SUCCESSION OF IMPORTANT PESTS AND ESTIMATION OF AVOIDABLE LOSSES DUE TO PEST COMPLEX IN OKRA UNDER SOUTH GUJARAT CONDITION

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ABSTRACT

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ABSTRACT

Field investigations were carried out on succession of important insect-pests and yield losses due to pest complex in okra during *kharif*, 2007 at the College farm, Navsari Agriultural University, Navsari. The pest sequence studies undertaken in five different cultivars *viz;* Parbhani Kranti, Arka Anamika, Pusa Sawani, GO-2 and LSVT (AOL-03-1) of okra revealed that the crop was attacked by several pest species. Important pests recorded at different stages of crop growth were aphid, *Aphis gossypii* Glover; jassid, *Amrasca biguttulla biguttulla* (Ishida); whitefly, *Bemisia tabaci* (Gennadius); mite, *Tetranychus macfarlanei* (Banker and Pritchard); shoot and fruit borer, *Earias vittella* (Fabricus) and *Helicoverpa armigera* (Hubner). Activity of green lacewing, *Chrysoperla scelestes* (Banks) and lady bird beetle, *Coccinella septempunctata* (Linnaeus) predating on sucking pests were also observed.

The incidence of sucking pests like jassid and whitefly commenced fourth week after sowing (WAS) i.e last week of July and fluctuated through out the crop season. Among them, whitefly

multiplied comparatively at a faster rate reaching to peak level (4.18 adults/leaf) during last week of August whereas population of leafhopper increased gradually and attended its peak during third week of September (5.52 jassids/leaf). Similarly, aphid population initiated in the first week of August and reached to peak level (18.50 aphids/leaf) during first week of October. Whereas, mite population started first week of September and reached to the peak level (18.20 mites/leaf) during the last week of September. In case of shoot and fruit borer, population built up was initiated in fourth week after sowing (last week of July) and reached to the peak level (1.35 larvae/plant) during the second week of September.

The two predators *viz*; green lacewing and lady bird beetle occurred first week of August to third week of October. Out of the two predators, chrysopid appeared first between 4 and 9 WAS and reached its maximum intensity 8 WAS. Later on, the coccinellids swung into action 9 WAS and prevailed throughout the remaining crop season, the later on reached to peak level 13 WAS. The two predators *viz*; green lacewing and lady bird beetle appeared at different period exerting to some extent natural check on sucking pests.

Among different okra cultivars tested, Parbhani Kranti cultivar was found to be the most susceptible than Arka Anamika, Pusa Sawani, GO-2 and LSVT (AOL-03-1) cultivars to the attack of most of the pests.

Among various weather parameters studied, temperature and sunshine hours had positive influence on the population of aphid, whitefly and also the green lacewing, while temperature, relative humidity, sunshine hours, rainy days and evaporation had positive influence on the population of jassid, mite and shoot and fruit borer. Rain fall and wind velocity had marked negative effect on the attack of most of the pests population.

Avoidable losses caused by insect-pests were worked out in Parbhani Kranti cultivar of okra. For this purpose, six levels of protection were tested alongwith no protection. Pesticide application was resorted to in a treatment only when one or more pest populations crossed their respective threshold level. Different protection levels were: Protection against insect pests throughout crop season. (Seed treatment + need based application of insecticides) (T_1), protection against insect pests from 30 days onwards (T_2), protection against insect pests from 45 days onwards (T_3), protection against insect pests from 60 day onwards (T_4), protection against insect pests up to 45 days i.e. seed treatment (T_5), protection against insect pests up to 60 days (Seed treatment + need based application of insecticides) (T_6) and no protection against insect pests (T_7).

The results revealed that the need based application of pesticide warranted maximum of two sprays of pesticides to protect the crop throughout the crop season (T_1) for controlling the pest complex during particular period of okra crop. The maximum reduction in population over control in aphid (62.93 %), jassid (71.41 %), whitefly (88.75 %), mite (81.90 %) and *E.vittella* (98.45 %) was recorded in treatment T_1.

The highest okra fruit yield was recorded in treatment of protection throughout the crop season (T_1) (1548 kg/ha), whereas the lowest (1090 kg/ha) in the treatment of no protection (T_7). Thus, the treatment T_1 proved to be the best among all the levels of protection. The maximum per cent increase in fruit yield over control was recorded in the treatment of T_1 (41.94 %) and proved to be the best in protecting okra crop against different pests. The corresponding lowest increase in okra yield over control was recorded in T_4 (11.09 %).

The highest loss (29.59 %) in yield of okra fruit could be avoided in T_1 followed by T_6 and T_2 with and extent of 29.08 and 17.80 per cent, respectively. Least avoidable loss (10.00 %) were recorded in T_4 followed by T_3 (10.65 %) and T_5 (11.09 %) treatments.

The best treatment from economic point of view was found to be T_6 (BCR=1: 9.63) which was followed by T_1 (1: 4.04) whereas, the lowest BCR (1: 0.42) was obtained in the treatment of T_4.

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CERTIFICATE

This is to certify that the thesis entitled **"SUCCESSION OF IMPORTANT PESTS AND ESTIMATION OF AVOIDABLE LOSSES DUE TO PEST COMPLEX IN OKRA UNDER SOUTH GUJARAT CONDITION"** submitted by **Mr. PATEL KETANKUMAR BHIKHUBHAI** in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY** of the Navsari Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place : Navsari

Date : 21st February, 2009

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DECLARATION

This is to declare that the whole of the research work reported in this thesis for the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY** by the undersigned is the results of investigation done by me under direct guidance and supervision of **Dr. M.B. Patel,** Professor and Head, Department of Agricultural Entomology, N.M. College of Agriculture, Navsari Agricultural University, Navsari and no part of the work has been submitted for any other degree so far.

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INTRODUCTION

I. INTRODUCTION

Okra or Lady's finger (*Abelmoschus esculentus* (Linn.) Moench), commonly known as '*Bhindi*' has origin in tropical and sub tropical Africa, belongs to the family Malvaceae. It has been grown in the Mediterranean as well as in the tropical and sub tropical regions of many countries. It is also one of the most common vegetables grown extensively all over India including Gujarat.

