gupta G P, Lal R and Lal R (1998) utilization of newer insecticides of neem in cotton pest management system. *Ann. Pl prot Sci* **6**: 155-60.
- Gupta G P, Mahapatro G K, Kundu S K and Lal R (1998) Impact of abiotic factors on population dynamics of whitefly in cotton. *Indian J Ent* **60**: 293-96.
- Hassan S M, Saad A S and Mansour M H (1974) Effect of certain insecticides on some cotton pests and on cotton plants. *Bull ent Soc Egypte* **8**: 221-26.
- Heinrichs E A (1988) Plant stress-insect interactions. John Wiley and Sons, New York pp.492.
- Hendrix D L, Steele T L and Perekins H H (1995) *Bemisia* Honeydew and cotton. In: Gerling D and Mayer R T (eds.) *Bemisia: 1995, Taxonomy, Biology, Damage Control and management*, pp: 189-99. Intercept UK.
- Hoffman C J and Byrne D N (1986) Effects of temperature and photoperiod upon adult eclosion of the sweet potato whitefly, *Bemisia tabaci*. *Entomol Exp Appl* **42**: 139-43.
- Horowitz A R and Gerling D (1992) Seasonal variation in sex ratio in *Bemisia tabaci* on cotton in Israel. *Environ Entomol* **21**: 556-59.
- Horowitz A R, Forer G and Ishaaya I (1994) Management Resistance in *Bemisia tabaci* in Israel with Emphasis on cotton. *Pestic Sci* **42**: 113-22.
- Horowitz A R, Mendelson Z and Ishaaya I (1997) Effect of abamectin mixed with mineral oil on the sweetpotato whitefly (Homoptera: Aleyrodidae) *J econ Ent* **90**: 349-53.
- Horowitz A R, Podole H and Gerling D (1984) Life table analysis of the tobacco whitefly, *Bemisia tabaci* (Gennadius) in cotton fields in Israel. *Acta Ecol- oecologia* **5**: 331-33 (Original not seen. Abstr in Crop C D: Entry No. 519206, 1984).
- Husain M A, Puri A N and aTrehan K N (1936) Cell sap acidity ;and the incidence of whitefly (*Bemisia gossypiperda*) on cotton. *Curr Sci* **10**: 101-09.
- Husain M A and Trehan K N (1933) Observations on the life history, bionomics and control of whitefly of cotton (*Bemisia gossypiperda* M & L). *Indian J agric Sci* **3**:113-22.
- Iersel M V, Oetting R D, Hall D B and Kang J G (2001) Application technique and irrigation method affect imidaclopride control of silverleaf whitefly (Homoptera: Aleyrodidae) on Poinsettias. *J econ Ent* **94**: 666-71.
- Ilyas M, Puri S M and Rote N B (1991) Effect of some morphophysiological characters of leaf on incidence of cotton whitefly. *J Maharashtra agric Univ* **16**: 386-88.
- Ishaaya I and Ascher K R S (1984) Synergized cypermethrin for controlling the whitefly, *Bemisia tabaci* in cotton. *Phytoparasitica* **12**: 139-43.

- Ishaaya I and Horowitz A R (1995) Pyriproxifen, a novel insect growth regulator for controlling whiteflies: Mechanisms and resistance management. *Pestic Sci* **43**: 227-32.
- Ishaaya I, Mendelson Z and Melamed-Madjar V (1988) Effect of buprofezin on embryogenesis and progeny formation of sweetpotato whitefly (Homoptera: Aleyrodidae) *J econ Ent* **81**: 781-84.
- Jarande N T and Dethle M D (1994) Effective control of brinjal pests by imidacloprid. *Pl Prot Bull* **46**: 43-44.
- Jayaraj S, Rangarajan A V, Murugesan S, Santharam S, Vijayaraghavan and Thangaraj D (1987) Studies on the outbreak of whitefly *Bemisia tabaci* (Gennadius) on cotton in Tamil Nadu. In: Jayaraj S (ed.) *Resurgence of Sucking Pests*. pp. 103-15. Tamil Nadu Agricultural University, Coimbatore, India.
- Jayaswal A P and Singh O P (1987) Resurgence of whitefly on cotton and its management. In: Jayaraj S (ed.) *Resurgence of sucking pests*. pp. 78-84. Tamil Nadu Agric University, Coimbatore, India.
- Johnson M W, Tascano N C, Reynolds H T, Sylvester E C, Kenkido and natwick E T (1982) Whitefly causes problems for Southern California growers. *Calif Agric* **36**: 24-26.
- Jones V P, Toscano N C, Johnson M W, Welter S C and Youngman R R (1986) Pesticide effects on plant physiology: Integration into a pest management program. *Bull Ent Soc Am*: 103-109.
- Jotwani M G, Sarup P, Sircaf P and Singh D S (1966) Control of Jassid (*Empoasca devastans*, Dist.) on Okra (*Abelmoschus esculentus*) seedling by treatment of seeds with different insecticides. *Indian J Ent* **28**: 477-81.
- Kaler D (1999) *Impact of some insecticides on population buildup of whitefly Bemisia tabaci (Genn.) on cotton (Gossypium hirsutum)*. Ph.D. thesis, Punjab Agricultural University, Ludhiana, India.
- Kaler K and Simvat (2001) Effect of different insecticides on the natural enemies complex of cotton whitefly *Bemisia tabaci* (Genn.) In: *Proc. Sym Biocontrol Based Pest Management for Quality Crop protection in the current Millennium*, pp. 175-76, July 18-19, 2001, PAU, Ludhiana.
- Kandil M A, El-Kabbany S M, Sewify G H and Abdallah M D (1991) Efficacy of some insecticides against the cotton whitefly, *Bemisia tabaci* (Gen.) with special regard to their side effect on predators. *Bull ent Sco Egypte Economic Series*, 1991-1992, **19**: 9-17.
- Katiyar K N (1987) Resurgence of cotton whitefly - A Review. In: Jayaraj S (ed.) *Resurgence of sucking pests*. pp. 85-89. Tamil Nadu Agricultural University, Coimbatore, India.

