

**STUDIES ON SEASONAL INCIDENCE OF PEST
COMPLEX AND ROLE OF MICRONUTRIENTS
AGAINST MAJOR INSECT PESTS OF TOMATO**

(Lycopersicon esculentum Mill.)



THESIS

Submitted to the



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In partial fulfillment of the requirement

For the Degree of

MASTER OF SCIENCE

In

AGRICULTURE

(Entomology)

By

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2007

CERTIFICATE – I

This is to certify that the thesis entitled “**Studies on seasonal incidence of pest complex and role of micronutrients against major insect pests of tomato (*Lycopersicon esculentum* Mill.)**” submitted in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE (Entomology)** of **Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur** is a record of the bonafide research work carried out by **Mr. Santosh Kumar Barfa** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instruction.

No part of thesis has been submitted for any other degree or diploma (Certificate awarded etc.) or has been published/ published part has been fully acknowledged. All the assistance and help received during the course of the investigation has been dully acknowledged by him.

Place: Jabalpur

Date 14/09/07



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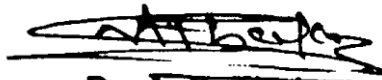
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CERTIFICATE – II

This is to certify that the thesis entitled "Studies on seasonal incidence of pest complex and role of micronutrients against major insect pests of tomato (*Lycopersicon esculentum* Mill.)" submitted by Mr. Santosh Kumar Barfa to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfillment toward the requirement for the degree of "MASTER OF SCIENCE IN AGRICULTURE" in the Department of ENTOMOLOGY has been approved by the Student's Advisory Committee and the External Examiner's (s) after an oral examination on the same.

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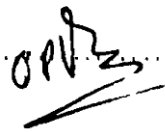
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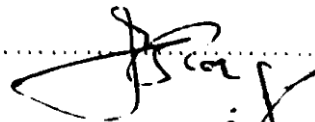
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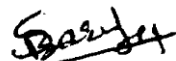
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Place: Jabalpur

Date: 14/09/07



(Santosh Kumar Barfa)

CHAPTER - I
INTRODUCTION

INTRODUCTION

Tomato (*Lycopersicon esculentum* Miller) is one the most popular and widely grown vegetable in the world. It is grown in all seasons and is the second most important crop among vegetables. Tomato fruits are eaten raw or cooked. It is used for preparation of soup, ketchup, paste and powder etc. Tomato is known for its outstanding nutritive value and contains sodium 45.6 mg, sulphur 24 mg, chlorine 38 mg, vitamin A 320 IU, calcium 20 mg, magnesium 15 mg and phosphorus 36 mg.

Tomato is also rich in medicinal value. The pulp and juice are digestible, mild apparent, promoter of gastric secretion and blood purifier. It is also considered to be intestinal antiseptic.

Total area under tomato crop in the country is assessed 4.66 million hectares with a total yield of about 8.272 million tones and an average yield of 16-17 tones/ha. In Madhya Pradesh, tomato is cultivated in an area of 23 thousand hectares with an average total yield of about 0.52 million tones (*The Hindu Survey, 2005*).

Tomato farming for profit cannot be imagined without adequate protection from principal enemies such as insects, fungus, weeds and mites. Among the above enemies insect pests are major because all parts of the plant offer food, shelter and reproduction site for insect.

The tomato agro-ecosystem is characterized by having a few major key pests and many minor or secondary pests. A complete list of all the insects and arthropod pests of tomato in the world is not available but would probably include between 100 and 200 species. (Langeand Bronson, 1981).

Insects attack tomatoes from the time of planting until the fruit is harvested. Insect can cause unthrifty growth or death of the tomato plant and damage to fruit in the form of scarring tissue destruction and aberration in shape or colour. Fruit can become contaminated by insect excreta and insect parts. Insect can also introduce decay organism in to fruit or can act as vector for many viruses and several mycoplasmas that cause growth disorder or death of the plant.

The major insect pests, which play most important role in the economic losses of tomato crop, are as follow:

Whitefly

Bemisia tabaci Genn. (Aleurodidae: Hemiptera) is a serious pest of tomato crop. It is a polyphagous pest and vector of mosaic like leaf curl caused by Gemini virus.

The damage is caused by both nymphs and adults. They suck the plant sap from lower surface of the leaves. The severe infestation resulting premature defoliation and plant become unable for flowering and fruiting. The losses caused by these insects and disease varied from 50-92.3 %.

Aphid

Aphis gossypii Glover (Aphididae: Hemiptera) is a serious pest of tomato crop. The damage is caused by both nymphs and adults that suck plant sap from the lower surface of leaves causing curling of leaves and leading to stunted growth of the plants. They excrete honey dew on the leaves inviting culture of the black mould which adversely affects photosynthesis. Infestation is higher in the young plants than the older ones.

Leaf miner

Liriomyza trifolii Burgess, (Agromyzidae: Diptera) is a serious pest of tomato crop. It was introduced in India during 1990-91 through imported chrysanthemum cuttings. It is a polyphagous pest feeding on the crops. The maggot is minute (2mm), orange yellow in colour. The maggot feeds in between two epidermal layers of the leaf and makes serpentine mines. Extensive leaf mining activity reduces photosynthetic process of plants, defoliation and produce unmarketable fruits. The losses caused by the leaf miner varied from 25-40 %.

Fruit borer

Helicoverpa armigera Hubner (Noctuidae: Lepidoptera) is a polyphagous and key pest of tomato throughout M.P., India and abroad. It feeds on tomato, gram, maize, okra, pigeonpea, sunflower etc. The larvae cause the damage to the tomato fruits. It bores the fruit and half body of larva

insert in to them and feed inner part resulting low production as fruits become unmarketable and unsuitable for human consumption. Losses from this pest varied from 40-50% fruit yield in M.P., Himachal Pradesh (35-45 %), Tamilnadu 40-50, and 23-38%

Various methods are used for controlling insect pests in tomato like chemicals, botanicals, use of resistant cultivars etc., of which the only practical method to control the pests is by chemical insecticides. However, it leaves a film of persistent insecticides poison over the foliage and fruits which is hazardous and uneconomical too. While micronutrients are cheap and affordable for small scale farmers compared to synthetic pesticides.

Micronutrients are generally safer to use. Micronutrients indirectly affect various insect pests. Hence "Studies on seasonal incidence of pest complex of tomato and role of micronutrients against major insect pests of tomato (*Lycopersicon esculentum* Miller)" was conducted with the following objectives:

1. To record the seasonal incidence of major insect pests of tomato.
2. To study the role of foliar spray of micronutrients against major insect pests of tomato.

CHAPTER - II
REVIEW OF
LITERATURE

REVIEW OF LITERATURE

The available literature relevant to the present studies has been reviewed as under the following headings.

Major insect pests in tomato

Dhamdhare (1990) mentioned *Bemisia tabaci* and *Helicoverpa armigera* as regular pests.

Salas (1992) recorded *Liriomyza* spp. as major pest in tomato.

Srinivasan (1993) reported white fly and fruit borers as major pests of tomato.

Nair (1995) mentioned *Helicoverpa armigera* as more destructive pest.

Gravena (1999) reported that *Bemisia tabaci*, *Helicoverpa armigera* and *Liriomyza trifolii* as major pests of tomato crop.

Rudednko *et al.* (2001) reported that *Helicoverpa armigera* had been major insect pests of tomato.

Reddy and Kumar (2004) a total of 41 insect species, belonging to 21 families, were recorded. These include the defoliators *Spodoptera litura*, *Monolepta andrawesi*, *Poekilocerus pictus* and *Atractomorpha crenulata*, leaf miner *Liriomyza trifolii*, sucking insects *Bemisia tabaci*, *Aphis gossypii*, *Myzus persicae* and *Nezara viridula*, stem feeders *Euzophera pericella* and *Leucinodes orbonalis* and fruit borers *Helicoverpa armigera* and *Othreis fullonia* [*Eudocima fullonia*].

Incidence of major insect pests in tomato

Wilcox *et al.* (1956) reported that the percentage of fruit damage caused by *Helicoverpa armigera* was highest at the beginning of the picking season.

Kadu *et al.* (1987) reported that the number of eggs laid per female and hatching percentage of eggs of *Helicoverpa armigera* increased with the rise in temperature per degree centigrade.

Yano *et al.* (1989) observed that the population growth rate of green house white fly in tomato was strongly affected by temperature.

Jagannatha (1994) found that the population of *Liriomyza trifolii* was negatively correlated with relative humidity ($r = -0.77$), wind velocity ($r = -0.53$) and rainfall ($r = -0.84$). However, it was positively correlated with minimum temperature in Bangalore.

Bagmare *et al.* (1995) found that the mean temperature and sunshine hours had a positive correlation with the population of *Liriomyza trifolii* on tomato, whereas rainfall and relative humidity had negative association with the population of leaf miners.

Jaglan and Kalra (1995) resulted that 55 and 91 plants were appropriate sample size for estimating the total fruits and damaged fruits per plant by *Helicoverpa armigera*, respectively, at the permissible error margin of 15%.

Borah (1996) studied cv. Arkavikas produced the highest mean yield of 6.69 t/ha. It had the lowest percentage (17.3%) of leaf curl through virus infestation, but had a higher level of infestation by *B. tabaci* and *H. zea* than cv. Arkalook.

Singh *et al.* (1996) studied the role of abiotic factors in seasonal abundance of the pest and reported that 84 - 92 per cent variability in the population of *Liriomyza trifolii* could be accounted by weather factors especially sunshine hours and rainfall at Hissar.

Wang and Tsai (1996) found that temperature effects on the development and reproduction of whitefly on brinjal.

Sharma and Sharma (1997) conducted a survey on food plants and pest status of agronomizid *Liriomyza trifolii* in Jabalpur district and identified 59 types of plants including vegetables, pulses, oilseeds, ornamentals, medicinal plants and weeds to be infested.

Walgenbach (1997) studied total yield did not vary significantly among treatments; yields were consistently lower by aphid in the control, 65, and

100% threshold treatments. Fruit quality was statistically highest in the 10 and 25 threshold treatments.

Prasad (1997) showed that wheat, barley, chickpea, pea, tomato, pigeon pea and lentil were infested by *Helicoverpa armigera*. Damage to tomato and pigeon pea was moderate.

Arnal *et al.* (1998) observed that the adult whiteflies (*Bemisia tabaci*) were present throughout the growing period in the course of the study in tomato field and concluded that their population was higher at the end of rainy season.

Men *et al.* (1998) reported that *Phaseolus vulgaris* grown on experimental farm, Akola, Maharashtra in 1991 was found to be attacked by *Liriomyza trifolii*.

Reddy *et al.* (1998) also reported the rapid multiplication of cotton white fly on brinjal at a temperature range of 29°C, 33°C and high rainfall suppressed the pest.

Oscar *et al.* (1999) reported that lower threshold temperature for development and oviposition were at 8°C and approximately 11°C, respectively. Optimum temperature for development and reproduction was 25°C for *Liriomyza trifolii*.

Samersov and Poplawskaya (1999) reported that the highest number of the leaf miner was observed at the glasshouses of the Minsk region. At the greenhouses the pest greatly damaged tomatoes. The peak of activity was in July.

Marcano and Issa (2000) observed that the larger number of larval populations for *Liriomyza trifolii* on tomato crop were present on the lower and middle stardum of plants and female preferred to oviposition on the first 5 leaflets of the leaf.

Chaudhuri *et al.*, (2001) observed the following pests were found to attack persistently in all 3 years studied: aphid (*Aphis gossypii*), whitefly (*Bemisia tabaci*), leaf miner (*Liriomyza trifolii*), tinged bug (*Urentius hystriellus*) and fruit borer (*Helicoverpa armigera*). Leaf miner and fruit borer

pests of tomato and damaged the crop both in winter and spring-summer season. Insect incidence and crop damage were higher in the spring-summer than in the winter season and Abinash-II was more susceptible than Pusa ruby. The high levels of infestation during spring-summer resulted in much lower yields in the spring-summer crop than in the winter crop (27.15 and 58.62 t/ha, respectively, in the control treatment).

Chaudhuri *et al.* (2001) studied the highest population density (1.68 white flies per plant) was observed during mid-February. High infestation levels were maintained from mid-February to mid-March when temperature, relative humidity (RH), sunshine h per day and rainfall were 17.07-22.13 degrees C, 65.29-72.78%, 7.79-8.9 h per day and 5 mm, respectively.

Umeh *et al.* (2002) a survey of some tomato producing areas of Nigeria indicated that the major insects attacking tomato included the fruit borer *Helicoverpa armigera*, the grasshopper *Zonocerus variegatus*, the whitefly *Bemisia tabaci*, and various species of aphids, mostly *Aphis gossypii*.

Asalatha (2002) reported that leaf infestation (%) by leaf miner and pest populations on leaf miner were correlated with meteorological parameters. She found that both were positively correlated with maximum temperature and sunshine hours and negatively correlated with relative humidity and minimum temperature.

Lee-DooHyung (2004) studied the incidence of the foliar leaf mines was examined three times in the commercial tomato greenhouse. The mine numbers in each tomato leaflet varied from 1 to 9, but the leaflets with 2 mines were the most frequent case.

Hath and Das (2004) observed that the peak population of aphid, during the first week of March, the population was 4.47 and 6.66 aphids/5 leaves in Pusa Ruby and Abinash-II, respectively. The highest leaf miner infestation was observed during the second week of April, being 70.65 and 59.54% in Pusa Ruby and Abinash-II, respectively. The peak fruit borer damage was recorded during the first week of April, and 23.97 and 12.12% fruits were damaged (in number) in Pusa Ruby and Abinash-II, respectively.