Okra fruit is a good source of nutrients and minerals as each 100 gm edible portion contain 1.9 gm protein, 0.2 gm fat, 0.7 gm minerals, 0.4 gm carbohydrates, 1.2 gm fiber, 66 mg calcium, 43 mg magnesium, 1.5 mg iron, 56 mg phosphorus, 10.3 mg potassium, 6.9 mg sodium, 0.19 mg copper, 30 mg sulphur, 8 mg oxalic acid, 88 I.U. vitamin A, 63 I.U. vitamin B, 13 mg vitamin C, 0.1 mg riboflavin, 0.07 mg thiamine and 0.6 mg nicotinic acid (Chaudhari, 1967). The okra fruits are also used in various medicinal purposes (Nadkarni, 1927). This suggests the fairly nutritive and medicinal value present in the fruits. Okra is an excellent source of iodine, which is necessary for the resistance against Goiter. It is also good for the people suffering from heart weakness (Yawalkar, 1980).

Besides the use of green fruits as vegetables, it is also used in the curry preparation, stewed with meat and cooked into soups. The fruits are also canned green or dried for off season consumption, when ripe; the black brown white eyed seed are roasted and used as a substitute of coffee in Turkey (Mehta, 1969). Twenty per cent edible oil can be obtained from okra seeds (Nandpuri and Singh, 1967). Its mucilaginous extract of green stem is used for clarifying sugarcane juice in jaggary and gur manufacturing (Chauhan, 1972). The mature fruits and stem contain crude fibre which are used in paper industries and mucilage as substitute for soap to remove oil. Its fibre from stem are spined into roaps in the villages.

Among the vegetables, okra is a hardy and short duration vegetable crop and can be profitably cultivated in summer, when other vegetables are not in the fields and markets, thus fetching handsome profit to the farmers. Okra raised for seed production is also profitable.

In India, okra grown mainly during *kharif* and summer seasons in the states of Uttar Pradesh, Madhya Pradesh, Karnataka, Maharashtra and Gujarat. In Gujarat state, it occupies an area about 43,011 ha with 3,66,125 MT annual production and productivity 8.51 tone per ha (Anonymous, 2007).

Introduction of high yielding varieties has induced ecological succession and increased the magnitude of pest problem in okra agro ecosystem thereby forcing the farmers to rely hearing on the use of insecticides. Frequent insecticidal application do not justify the economic losses and ecological disturbances eventually create many problems like resurgence of minor pests, destruction of natural enemies, development of resistant biotypes and environmental pollution. Apart from this, the okra fruits are harvested at shorter interval and hence insecticidal application at fruiting stage is always considered as crucial due to possibilities of residue hazards to the consumer. Under this distressing situation the need of the hour is to initiate varied and sophisticated research for developing a sound, safe and economic pest management strategy in which the use of insecticides should be minimized or avoided.

Okra is attacked by number of insect pests and mites, during different growth stages and seasons. The major pests of okra include spotted bollworm, *Earias vittella* Fabr.; jassid, *Amrasca biguttula biguttula* (Ishida); aphid, *Aphis gossypii* (Glover), leaf roller, *Sylepta derogate* Fabr.; mite, *Tetranychus macfarlanei* Baker and Pritchard and whitefly, *Bemisia tabaci* (Gennadius). Among the pest of minor importance, mention may be made of banded blister beetles (*Mylabris phalerate* Palls and *M. pustulata* Tunbergo), blue flea beetle (*Podagarica bowringi* Baly.), cutworm (*Agrotis* spp.), dusky cotton bug (*Oxycarenus laetus* (Kirby)), grey weevil (*Myllocerus blandus* Faust), mealybugs (*Nipaecoccus napae* Maskell and *Ferrisia virgatas* Cockerell), plant bug (*Coptosoma cribraria* Fabr.), scale insect (*Saissetia nigra* Nietner), semiloopers (*Acontia graellsi* Feisth and *Anomis flava* Fabricius), shoot bug (*Eurybrachys tomentosa* Fabr.), shoot weevil (*Alcides bubo* Fabr.), stem weevils (*Alcides afflaber* Aurive.) and stem borer (*Sphenoptera gossypii* Cotes) (Vevai, 1969).

Fruit and shoot borer and jassid are serious pests of okra throughout the India. These pests are found active in okra fields all the year round in overlapping generation and cause considerable damage to the crops. They are also the major responsible pests for its effects on production (Srinivasan *et al.*, 1973 and Prasad *et al.*, 1983).

Average loss in plant height, the number of leaves per plant and weight of healthy fruits can be as much as 49.8, 45.1 and 69.0 per cent respectively due to combined effect of jassid and shoot and fruit borer (Rawat and Sahu, 1973). According to Singh and Kumar (1974) and Uthamaswamy *et al.* (1977) shoot and fruit borer is the most important pest and one of the major limiting factors in profitable cultivation of okra. There can be as much as 49 to 77 per cent fruit damage by *Earias spp.* (Mote, 1977; Krishnaiah *et al.*, 1976 and Krishnaiah, 1980). The jassid alone can cause 40 to 50 per cent loss in yield (Krishnaiah, 1980). Whitefly *B. tabaci* is a serious pest as well as vector of the yellow vein mosaic disease. It is found that in advance stage of virus infection, the photosynthetic activity is reduced to a tune of 15 to 20 per cent in infested plant (Goodman *et al.*, 1967). The virus is reported to cause reduction in pigments (Mandahar and Singh, 1972 and Ramaih *et al.*, 1972), reduction in leaf size, delayed flowering (Dubey, 1974) and reduction in plant growth (Sastry and Singh, 1974).

In Gujarat, it has been reported that whitefly can cause as much as 16.28 per cent losses to marketable fruits due to virus infection (Anonymous, 1984). Aphid is a polyphagous sucking pest and also found damaging okra all over India. It also act as vectors of virus diseases and transmit mosaic, leaf curl etc. (Butani and Verma, 1976). Mites feeding on okra plant also tend to have reduction in leaf carbohydrates; moisture, resin, phosphorus and calcium content (Palaniswamy *et al.*, 1977). Spider mite *T. macfarlanei* cause damage and exert a loss in yield of okra fruits upto 23.55 per cent in South Gujarat conditions (Anonymous, 1995).

A study of pest succession is very useful in devising ecologically sound and economically viable "Integrated Pest Management" programme. Such studies in crop ecosystem are important in anticipating incidence of insects with regard to the crop stand and environment (Vekaria and Patel, 1999). In view of this, the present study was under taken with the following objectives.