- Khodke S M (1989) *Biology, Seasonal incidence and chemical control of whitefly, Bemisia tabaci (Gennadius) and Bioefficacy of plant extracts against bollworm on cotton*. M.Sc. Thesis submitted to PKV, Akola.
- Krishnaiah N V and Kalode M B (1985) Resurgence of arthropod pests in crop plants. *Asian Farm Chem* **1**: 132.
- Kumar R and Dikshit A K (2001) Imidacloprid: An effective and prospective insecticide – A review. *Pestology* **15**: 36-47.
- Kurhatkar T V (1988) *Studies on biology of whitefly, Bemisia tabaci (Genn.) and seasonal incidence and chemical control of sucking pests on cotton*. M.Sc. Thesis submitted to PKV, Akola.
- Lee Y P and Takahashi T (1966) An improved calorimetric determination of amino acids with the use of ninhydrin. *Anal Biochem* **14**: 71-77.
- Li T, Vinson B S and Gerling D (1989) Courtship and mating behaviour of *Bemisia tabaci* (Homoptera: Aleyrodidae) *Environ Entomol* **18**: 800-06.
- Lopez-Avila A (1986) Taxonomy and biology. In: Cock M J W (ed.) *Bemisia tabaci – a Literature Survey*. CAB International Institute of Biological Control, pp. 3-11.
- Luckey T K (1968) Insecticide Hormoligosis. *J econ Ent* **61**(1): 7-12.
- Mansour F A, Ascher K R S, Abo M F (1993) Effects of Margosan-O, Azatin and RD9-Repelin on spiders and on predacious and phytophagous mite. *Phytoparasitica* **21**: 205-11.
- Mariam A M and Chandramohan N (2000) Evaluation of chemical insecticides and botanical against various stages of spiraling whitefly (*Aleurodicus disperses* Russel) on Mulberry. *Madras agric J* **87**: 379-81.
- Markham P G, Bedford I D, Liu S and Pinner M S (1994) The transformation of geminiviruses by *Bemisia tabaci*. *Pestic Sci* **42**: 123-28.
- *Meganathan P and David B V (1994) Aleyrodid fauna (Aleyrodidae: Homoptera) of Silent Valley, a tropical evergreen rain-forest, in Kerala, India. *FIPAT Eng Serv* **5**: 1-66.
- Misra C S and Lamba K S (1929) The cotton whitefly *Bemisia gossypiperda* n. sp.) *Bull agric Res* **196**: 7.
- Mohan M and Katiyar K N (2000) Impact of different insecticides used for bollworm control on the population of jassid and whitefly in cotton. *Pestic Res J* **12**: 99-102.

- Mohanty A K and Basu A N (1987) Biology of whitefly vector, *Bemisia tabaci* (Genn.) on four host plants throughout the year. *J ent Res* 11: 15-18.
- Mote U N, Datkhile R V and Pawar S A (1993) A new insecticide, imidacloprid, as a seed dresser for the control of sucking pests of cotton. *Pestology* 17(12): 5-9.
- Mound L A (1965) Effect of Leaf hairs on cotton whitefly population in the Sudan Gezira. *Empire Cott Grow R* 42: 33-40.
- Mound L A (1983) Biology and identification of whitefly vectors of plant pathogens. In: Plumb R T and Thresh J M (eds.) *Plant Virus Epidemiology*. pp. 305-13, Oxford, England: Blackwell Scientific.
- Mound L A and Halsey (1978) *Whitefly of the world*, John Wiley and Sons, New York, USA, pp. 340.
- *Murthy K S R K and Ram M G (2000) Studies on the management of cotton pest complex with ecofriendly component neem 1500 ppm (Nivaar EC 1500 ppm) *Pestology* 24(10): 15-18.
- Musuna A C Z (1983) A potentially serious pest, Whitefly. *Zimbabwe agric J* 80:143-146.
- Muthukrishnan N, Ramamoorthy R and Rajamani A (1992) Impact of neem and insecticide formulations against sucking pests of summer cotton. In: *Abs Nat Symp Recent Advance in Integrated Pest Management*. p.107, Indian Society for the advancement of insect science, Punjab Agricultural University, Ludhiana, India.
- Nandihalli B S, Patil B V, Hugar P and Parameshwar H (1992) Influence of synthetic pyrethroids usage on aphid resurgence in cotton. *Karnataka agric Sci* 5: 234-37.
- Naranjo S E, Flint H M and Henneberry T J (1995) Competitive analysis for Selected Sampling Methods for Adult *Bemisia tabaci* (Homoptera: Aleyrodidae) in cotton. *J econ Ent* 88: 1666-78.
- Natarajan K (1990) Natural enemies of *Bemisia tabaci* (Gennadius) and effect of insecticides on their activity. *J Biol Control* 4: 86-88.
- Natarajan K and Shanthi P (1994) Evaluation of neem products against *Helicoverpa armigera*. In: *Abs. 2nd Conf Recent Trends in Pl, Animal and Human Pest Mgt: Impact on Environ* p. 16. Madras Applied Zoologist Research Association, Central Rice Research Institute, Cuttack, India.
- Natarajan K and Sundaramurthy V T (1990) Effect of neem oil on cotton whitefly (*Bemisia tabaci*) *Indian J agric Sci* 60: 290-91.
- Natarajan K, Sundaramurthy V T and Basu A K (1986) Meet the menace of whitefly to cotton. *Indian Fmg* 36: 37-44.