The maximum (76.67%) leaf infestation by leaf miner was recorded at middle of the March while the white fly population peaked (13 flies/10 cm twigs) during first week of March and the fruit borer population peaked (26 larvae/10 plant) in the third week of March (Kharpuse. 2005)

Role of micronutrients against major insect pests of tomato

Oliveira *et al.* (1995) studied yields were highest in plants supplied with NPK + dolomite or NPK + dolomite + calcium. Calcium and dolomite application both reduced the percentage of fruits with styler decay whereas boron application reduced yields and increased the percentage of fruits with styler decay.

Jauset *et al.* (1998) determined the influence of nitrogen application on feeding and oviposition site selection by green house w.f. (*Trialeurodes vaporariorum*) adults. The number of adults was higher on the plants supplied with high nitrogen. Within plants, adult distribution was affected by leaf position, the upper plant stratum being preferred feeding. *Trialeurodes vaporariorum* females selected for oviposition and laid more eggs on plants and leaves of plants with high nitrogen and water contents.

EL Rafie (2000) reported the plants treated with high levels of N (ammonium sulphate, 21% N) had increased numbers of *Bemisia tabaci* & decreased yields. A mixture of moderate levels of N with potassium sulphate and phosphorus resulted in low population of *B. tabaci* & increased yield.

Berlinger and Wermelinger (2001) studied life history-parameters of whitefly (*Trialeurodes vaporariorum*) and reported that longevity and fecundity increased with higher N-levels in the nutrient solution, whereas the development time decreased. Overall population growth was faster on high N plants than on low N plants.

Inbar *et al.* (2001) studied that the adult whitefly oviposition was not affected by either vigour or punching but was reduced on the other plants. Leaf miner feeding and oviposition, and corn earworm larval growth rates were higher on the vigorous plants and lower on the punched, no fertilizer, and no water and no fertilizer host plants

Leite *et al.* (1998) recorded that increasing N and K fertilization increased the leaf miner *Tuta absoluta* oviposition rate on *Lycopersicon hirsutum*. Reduced oviposition was observed on leaves in the apical and mid parts of 4 month old *L. hirsutum* plants. The greatest amount of oviposition was recorded on leaves in the apical and mid parts of *L. esculentum* plants. No significant effects of the treatments on adult mortality were observed.

Leite *et al.* (1999) reported that the effect of fertilization on leaf miner (*Tuta absoluta*) oviposition attack was also studied. The increase in fertilization with N&K did not reduce the concentration of 2-TD (trideca-2-nona) & 2-UD (undeca-2-nona) in the leaves of *Lycopersicon hirsutum* nor its resistance to *T. absoluta*. In *L. esculentum* plants with low levels of fertilization, greater oviposition by the insect was observed and an increase in fertilization with N & K favored attack by *T. absoluta*.

Leite *et al.* (1999) recorded different N K fertilization levels had no effect on the resistance of *Lycopersicon hirsutum* to *Aculops lycopersici*. No significant differences were found in *A. lycopersici* attack rates on leaves of the top and median parts of the *L. hirsutum* showed a high resistance level to *A. lycopersici* due to high densities of type VI glandular trichomes and consequently higher levels of tridecan-2-one in its leaves.

Leite *et al.* (1999) reported that the plants fertilized with 120 kg/ha of K were more infested by *Aculops lycopersicia*. There was a direct relationship between mite infestation & the levels of P applied to the soil. At a K level of 120 kg/ha the infestation increased with P levels. At N levels of 60 & 180 kg/ha the infestation increased, whereas at 120 kg/ha, it was reduced. However the N P interaction presented a low effect on the infestation at higher levels of N. The levels of N & P applied to the soil were positive & significantly correlated to the content found in the tomato leaves. No significant correlation was observed with regard to K.

Gertz and Batch (1994) studied light and nutrients, however, each influenced how herbivory affected plant growth. Defoliation by larvae of *Manduca sexta* significantly decreased growth rate only under condition of low light and high nutrients. Thus, plants appeared to compensate for

damage, in terms of biomass, only under condition of either low light and / or low nutrients.

Klotz *et al.* (1998) evaluated in the laboratory for use against ant (*Linepithema humile*), boric acid bait showed a significant and continues reduction (80%) of argentine ants.

CHAPTER - III
MATERIAL AND
METHODS

MATERIALS AND METHODS

The present investigation entitled, "Studies on seasonal incidence of pest complex and role of micronutrients against major insect pests of tomato (*Lycopersicon esculentum* Miller)" was carried out at the Department of Entomology, College of Agriculture, J.N.K.V.V., Jabalpur during rabi season 2006-07.

Location:

The field experiments were conducted during rabi season of 2006-07 at the Seed Breeding Farm, Adhartal, Department of Horticulture, JNKVV, Jabalpur, M.P.

Geographical location and climate:

Jabalpur is situated between 22° 49" and 24° 8" North latitude and 78° 21" and 80° 58" East longitude and at an altitude of 411.78 m above the mean sea level.

The climate of the region is typically semi-humid and sub-tropical. Jabalpur comes under the agro-climatic region of Kymore Plateau and Satpura Hills and lies in rice-wheat crop zone of the state. The mean annual rainfall is nearly 1423 mm, which is received mostly between mid-June to mid-September. The mean maximum temperature during the hottest months of May and June varies from 45.5 to 46.4°C. January is the coldest month with maximum and minimum temperatures of 24.4°C and 7.3°C, respectively.

The weather conditions during the course of studies i.e. from December 2006 to April 2007 are given in table 3.1 and Fig.1.

**Table 3.1: Weekly meteorological observation during rabi season
(November - April) 2006-07 at Jabalpur**

Date	Temperature		Rainfall (mm)	No. of rainy days	Relative Humidity (%)
	Max.	Min.			
29-06 Dec. 06	26.4	12.8	1.3	-	63.5
07-13 Dec. 06	29.1	14.0	0.0	-	62.0
14-20 Dec. 06	26.1	10.5	0.0	-	60.0
21-27 Dec. 06	25.1	8.1	0.0	-	64.5
28-03 Jan 07	25.1	8.9	0.0	-	66.5
04-10 Jan 07	24.1	7.8	0.0	-	63.5
11-17 Jan. 07	24.8	9.0	0.0	-	62.5
18-24 Jan. 07	24.0	7.0	0.0	-	58.5
25-31 Jan. 07	26.3	7.3	0.0	-	57.0
01-07 Feb. 07	29.2	13.4	0.0	-	60.5
08-14 Feb. 07	27.7	13.1	55.3	2	66.5
15-21 Feb. 07	25.3	12.5	27.8	2	66.0
22-28 Feb. 07	28.7	11.8	0.3	-	59.0
01-07 Mar. 07	27.7	11.3	1.0	-	61.5
08-14 Mar. 07	29.0	11.3	0.0	-	52.5
15-21 Mar. 07	30.4	15.3	46.6	2	58.0
22-28 Mar. 07	34.7	17.7	0.0	-	58.5
29-04 Apr. 07	35.4	16.0	0.0	-	42.0
05-11 Apr. 07	38.1	18.1	0.0	-	41.0
12-18 Apr. 07	38.6	19.9	0.0	-	31.5
19-25 Apr. 07	37.8	24.0	1.7	-	40.0
26-30 Apr. 07	40.2	29.6	0.0	-	24.5

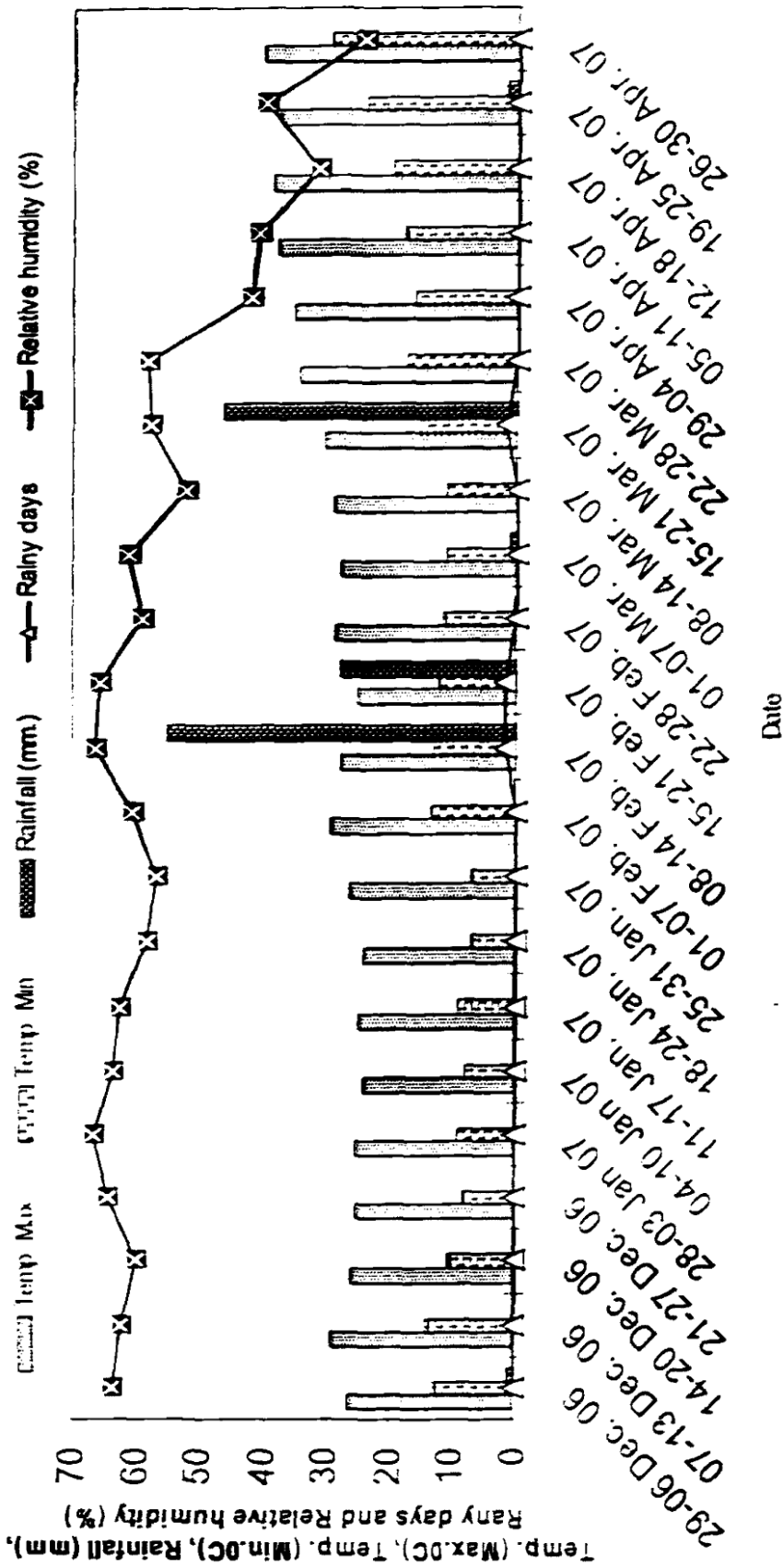


Fig. 1 Meteorological data during crop session (Nov.2006 to April 2007)

Plot specification:

1)	Design	:	Randomized Block Design
2)	Number of treatments	:	9
3)	Number of replications	:	3
4)	Plot size	:	3.6 x 3.0 m (10.8 m ²)
5)	Number of plots	:	9 x 3 = 27
6)	Distance between replications	:	1 m
7)	Plot to plot distance	:	0.5 m
8)	Plant to plant distance	:	40 cm
9)	Row to row distance	:	60 cm
10)	Variety	:	Jawahar tomato 99
11)	Date of transplanting	:	12-12-2006

The experiment was laid out in two sets

1. For seasonal incidence.
2. For effect of micronutrients

Experiment No.1: Studies on seasonal incidence of major insect-pests of tomato:

Tomato variety jawahar tomato-99 was used for studying the seasonal incidence of major insect pests. The observations on the appearance of major insect pests were recorded from transplanting to harvest of the crop at weekly (7 days) interval as per procedure approved.

Method of observation:

1. **White fly:** The observations were taken on one selected twig of 10 cm in each plant at 5 randomly selected plants. Each twig was covered carefully with transparent polythene bags. The numbers of nymph and adult flies were counted in each twig.
2. **Aphid:** Number of aphids per 10 cm/twig was recorded on 5 randomly selected plant/plot throughout the crop season.