OBJECTIVES:

1. To study the succession of important pests in different cultivars of okra under South Gujarat conditions.
2. To work out correlation between incidence of pest and weather parameters.
3. To estimate the avoidable yield losses due to important insect and mite pests.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Okra crop is attacked by several insect pests starting from the seedling stage till harvesting of the crop, causing substantial reduction in yield of okra. Succession in general refers to the act of repeated following up of one by another in order of time or space. Successional changes are orderly and develop in a certain sequence. Information on succession of different pests of a crop helps in understanding the order of occurrence of various pests and the critical period during which pest management measures are to be initiated. Studies of pest succession will also give an idea of simultaneous occurrence of insect pests causing identical damage during the particular period of crop growth so that it may be helpful in divicing "Integrated Pest Management" strategy.

2.1 Succession of important insect and mite pests

Dhamdhere *et al.* (1984) studied occurrence and succession of pests of okra during *kharif* season 1980 and summer 1981 at Gwalior, Madhya Pradesh, India. The result revealed that the jassid (*A. biguttula biguttula*) remained active throughout the crop season. Moreover, the low humidity during *kharif* appeared to be conducive for the population build up, whereas shoot and fruit infested due to the borer (*E. vittella*) in *kharif* ranged between 5.5 to 23.90 and 25.93 to 40.90 per cent and in summer season it ranged between 4.65 to 17.15 and 1.75 to 16.62 per cent, respectively. Temperature and humidity had no apparent effect on the pest activity in *kharif* but in summer the pest activity increased with rise in humidity.

Dubey *et al.* (1999) studied the insect pest succession in okra during summer in 1996 at Chhattisgarh, Madhya Pradesh, India, to determine the pest infesting okra cultivar. Parbhani Kranti was found to be infested by *A. bigutttula biguttula*, *E. vittella, B. tabaci, H. armigera, Aerocercops bifasciata, Thrips tabaci, A. gossypii, Podogria, Anomsis flava, Sylepta derogata, Dysderchus koenigii*, and *Nezara viridula*, whereas, on the basis of there occurance and infestation, *A. bigutttula biguttula, E. vittella, B. tabaci*, and *H. armigera* were the major pests and remaining were considered as minor pests.

An experiment was conducted on insect pest infesting okra during the *kharif* and summer seasons of 2002 and 2003, respectively at Raipur by Netam *et al.* (2007b). The results revealed that during *kharif* 2002, important insect pests *viz., A. biguttula bigutulla, B. tabaci, H. armigera, A. flava, D. koeniggi*, and *N. viridula* were recorded in okra. However, during *rabi* 2003, five insect pests were found damaging to the okra *viz.*, jassid, whitefly, shoot and fruit borer, semilooper and leaf miner. Moreover, the whitefly, aphid and leaf miner were recorded with low incidence in vegetative stages of crop during both the season.

2.1.1 Varietal screening

Srinivasa and Sugeetha (2001) screened nine okra cultivars *viz*., Arka Abhai, Line 199, KS 410, Parbhani Kranti, Hybrid 7, Varsha Uphar and Pusa Sawani for resistance to the major pests including leaf hopper, red cotton bug, fruit and shoot borer and spider mite, during the *kharif* 1997 and summer 1998 in Karnataka, India. The result showed that cv. KS 410 had lowest number of hopper, while Parbhani Kranti, Line 199 and GOH-1 were most preferred by hoppers during the *kharif* season, whereas red cotton bug was abundant only during *kharif*. Cultivars Arka Abhay and GOH-1 had low number of bugs, while Parbhani Kranti and KS-410 had high number of bugs. Moreover, the fruit borer and spider mite were more severe during summer than *kharif* season. However, GOH-1 had low mite incidence during *kharif* and high incidence during summer.

Kumar and Singh (2002) screened twenty-two okra cultivars for their resistance to *A. biguttula bigutulla* in Faizabad, Uttar Pradesh, India during summer season of 1999. The result showed that *A. biguttula bigutulla* was observed fourteen days after transplanting of okra cultivars. The pooled nymphal population of the pest was found lowest in Punjab Padmini followed by DOV-91-4 and Arka Anamika and highest in Pusa Sawani. Whereas, the lowest leaf injury was recorded in Arka Anamika followed by Punjab Padmini and highest in Pusa Sawani.

An experiment was conducted during 2000 and 2001 *kharif* season in Rajendranagar, Andhra Pradesh, India, on okra cultivars *viz*., Vijaya, Varsha, HYOH-1, AROH-47, MBORH-913, NOH-15, JNDOH-1, KOH-1 Arka Anamika and Arka Abhay to screen the resistance for yellow vein mosaic virus and fruit borer incidence. The result revealed that the NOH-15 had the highest yield (74.8 q/ha) with 11.9 per cent yellow vein mosaic disease incidence. However, NOH-15, JNDOH-1, AROH-47 and HYOH-1 were at par with each other for yield and yellow vein mosaic virus disease incidence. Whereas, the incidence of fruit borer ranged from 21.7 per cent (MBORH-913) to 29.2 per cent (Vijaya). MBORH-913 had the lowest fruit borer incidence and NOH-15 had the highest marketable fruit yield which was at par with JNDOH-1, HYOH-1, AROH-47 and Vijaya (Neeraja *et al.*, 2004).

A field experiment was conducted at Haryana, India, in 2000 and 2001, to screen different okra genotypes for resistance to the cotton leaf hopper based on nymph population and leaf injury indices by Singh and Dhankar (2005). The result revealed that the genotypes HRB 128-1-1, HRB 118-2-1, HRB 105-2-2 (GS) and HRB 111-1-1, which harboured lower nymph population and showed visual injury indices (2.71 to 2.89) were designated as resistant. Whereas, the genotypes having higher nymphal populations (HRB 107-4-1, HRB 121-1-1, HRB 130-1-1) exhibited severe injury indices (4.08 to 4.21). Moreover, the genotypes HRB 108-2-1, ST 2 and the cultivar Varsha Uphar were moderately resistance to the leaf hopper.