- Natarajan K, Sundaramurthy V T and Chidambaram P (1987) Whitefly and aphid resurgence in cotton as induced by certain insecticides. In: Jayaraj S (ed.) *Resurgence of Sucking Pests*. pp. 137-43, Tamil Nadu Agricultural University, Coimbatore, India..
- Nauen A G, Koob-B, Elbert A (1998) Antifeedant effects of sublethal doses of imidacloprid on *Bemisia tabaci*. *Entomologia-Exp Appl* **88**(3): 287-293.
- Nimbalkar S A, Khodke S N, Taley Y M and Patel K J (1993) Bioefficacy of some insecticides including neem seed extract and neem oil for control of whitefly, *Bemisia tabaci* (Genn.) on cotton. In: Chair M S and Rama Prasad G (eds.) *Botanical Pesticides in Integrated Pest Management*. pp. 343-50, Indian Society of Tobacco Sci., Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh, India.
- Patel H M, Jhala R C, Pandya H V and Patel C B (1992) Biology of whitefly (*Bemisia tabaci*) on okra (*Hibiscus esculentus*). *Indian J agric Sci* **62**: 497-99.
- Patil B V, Nandihalli B S and Hugar P (1990) Effect of synthetic pyrethroids on population buildup of cotton whitefly, *Bemisia tabaci* (Gennadius). *Pestology* **14**(10): 17-21.
- Patil B V, Sreenivas A G, Mujibur-Rahman S and Bheemanna M (1999) Imidacloprid 70 WS seed treatment against early cotton sucking pests: *Pestology* **23**(4): 35-39.
- Pawar A D and Prasad j (1985) Evaluation of some exotic parasites in biological control of cotton bollworms in Haryana. *Indian J Pl Prot* **13**: 21-24.
- Pedigo L P (1999) Entomology and Pest Management. Prentice Hall of India Private :Ltd., New Delhi, pp 691.
- Phadke A D, Khandoel V S and Rahalkar S R (1988) Use of neem products in insect resistance management (IRM) in cotton. *Pesticides* **22**: 36-37.
- Phadke A D and phadke B (2000) Evaluation of Verti-Guard along with conventional and non-conventional insecticides and repellents for control of brinjal whitefly. *Pestology* **24**(5): 28-32.
- Pimpale T D and Summanwar A S (1984) Studies on different stags in the life cycle and influence of season on the duration of different generations of the whitelfy, *Bemisia tabaci* Genn. *Pestology* **8**(2):15-19.
- Powell D A and Bellows T S Jr (1992a) Preimaginal development and survival of *Bemisia tabaci* on cotton and cucumber. *Environ Entomol* **21**: 359-63.
- Powell D A and Bellows T S Jr (1992b) Adult longevity, fertility and population growth rates for *Bemisia tabaci* (Genn.) (Homoptera: Aleyrodidae) on two host plant species. *Appl Ent* **113**: 68-78.

- Prabhakar N, Toscano N C and Coudriet D L (1989) Susceptibility of the immature and adult stages of the sweetpotato whitefly (Homoptera:Alegodidae) in selected insecticides. *J econ Ent* **82**: 983-88.
- Prabhaker N, Toscano N C, Castle S J and Thomas J (1997) Selection for Imidacloprid Resistance in Silverleaf Whiteflies from the Imperial Valley and development of a hydroponic bioassay for resistance monitoring. *Pestic Sci* **51**: 419-28.
- Prabhakar N Toscano N C and Henneberry T J (1998) Evaluation of insecticide rotations and mixtures as resistance management strategies for *Bemisia argentifolii* (Homoptera: Aleyrodidae). *J econ Ent* **91**: 820-26.
- .Prabhaker N, Toscano N C and Henneberry T J (1999) Comparison of neem, urea and amitraz as oviposition suppressants and larvicides against *Bemisia argentifolii* (Homoptera; Aleyrodidae) *J econ Ent* **92**: 40-46.
- Pradan S, Jotwani M G and Sarup P (1960) Control schedule for mustard crop against mustard aphid. *Indian Oilseeds J* **4**: 125-41.
- Prasad V D, Bharati M and Reddy G P V (1993) Relative resistance to conventional insecticides in three populations of cotton whitefly *Bemisia tabaci* (Gennadius) in Andhra Pradesh. *Indian J agric Sci* **21**: 102-103.
- Pruthi H S and Samuel C K (1942) Entomological investigatio on the leaf curl disease of tobacco in Northern India: Biology and population of the whitefly vector, *Bemisia tabaci* (Genn.) in relation to incidence of the disease. *Indian J agric Sci* **12**; 35-37.
- Puri S N, Bhosle b B, Ilyas M, Butler G D Jr and Henneberry T J (1994) Detergents and plant-derived oils for control of the sweetpotato whitefly on cotton. *Crop Prot* **13**: 45-48.
- Purohit M S and Deshpande A D (1991) Effect of inorganic fertilizers and insecticides on population density of cotton whitefly (*Bemisia tabaci*). *Indian J agric Sci* **61**: 696-98.
- Radwan H S A, Ammar I M A, Eisa A A, Assal O M and Omar H J H (1982) Development retardation and inhibition of adult emergence in cotton whitefly, *B. tabaci* (Genn.) following immature stage treatment with two growth inhibitors. *Bull ent Soc Egypt* **13**: 175-81.
- Raguraman S and Singh R P (1999) Biological effects of neem (*Azadiracta indica*) seed oil on an egg parasitoid, *Trichogramma chilonis*. *J econ Ent* **92**(6): 1274-80.
- Raju N, Saivaraj K and Kareem A A (1992) Effect of neem products and insecticides against insect pests on MCU-7 cotton. *All India Coordinated Cotton improvement project* (Silver Jubilee Souvenir), Central Institute of Cotton Research, Nagpur, india, p. 129.