FIRST SET

SECOND SET

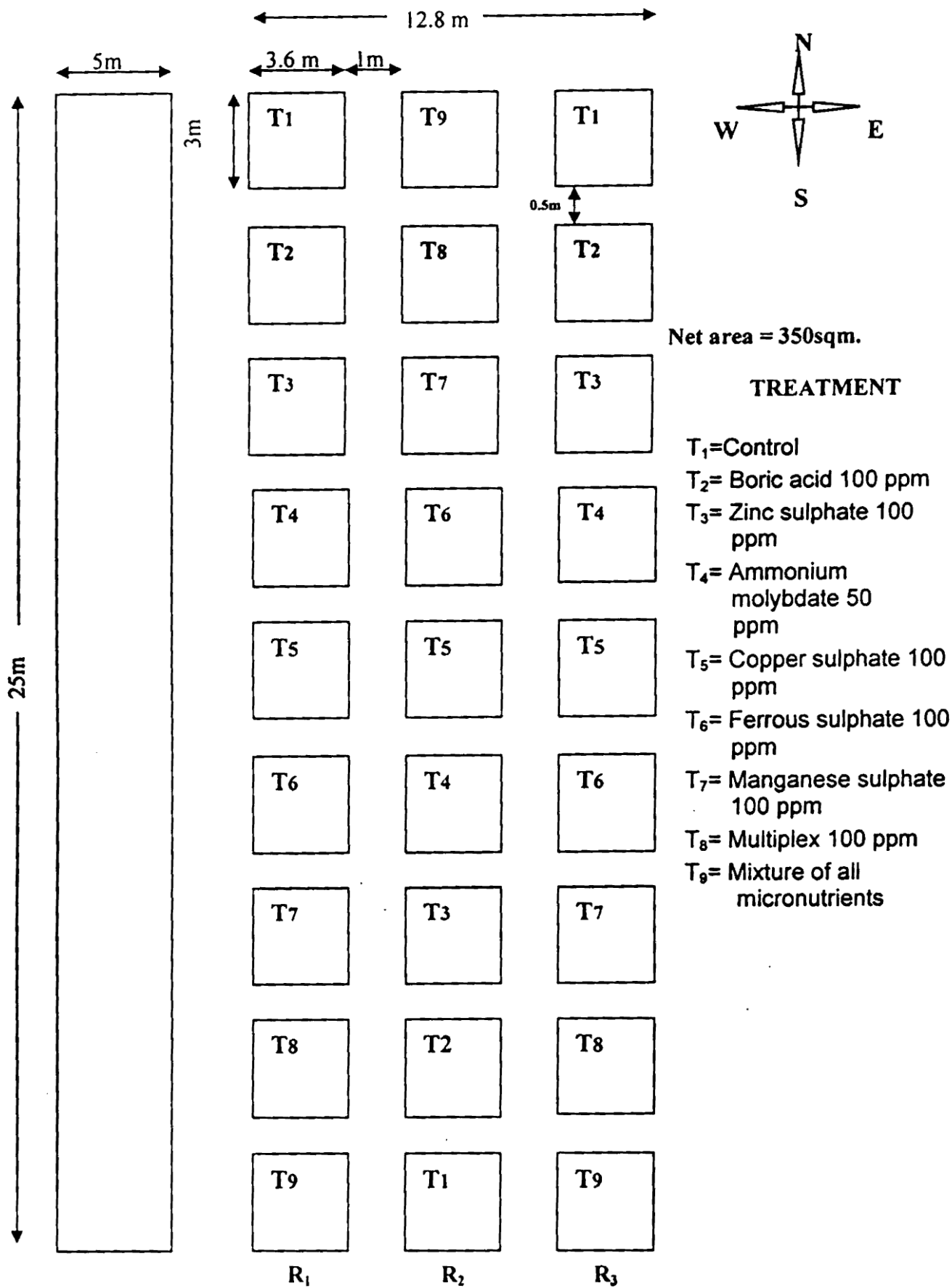


Fig. Layout of the plot

3. Leaf miner: 5 plants were selected at random and three leaves (upper, middle and lower) in every plant were observed for the incidence of leaf miner.
4. Fruit borer: Number of larvae was counted at 5 randomly selected plant/plot. For the percentage of damage fruit in the total fruit and damage fruit was recorded on that 5 randomly selected plant/plot at each picking.

Experiment No.2: Role of micronutrients against major insect pests of tomato:

The experimental details are given below:

Number of treatments:

S.No.	Name of micronutrients	Doses
1.	Control (N P K recommended)	120:60:80 kg/ha
2.	Boric acid	100 ppm
3.	Zinc sulphate	100 ppm
4.	Ammonium molybdate	50 ppm
5.	Copper sulphate	100 ppm
6.	Ferrous sulphate	100 ppm
7.	Manganese sulphate	100 ppm
8.	Commercial formulation (multiplex)	100 ppm
9	Mixture of all micronutrients (mm)	-

Method of observation:

The pre-treatment observation was recorded at 24 hours before spraying, while the post treatment observations were recorded on 3rd and 7th days after each spray.

1. White fly: The observations were taken on one selected twig of 10 cm in each plant at 5 randomly selected plants. Each twig was covered carefully with transparent polythene bags. The numbers of nymph and adult flies were counted in each twig.

2. Aphid: Number of aphids per 10 cm/twig was recorded on 5 randomly selected plant/plot throughout the crop season.
3. Leaf miner: 5 plants were selected at random and three leaves (upper, middle and lower) in every plant were observed for the effect of micronutrients.

Fruit borer:

- (i) Record of larval population: The observations were taken on 5 randomly selected plants per plot. The number of larvae was physically recorded at pre-treatment and 3 days and 7 days after post treatment.
- (ii) Percentage of damaged fruits: After picking, the numbers of damaged and healthy fruits were observed to calculate the damage percentage.

Statistical analysis:

The insect population data were transformed to square root transformation as $\sqrt{x + 0.5}$. The percentage data were transformed in to angular transformation (Arcsin). The values so obtained were analysed to test significant variation among different treatments.

The skeleton of analysis of variance table is given below:

Skeleton of analysis of variance (ANOVA)

Source of variation	D.F.	SS	MSS	F. cal.	F. tab.
Treatment	t - 1				
Block	r - 1				
Error	(t-1) (r-1)				
Total	(r t - 1)				

The differences between means were subjected to further testing by computing CD at 5% probability level.

The following formulae were used to various estimation:

1. **Standard error for observation mean:**

$$S. Em_{\pm} = \frac{\sqrt{EMS}}{r}$$

2. **Critical difference (C.D.):**

$$C.D. = S E (m) \times \sqrt{2} \times t (5\%)$$

Coefficient of Correlation:

$$r(X, Y) = \frac{\text{Cov} (X, Y)}{\sigma_X \sigma_Y}$$

If $(x_i, y_i); i = 1, 2, \dots, n$ is the bivariate distribution, then

$$\text{Cov} (X, Y) = E\{[X-E(X)][Y-E(Y)]\}$$

$$= 1/n \sum (x_i - \bar{x})(y_i - \bar{y})$$

$$\sigma_X^2 = E\{X-E(X)\}^2 = 1/n \sum (x_i - \bar{x})^2$$

$$\sigma_Y^2 = E\{Y-E(Y)\}^2 = 1/n \sum (y_i - \bar{y})^2$$

* * *

CHAPTER - IV

RESULTS

RESULTS

This chapter deals with the experimental results which are elucidated in the following headlines:

1. Incidence of major insect pests in tomato:

Survey was conducted on tomato crop from November 2006 to April, 2007. During the course of study, following major insect pests were recorded.

S. No	Common name	Scientific name	Order	Family
1.	White fly	<i>Bemisia tabaci</i> (Genn.)	Hemiptera	Aleurodidae
2.	Aphid	<i>Aphis gossypii</i> (Glover)	Hemiptera	Aphididae
3.	Leaf miner	<i>Liriomyza trifolii</i> (Burgess)	Diptera	Agromyzidae
4.	Fruit borer	<i>Helicoverpa armigera</i> (Hub.)	Lepidoptera	Noctiudae

White fly:

White flies were observed to suck the cell-sap from the lower surface of leaves and spread leaf curl disease virus. It appeared during last week of December and remained active until the crop was harvested. Population peaked (12 flies/5 twigs of 10 cm) during first week of February when the maximum and minimum temperature was 29.2 and 13.4°C respectively with 87 per cent morning and 34 per cent evening relative humidity and zero mm rainfall (Table 4.1 and 2).

Correlation of white fly population with meteorological parameters revealed was non-significant.

Correlation was observed between white fly population and temperature minimum, rainfall, rainy days, sunshine hours, wind speed,

evaporation, vapour pressure morning negatively but was found non-significant, further positive correlation was observed between white fly population and temperature maximum, relative humidity morning, relative humidity evening and vapour pressure evening but were found to be non-significant. (Table 4.2)

Aphid:

Aphids were observed to suck the cell-sap from the leaves and stem. It appeared during last week of December and remained active till crop was harvested. Population peaked (24/5 twigs of 10 cm) during first week of February when the maximum and minimum temperature was 29.2 and 13.4°C, respectively with 87% morning and 34% evening relative humidity and zero mm rainfall (Table 4.1 and Fig 2).

Correlation was observed between aphid population and temperature (minimum), rainfall, rainy days, sunshine hours, wind speed, evaporation, vapour pressure morning negatively but, was found non-significant. Further, positive correlation was observed between aphid population and temperature (maximum), relative humidity (morning), relative humidity (evening) and vapour pressure (evening) but, were found to be non-significant. (Table 4.2)

Leaf miner:

Leaf miner appeared on the crop on 29th December. Its apodous maggot was found damaging the crop by making whitish zig-zag tunnels between the epidermal layers of leaf which could be seen by holding the leaf against bright-light. The maximum (27 mines/3 leaves/5 plants) was recorded at second week of the March when the average maximum and minimum temperature was 29 and 11.3°C, respectively with 81 per cent morning and 24 per cent evening relative humidity and zero mm rainfall. (Table 4.1 and Fig.2).

Correlation was observed between leaf miner population and relative humidity (morning) negatively but was found non-significant. Further, positive correlation was observed between leaf miner population and temperature (maximum), temperature (minimum), relative humidity (evening), rainfall, rainy days, sunshine hours, wind speed, evaporation, vapour pressure

(morning) and vapour pressure (evening) but, were found to be non-significant. (Table 4.2)

Table 4.1: Incidence of major insect pests on tomato (December 2006 to March 2007)

Months	Intervals (Date)	White fly	Aphid	Leaf miner	Fruit borer
		Population/5 twigs of 10 cm	Population/5 twigs of 10 cm	No. of mines/3 leaves/5 plants	Larvae /5 plants
December	28	6	10	6	-
January	4	8	12	5	-
	11	8	10	4	-
	18	5	8	7	-
	25	10	18	10	-
February	1	12	24	12	2
	8	5	6	15	5
	15	5	5	17	7
	22	9	10	20	8
March	1	10	14	24	11
	8	8	10	27	13
	15	5	6	22	14
	22	4	6	25	15
	29	-	-	-	16
Overall mean		7.46	10.69	15.15	10.11

Fruit borer:

Caterpillar of this pest was observed feeding on tomato fruits by making holes. The pest infestation commenced from first week of February and gradually increased till the crop was harvested. Population peaked (16 larvae/5 plants) in the last week of March. At that time the average maximum and minimum temperature were 35.4 and 16°C, respectively with 68 per cent morning and 16 per cent evening relative humidity and zero mm rainfall (Table 4.1 and Fig. 2).

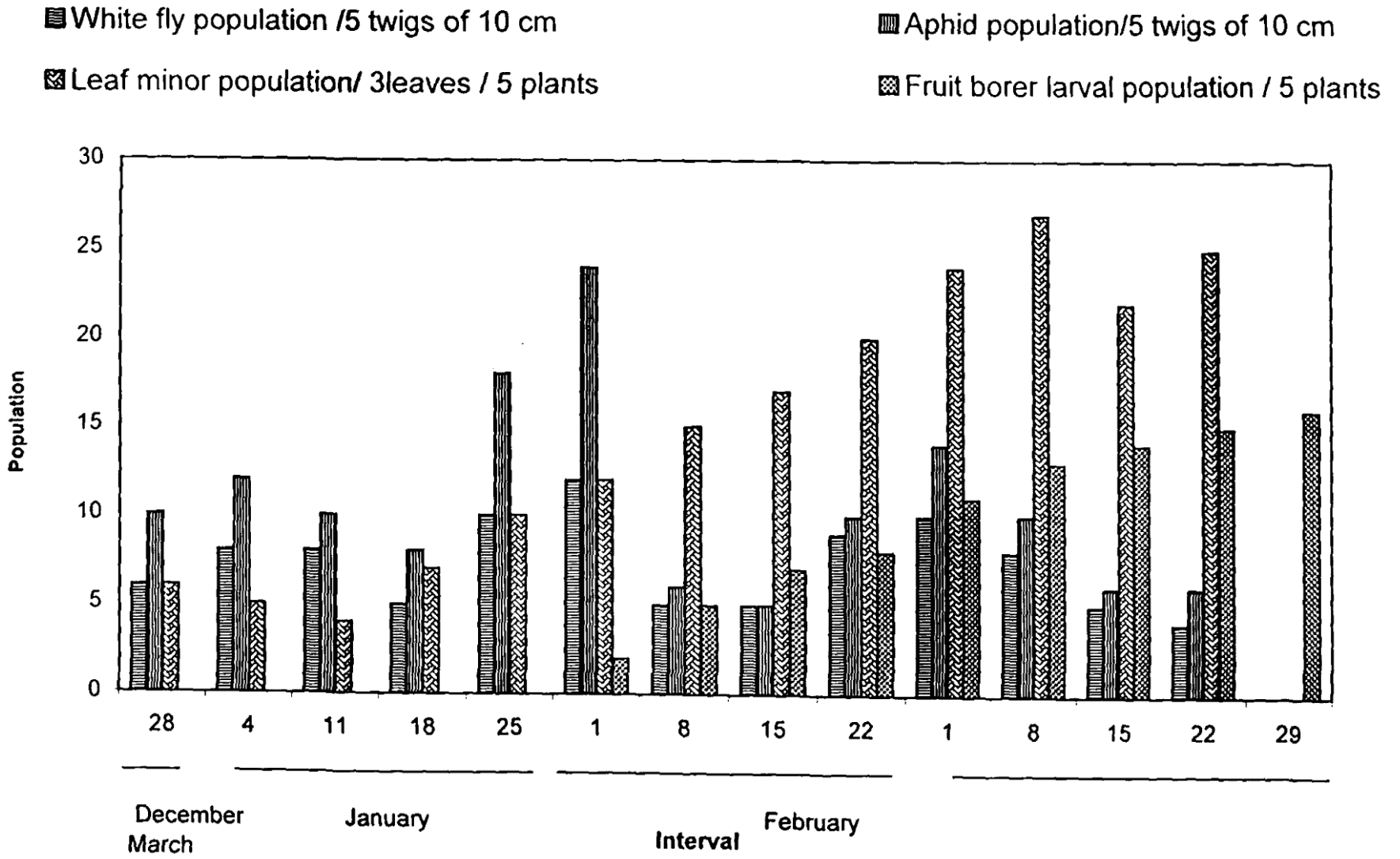


Fig. 2: Incidence of insect pests on tomato

Table 4.2: Correlation coefficient of different insects with meteorological parameters