Sumathi (2005) screened fifteen okra varieties against aphid and leaf hopper and revealed that cultivars MF_1 (AA), $AAXOHD_2$, OHD_1, $XOHD_2$, Varsha Uphar, OHD_1, MF_1XOHD_2, Arka Anamika, MF_2XMF_3, MF_1XMF_2 and MF_2XMF_1 were moderately resistant to the aphid and MF_1, OHD_2 and MF_2XMF_3 were resistant to the leaf hopper.

Mandal *et al.* (2006a) evaluated different okra cultivars *viz.*, Arka Abhay, Arka Anamika, D-1-87-5, D-1-87-16, HRB-55, KS-312 and Pusa sawani against the fruit and shoot borer. The result showed that the shoot and fruit infestation was lowest in D-1-87-5 and highest in Pusa sawani whereas, D-1-87-5 and D-1-87-16 were considered as highly resistant to the shoot and fruit borer.

Manual *et al.* (2007) studied the field screening of okra cultivars against red spider mite during 2000 and 2001. The result showed that the cultivars *viz;* Arka Anamika, Arka Abhay, D-1-87-5, D-1-87-16 and HRB-55 had lower infestation while, the cultivar Pusa Sawani showed comparatively more infestation. The cultivars *viz;* Arka Anamika and D-1-87-5 were categorized as resistant whereas, the cultivar Pusa Sawani was found comparatively susceptible to the mite.

Netam *et al.* (2007a) studied the resistance of twenty-four cultivars against *E. vittella* on percentage of fruit damage, total number of damaged fruit, total yield and yield losses were evaluated during *kharif* 2002 in Chattisgarh, India. The result showed that the cultivars VRO-5, VRO-6, BLS-55, OH-77 and VRO-3 recorded lower percentage of fruit damage.

On the basis of screening of twelve okra genotypes against spider mite for two years the result showed that cultivar

AOL-04-02 and JOL-05-07 were found less susceptible while Parbhani Kranti, GO-2 and JOL-05-07 were found highly susceptible to mite population (Anonymous, 2008).

2.1.2. Correlation between incidence of pest and weather parameters

A) Sucking pests:

a) Aphid: *Aphis gossypii* Glover

According to Butani and Verma (1976), the *A. gossypii* was found to damage okra during winter and the dry weather was very congenial for its rapid multiplication while the rain brought down its population considerably.

In Russia, cotton aphid (*A. gossypii*) had two peaks, one in May-June and second in August-September. Further, the fluctuation in number and distribution of the aphid was affected by weather condition and favoured by low temperature and high humidity. The optimum conditions for its multiplication were mean day and night temperature of 20°C (68°F) and relative humidity of 60 per cent (Stepantzev, 1939).

According to Senapati and Mohanthy (1980), the *A. gossypii* on cotton occurred in August-February and July at Keonjhar in Orissa. The maximum incidence was recorded during August-December and December-January in *kharif* and *rabi* season, respectively. Roy and Behura (1983) have suggested that for winter cropping of cotton, control measures against aphid should be taken during November-January in Orissa as *A. gossypii* population remained high during this period.

Khan *et al.* (1984) reported that population of aphid (*A. gossypii*) reached to a peak in the fourth week of January and the first week of February, thereafter it declined sharply.

According to Dhamdhere *et al.* (1984), the *A. gossypii* was noticed only on *kharif* okra crop and remained active from last week of August to 1st week of October with peak population in last week of September.

In Brazil, the studies on influence of climate on population dynamics of *A. gossypii* in cotton showed that the population was not affected by minimum, maximum or mean temperature, the relative humidity, the direction or velocity of the wind, the evaporation rate, rain, or the number of mature bolls. However, increase in population was favoured by the presence of flower buds and by sunshine hours (Araujo and Sales, 1985).

Kadivar (1996) found that there was no incidence of aphid in summer, while in *kharif* the pest appeared after fourth week of sowing and attained peak level after seventh to ninth weeks of sowing. The population of aphid was significantly positively correlated with the maximum temperature, whereas, it was significantly negatively correlation with the minimum temperature.

Devasthali and Saran (1997) reported that the okra crop was suffered from sucking pests starting from the age of 11 days. Jassid was first appeared followed by aphid. The infestation period of aphid was 49 days and weekly mean population density was 18.32/3 leaves. Similarly, Patel *et al.* (1997) reported that there was no significant relationship between the populations of *A. gossypii* with any weather parameter.

Shyamprasad and Logiswaran (1997) reported that the population of aphid showed a positive association with maximum temperature and negative association with wind velocity and rainfall during both summer and winter season, whereas minimum temperature and rainfall exhibited negative association.

Narangalkar (2003) recorded the aphid activity on okra and found the negative association of pest population with bright sunshine hours, mean temperature, maximum temperature, temperature range, mean vapour pressure deficit and evening vapour pressure deficit.

b) Jassid: *Amrasca biguttula biguttula* (Ishida)

Jayraj and Basheer (1964) reported that the population of *Empoasca devastans* Distant on okra was higher in humid region than dry region at Coimbatore. A negative correlation was found between minimum temperature and Cicadellid jassid. They further noticed that the population of *E. devastans* was very less on plant infested by *A. gossypii* or *T. telarius* (owing to competition) or affected by the yellow vein clearing mosaic.

As regard the population study of jassid made on cotton crop, Atwal *et al.* (1969) recorded the population of

E. devastans in the field on cotton during 1965-66 in Punjab and observed the population peaks in August and September when the average temperature was 28.2 to 30.0°C and the relative humidity was 50 to 70 per cent in 1965 and 77 to 83 per cent in 1966. The population was less in 1996 and related to consistently high humidity during the peak period.

According to Jayram and Jankiraman (1969) the cloudy humid and drizzling weather was favourable for the multiplication of the jassid on cotton, while the heavy showers and bright sunshine were not congenial.

Seven to eleven weeks old okra plants were most susceptible to jassid (Rawat and Sahu, 1973; Senapati and Khan, 1978). According to Senapati and Khan (1978), the population of *A. bigutulla bigutulla* occurred on okra throughout the year, highest during November to February and reaching to peak in December when temperature and relative humidity were low in Orissa.

The results of the analysis of the data collected by Natarajan and Sundram (1978) at Kovilpatti in Tamil Nadu revealed that among the macro climatic factors, the maximum temperature and sunshine hours had negative correlation with population indicating that higher temperature and the resultant long of sunshine hours were not conducive for the prolification of leaf hoppers on cotton. The minimum temperature during the period of observation varied from 15.1 to 22.6°C and it had positive relationship with the pest, indicating that very low temperature was also not favourable for the development of the pest population. Relative humidity on the other hand, exercised the most potent influence on the pest population. The correlation co-efficient of both the morning and evening relative humidity was highly positive indicating the conducive factor for the pest activity.