- Raman K, Ganesan S, Vyas B N, Godrej N B and Mistry K B (1993) Development of neem formulations and its evaluation for the control of crop pests. In: *Abst. World Neem Conf*, pp. 154-55, bangalore, India.
- Rao M S and Reddy K D (1999) Non-pesticidal approaches in cotton. IPM –a review. *Agric R Karnal* **20**: 203-19.
- Rao N CH. V, Punnaiah K C, Prasad D V and Krishnaiah P V (1996) Study in the efficacy of certain newer insecticides against brinjal whitefly *Bemisia tabaci* (Genn.). *Pestology* **20**(7): 17-19.
- Rao V N and Reddy A S (1989) Seasonal influence on developmental duration of whitefly (*Bemisia tabaci*) in upland cotton (*Gossypium hirsutum*). *Indian J agric Sci* **59**: 283-85.
- Rao V N, Reddy A S, Ankaiah R and Mukundan S (1989) Effects of whitefly, *Bemisia tabaci* (Genn.) on cotton yield and associated components. *Insect Sci and its appl* **10**: 685-690.
- Rao V N, Reddy A S and Reddy S P (1990) Relative efficacy of some new insecticides on insect pests of cotton. *Indian J Pl Prot* **18**: 53-58.
- Rao V N, Reddy A S and Tirumala Rao K (1991) Influence of spray applications on cotton whitefly, *Bemisia tabaci* (Genn.) *J Cott Res Dev* **5**(1) 67-71.
- Ravindhran R and Anne Xavier (1997) Effect of pyrethroids on resurgence of aphids (*Aphis gossypii* G.) and alteration of plant metabolism in cotton. *Pestic Res J* **9**: 79-85.
- Reddy A S, Rosaiah B, Bhaskara Rao T, Rama Rao B and Rao V N (1986) The problem of whitefly on cotton. *Proc Seminar on Problem of Whitefly on Cotton*, March 14, 1986, Pune.India.
- Reddy A S, Rosaiah B and Rao T B (1985) Control of cotton whitefly in Andhra Pradesh. *Indian Fmg*: 19-22.
- Reddy A S, Rosaiah B and Rao B T (1989) Seasonal occurrence of whitefly, *Bemisia tabaci* (Genn.) on cotton and its control. *Andhra agric J* **36**: 275-79.
- Reddy A S, Reddy O C, Rosaiah B and Rao B T (1987) Studies on the Resurgence of Spider Mites and Whitefly of Cotton. In: Jayaraj S (ed.) *Resurgence of Sucking Pests*. pp. 174-79, Tamil Nadu Agricultural University, Coimbatore, India.
- Regu K, Tamilselvan C, Sundararaj R and David b V (1990) Influence of certain insecticides on the population build up of whitefly *Bemisia tabaci* (Genn.) on cotton. *Pestology* **14**: 8-10.
- Roan C C and Hopkins T L (1961) Mode of action of insecticides. *A R Ent* **6**: 333-46.

- Saini H K (1997) *Effect of synthetic pyrethroids on the biology of whitefly, Bemisia tabaci (Gennadius) on Gossypium hirsutum (Linnaeus)*. M.Sc. thesis, Punjab Agricultural University, Ludhiana, India.
- Sakalbale R V, Dhanerka B K and Puri S N (1991) Chemical control of cotton whitefly, *Bemisia tabaci* (Genn.). *Pestology* 15(6): 40-43.
- Secker A E, Bedford I D, Markham P G and Williams M E C de (1998) Squash, a reliable field indicator of the presence of B-biotype of tobacco whitefly, *Bemisia tabaci*. Brighton Crop Protection: Pests and Diseases Vol.3: *Proc International Conf*. pp 837-842., Brighton, UK, 16-19 Nov 1999.
- Shalaby F F, Abdel-Gawaad A A, El-sayad A M, Abo-El-Ghar, Gawaad A A A and El-Ghar M R A (1990) Natural role of *Eretmocerus mundus* Mercet and *Prospaltella lutea* Masi on populations of *Bemisia tabaci* Genn. *Agric Res Rev* 68: 197-208.
- Shanks Jr C H (1966) Apparent increase in the population of Strawberry aphid caused by phorate and disulfoton. *J econ Ent* 59: 935-37.
- *Sharaf N and Batta Y (1985) Effect of some factors on the relationship between the whitefly, *Bemisia tabaci* Genn. (Homoptera: Aleyrodidae) and the parasitoid *Eretmocerus mundus* (Hymenoptera: Aphelinidae). *Z Angew Entomol* 99: 267-76 (Original not seen. Abstr iun Crop CD: Entry No. 525397, 1985).
- Shelke S S, Mali A R and Ajri D S (1987) Effect of different schedules of insecticidal sprays on pest incidence, yield of seed cotton and quality of seed in Laxmi Cotton. *Curr Res Rep Mahatma Phule agric Univ* 3: 39-45.
- Siddiq S A (1991) Evaluation of neem seed and leaf water extracts and powder for the control of insect pests in the Sudan. *Agric Res Crop Shambat Res Station Tech Bull* 6: 39.
- Simwat G S and Gill B S (1992) Population build-up of cotton jassid and whitefly on *Gossypium arboreum* and its correlation with weather factors. *J Res Punjab agric Univ* 29: 70-76.
- Singh D, Denholm I, Russel D, Sharma N and Sarao P S (1998) Insecticide resistance pattern in whitefly, *Bemisia tabaci* (Gennadius) from Punjab. In: Bakhettia D R C, Dilawari V K, Singh J, Joia B S (eds.) *Proc Critical Issues of IPM in the changing Agricultural Scenario in India*, pp. 26-27, PAU, Ludhiana, India.
- Singh G (2000) *Management of whitefly, Bemisia tabaci (Gennadius) on cotton with neem based insecticides*. Ph.D. thesis, Punjab Agricultural University, Ludhiana, India.
- Singh G, Simwat G S and Sidhu A S (1973) Comparative efficacy of some new insecticides for the control of cotton pests. *Indian J agric Sci* 43: 653-58.