Parameters	White fly			Aphid			Leaf miner			Fruit borer		
	r value	T calculated		r value	T calculated		r value	T calculated		r value	T calculated	
Temperature °c (max.)	0.357	1.29	NS	0.268	0.96	NS	0.342	1.25	NS	-0.26	0.71	NS
Temperature °c (min.)	-0.450	1.74	NS	-0.398	1.50	NS	0.421	1.60	NS	0.495	1.49	NS
Relative humidity mor (%)	0.510	2.04	NS	0.418	1.59	NS	-0.159	0.55	NS	-0.438	1.28	NS
Relative humidity eve (%)	0.326	1.19	NS	0.190	0.66	NS	0.051	0.17	NS	-0.661	2.32	NS
Rainfall (mm)	-0.295	1.11	NS	-0.360	1.33	NS	0.246	0.87	NS	-0.213	0.57	NS
Rainydays	-0.312	1.13	NS	-0.389	1.46	NS	0.254	0.9	NS	-0.222	0.6	NS
Sunshine hours	-0.045	0.15	NS	-0.056	0.19	NS	0.217	0.76	NS	0.473	1.41	NS
Wind speed (km/hours)	-0.110	0.38	NS	-0.272	0.97	NS	0.357	1.26	NS	0.107	0.28	NS
Evaporation	-0.375	1.38	NS	-0.453	1.75	NS	0.268	0.96	NS	0.361	1.02	NS
Vapour pressure mor.	-0.420	1.59	NS	-0.391	1.46	NS	0.460	1.79	NS	0.233	0.63	NS
Vapour pressure eve.	0.215	0.76	NS	0.165	0.57	NS	0.421	1.60	NS	-0.224	0.60	NS
T tabulated at 5 %	2.17			2.17			2.17			2.36		

NS= Non-significant

Correlation was observed between fruit borer population and temperature (maximum), relative humidity (morning), relative humidity (evening), rainfall, rainy days, vapour pressure (evening) negatively but, was found non-significant. Further, positive correlation was observed between fruit borer population and temperature (minimum), sunshine hours, wind speed, evaporation and vapour pressure (morning) but, were found to be non-significant.(Table 4.2)

2. Role of micronutrients against major insect pests:

White fly:

The pre-treatment population of white fly was recorded uniform (2.33 to 3.33/5 twigs of 10 cm) in different treatments with non-significant differences (Table 4.3 and Fig. 3).

After 1st spray:

3 days: White fly population in all treatments were significantly lower than untreated control (3.66/5 twigs of 10 cm). Among different treatments, mixture of all micronutrients and manganese sulphate had significantly less (0.66 flies and 1.00/5 twigs of 10 cm) population than all other treatments.

7 days: All the treatments registered significantly lower pest population than untreated control (3.33/5 twigs of 10 cm). Among different treatments, mixture of all micronutrients, manganese sulphate, ferrous sulphate and zinc sulphate had less white fly population (0.66 to 1.33/5 twigs of 10 cm) than rest of the treatments.

After 2nd spray:

3 days: Significantly less white fly population was recorded in all the treatments than untreated control (4.33/5 twigs of 10 cm). However, among different treatments, mixture of all micronutrients and sulphate had significantly less population (0.66 and 1.33/5 twigs of 10 cm) than other treatments.



Plate 1: White fly infestation on tomato leaf



Plate 2: Aphid infestation on tomato leaf

Table 4.3: Role of micronutrients against white fly on tomato

Treatment	Doses	Pre treatment observation	Population of nymph and adult /5 twigs of 10 cm (Mean of three replications)						Overall Mean
			First spraying		Second spraying		Third spraying		
			3days after	7 days after	3days after	7 days after	3days after	7 days after	
Control	-	3.00 (1.85)	3.66 (2.03)	3.33 (1.95)	4.33 (2.19)	3.33 (1.95)	3.33 (1.95)	4.33 (2.19)	3.61 (4.11)
Boric Acid	100 ppm	2.66 (1.77)	2.00 (1.55)	2.33 (1.67)	1.66 (1.46)	2.33 (1.67)	1.00 (1.16)	2.00 (1.55)	1.83 (1.52)
Zinc sulphate	100 ppm	2.33 (1.67)	2.00 (1.55)	1.33 (1.34)	2.66 (1.77)	2.00 (1.55)	1.66 (1.46)	2.33 (1.67)	1.99 (1.57)
Ammonium molebdate	50 ppm	3.00 (1.85)	1.66 (1.46)	2.00 (1.55)	3.66 (1.85)	4.00 (2.11)	1.33 (1.34)	2.00 (1.55)	2.27 (1.66)
Copper sulphate	100 ppm	2.33 (1.67)	1.33 (1.34)	2.33 (1.67)	1.66 (1.46)	2.33 (1.67)	1.33 (1.34)	2.00 (1.58)	1.83 (1.52)
Ferrous sulphate	100 ppm	2.66 (1.77)	1.33 (1.34)	1.33 (1.34)	2.66 (1.77)	2.00 (1.67)	1.66 (1.43)	2.00 (1.58)	1.83 (1.52)
Manganese sulphate	100 ppm	3.00 (1.85)	1.00 (1.22)	0.66 (1.04)	1.33 (1.34)	1.33 (1.34)	1.00 (1.16)	1.33 (1.34)	1.11 (1.26)
Commercial formulation (Multiplex)	100 ppm	2.66 (1.76)	2.00 (1.58)	1.66 (1.46)	2.33 (1.67)	2.33 (1.67)	1.66 (1.46)	2.00 (1.55)	1.99 (1.57)
Mixture of all micronutrients	-	3.33 (1.94)	0.66 (1.04)	0.66 (1.04)	0.66 (1.04)	1.33 (1.34)	0.66 (1.04)	1.00 (1.16)	0.83 (1.15)
S.Em _±	-	NS	0.15	0.13	0.10	0.12	0.13	0.15	0.05
C.D. at 5%	-	-	0.45	0.41	0.31	0.38	0.41	0.45	0.17

NS= Non-significant.

Figures in parentheses are transformed value = $\sqrt{X + 0.5}$

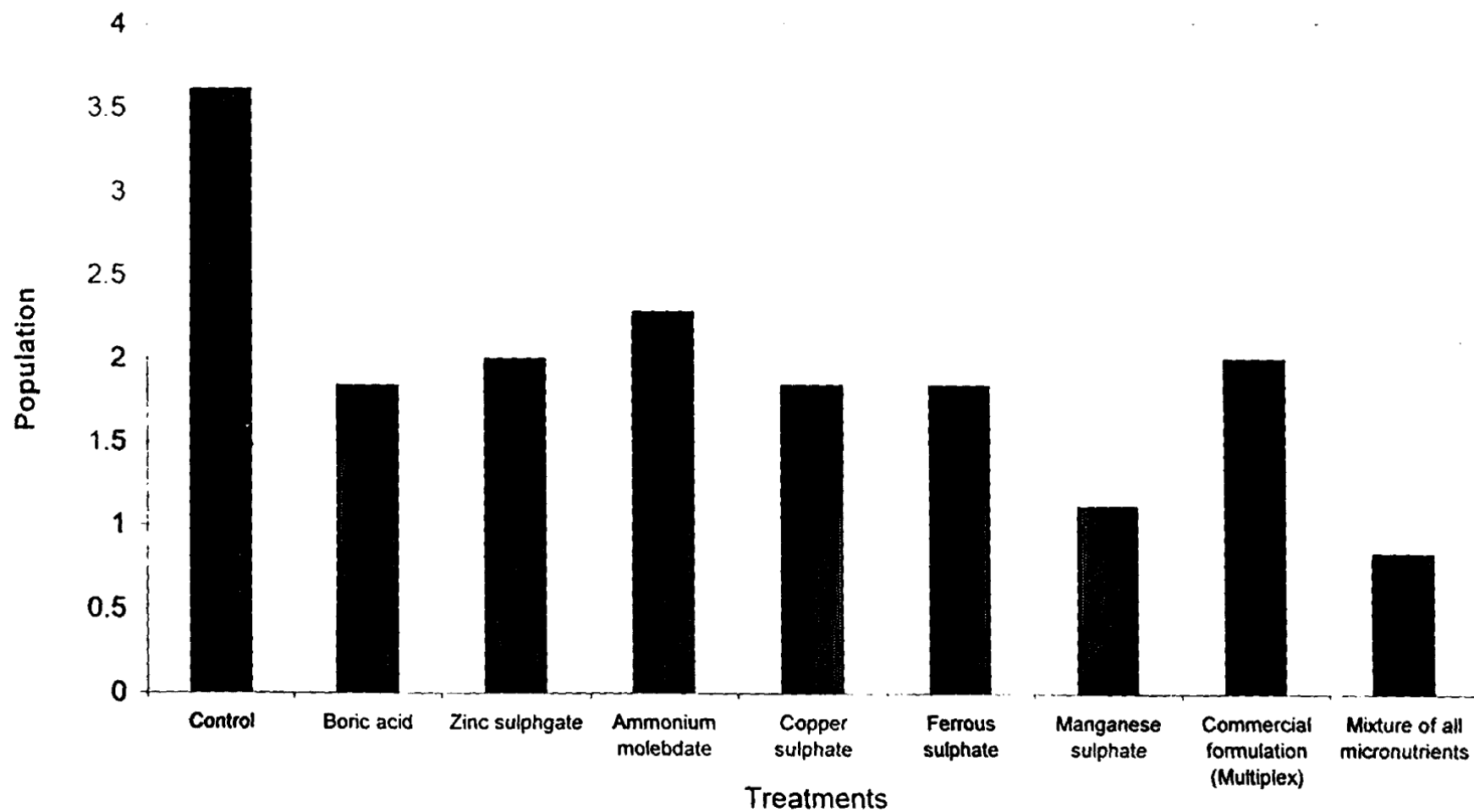


Fig.3: Average whitefly population/5 twigs of 10 cm in different micronutrients treatments

7 days: All the treatments had significantly less white fly population than untreated control (3.33/5 twigs of 10 cm) except ammonium molybdate (4.00/5 twigs of 10 cm).

After 3rd spray:

3 days: All the treatments had significantly less white fly population than untreated control (3.33/5 twigs of 10 cm). Among different treatments, the lowest white fly population (0.66 to 1.33/5 twigs of 10 cm) was recorded in the plots treated with mixture of all micronutrients, manganese sulphate, boric acid, ammonium molybdate, copper sulphate and they were at par with each other.

7 days: All the treatments registered significantly lower white fly population than untreated control (4.33/5 twigs of 10 cm). The lowest white fly population (1.00/5 twigs of 10 cm) was recorded in the treatment of mixture of all micronutrients, followed by manganese sulphate (1.33/5 twigs of 10 cm) and both had significantly less population than rest of the treatments.

Overall mean effect:

All the treatments had significantly less population than untreated control (3.61/5 twigs of 10 cm). Among the different treatments, mixture of all micronutrients and manganese sulphate had significantly less (0.83 and 1.11 flies/5 twigs of 10 cm) white fly population (Table 4.3 and Fig. 3).

Aphid:

The pre-treatment population of aphid was (4.66 to 6.00/5 twigs of 10 cm) in different treatments with non-significant differences (Table 4.4 and Fig 4).

After 1st spray:

3 days: Aphid populations in all treatments were significantly less than untreated control (6.00/5 twigs of 10 cm). Among different treatments, manganese sulphate, mixture of all micronutrients, ferrous sulphate and multiplex were at par and had significantly less (0.66 to 2.00 aphids/ 5 twigs of 10 cm) population than all other treatments.

Table 4.4: Role of micronutrients against aphid on tomato

Treatment	Doses	Pre treatment observation	Population of nymph and adult /5 twigs of 10 cm (Mean of three replications)						Overall Mean
			First spraying		Second spraying		Third spraying		
			3days after	7 days after	3days after	7 days after	3days after	7 days after	
Control	-	6.00 (2.48)	6.33 (2.60)	8.00 (2.90)	6.00 (2.53)	7.00 (2.72)	5.33 (2.40)	5.00 (2.33)	6.27 (2.60)
Boric Acid	100 ppm	4.66 (2.26)	5.33 (2.40)	4.00 (2.11)	1.33 (1.34)	2.66 (1.77)	1.00 (1.16)	1.66 (1.46)	2.66 (1.77)
Zinc sulphate	100 ppm	5.00 (2.30)	2.33 (1.64)	1.66 (1.43)	2.00 (1.67)	2.66 (1.73)	1.33 (1.34)	2.66 (1.77)	2.11 (1.61)
Ammonium molybdate	50 ppm	5.33 (2.37)	2.66 (2.77)	1.66 (1.46)	3.00 (1.85)	5.66 (2.47)	1.33 (1.34)	2.00 (1.55)	2.71 (1.79)
Copper sulphate	100 ppm	5.33 (2.40)	2.66 (1.76)	1.33 (1.34)	2.00 (1.67)	3.00 (1.85)	1.33 (1.34)	2.33 (1.67)	2.11 (1.61)
Ferrous sulphate	100 ppm	5.00 (2.33)	1.33 (1.34)	1.00 (1.16)	2.00 (1.67)	2.66 (1.76)	2.00 (1.55)	2.00 (1.55)	1.83 (1.52)
Manganese sulphate	100 ppm	5.33 (2.40)	0.66 (1.04)	0.66 (1.04)	1.33 (1.34)	2.00 (1.67)	0.66 (1.04)	1.00 (1.22)	1.05 (1.24)
Commercial formulation (Multiplex)	100 ppm	5.66 (2.44)	2.00 (1.55)	1.33 (1.34)	2.33 (1.67)	2.66 (1.76)	1.66 (1.46)	1.66 (1.46)	1.94 (1.56)
Mixture of all micronutrients	-	5.00 (2.22)	1.00 (1.16)	1.00 (1.16)	1.00 (1.16)	2.00 (1.67)	0.66 (1.04)	1.00 (1.22)	1.22 (1.31)
S.Em±	-	NS	0.17	0.17	0.16	0.17	0.12	0.15	0.04
C.D. at 5%	-	-	0.57	0.53	0.50	0.52	0.38	0.47	0.14

NS= Non-significant.