Senapati and Mohanty (1980) reported that the population of jassid was occurred throughout the year on cotton at Koenjhar (Orissa). They further found that there was a progressive increase in jassid from the second week of December, reaching peak in the third week of January and then there was a decline from the second week of March until the end of July.

An experiment on seasonal abundance of different insect-pest on *Desi* cotton indicated that *A. biguttula biguttula* was more during July-August, the continuous and heavy rains caused mortality, while early and light showers of monsoon helped in multiplication of this pest at Ludhiana in Punjab (Sidhu and Dhawan, 1980)

Dhamdhere *et al.* (1984) observed that *A. bigutulla bigutulla* to be remained active throughout *kharif* and summer season and the low humidity in *kharif* crop was conducive to population built-up on okra crop at Madhya Pradesh.

In Gujarat, the Jassid population on okra was found throughout the crop period during summer and *kharif* season. Further, jassid population was higher in *kharif* season as temperature was also not favourable for the development of the pest population. Relative humidity on the other hand, exercised the most potent influence on the pest population. The correlation co-efficient of both the morning and evening relative humidity was highly positive indicating the conducive factor for the pest activity.

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In Gujarat, the Jassid population on okra was found throughout the crop period during summer and *kharif* season. Further, jassid population was higher in *kharif* season as compared to summer season. There was no significant correlation of jassid population with all weather parameters during summer season. However, during *kharif* season a significant correlation of jassid population was observed with the minimum temperature, while other parameters had a non-significant correlation (Patel, 1988).

A field experiment was conducted at Jorhat (Assam), India, during 1998-99, to record the seasonal abundance of cotton jassid, *A. biguttula biguttula*, on okra by Gogoi and Dutta (2000). The results revealed that the jassid population was maximum in the last week of May during 1998 and middle of April dring 1999, whereas high temperature, evening relative humidity and low rainfall period with bright sunshine hours favoured the development of cotton jassid population.

Kumawat *et al.* (2000) reported the seasonal incidence of jassid and whitefly on okra and their correlation with abiotic factors during *kharif* 2006 in the semi arid region of Rajasthan and revealed that infestation of jassid and whitefly started in the fourth week of July and reached peaks in the second and fourth weeks of September, respectively. Whereas, the maximum temperature was significantly correlated with whitefly density.

Narangalkar (2003) studied on population dynamics of jassid, *A.biguttula biguttula* on okra at Anand, Gujarat and found a positive correlation between jassid and bright sunshine hours, minimum, maximum and mean temperature as well as morning, evening and mean vapour pressure deficit, when the crop was planted in February, whereas such effect of mean temperature, morning, evening and mean relative humidity, morning, evening and mean vapour pressure deficit was observed in March planting with highly significant negative correlation with temperature range. However, the entire factor except morning relative humidity (RH) and minimum temperature (MinT) showed significant positive correlation when crop was planted in July.

c) Whitefly: *Bemisia tabaci* (Gennadius)

Sidhu and Dhawan (1981) reported that activity of whitefly, *B. tabaci* was maximum during July to August in Punjab on cotton.

Singh and Butter (1985) found that the population of *B. tabaci* on cotton was positively correlated with temperature and rainfall. However, the population buildup was negatively correlated with relative humidity.

Patel (1988) reported that activity of whitefly reached its peak level after 7-8 weeks of sowing. The peak activity was found in the month of December. The highest population was recorded on November sown crop.

Patel and Jhala (1992) studied population dynamics of whitefly *B. tabaci* on different hosts and revealed that population showed increasing trend from August and the highest population was recorded in December, which gradually declined and disappeared in May.

Kadivar (1996) found that whitefly was not appeared during summer season. However, during *kharif* season the pest was observed after 4th week of sowing, and the peak activity was observed after 10th week of sowing. The incidence of whitefly exhibited significant negative correlation with minimum temperature.

Ghosh *et al.* (1999) studied incidence of *B. tabaci* on okra and revealed that the population was at peak level at the end of crop growth period (4th week of July). Minimum temperature was positively correlated with whitefly population.

Ali *et.al* (2005) studied correlation of environmental conditions with okra yellow vein mosaic virus disease and *B.tabaci* population was determined on commercially grown varieties of okra. The result revealed that minimum temperature and relative humidity had significant correlation with okra yellow vein mosaic virus disease severity and whitefly population whereas, the disease incidence increased with the rise in minimum temperature and whitefly population decreased with increase in the relative humidity.

d) Mite: *Tetranychus macfarlanei* Baker and Pritchard

In Bihar, the incidence of *T. telarius* in cotton was observed during September to April (Lall and Dutta, 1959) while in Rajasthan, this mite was active from July to March on castor (Srivastava and Mathur, 1962). Bindra and Goyal (1966) from Punjab reported high intensity of this mite from April to October on *bhindi* except during the rainy season. In Punjab, major activity of this acarine pest was reported during September-October in *bhindi* and March-April in castor (Gurdipsingh and Saini, 1971).

In Egypt, the simultaneous effect of maximum day temperature, minimum night temperature and daily mean relative humidity on population of *T. cinnabarinus* and *T. telarius* was studied by EL-Sadney *et al.* (1977) during two cotton growing season. Maximum day temperature was positively correlated with population size of both mites. Minimum night temperature was also positively correlated with the population of both mites. Daily mean relative humidity was positively correlated with the population with the population size of adult of *T. cinnabarinus* but generally negatively correlated with that of *T. urticae*.

In South Gujarat conditions, *T. urticae* was observed to infest cotton crop from October to December when the temperature was high accompanied by low humidity and no rainfall (Lad, 1974). Later on, Jose (1983) from same place (Navsari, Gujarat) observed the incidence of spider mite (*T. macfarlanei*) on cotton which lasted for longer period between the month of October and February. However, in Madhya Pradesh, the incidence of *T. telarius* started earlier during last week of August to second week of October, its peak level being in third week of September in soybean (Singh *et al.*, 1990).