- Singh J and Butter N S (1985) Influence of climatic factors on the build-up of whitefly, *Bemisia tabaci* (Genn.) on Cotton. *Indian J Ent* **47**: 359-60.
- Singh J, Bakhetia D R C, Sohi A S and Brar D S (1998). Progress report of cotton IPM in eleven villages of Lambi block of district Muktsar, Punjab during kharif 1990 crop season. PAU, Ludhiana, India. pp. 13
- Singh J P and Gupta G P (1993) Impact of various insecticides on intermittent population of jassid and whitefly infesting American Cotton during different spray schedules followed for the control of bollworm complex. *J ent Res* **17**: 297-303.
- Singh J, Mahal M S, Rajwant Singh, Brar D S, Dhaliwal Z S and Balraj Singh (1995) A Plan for sampling cotton jassid and whitefly populations on *hirsutum* cotton. *J Res Punjab agric Univ* **32**: 46-50.
- Singh J, Sohi A S, Mann H S and Kapur S P (1994) Studies on whitefly *Bemisia tabaci* (Genn.) transmitted cotton leaf curl disease in Punjab. *J Insect Sci* **7**(2): 194-198.
- Singh J, Singh D, Sohi A S, Brar D S, Kapoor S K and Russel D (1999) Management of resistant insect pests of cotton in north India – an analysis. *Proc ICAC – CCRI Regional consultation insecticide resistance management in cotton*, p. 131-142, June 29 to July1, 1999, Multan, Pakistan.
- Sithanantham S, Jayaraj S and Subramaniam T R (1973) Some changes in the biochemical status of cotton plants due to systemic insecticidal protection, in relation to resurgence of the aphid *Aphis gossypii* Glov. (Homoptera: Aleyrodidae). *Madras agric J* **60**: 512-18.
- Sota N, Motoyama N, Fujisaki K ;and Nakasuji F (1998) Possible amplification of insecticide hormoligosis from resistance in the dimondback moth, *Plutella xylostella* (Lipodoptera: Yponomentidae). *Appl Ent Zool* **33**: 435-40.
- Sreenivas A G and Patil B V (2001) Role of commercial neem products in cotton insect pest management. *J Cott Res Devl* **15**: 58-62.
- Stansley P A and Liu T X (1997) Selectivity of insecticides to *Encarsia Pergandiella* (Hymenoptera: Aphelinidae) an endoparasitoid of *Bemisia argentifolii* (Homiptera: Aleyrodidae). *Bull ent Res* **87**: 525-31.
- Stansley P A, Liu T and Vavrina C S (1998) Response of *Bemisia argentifolii* (Homoptera:Aleyrodidae) to imidacloprid under greenhouse, field and laboratory conditions. *J econ Ent* **91**: 686-92.
- Sudhakar K and Paul M D (1991) Efficacy of conventional insecticides for the control of cotton whitefly (*Bemisia tabaci*) and gram pod borer (*Helicoverpa armigera*) on cotton (*Gossypium* species). *Indian J agric Sci* **61**: 685-87.

- Sudhakar K, Punnaiah K C and Krishnayya P V (1998a) Efficacy of certain selected insecticides on the sucking pest complex of brinjal (*Solanum melongena*) *Indian J Ent* **60**: 241-44.
- Sudhakar K, Punnaiah K C and Krishnayya P V (1998b) Influence of different fertilizers and selected insecticides on the incidence of sucking pest of brinjal. *Indian J Ent* **60**: 245-49.
- Sukhija H S, Butter N S and Singh J (1986) Determination of the economic threshold of whitefly, *Bemisia tabaci* (Genn) on American cotton in Punjab. *Crop Pest Mgmt* **32**: 134-36.
- Sundaramurthy V T and Chitra K (1992) Integrated pest management. *Indian J Pl Prot* **20**: 1-17.
- Surulivelu T (1991) Effect of insecticides on the occurrence and association of whitefly, aphid and parasites on cotton. *J Biol Control* **5**: 4-7.
- Swain T and Hillis W E (1959) The phenolic constituents of *Prunus domestica*. 1. The qualitative analysis of phenolic constituents. *J Sci Food Agric* **10**: 63-68.
- Tamilselvan C, Sundararaj R, Regu K and David D V (1990) Influence of deltamethrin on the biochemical parameters of cotton and biology of the whitefly *Bemisia tabaci* (Genn.). *Pestology* **14**: 17-19.
- Tanweer A and Rao n P (1997) Evaluation of certain integrated pest management components for management of whitefly and American bollworm of cotton. *Pestology* **21**(3): 47-62.
- Thakare H S, Gawande R B, Satpute U S, Saroda D B and Aherkar S K (1986) Problem of whitefly on cotton in Vidarbha region. Seminar on "*Problems of Whitefly on Cotton*", Pune, March 14, 1986.
- Udaiyan K and Ramarathinan S (1994) Bioefficacy of neem derivatives on some major pests of rice, jawar, cotton, groundnut, vegetable and tea. *Pestology* **14**(1): 40-52.
- Uk S and Dittrich V (1986) Behaviore modifying effect of chlordimeform and endosulfan on the adult whitefly, *B. tabaci* (Ginn.) which attacks cotton on the Sudan. *Crop Prot* **5**: 341-347.
- Van Lenteran J C and Noldus J C (1990) Whitefly-plant realationship: behavioural and ecological aspects In: Gerling D (ed.) *Whitefly, Their Binomics, Pest Status and Management*. pp. 47-89, Wimborne, , Intercept, U K.
- Verma R S, Das S V, Mandioy K C and Baldaya A K(1989) Chemical control of whitefly on cotton. *J Cott Res Dev* **3**: 49-50.
- Walunj A R and Mote U N (1995) Evaluation of imidacloprid against thrips and whitefly on tomato. *Pestology* **19**(11): 21-24.
- Wanghoonkong S (1981) Chemical control of cotton pests in Thailand. *Trop Pest Mgmt* **27**: 495-500.