Figures in parentheses are transformed value = $\sqrt{X + 0.5}$

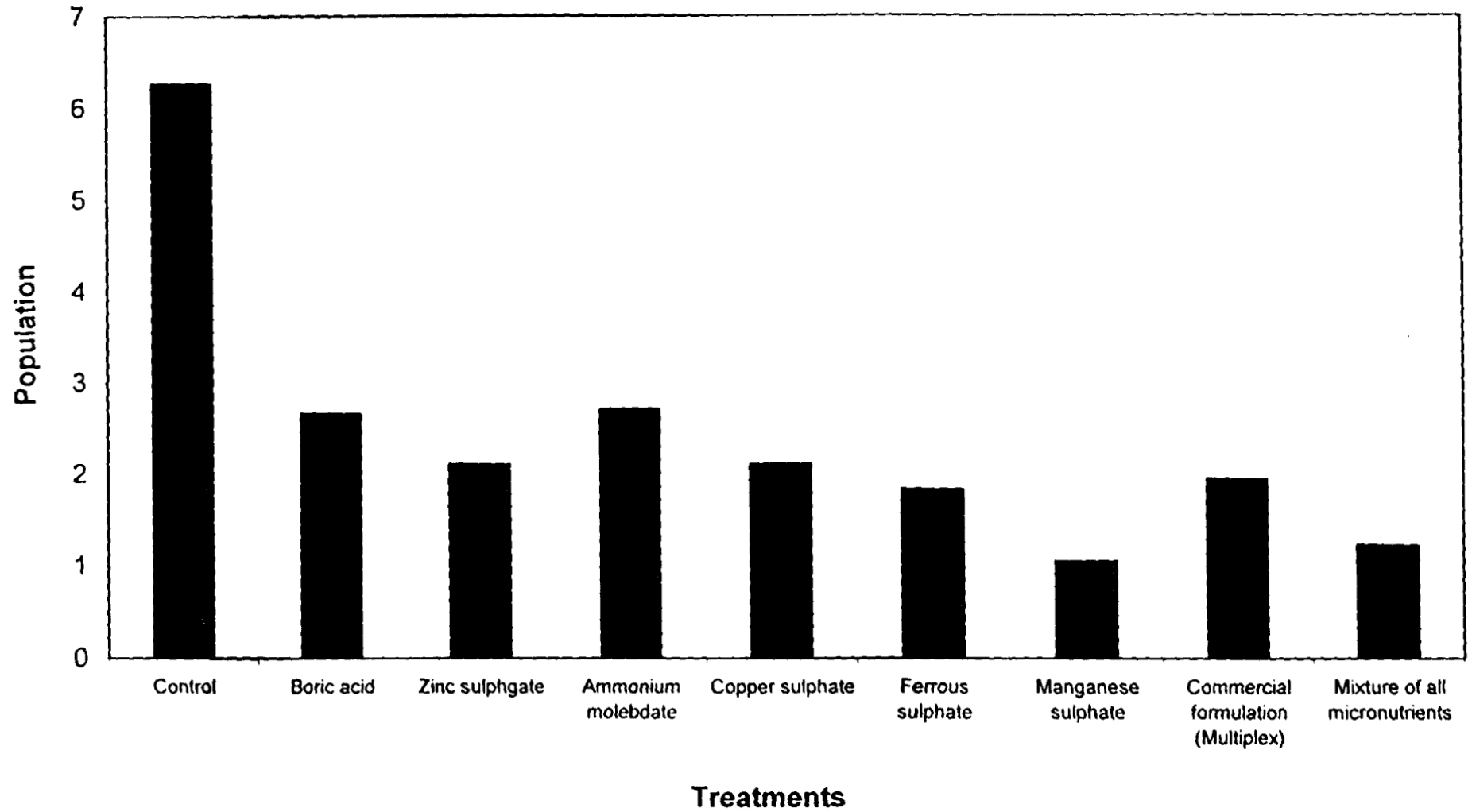


Fig. 4: Average aphid population/5 twigs of 10 cm in different micronutrients treatments

7 days: All treatments had significantly less population than untreated control (8.00/5 twigs of 10 cm). The significantly less population (0.66 to 1.66/5 twigs of 10 cm) was observed in all the treatments except boric acid (4.00/5 twigs of 10 cm)

After 2nd spray:

3 days: All the treatments registered significantly less aphid population than untreated control (6.00/5 twigs of 10 cm). Among different treatments, mixture of all micronutrients, manganese sulphate and boric acid were at par to each other with (1.00 to 2.00/5 twigs of 10 cm) aphid population.

7 days: All the treatments had significantly less aphid population than untreated control (7.00/5 twigs of 10 cm) except ammonium molybdate (5.66/5 twigs of 10 cm).

After 3rd spray:

3 days: All the treatments registered significantly less aphid population than untreated control (5.33/5 twigs of 10 cm). The significantly less population (0.66 to 1.33/5 twigs of 10 cm) was observed in all the treatments except multiplex (1.66/5 twigs of 10 cm) and ferrous sulphate (2.00/5 twigs of 10 cm)

7 days: All the treatments registered significantly less aphid population than untreated control (5.00/5 twigs of 10 cm).

Over all mean effect:

All the micronutrients had significantly less aphid population than untreated control (6.27//5 twigs of 10 cm). Among the different treatments, manganese sulphate and mixture of all micronutrients had significantly less (1.05 to 1.22/5 twigs of 10 cm /) aphid population (Table 4.4 and Fig 4).

Leaf miner:

The pre-treatment observation showed that there were quite high (0.66 to 1.33/3 leaves/5 plants) mines and it increased gradually throughout the crop season. The differences in pre-treatment leaf miners among different treatments were non-significant (Table 4.5 and Fig. 5).



Plate 3: Leaf miner infestation on tomato leaf



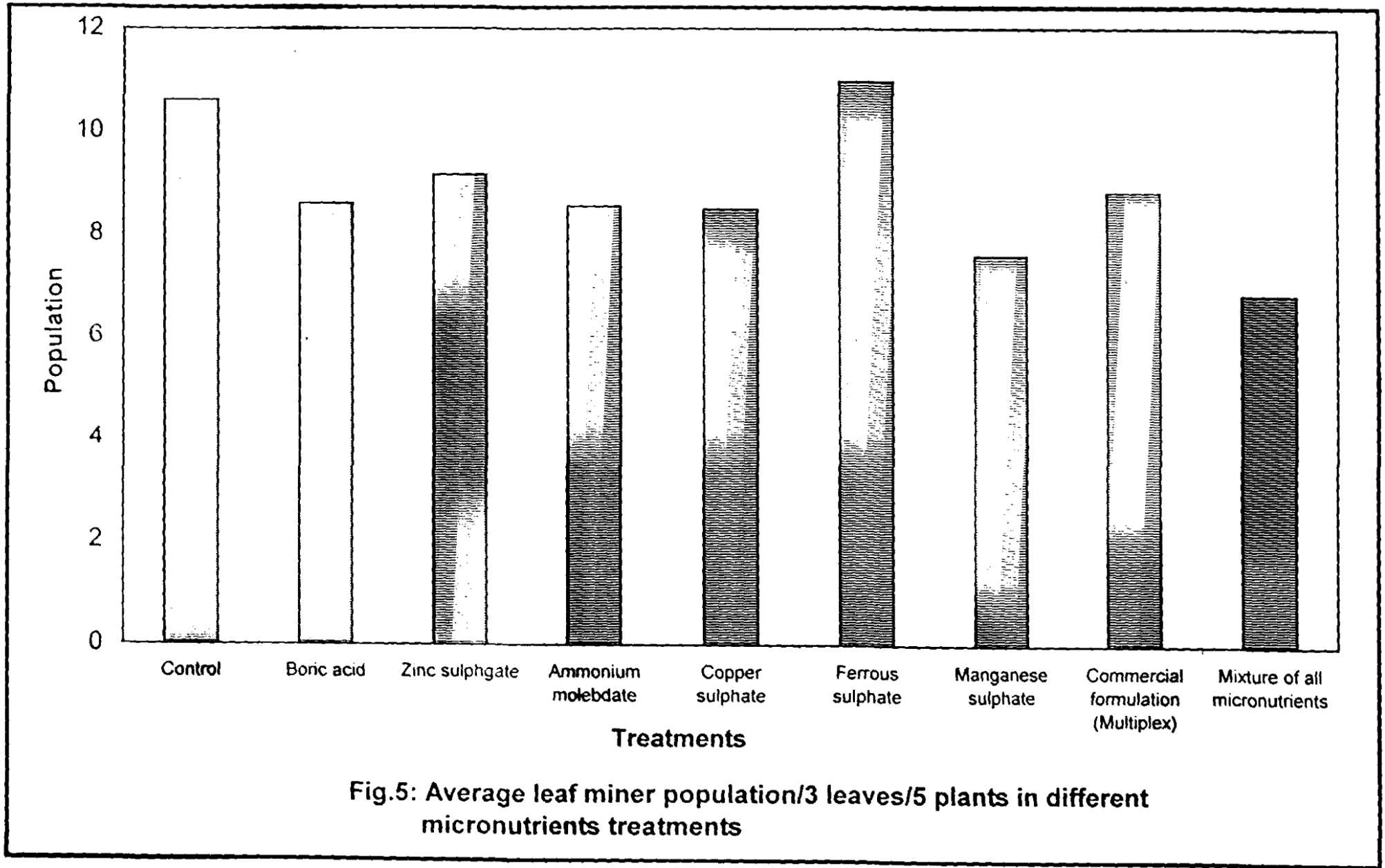
Plate 4: Healthy plant of tomato

Table 4.5: Role of micronutrients against leaf miner on tomato

Treatment	Doses	Pre treatment observation	Population of mines/3 leaves/5 plants (Mean of three replications)						Overall Mean
			First spraying		Second spraying		Third spraying		
			3 days after	7 days after	3 days after	7 days after	3 days after	7 days after	
Control	-	1.33 (1.34)	9.66 (3.18)	9.00 (3.07)	12.33 (3.47)	15.00 (3.93)	9.00 (3.07)	8.66 (3.04)	10.61 (3.33)
Boric Acid	100 ppm	0.66 (1.04)	7.66 (2.85)	8.66 (3.02)	9.33 (3.13)	12.33 (3.57)	7.00 (2.72)	6.66 (2.66)	8.60 (3.01)
Zinc sulphate	100 ppm	1.00 (1.16)	9.00 (3.07)	9.00 (3.07)	8.66 (3.02)	13.66 (3.75)	7.66 (2.84)	7.00 (2.71)	9.16 (3.10)
Ammonium molybdate	50 ppm	0.66 (1.04)	9.00 (3.07)	7.00 (2.72)	8.66 (3.01)	13.33 (3.71)	7.00 (2.72)	6.33 (2.59)	8.55 (3.00)
Copper sulphate	100 ppm	1.00 (1.16)	7.33 (2.78)	8.66 (3.01)	10.00 (3.23)	12.00 (3.52)	6.66 (2.66)	6.33 (2.58)	8.49 (2.99)
Ferrous sulphate	100 ppm	1.33 (1.34)	8.66 (3.02)	10.66 (3.28)	13.33 (3.71)	15.66 (4.01)	8.00 (2.90)	9.66 (3.18)	10.97 (3.38)
Manganese sulphate	100 ppm	0.66 (1.04)	7.66 (2.72)	6.66 (2.66)	9.33 (3.13)	12.00 (3.52)	5.00 (2.33)	5.66 (2.47)	7.60 (2.84)
Commercial formulation (Multiplex)	100 ppm	0.66 (0.99)	8.33 (2.96)	7.00 (2.72)	9.33 (3.12)	12.66 (3.61)	6.33 (2.59)	6.66 (2.66)	8.38 (2.97)
Mixture of all micronutrients	-	1.00 (1.16)	6.00 (2.53)	6.66 (2.66)	7.00 (2.72)	9.33 (3.13)	4.66 (2.26)	4.66 (2.26)	6.38 (2.62)
S.E.m _t	-	NS	0.08	0.12	0.11	0.13	0.12	0.14	0.05
C.D. at 5%	-	-	0.26	0.37	0.33	0.39	0.38	0.43	0.16

NS= Non-significant.

Figures in parentheses are transformed value = $\sqrt{X + 0.5}$



After 1st spray:

3 days: Leaf miners in all the treatments were significantly lower than untreated control (9.66/3 leaves/5 plants). Among the treatments, the lowest (6.00 to 7.33/3 leaves/5 plants) mines was recorded in the plots treated with mixture of all micronutrient, manganese sulphate and copper sulphate which were at par with each other and differed significantly with rest of the treatments.

7 days: All the treatments registered significantly less leaf mines than untreated control (9.00/3 leaves/5 plants). The significantly less mines (6.66 to 8.66/3 leaves/5 plants) was recorded in all the treatments except ferrous sulphate (10.66/3 leaves/5 plants).