Kapoor *et al.* (2000) studied the population dynamics of mites associated with okra cv. Punjab-7 at the end of March and the end of June in 1997 and 1998. The result revealed that the Tetranychid mites appeared in okra sown in March 1997 in the last two weeks of June with a population of 3.33 mites per leaf. Whereas, okra sown in June 1997, Tetranychid infestation was highest (6.24 mites per leaf) in the last two weeks of August. While *T. cinnabarinus* population peaked in the final two weeks of August. However, in okra sown in March 1998, phytophagous mites appeared in the last two weeks of May and the population peaked in June at 2.82 mites per leaf whereas, okra sown in June 1998, the Tetranychid population was low from July to September and high from October and November were 7.55 and 7.98 mites per leaf, respectively.

Gulati (2004) studied the incidence of *T. cinabarinus* infestation in different cultivars of okra *viz.*, Pusa Sawani, Sanjam, Varsha Uphar, Arka Anamika, PK-10 and Parbhani Kranti at Hisar, Haryana, India, during 1997-99 for resistance to *T. cinabarinus*. The result reveled that in summer crop, highest number of mites was recorded compared to winter crop and the first peak in mite population was observed in June whereas the second was observed in October. Moreover, the highest number of mites was observed in middle leaves, followed by top and bottom leaves. The mite population was positively correlated with maximum temperature and relative humidity. However, it was negatively correlated with maximum temperature. Pusa Sawani and Varsha Uphar harboured the highest number of mites in both seasons, whereas Sanjam was the less susceptible to mite attack.

B) Bollworm pests

a) Shoot and Fruit borer: *Earias vittella* (Fabricus)

As reported by Mote (1977) the infestation of borer on okra pest start in 6 weeks after germination (*i.e.* as soon as fruit set), both in *kharif* and summer season at Maharashtra. The pest intensity in summer was found to increase rapidly and reached at its peak level (i.e., 69.9 %) in 9th week after germination, while in *kharif*, it increased gradually upto 10th weeks after germination. From 11th and 10th weeks age of the crop, the pest was found to decline suddenly in *kharif* and summer seasons, respectively. Again there was an increase at the end of both the season. Throughout the summer season, the intensity of infestation was more being in the range of 20.67 to 69.91 per cent, while in case of *kharif*, it was 17.31 to 37.18 per cent. According to Radke and Undirwade (1981) the average number of larvae (32.04%) and larval population (1.4 larvae/plant) was in the end of July. The pest population of *Earias* spp. was increased slowly upto mid September and then after abruptly increased. Heavy rainfall had detrimental effect on its build up.

In Haryana, the seasonal incidence of *Earias spp.* on okra was studied by Kashyap and Verma (1982) and it was found that between August and October 1977, the population density of the pest and percentage of infested fruits were not correlated with the prevailing temperature, relative humidity or rainfall. The incidence of the pest was highest in humid period which generally occurred after rainfall.

The infestation of *E. vittella* started on okra shoots in the second week after germination and continues upto 6^{th} week, when the crop reaches the flowering and fruiting stage. Further, they reported the highest infestation level of the pest during the months of May and June and lowest during December at Bangalore in Karnataka (Urs and Kumar ,1987).

Zala *et al.* (1999) studied on the impact of weather on magnitude of *E. vittella* infesting okra cv. Parbhani Kranti and revealed that the pest was active when the crop was 3 to 4 weeks old and remained active until the okra crop was uprooted. However, bright sunshine hours, maximum and mean temperature showed a significant positive effect, whereas mean vapour pressure and relative humidity had a significant negative influence on larval activity on okra.

Ahmad *et al.* (2000) correlated weather factor and larval population of *E. vittella* in summer sown okra cv. Parbhani Kranti. They recorded significant positive relationship with minimum temperature and negative correlation with the maximum temperature as well as positive correlation with both the RH at 7hr and 14hr, respectively. Rainfall too had significant impact on the larval population as the co-efficient of correlation was significant.

Mandal *et al.* (2006b) studied on the prediction of the okra fruit and shoot borer (*E. vittella*) incidence using weather variables at Pusa, Bihar on okra cv. Pusa Sawani during summer 2000-01, the result revealed that with delayed sowing the borer attack increased in the late sown crop (7th April) with nearly 31 per cent reduction in the yield of okra.

A field experiment was conducted during summer 2000 and 2001 at Pusa, Bihar, to evaluate the impact of weather parameters on the incidence and activity of *E. vittella* in okra cv. Pusa Sawani by Mandal *et al.* (2006c). The results revealed that the pest activity started to buildup from four-week-old crop and remained intensified critically below a maximum temperature of 35^{0}C and above the minimum temperature of 22^{0}C. A significant negative correlation with the maximum temperature and positive relationship with the minimum temperature, relative humidity, vapour pressure and rainfall were observed.

b) Heliothis: *Helicoverpa armigera*

The studies regarding periodic incidence of *Helicoverpa* carried out at Surat, Gujarat during 1984-1985 to 1987-88 did not reveal specific trend between the pest population and weather parameters. It was also opined that the stage of crop was rather more important for high population of the pest (Anon., 1985b; Anon., 1986; Anon., 1987; Anon., 1988 and Anon., 1989). Similarly, in Madhya Pradesh, Thakur *et al.* (1990) observed that the temperature and relative humidity did not affect the population build up of *Helicoverpa* and thus, some other intricate factors seemed to be responsible for the population build up of this pest.

A field experiment was conducted during 1997-98 in Parbhani, Maharashtra, India to determine the incidence of American bollworm (*H. armigera*) in cotton *cv.*NHH-44 (Jawalkar *et al.*, 2004) and reported that american bollworm incidence in fruiting bodies started in the last week of August and remained up to the first week of January. The peak incidence was observed from 2^{nd} week of September to the 2^{nd} week of October. Rainfall and morning relative humidity showed negative effects on the incidence of bollworm while other variables (maximum temperature, minimum temperature, evening humidity and bright sunshine hours) showed positive effects on bollworm incidence.

Rao *et al.* (2004) studied the relationship between *H. armigera* population and weather factors was evaluated on cotton (cv. HS-6 and H-1098) in Hissar, Haryana, India during 1990-91 and 2000-01. The result showed that the increase in population varied with the month. Weather parameters played a significant role in the development of the pest population during August. Wind speed and direction during September, and wind speed and temperature during October were important factors for the multiplication of *H. armigera*.