- Yadav D N and Patel A R (1990) Effect of some botanical insecticides on oviposition of *Chrysoperla sceletes* and their ovicidal action. In: Char M S and Ramaprasad G (eds.) *Botanical Pesticides in Integrated pest Management*. pp. 166-69, Indian Soc of Tobacco Sci, Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh, India.
- *Zamora G J E and Gallardo J M (1999) Development and reproduction of *Bemisia tabaci* (Gennadius) (Homoptera; Aleyrodidae) on sweet pepper at three temperatures. *Boletin de Sanidad Vegetal Plagas* **25**(1): 3-11.
- Zolam F G, Natwick E T and Toscano N C (1985) Temperature regulation of *Bemisia tabaci* (Homoptera: Aleyrodidae) population in Imperial Valley cotton. *J econ Ent* **74**: 61-64.¹²

*
original not seen

APPENDIX-1

Weather data during the period of conducting various experiments

Experiment	Date	Temperature (°C)		Mean RH(%)	Mean wind velocity (km/hr)	Rain fall (mm)	Sunshine (hr/day)
		Maximum	Minimum				
Fecundity							
2001 crop season (05.11.2001 to 19.11.2001)							
	05.11.2001	28.6	14.4	54	1.5	0.0	8.4
	06.11.2001	28.5	12.6	64	1.5	0.0	6.7
	07.11.2001	28.0	13.0	67	1.2	0.0	6.3
	08.11.2001	27.6	11.6	63	2.5	0.0	9.3
	09.11.2001	28.2	10.0	59	1.9	0.0	10.2
	10.11.2001	27.7	9.5	59	1.2	0.0	9.2
	11.11.2001	27.4	10.2	71	2.1	0.0	8.4
	12.11.2001	28.4	10.6	75	4.1	0.0	9.6
	13.11.2001	29.4	9.5	62	2.1	0.0	10.3
	14.11.2001	30.6	10.2	58	1.8	0.0	9.5
	15.11.2001	29.5	11.6	64	1.7	0.0	8.6
	16.11.2001	28.6	11.2	69	1.1	0.0	7.6
	17.11.2001	28.6	11.0	68	10.5	0.0	8.7
	18.11.2001	27.6	10.6	67	9.7	0.0	8.8
	19.11.2001	28.5	10.0	67	10.3	0.0	8.6
2002 crop season (03.06.2002 to 11.06.2002)							
	03.06.2002	35.0	23.2	52	3.8	0.0	5.5
	04.06.2002	39.0	23.6	53	2.9	0.0	11.6
	05.06.2002	40.2	26.0	50	7.9	Trace	10.8
	06.06.2002	39.7	24.4	51	4.4	3.4	11.6

Experiment	Date	Temperature (°C)		Mean RH(%)	Mean wind velocity (km/hr)	Rain fall (mm)	Sunshine (hr/day)
		Maximum	Minimum				
Fecundity							
2002 crop season (contd.)							
	07.06.2002	40.5	24.6	58	5.7	0.0	12.3
	08.06.2002	41.8	28.7	56	5.5	0.0	11.5
	09.06.2002	41.5	30.0	53	8.5	0.0	9.5
	10.06.2002	41.5	30.5	49	8.3	0.0	9.2
	11.06.2002	39.0	31.2	57	10.7	8.0	8.8
Longevity							
2001 crop season (15.11.2001 to 22.12.2001)							
	15.11.2001	29.5	11.6	64	1.7	0.0	8.6
	16.11.2001	28.6	11.2	69	1.1	0.0	7.6
	17.11.2001	28.6	11.0	68	1.4	0.0	8.7
	18.11.2001	27.6	10.6	67	2.3	0.0	8.8
	19.11.2001	28.5	10.0	67	0.9	0.0	8.6
	20.11.2001	28.0	9.8	61	2.0	0.0	9.4
	21.11.2001	27.6	8.8	62	1.5	0.0	9.5
	22.11.2001	27.4	9.2	67	1.2	0.0	8.8
	23.11.2001	26.5	9.5	67	2.4	0.0	8.8
	24.11.2001	27.4	9.8	67	0.9	0.0	8.0
	25.11.2001	26.4	8.8	69	1.3	0.0	7.2
	26.11.2001	25.6	9.2	65	2.5	0.0	9.3
	27.11.2001	25.0	8.4	68	1.8	0.0	8.2