After 2nd spray:

3 days: All the treatments registered significantly less mines than ferrous sulphate and untreated control (13.33 and 12.33/3 leaves/5 plants). The lowest mines (7.00/3 leaves/5 plants) were recorded in the plots treated with mixture of all micronutrients.

7 days: All the treatments registered significantly less leaf mines than untreated control and ferrous sulphate (15 and 15.66/3 leaves/5 plants). Mixture of all micronutrients had less with 9.33 mines.

After 3rd spray:

3 days: All the treatments registered significantly less leaf mines than untreated control (9.00/3 leaves/5 plants). Mixture of all micronutrients, manganese sulphate, and commercial formulation (Multiplex) were at par with 4.66, 5.00 and 6.33 mines and differ significantly than rest of the treatments.

7 days: All the treatments registered significantly less leaf mines than ferrous sulphate (9.66/3 leaves/5 plants). Among the treatments, mixture of all micronutrients, manganese sulphate, copper sulphate, ammonium molybdate, boric acid and multiplex were at par with 4.66 to 6.33 mines.

Overall mean effect:

All the treatments registered significantly lower leaf mines than untreated control and ferrous sulphate (10.61 and 10.99/3 leaves/5 plants). The lowest leaf mines (6.38/3 leaves/5 plants) were recorded in the plots treated with mixture of all micronutrients, followed by manganese sulphate, commercial formulation (Multiplex), copper sulphate and ammonium molybdate with a leaf mines of 7.60, 8.38, 8.49 and 8.55 respectively (Table 4.5 and Fig. 5).

Fruit borer:**Pre-treatment observations:**

Non-significant differences were observed among the different treatments as the fruit borer population ranged between 5.00 to 7.00 larvae/5 plants (Table 4.6 and Fig. 6).

After 2nd spray:

3 days: All the treatments had significantly less larval population than untreated control (7.33 larvae/5 plants). The significantly lower population (3.33 larvae/5 plants) was observed in manganese sulphate than the other treatments, except copper sulphate (4.66 larvae/5 plants).

7 days: All the treatments were found significantly less larval population than untreated control (6.33 larvae/5 plants). Among the different treatments, manganese sulphate (2.66 larvae/5 plants) was significantly superior to rest of the treatments.

After 3rd spray:

3 days: All the treatments had significantly less larval population than untreated control (7.00 larvae/5 plants). Among the treatments, lowest larval population was observed in the treatments of manganese sulphate (4.00 larvae/5 plants) than other treatments.



Plate 5: Healthy fruit of tomato



Plate 6: Damage fruit of tomato



Plate 7: *Helicoverpa armigera* larvae infestation on tomato

Table 4.6: Role of micronutrients against fruit borer on tomato

Treatment	Doses	Pre treatment observation	Larval population/5 plant (mean of three replication)				Overall Mean
			Second spraying		Third spraying		
			3days after	7 days after	3days after	7 days after	
Control	-	7.00 (2.72)	7.33 (2.78)	6.33 (2.60)	7.00 (2.72)	10.00 (3.23)	7.66 (2.85)
Boric Acid	100 ppm	6.33 (2.60)	5.66 (2.47)	4.00 (2.11)	6.33 (2.60)	7.33 (2.79)	5.83 (2.51)
Zinc sulphate	μππ 001	6.33 (2.59)	5.00 (2.33)	4.33 (2.19)	6.00 (2.53)	8.33 (2.96)	5.91 (2.53)
Ammonium molebdate	50 ppm	6.33 (2.60)	6.66 (2.66)	4.66 (2.26)	6.33 (2.60)	7.66 (2.84)	6.33 (2.61)
Copper sulphate	100 ppm	5.66 (2.47)	4.66 (2.26)	4.33 (2.18)	5.66 (2.47)	7.66 (2.84)	5.58 (2.46)
Ferrous sulphate	100 ppm	6.33 (2.60)	5.33 (2.40)	3.66 (2.03)	6.33 (2.60)	7.66 (2.84)	5.75 (2.50)
Manganese sulphate	100 ppm	5.00 (2.33)	3.33 (1.95)	2.66 (1.77)	4.00 (1.95)	5.00 (2.33)	3.58 (2.01)
Commercial formulation (Multiplex)	100 ppm	5.33 (2.40)	5.00 (2.33)	4.66 (2.26)	5.33 (2.40)	9.00 (3.07)	6.00 (2.54)
Mixture of all micronutrients	-	6.66 (2.66)	6.33 (2.59)	5.00 (2.33)	6.66 (2.66)	9.33 (3.10)	6.83 (2.70)
S.Em+	-	NS	0.10	0.11	0.10	0.12	0.05
C.D. at 5%	-	-	0.32	0.33	0.31	0.36	0.16

NS= Non-significant.

Figures in parentheses are transformed value = $\sqrt{X + 0.5}$

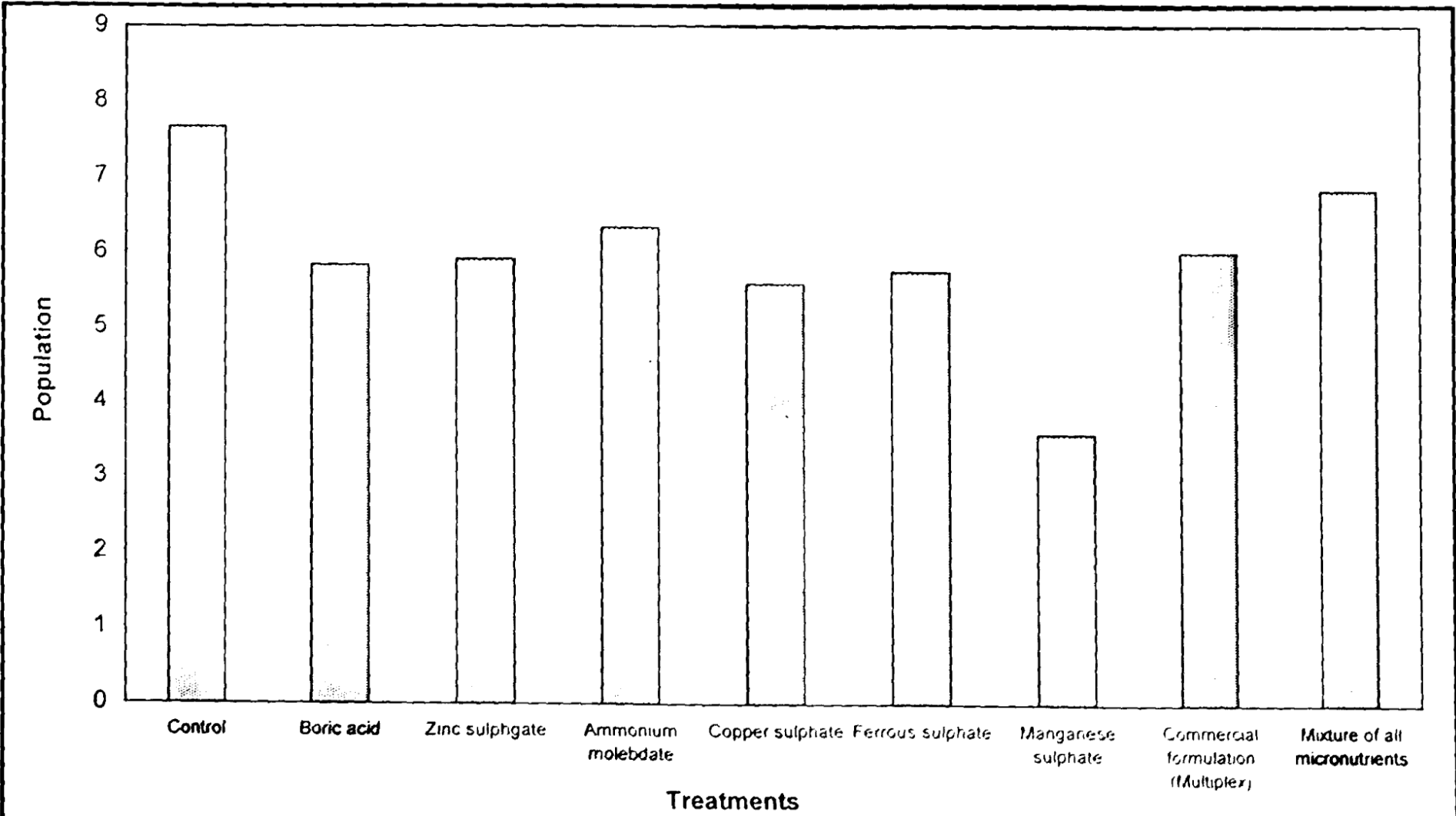


Fig.6: Average fruit borer larval population/5 plants in different micronutrients treatments

7 days: All the treatments had significantly less larval population than untreated control (10.00 larvae/5 plants). However, significantly less larval population was recorded in the treatment of manganese sulphate (5.00 larvae/5 plants). Rest of the treatments was at par with each other.

Overall mean effect:

All the treatments had significantly less larval population than untreated control (7.66 larvae/5plants). Among different treatments, manganese sulphate had significantly less larval population (3.58 larvae/5 plants). Rest of the treatments was at par with each other (Table 4.6 and Fig. 6).

Percentage of fruit damage:

1st picking: There was non-significant difference among different treatments during 1st picking. The minimum (12.94%) fruit damage was found in boric acid. The maximum (19.85%) fruit damage was found in untreated control.

2nd picking: All the treatments registered significantly less fruit damage as compared to untreated control (28.71%). Among the different treatments, manganese sulphate (15.19% fruit damage) and copper sulphate (16.04%) had less per cent fruit damage in such treatments.

3rd picking: All the treatments had significantly lower fruit damage as compared to untreated control (48.33%). The significantly lowest fruit damage (14.64%) was observed in manganese sulphate, followed by copper sulphate (15.61%) and they had less per cent fruit damage than rest of the treatments.

4th picking: All the treatments had significantly less per cent fruit damage than untreated control (30.03%). However, all the treatments also differ significantly with each other. The lowest fruit damage (8.70%) was recorded in the plots treated with copper sulphate, followed by manganese sulphate (10.14%).

Table 4.7: Role of micronutrients against fruit borer on tomato

Treatment	Doses	Percentage of damage fruit (Mean three replication)						Overall mean
		I st Picking	II nd Picking	III rd Picking	IV th Picking	V th Picking	VI th Picking	
Control	-	19.85 (26.36)	28.71 (32.31)	48.33 (44.01)	30.03 (33.19)	42.67 (40.70)	46.00 (42.69)	35.93 36.54
Boric Acid	100 ppm	12.94 (21.05)	21.78 (27.78)	27.94 (31.87)	15.02 (22.74)	31.72 (34.22)	31.05 (33.85)	23.40 28.58
Zinc sulphate	100 ppm	17.87 (24.68)	21.21 (27.34)	20.30 (26.70)	17.67 (24.80)	31.42 (34.09)	37.58 (37.78)	24.34 29.23
Ammonium molybdate	50 ppm	17.91 (25.01)	26.01 (30.64)	27.14 (31.34)	27.08 (31.37)	38.20 (38.17)	41.74 (40.23)	29.68 32.79
Copper sulphate	100 ppm	18.61 (25.43)	16.04 (23.54)	15.61 (22.91)	8.70 (16.94)	28.11 (32.00)	30.75 (33.66)	19.63 25.74
Ferrous sulphate	100 ppm	18.91 (25.73)	22.74 (28.39)	19.52 (26.14)	17.89 (25.00)	25.84 (30.56)	30.20 (33.31)	22.51 28.18
Manganese sulphate	100 ppm	18.80 (25.62)	15.19 (22.83)	14.64 (22.31)	10.14 (18.48)	19.70 (26.34)	23.71 (29.06)	17.03 24.10
Commercial formulation (Multiplex)	100 ppm	13.23 (21.14)	27.00 (31.22)	24.27 (29.50)	22.19 (28.01)	35.09 (36.33)	38.22 (38.19)	26.68 30.73
Mixture of all micronutrients	-	18.72 (25.45)	27.53 (31.61)	39.37 (38.81)	28.33 (32.11)	39.96 (39.20)	44.23 (41.68)	33.02 34.81
S.Em+	-	NS	1.39	1.51	1.31	0.91	1.13	0.35
C.D. at 5%	-	-	4.19	4.53	3.93	2.75	3.40	1.05