Mohapatra (2006) studied the distribution pattern of *H. armigera* on cotton during the *kharif* seasons of 2001-02 and 2002-03, in Umerkote, Orissa, India. The result showed that in 2001, infestation started during last week of August and lasted until mid November while in 2002, infestation started during second week of September and continued up to early November.

Patil *et al.* (2007) studied the population dynamics of bollworm complex in cotton during *kharif* 2005-06 and 2006-07 seasons in Dharwad, Karnataka, India. The result revealed that the *H. armigera* incidence started from second fortnight of August during both the seasons, with a peak of 10.50 larvae per five plants (2005-06) and 9.70 larvae per five plants (2006-07) during the first and third week of October, respectively.

C) Insect predators of okra pest

a) Lady bird beetle: *Coccinella septempunctata* L.

Gupta (1966) has been found that the population of *M. sexmaculatus* at Udaipur in Rajasthan, increased gradually from a low incidence averaging 5.0 in October to 57.0 numbers in February and suddenly rised to a peak during March, after which it declined from April-May. He further noticed that the rise in population depends on the rise in temperature from 15-20^{0}C combined with fall in humidity from 87 to 58 per cent.

The population dynamics of *A.gossypii* and its coccinellid predator on okra have been studied by Venugopal *et al.* (1975) in Tamil Nadu. It is reported that the pre-dominant species *M. sexmaculatus* was found predating on *A.gossypii* during September to October.

The population of the predacious coccinellid, *M. sexmaculatus* was found to be present from the last week of December, reached a peak in second week of February, then gradually declined on safflower, in Rajasthan (Upadhyay *et al.*, 1980 and 1983).

Upadhyay (1984) has made the population dynamics study on coccinellid predator occurring on groundnut. He reported that during *kharif* season coccinellid grubs and adult beetles were appeared from second week of July and maximum population (10.0 adults/ten plants) was recorded during second week of August. In summer they appeared from first week of March and their activity was maximum (10.5 adults/ten plants) during first week of April. As regard the population of different species of predatory coccinellids, *M. sexmaculatus* predominated with 50-52 per cent population during *kharif* and 49.50 per cent in summer. Coccinellids population showed positive correlation with minimum temperature and relative humidity as well as negative correlation with maximum temperature in *kharif*.

Chandra and Kushawaha (1987) reported that the predators, *C.septempunctata* and *M. sexmaculatus* activity suppressed the aphid population after two to four weeks of their appearance. According to them, the population started to build up in the third week of January, increased through the second week of February and reached the highest level in the first week of March.

Patel *et al.* (1990) reported predator *M. sexmaculatus* attained maximum activity after 10^{th} week of sowing of okra *i.e.* in the month of January, but it declined in the later period of the crop. Whereas, coccinellid *M. sexmaculatus* peaked in early September on sorghum and pigeonpea (Duffield, 1995).

Linxia *et al.* (2004) studied the population dynamics of cotton aphids in different cotton variety fields and the effects of ladybird beetles on the population dynamics of cotton aphids. The results showed that the quantity of cotton aphids in the different cotton variety fields increased or decreased exponentially. The quantity of cotton aphids in the cotton field in Kongque Farm, Yuli County, increased exponentially during the period from May 31st to June 28th, 2001, but decreased exponentially during the period from June 28th to July 26th. Ladybird beetles were the main natural enemy of cotton aphid, their quantity corresponding with that of cotton aphids, and their occurrence time was late by about one week compared to that of cotton aphids.

b) Green lacewing: *Chrysoperla scelestes* Banks

Patel and Vyas (1985) from Gujarat reported that both larvae and adult of *chrysopa* spp. feed on stages of various sucking pests such as aphid, jassid and whitefly. Studies on population dynamics revealed that incidence of green lacewing adults started during October and lasted upto the first fortnight of November at Sardar Krushinagar (Anon., 1985a). However two years later, Gadhia (1988) reported that incidence of *Chrysopa* commenced from October with minimum number during January at the same location.

Kalariya (1993) from Sardar Krushinagar observed significant correlation between relative humidity and lacewing population in pigeanpea crop. From the same station, Khanpara (1993) also reported that the relative humidity was negatively correlated with *Chrysopa* population in castor crop and the correlation coefficient was significant. Other weather parameters *viz;* maximum and minimum temperature, morning relative humidity, sunshine hours and rainfall did not show significant influence on the population of green lacewing.

Field experiments were conducted to determine the correlation between retainability and egg laying of *C. carnea* adults and weather parameters in a cotton ecosystem at the Tamil Nadu Agricultural University, Tamil Nadu, India. The result revealed that there was significant positive correlation between retainability and egg laying of the adults with relative humidity and prey (aphid) population and a significant negative association with temperature and wind speed. (Geetha and Swamiappan, 1998).

Saminathan *et al.* (2003) conducted the survey on the occurrence of *C. carnea* at the 3 main cotton producing area *viz;* Aruppukottai, Thirumangalam and T. kallypatti, in Tamil Nadu, India, during winter 1995-96 and summer 1996. In the three locations, the population of *C. carnea* was higher during winter than during summer. During winter the population per twenty plants was 377, 356 and 341 during the entire period of observation at three locations, respectively. While during summer, it was 200, 205 and 198, respectively.

Afsari *et al.* (2006) studied the population fluctuation of the cotton aphid, *A.gossypii* and its natural enemies under sprayed and unsprayed conditions during the year 2002 and 2003. The result showed that the first aphid colonies appeared during late June to early July and reached peak numbers during mid September whereas, natural enemies population fluctuated in a similar pattern. Results of correlation analysis showed significant relationship between aphid population, main natural enemies and some climatic factors. However, these relationships were depended on species of natural enemies, growing season and chemical treatments. Coccinellids, Chrysopids as biotic factors and , temperature, daily sunshine hours and wind speed as abiotic factors which were linearly correlated with total aphid population.

2.2 Estimation of yield losses due to important insect and mite pests of okra

Srinivasan and Gowder (1959) reported that 40 to 50 per cent fruits damage due to *E. vittella* in Madras.

Rawat and Sahu (1973) studied the estimation of losses in growth and yield of okra due to jassid and *Earias spp.* and observed that the average percentage of damaged fruits by *Earias spp.* in untreated plots was 22.60 as against 1.02 per cent in treated plots. Whereas, the losses in number and weight of fruit which were due to jassid and *Earias spp.* were recorded as 53.9 and 61.4 per cent, respectively.