Experiment	Date	Temperature (°C)		Mean RH(%)	Mean wind velocity (km/hr)	Rain fall (mm)	Sunshine (hr/day)
		Maximum	Minimum				
Longevity							
2001 crop season (contd.)							
	28.11.2001	24.0	8.2	16.1	59	1.7	8.0
	29.11.2001	24.0	8.0	16.0	69	1.4	8.2
	30.11.2001	24.5	7.4	15.9	70	3.9	9.0
	01.12.2001	23.8	9.6	16.7	65	3.0	9.0
	02.12.2001	23.6	8.4	16.0	67	3.1	8.5
	03.12.2001	25.0	8.2	16.6	68	2.2	8.8
	04.12.2001	25.4	9.0	17.2	69	1.4	7.8
	05.12.2001	24.6	9.6	17.1	72	2.6	9.0
	06.12.2001	23.6	7.6	15.6	69	2.3	9.1
	07.12.2001	24.2	8.2	16.2	72	1.7	9.0
	08.12.2001	23.4	8.0	15.7	71	1.9	8.4
	09.12.2001	24.0	7.0	15.5	70	2.5	8.8
	10.12.2001	22.6	8.2	15.4	69	7.6	7.5
	11.12.2001	22.4	10.8	16.6	75	4.1	7.2
	12.12.2001	20.2	8.6	14.4	87	2.1	6.1
	13.12.2001	22.4	8.0	15.2	74	2.2	8.0
	14.12.2001	22.2	9.2	15.7	73	3.2	1.7
	15.12.2001	14.6	13.6	14.1	87	2.2	0.0
	16.12.2001	20.6	7.2	13.9	81	2.0	9.4
	17.12.2001	21.2	8.4	14.8	80	2.0	8.2

Experiment	Date	Temperature (°C)			Mean RH(%)	Mean wind velocity (km/hr)	Rain fall (mm)	Sunshine (hr/day)
		Maximum	Minimum	Mean				
Longevity								
2001 crop season (contd.)								
	18.12.2001	20.5	9.0	14.7	77	3.2	2.4	6.0
	19.12.2001	19.0	9.2	14.1	89	1.5	0.0	6.0
2002 crop season (10.06.2002 to 28.06.2002)								
	10.06.2002	41.5	30.5	36.0	49	8.3	0.0	9.2
	11.06.2002	39.0	31.2	35.1	57	10.7	8.0	8.8
	12.06.2002	35.5	23.6	29.5	63	6.9	0.0	11.8
	13.06.2002	38.7	27.0	32.9	63	6.6	0.0	11.8
	14.06.2002	35.0	27.2	31.1	69	5.5	2.3	3.0
	15.06.2002	39.5	25.6	32.5	59	8.3	0.0	12.2
	16.06.2002	36.2	27.0	31.6	49	7.5	3.0	10.3
	17.16.2002	34.5	27.9	31.2	67	6.5	1.2	8.0
	18.06.2002	35.5	26.4	30.9	65	7.0	0.0	7.0
	19.06.2002	34.2	25.4	29.8	71	3.5	0.0	4.8
	20.06.2002	38.6	25.0	31.8	65	4.7	0.0	11.6
	21.06.2002	40.2	27.7	33.9	57	4.9	0.0	12.0
	22.06.2002	41.4	28.4	34.9	57	7.0	0.0	12.2
	23.06.2002	39.0	30.8	34.9	63	11.6	0.0	10.5
	24.06.2002	36.2	31.4	33.8	69	11.8	0.0	8.4
	25.06.2002	37.2	29.0	33.1	60	7.2	0.0	8.5
	26.06.2002	37.6	30.2	33.9	58	8.1	0.0	9.6
	27.06.2002	34.6	29.2	31.9	76	6.9	12.2	6.3
	28.06.2002	36.2	28.0	32.1	69	5.0	0.0	11.5

Experiment	Date	Temperature (°C)		Mean RH(%)	Mean wind velocity (km/hr)	Rain fall (mm)	Sunshine (hr/day)
		Maximum	Minimum				
Immature stages and sex ratio							
1 st spray :	21.08.2002 to 12.09.2002	34.6	26.4	30.5	75	0.0	7.5
2 nd spray :	27.08.2002 to 17.09.2002	33.0	26.6	29.8	71	0.0	6.5
3 rd spray :	01.09.2002 to 25.09.2002	34.2	26.0	30.1	78	0.0	6.2
4 th spray :	11.09.2002 to 05.10.2002	35.5	27.2	31.3	65	0.0	9.2
5 th spray :	14.09.2002 to 07.10.2002	34.8	27.4	31.1	67	0.0	11.0
	21.08.2002	34.6	27.0	30.8	70	0.0	11.8
	22.08.2002	35.6	27.2	31.4	67	Trace	6.0
	28.08.2002	34.0	27.4	30.7	81	0.0	2.4
	29.08.2002	34.5	27.0	30.7	80	0.0	3.5
	30.08.2002	34.5	26.0	30.3	73	0.0	9.2
	31.08.2002	34.5	27.0	30.7	81	7.4	4.6
	01.09.2002	31.6	23.5	27.5	84	0.0	5.0
	02.09.2002	32.7	25.6	29.1	91	14.2	5.0
	03.09.2002	29.5	23.0	24.7	84	0.0	6.0
	04.09.2002	33.2	24.0	28.6	73	0.0	10.0
	05.09.2002	33.0	23.2	28.1	69	0.0	10.5