NS= Non significant

Figures in parentheses are angular transformed value

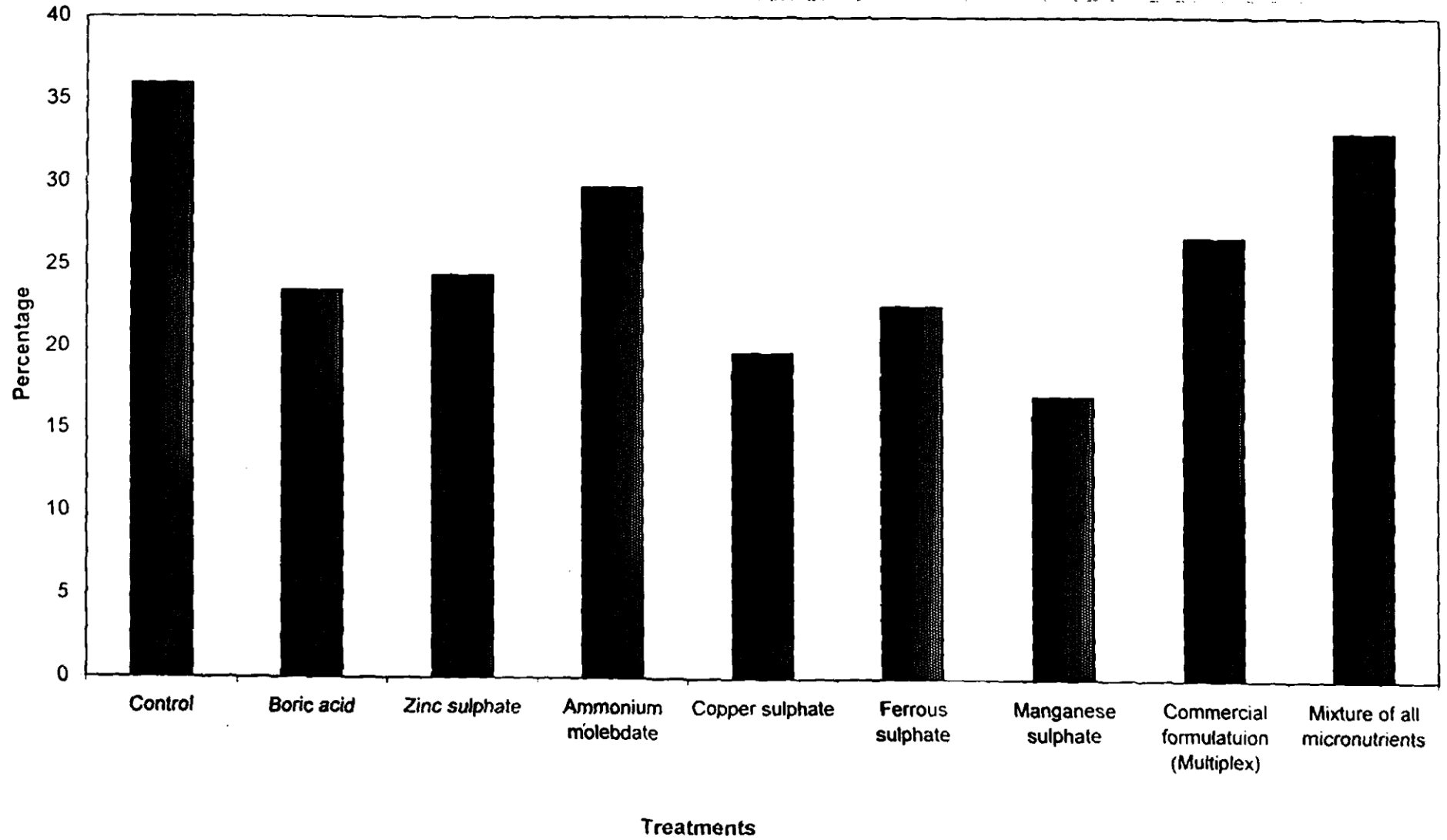


Fig.7: Average fruit borer damage percentage in different micronutrients treatments

5th picking: All the treatments had significantly low fruit damage than untreated control (42.67%). Among the different treatments, significantly lowest (19.70%) fruit damage was recorded in manganese sulphate. Fruit damage in other treatments ranged between 25.84 to 39.96 per cent.

6th picking: All the treatments had significantly less fruit damage than untreated control (46.00%). The significantly lowest (23.71%) fruit damage was record in manganese sulphate. Ferrous sulphate, copper sulphate and boric acid had moderate 30.20, 30.75 and 31.05 per cent fruit damage.

Overall mean effect:

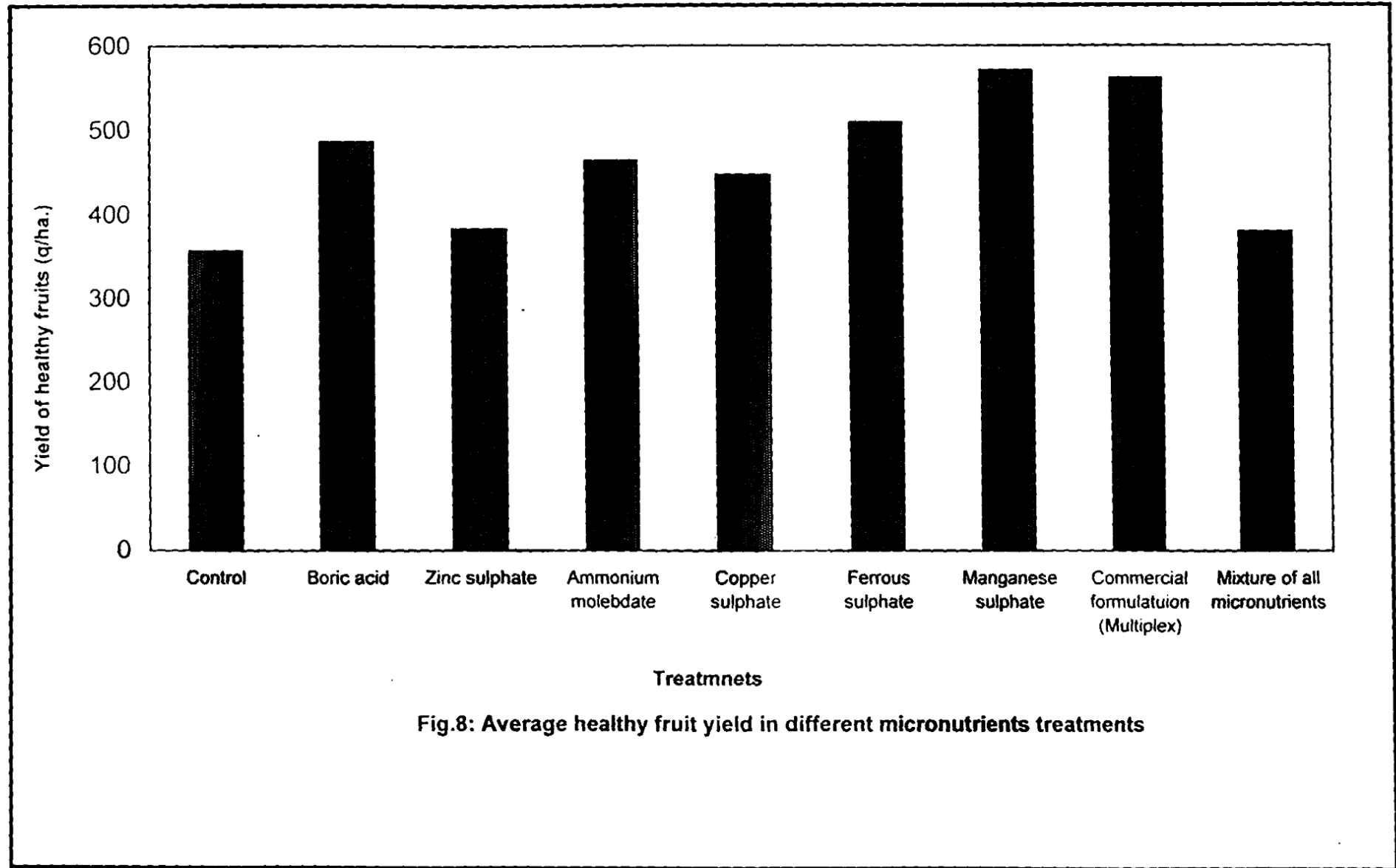
All the treatments had significantly less per cent fruit damage than untreated control (35.93%). Among the different treatments, manganese sulphate (17.03%) and copper sulphate (19.63%) had significantly less per cent fruit damage than rest of the treatments. Ferrous sulphate (22.51%), boric acid (23.40%) and zinc sulphate (24.34%) had moderate per cent fruit damage than other treatments (Table 4.7 and Fig. 7).

Yield q/ha:

All the micronutrients treatments had significantly higher yield than untreated control (357.59q/ha). However, among the micronutrients, manganese sulphate and multiplex registered significantly more yield (570.82 and 561.57 q/ha) than rest of the treatments. (Table 4.8 and Fig. 8).

Table 4. 8: Healthy fruit yield in different treatments

Treatments	Doses	Kg/plot	Q/ha
Control	-	38.62	357.59
Boric Acid	100 ppm	52.6	487.03
Zinc sulphate	100 ppm	41.4	383.33
Ammonium molybdate	50 ppm	50.1	463.88
Copper sulphate	100 ppm	48.3	447.21
Ferrous sulphate	100 ppm	55	509.25
Manganese sulphate	100 ppm	61.65	570.82
Multiplex	100 ppm	60.65	561.57
Mixture of all micronutrients	-	41.1	380.55
S.E.m _t	-	0.41	1.23
C D at 5 %	-	3.81	11.43



CHAPTER - V

DISCUSSION

DISCUSSION

The results of the experiments conducted are being discussed in this chapter.

Incidence of major insect pests of tomato:

During the course of study from December 2006 to April 2007, white fly (*Bemisia tabaci* Genn.), aphid (*Aphis gossypii* Glover), leaf miner (*Liriomyza trifolii* Burgess), and fruit borer (*Helicoverpa armigera* Hub.) were observed to be infesting on tomato crop. These insect pests were also reported by Dhamdhere (1990), Srinivasan (1993) and Nair (1995).

White fly:

Banjar (diss)

White fly appeared in last week of December and continued up to last week of March. The peak activity (12 flies/5 twigs of 10 cm) of this pest was observed in first week of February, when average maximum and minimum temperatures were 29.2°C and 13.4°C, respectively with 87 per cent morning and 34 per cent evening relative humidity and zero mm rainfall. Arnal *et al.* (1998) also reported that adult white flies were present throughout the growing period in tomato. Yano *et al.* (1989) reported that the white fly population growth rate was strongly affected by maximum temperature and relative humidity.

Aphid:

Aphid appeared in last week of December and remained active till crop was harvested. The peak activity (24/5 twigs of 10 cm) during first week of February when the maximum and minimum temperature was 29.2°C and 13.4°C, respectively with 87 per cent morning and 34 per cent evening relative humidity and zero mm rainfall. Walgenbach (1997) found that yield were consistently lower by aphid in the control. Chaudhuri *et al.* (2001) the aphid was found to attack persistently in all 3 years. Hath and Das (2004) observed that the peak population of aphid during the first week of March.



Leaf miner:

Leaf miner appeared in last week of December and continued up to last week of March. It was observed that the infestation of leaf miner began in last week of December, with peak (27 mines/3 leaves/5 plants) during 2nd week of March when average maximum and minimum temperatures were 29°C and 11.3°C, respectively with 81 per cent morning and 24 per cent evening relative humidity. Present observations were more or less similar with the results of earlier workers Jagannatha (1994), Bagmare *et al.* (1995), Oscar and Cess (1999) and Marcano and Issa (2000) who have reported the incidence of *Liriomyza trifolii* on tomato throughout the crop season and found that the temperature had positive correlation with population levels and the life cycle of *Liriomyza trifolii* on tomato crop.

Fruit borer:

The larvae of tomato fruit borer were first observed on tomato crop in first week of February and were present through the cropping season. Larval population was highest (16 larvae/5 plants) in the last week of March when average maximum and minimum temperature were 35.4°C and 16.3°C, respectively with 68 per cent morning and 16 per cent evening relative humidity and zero mm rainfall. Wilcox *et al.* (1956) also reported that the per cent fruit damage caused by *Helicoverpa armigera* Hub. was highest at the beginning of the picking season. The present findings are not in agreement with their results as the fruit infestation was highest in last picking. Kadu *et al.* (1987) also reported that the life cycle of fruit borer (*Helicoverpa armigera* Hub.) increased with rise in temperature per degree centigrade.

Role of micronutrients against major insect pests of tomato:

The role of eight micronutrients [Boric acid 100 ppm, Zinc sulphate 100 ppm, Ammonium molybdate 50 ppm, Copper sulphate 100 ppm, Ferrous sulphate 100 ppm, Manganese sulphate 100 ppm, Commercial formulation (Multiplex) 100 ppm and Mixture of all micronutrients] were tested against white fly (*Bemisia tabaci*), aphid (*Aphis gossypii* Glover), leaf miner (*Liriomyza trifolii*), and fruit borer (*Helicoverpa armigera*) on tomato. On the basis of average white fly population, aphid population, leaf mines and per

cent fruit infestation due to fruit borer in different treatments their role was assessed.

White fly:

On the basis of overall white fly population, all the micronutrients treatments differed significantly over untreated control (3.60 flies/5 twigs of 10 cm). However, among the micronutrients, mixture of all micronutrients (0.83 flies/5 twigs of 10 cm) and manganese sulphate (1.11 flies/5 twigs of 10 cm) proved superior to rest of the treatments. In the present investigation, mixture of all micronutrients and manganese sulphate were found most effective treatments against white fly in tomato. There is no research work review on the role of micronutrients on the incidence of white fly in tomato.

Aphid:

On the basis of overall aphid population, all the micronutrients differed significantly over untreated control (6.27/5 twigs of 10 cm). However, among the micronutrients, manganese sulphate (1.05/5 twigs of 10 cm) and mixture of all micronutrients had minimum (1.22/5 twigs of 10 cm) population than the rest of the treatments. Ferrous sulphate (1.83/5 twigs of 10 cm), multiplex (1.94/5 twigs of 10 cm), zinc sulphate (2.11/5 twigs of 10 cm) and copper sulphate (2.11/5 twigs of 10 cm) treated plots had moderate population of aphid. No work was reported on the role of micronutrients against the incidence of aphids in tomato.

Leaf miner:

All the treatments had less leaf mines than untreated control (10.61/3 leaves/5 plants) and ferrous sulphate (10.97/3 leaves/5 plants). Among the micronutrients, mixture of all micronutrients (6.38/3 leaves/5 plants) had less mines than other treatments. Manganese sulphate, multiplex and copper sulphate had moderate (7.60, 8.38 and 8.49/3 leaves/5 plants) population of leaf miner. This is the new investigation on the role of micronutrients on the incidence of leaf miner on tomato.

Fruit borer:

Overall mean larval population of fruit borer (3.58 larvae/5 plants) was found in plots treated with manganese sulphate significantly superior treatments.