Experiment	Date	Temperature (°C)			Mean RH(%)	Mean wind velocity (km/hr)	Rain fall (mm)	Sunshine (hr/day)
		Maximum	Minimum	Mean				
	06.09.2002	33.5	24.0	28.7	71	3.2	0.0	10.3
	07.09.2002	30.8	22.4	26.6	83	7.8	18.7	5.6
	08.09.2002	30.8	21.6	26.2	73	3.1	0.0	10.0
	09.09.2002	33.4	22.8	28.1	73	2.0	0.0	12.0
	10.09.2002	34.6	23.4	29.0	73	4.5	2.8	9.6
	11.09.2002	33.5	23.4	28.5	69	5.1	0.0	11.7
	12.09.2002	26.0	22.8	24.4	84	7.8	81.3	1.2
	13.09.2002	24.5	21.0	22.7	99	9.5	62.0	0.0
	14.09.2002	29.0	22.0	25.5	86	4.7	4.2	3.0
	15.09.2002	31.4	22.4	26.9	79	1.8	0.0	10.0
	16.09.2002	32.2	23.6	27.9	79	2.6	9.2	10.0
	17.09.2002	31.0	20.4	25.7	79	2.3	0.0	5.3
	18.09.2002	32.7	22.2	27.5	77	3.3	0.0	9.2
	19.09.2002	31.6	20.8	26.2	71	1.8	0.0	10.6
	20.09.2002	31.6	22.0	26.8	76	3.4	0.0	11.0
	21.09.2002	32.8	21.4	27.1	73	3.7	0.0	11.0
	22.09.2002	34.0	21.6	27.8	69	2.0	0.0	11.8
	23.09.2002	33.4	24.2	28.8	72	1.6	0.0	9.2
	24.09.2002	33.0	23.0	28.0	73	5.3	0.6	10.6
	25.09.2002	32.2	20.8	26.5	58	3.2	0.0	9.6
	26.09.2002	33.0	18.6	25.8	64	4.3	0.0	10.7

Experiment	Date	Temperature (°C)			Mean RH(%)	Mean wind velocity (km/hr)	Rain fall (mm)	Sunshine (hr/day)
		Maximum	Minimum	Mean				
	27.09.2002	33.2	19.0	26.1	67	2.0	0.0	9.5
	28.09.2002	34.0	20.0	27.0	65	2.1	0.0	10.5
	29.09.2002	34.4	19.8	27.1	62	2.3	0.0	8.0
	30.09.2002	33.6	19.5	26.5	65	3.3	0.0	10.6
	01.10.2002	34.5	17.8	26.1	60	3.6	0.0	11.0
	02.10.2002	35.4	17.6	26.5	61	2.7	0.0	11.0
	03.10.2002	36.0	19.0	27.5	57	1.6	0.0	10.5
	04.10.2002	36.0	18.2	27.1	62	1.7	0.0	11.0
	05.10.2002	35.8	18.8	27.3	57	2.0	0.0	10.3
	06.10.2002	34.4	19.8	27.1	67	1.6	0.0	10.3
	07.10.2002	34.2	18.2	26.2	45	3.2	0.0	10.0
Attractiveness and oviposition								
August 2001 experiment								
(20.08.2001 to 27.08.2001)								
	20.08.2001	34.6	27.2	30.9	73	1.4	0.0	5.2
	21.08.2001	35.2	28.5	31.9	77	2.7	0.0	4.9
	22.08.2001	34.6	27.2	30.9	79	3.1	0.0	11.3
	23.08.2001	34.6	27.6	31.1	73	4.3	51.6	10.5
	24.08.2001	32.4	22.2	27.3	83	6.6	0.0	7.2
	25.08.2001	34.0	25.2	29.6	81	2.4	0.0	8.8
	26.08.2001	34.2	26.4	30.3	75	3.0	0.0	11.3
	27.08.2001	35.2	26.6	30.9	69	2.4	0.0	12.0

Experiment	Date	Temperature (°C)		Mean RH(%)	Mean wind velocity (km/hr)	Rain fall (mm)	Sunshine (hr/day)
		Maximum	Minimum				
September 2001 experiment (11.09.2001 to 08.09.2001)							
	11.09.2001	35.0	24.4	73	3.9	0.0	10.5
	12.09.2001	34.8	24.2	75	3.0	0.0	8.2
	13.09.2001	34.4	23.0	69	2.9	0.0	10.5
	14.09.2001	32.2	25.0	77	5.8	8.4	5.5
	15.09.2001	30.8	19.4	71	4.0	0.0	6.2
	16.09.2001	32.2	20.6	73	2.7	0.0	10.8
	17.09.2001	33.6	21.4	74	2.6	0.0	10.6
	18.09.2001	35.0	22.5	71	1.6	0.0	10.4

Source : Department of Agronomy and Agrometeorology, PAU, Ludhiana.

VITA

Name of Student : Abdallh Nasher Morshed Mokbal
Father's name : Mr. Nasher Morshed Mokbal
Mother's name : Mrs. Lol Abdullah Mohamed
Nationality : Yemen
Date of Birth : 21.12.1965
Permanent Home Address : Wadi Al-madam,
P.O. Box 55702,
Taiz,
Yemen Republic

EDUCATIONAL QUALIFICATION

Bachelor's degree : B.Sc. Agri. (Pesticides)
University and year of award : Cairo University (Egypt)
1990
OGPA/OCPA/% marks : 76.47 %
Master's degree : M.Sc. Agri. (Entomology)
University and year of award : University of Agricultural Sciences(UAS),
Bangalore (India)
1998
OGOAO/OCPA/% marks : 8.34
Ph.D. : in Entomology
OCPA : 74.1 %
Title of Ph.D. Thesis : Hormoligosis of insecticidal sprays in *Bemisia tabaci* (Genn.) on cotton