Overall role of different micronutrients on the per cent fruit infestation, all the treatments had less percentage of fruit infestation than untreated control (35.93%). However, among the different micronutrients treatments, manganese sulphate had 17.03 per cent fruit infestation followed by copper sulphate 19.63 per cent fruit infestation.

* * *

CHAPTER - VI

SUMMARY,

CONCLUSION AND

SUGGESTIONS FOR

FURTHER WORK

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

Present research work on "Studies on seasonal incidence of pest complex and role of micronutrients against major insect pests of tomato (*Lycopersicon esculentum* Mill.) was carried out at Seed Breeding Farm, Adhartal, JNKVV, Jabalpur during the winter season of 2006-07. The experiment was laid out in two sets, first set to record the seasonal incidence and second set to test the role of micronutrients. The second set of experiment was laid out in Randomized Block Design with three replications and nine treatments for testing the role of micronutrients. The treatments included boric acid 100 ppm, zinc sulphate 100 ppm, ammonium molybdate 50 ppm, copper sulphate 100 ppm, ferrous sulphate 100 ppm, manganese sulphate 100 ppm, commercial formulation (multiplex), mixture of all micronutrients and one untreated control.

1. Incidence of major insect pests in tomato:

White fly (*Bemisia tabaci* Genn.), aphid (*Aphis gossypii* Glover), leaf miner (*Liriomyza trifolii* Burgess) and fruit borer (*Helicoverpa armigera* Hub.) were observed to be infesting the tomato crop. White fly, aphid and leaf miner appeared on last week of December, 2006, while fruit borer appeared during first week of February, 2007, respectively. The peak activity of white fly, aphid leaf miner and fruit borer was recorded during first week of February, first week of February, second week of March and last week of March 2007, respectively.

The seasonal mean population of white fly, mean population of aphid, mean population of leaf miner and mean larval population of fruit borer, recorded were 7.46 flies/5 twigs, 10.69 aphids/5 twigs, 15.15 mines/3 leaves/5 plants and 10.11 larvae/5 plants, respectively. The seasonal mean population of all these pests was recorded at higher level and considered as major pests of tomato.

2. Role of micronutrients against major insect pests of tomato:

Studies on role of micronutrients revealed that the overall mean white fly population was least (0.83/5 twigs of 10 cm) in treatments where mixture of all micronutrients was applied, followed by manganese sulphate, ferrous sulphate, copper sulphate and boric acid with less overall mean population (1.11, 1.83, 1.83 and 1.83/5 twigs of 10 cm), respectively. The overall mean aphid population was least (1.05) in plots where manganese sulphate was applied, followed by mixture of all, ferrous sulphate, multiplex (1.22, 1.83 and 1.94 aphids/5 twigs of 10 cm), respectively. The overall mean leaf miner infested leaves was found to be significantly lowest (6.38) where plots treated with mixture of all micronutrients, followed by manganese sulphate and multiplex (7.60 and 8.38/3 leaves/5 plants), respectively. The lowest overall mean larval population of fruit borer (3.58 and 5.58/5 plants) was observed in manganese sulphate and copper sulphate treated plots.

The lowest average percentage of fruit damage (17.03 and 19.63 %) was recorded in manganese sulphate and copper sulphate treated plots. On the basis of above result, manganese sulphate and mixture of all micronutrients plays an important role against white fly, aphid and leaf miner, while manganese sulphate treated plots had less fruit borer infestation. Copper sulphate, ferrous sulphate and multiplex treated plots were moderately infested, whereas ammonium molybdate, zinc sulphate and boric acid treated plots had no effect on the above mentioned pests.

Significantly highest yield was recorded with manganese sulphate and multiplex treated plots.

Conclusion:

On the basis of higher seasonal mean population white fly, aphid, leaf miner and fruit borer were recorded as major pests in tomato crop. Manganese sulphate treated plots had minimum population of the white fly, aphid, leaf miner and fruit borer and recorded highest yield.

Suggestions for further work:

1. Large scale trials should be conducted to confirm the role of micronutrients against major insect pests of tomato and cost should also be calculated.
2. Studies on seasonal incidence of insect pests complex in tomato should be studied continuously for three years in order to establish status of the pests and to determine the suitable time for adopting control measures.

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APPENDICES

APPENDIX
Whitefly population

ANOVA 1: Pre-treatment

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.64	0.03	0.53	3.63
Treatments	8	0.18	0.23	0.38	2.59
Error	16	0.98	0.06		
S,Em ±	0.14		C.D. at5%	N.S.	

ANOVA 2: 3 days after first spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.42	0.21	3.09	3.63
Treatments	8	1.93	0.24	3.56	2.59
Error	16	1.08	0.06		
S,Em ±	0.15		C.D. at5%	0.45	

ANOVA 3: 7 days after first spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.04	0.02	0.40	3.63
Treatments	8	2.15	0.26	4.58	2.59
Error	16	0.93	0.05		
S,Em ±	0.13		C.D. at5%	0.41	

ANOVA 4: 3 days after second spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.26	0.13	4.17	3.63
Treatments	8	2.67	0.33	10.38	2.59
Error	16	0.51	0.03		
S,Em ±	0.10		C.D. at5%	0.31	

ANOVA 5: 7 days after second spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.12	0.06	1.29	3.63
Treatments	8	1.54	0.19	3.91	2.59
Error	16	0.79	0.04		
S,Em ±	0.12		C.D. at5%	0.38	

ANOVA 6: 3 days after third spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.71	0.35	6.24	3.63
Treatments	8	1.64	0.20	3.60	2.59
Error	16	0.91	0.05		
S,Em ±	0.13		C.D. at5%	0.41	

ANOVA 7: 7 days after third spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.50	0.25	3.55	3.63
Treatments	8	1.84	0.23	3.28	2.59
Error	16	1.12	0.07		
S,Em ±	0.15		C.D. at5%	0.45	

ANOVA 8: Average

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.009	0.004	0.45	3.63
Treatments	8	1.45	0.18	17.34	2.59
Error	16	0.16	0.01		
S,Em ±	0.05		C.D. at5%	0.17	

Aphid population

ANOVA 9: Pretreatment

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.07	0.03	0.14	3.63
Treatments	8	0.16	0.02	0.08	2.59
Error	16	4.36	0.27		
S,Em ±	0.30		C.D. at5%	N.S.	

ANOVA 10: 3 days after first spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.16	0.08	0.93	3.63
Treatments	8	6.56	0.82	9.27	2.59
Error	16	1.41	0.08		
S,Em ±	0.17		C.D. at5%	0.57	

ANOVA 11: 7 days after first spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.17	0.08	0.93	3.63
Treatments	8	8.43	1.05	11.23	2.59
Error	16	1.50	0.09		
S,Em ±	0.17		C.D. at5%	0.53	

ANOVA 12: 3 days after second spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.10	0.05	0.59	3.63
Treatments	8	3.82	0.47	5.55	2.59
Error	16	1.37	0.08		
S,Em ±	0.16		C.D. at5%	0.50	

ANOVA 13: 7 days after second spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.46	0.03	0.34	3.63
Treatments	8	3.99	0.49	5.39	2.59
Error	16	1.47	0.09		
S,Em ±	0.17		C.D. at5%	0.52	

ANOVA 14: 3 days after third spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.54	0.27	5.57	3.63
Treatments	8	4.06	0.50	10.32	2.59
Error	16	0.78	0.04		
S,Em ±	0.12		C.D. at5%	0.38	

ANOVA 15: 7 days after third spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.39	0.19	2.67	3.63
Treatments	8	2.95	0.36	4.99	2.59
Error	16	1.18	0.07		
S,Em ±	0.15		C.D. at5%	0.47	

ANOVA 16: Average

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.01	0.008	1.91	3.63
Treatments	8	3.75	0.469	66.17	2.59
Error	16	0.11	0.006		
S,Em ±	0.04		C.D. at5%	0.14	

Leaf miner

ANOVA 17: Pre-treatment

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.29	0.14	1.11	3.63
Treatments	8	0.38	0.04	0.37	2.59
Error	16	2.11	0.13		
S,Em ±	0.20		C.D. at5%	N.S.	

ANOVA 18: 3 days after first spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.21	0.10	4.49	3.63
Treatments	8	1.01	0.12	5.35	2.59
Error	16	0.38	0.02		
S,Em ±	0.08		C.D. at5%	0.26	

ANOVA 19: 7 days after first spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.05	0.02	0.62	3.63
Treatments	8	1.22	0.15	3.22	2.59
Error	16	0.76	0.04		
S,Em ±	0.12		C.D. at5%	0.37	

ANOVA 20: 3 days after second spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.03	0.01	0.43	3.63
Treatments	8	2.10	0.26	6.84	2.59
Error	16	0.61	0.03		
S,Em ±	0.11		C.D. at5%	0.33	

ANOVA 21: 7 days after second spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.09	0.04	0.89	3.63
Treatments	8	1.59	0.19	3.87	2.59
Error	16	0.82	0.05		
S,Em ±	0.13		C.D. at5%	0.39	

ANOVA 22: 3 days after third spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.07	0.03	0.78	3.63
Treatments	8	1.63	0.20	4.11	2.59
Error	16	0.79	0.04		
S,Em ±	0.12		C.D. at5%	0.38	

ANOVA 23: 7 days after third spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.08	0.04	0.68	3.63
Treatments	8	1.81	0.22	3.54	2.59
Error	16	1.02	0.06		
S,Em ±	0.14		C.D. at5%	0.43	

ANOVA 24: Average

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.01	0.005	0.60	3.63
Treatments	8	1.24	0.156	17.82	2.59
Error	16	0.14	0.008		
S,Em ±	0.05		C.D. at5%	0.16	

Fruit borer

ANOVA 25: Pre-treatment

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.06	0.03	0.76	3.63
Treatments	8	0.39	0.04	1.09	2.59
Error	16	0.71	0.04		
S,Em ±	0.12		C.D. at5%	N.S.	

ANOVA 26: 3 days after second spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.11	0.05	1.66	3.63
Treatments	8	1.46	0.18	5.26	2.59
Error	16	0.55	0.03		
S,Em ±	0.10		C.D. at5%	0.32	

ANOVA 27: 7 days after second spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.03	0.01	0.43	3.63
Treatments	8	1.21	0.15	3.94	2.59
Error	16	0.61	0.03		
S,Em ±	0.11		C.D. at5%	0.33	

ANOVA 28: 3 days after third spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.10	0.05	1.56	3.63
Treatments	8	1.26	0.15	4.66	2.59
Error	16	0.54	0.03		
S,Em ±	0.10		C.D. at5%	0.31	

ANOVA 29: 7 days after third spray

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.05	0.02	0.57	3.63
Treatments	8	1.63	0.20	4.67	2.59
Error	16	0.69	0.04		
S,Em ±	0.12		C.D. at5%	0.36	

ANOVA 30: Average

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	0.011	0.005	0.64	3.63
Treatments	8	1.229	0.153	17.33	2.59
Error	16	0.141	0.008		
S,Em ±	0.05		C.D. at5%	0.16	

Percentage fruit damage by fruit borer**ANOVA 31: 1st picking**

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	37.99	18.99	2.27	3.63
Treatments	8	95.03	11.87	1.42	2.59
Error	16	133.62	8.35		
S,Em ±	1.66		C.D. at5%	5.00	

ANOVA 32: 2nd picking

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	37.66	7.33	1.25	3.63
Treatments	8	283.70	35.46	6.03	2.59
Error	16	94.07	5.87		
S,Em ±	1.39		C.D. at5%	4.19	

ANOVA 33: 3rd picking

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	6.13	3.06	0.84	3.63
Treatments	8	1226.77	153.34	22.39	2.59
Error	16	109.60	6.85		
S,Em ±	1.51		C.D. at5%	4.53	

ANOVA 34: 4th picking

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	27.86	13.93	2.70	3.63
Treatments	8	820.19	102.52	19.87	2.59
Error	16	82.53	5.15		
S,Em ±	1.31		C.D. at5%	3.93	

ANOVA 35: 5th picking

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	3.46	1.73	0.68	3.63
Treatments	8	500.49	62.56	24.73	2.59
Error	16	40.48	2.53		
S,Em ±	0.91		C.D. at5%	2.75	

ANOVA 36: 6th picking

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	22.50	11.25	2.91	3.63
Treatments	8	49.63	61.32	15.88	2.59
Error	16	61.80	3.86		
S,Em ±	1.13		C.D. at5%	3.40	

ANOVA 37: Overall percentage fruit damage

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	5.46	2.73	7.38	3.63
Treatments	8	382.86	47.85	129.22	2.59
Error	16	5.92	0.37		
S,Em ±	0.35		C.D. at5%	1.05	

ANOVA 38: Healthy fruit yield (kg/plot)

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	13.305	6.652	13.07	3.63
Treatments	8	4.887	0.610	1.20	2.59
Error	16	8.141	0.508		
S,Em ±	0.41		C.D. at5%	1.23	

ANOVA 39: Healthy fruit yield (q/ha)

Source	D.F.	SS	MSS	F. cal.	F. Tab.
Replications	2	1141.044	570.22	13.08	3.63
Treatments	8	419.226	52.403	1.20	2.59
Error	16	697.938	43.403		
S,Em ±	3.81		C.D. at5%	11.43	

VITA

The author of this thesis is Santosh Kumar Barfa S/o Shri Dagaduji Barfa, was born on 4th June 1981, at, Village Sali, Teh. Rajpur, Distt. Barwani, Madhya Pradesh. He passed his High School with 45.00 per cent and Higher Secondary with 53.00 per cent in second division from M. P. Board Bhopal.

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