Mote (1977) reported maximum incidence of fruit borer in *kharif* and summer crops to the tune of 37.18 and 69.91 per cent, respectively. Similarly, Kadam (1993) reported that shoot and fruit borer alone causes 66.28, 46.45 and 69.04 per cent losses in fruit yield of okra crops sown in summer, *kharif* and *rabi* seasons respectively, with an average loss of 60.69 per cent in absence of plant protection umbrella.

An experiment was conducted on incidence of *Earias spp.* on okra by Dhawan and Sidhu (1984) at Ludhiana (Punjab). They reported that the maximum damage in fruits (67.70 per cent) and buds (52.40 per cent) was at the end of October, while maximum shoot (1.70 per cent) and flower damage (1.50 per cent) was in mid August. In spring crop, maximum fruit damage (32.04 per cent) and larval population (1.4 per plant) was at the end of July. The population of *Earias spp.* was increased slowly upto mid September and thereafter abruptly increased. Heavy rain fall had detrimental effect on its built up.

In Gujarat, Patel (1988) reported that the average per cent fruit damage to be higher on okra during *kharif* season (34.95 per cent) as compared to summer (3.44 per cent). The results revealed that there was no significant correlation between *Earias* damage and weather parameters in summer. However, during *kharif*, significantly positive correlation of shoot damage was observed with minimum temperature and rainy days.

The red spider mite *T.macfarlanei* Banker and Pritechard can alone cause on an average of 23.55 per cent loss in yield of okra under South Gujarat condition (Anonymous, 1995).

A field experiment was conducted at Hissar, Haryana, India to estimate the avoidable losses caused by the leaf hopper on different cultivars of okra *viz.*, MR-8, MR-8-1, MR-9, MR-9-2, MR-12-1, Pusa Sawani, MR-52-1, MR-12 and P-7 by Sharma *et al.* (2001). The result revealed that the highest number of green fruit was recorded for the cultivar MR-12 and lowest was recorded for Pusa Sawani whereas, the corresponding avoidable losses (weight basis) were 63.41 and 88.21%, respectively. The highest seed yield was obtained in MR-9-2 and lowest in Pusa Sawani and the avoidable seed loss (wt basis) was highest in MR-8 (80.53 per cent) and lowest in MR-12-1 (63.78 per cent).

Kanwar and Ameta (2007) studied assessment of losses caused by insect pest of okra and they reported that in marketable fruit yield of okra, the insect pest caused 48.97 per cent loss in fruit yield of okra equivalent to the loss of 77.78 q/ha. Moreover, the per cent fruit damage and reduction in growth of okra plants were higher in unprotected plots than protected plots.

A field experiment conducted with okra cv. Parbhani Kranti to assess yield loss caused by the spider mite (*T. urticae*) during summer season of 2000 and 2001 in Uttar Pradesh, India. The results revealed that early sown crop of okra suffered from substantially lower reduction in fruit yield 9.12 and 12.72 per cent as against the higher loss (32.22 and 36.41 %) in yield obtained from the late sown crop during 2000 and 2001, respectively, due to much more population of the red spider mite harboured by the late sown crop as compared to that of early sown crop (Prasad and Singh, 2007).

MATERIALS AND METHODS

III. MATERIALS AND METHODS

The present investigation on succession of important pests of okra in different cultivars and estimation of avoidable losses due to pest complex in okra cv. Pabhani Kranti were carried out at College farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari during *kharif*-2007. The materials used and techniques employed for conducting various experiments are presented here.

3.1 Succession of important pests in different cultivars of okra

Study on the important pests in different cultivars of okra was carried out at Navsari Agricultural University, Navsari during *kharif* 2007 without insecticide application. The other details of the experiments are given below.

3.1.1 Experimental details

1.	Location	: College Farm, N.A.U; Navsari.
2.	Season and Year	: *Kharif*-2007
3.	Design	: Randomized Block Design (R.B.D.)
4.	No. of Replication	: 4
5.	Variety	: 1. Parbhani Kranti 2. Arka Anamika 3. Pusa Sawani 4. GO – 2 5. LSVT (AOL-03-1)

6. Plot size : 4.5×2.25 m (Gross)
: 3.30×1.35 m (Net)
7. Spacing : 45 × 30 cm
8. No. of Row per plot : 5
9. Method of Sowing : Dibbling
10. Fertilizer : N-P-K as per recommendation dose
11. Irrigation : As per requirement

All the post sowing recommended agronomical practices were followed. Experimental area was kept free from insecticidal spray throughout the season in order to record the incidence of insect pests.

3.1.2 Method of observation

With a view to find out the seasonal fluctuations in important pests and their succession in okra, weekly observation were recorded in five cultivars *viz.*, Parbhani Kranti, Arka Anamika, GO-2 and LSVT(AOL-03-1) during *kharif* 2007. The crop grown for this purpose was kept unsprayed throughout the season. Observation on insect and mite pests population were recorded at weekly interval starting twenty days after sowing till harvesting of the crop, following methods of observation were used for various pests.

A. Sucking pest complex:

To determine the population of sucking pests *viz;* aphid, jassid, whitefly and mite, were taken on five plants per plot randomly selected, from each plant three leaves each from the top, middle and lower part were observed at weekly interval starting from twenty days after sowing till uprooting the crop. Mean jassid, whitefly, aphid and mite population per leaf was worked out separately.

B. Bollworm pests

To determine the population of bollworms *viz*; spotted bollworm and *Helicoverpa*, observation were recorded from randomly selected ten plants per plot. Number of larvae of *Earias vittella* and *Helicoverpa* were recorded separately and mean number of each bollworm per plant were worked out from these data for further analysis.

C. Natural predators of insect and mite pests

The number of larvae and adults of green lacewing and lady bird beetle were recorded from randomly selected five plants in each plot of different cultivars of okra. Mean population of green lacewing and lady bird beetle per plant were calculated separately.

12 Statistical analysis

The observations recorded on population of sucking pests *viz*; aphid, jassid, whitefly and mite; population of bollworm *viz*; spotted bollworm and *Helicoverpa*; and population of natural predators *viz*; green lacewing and lady bird beetle were statistically analyzed after due square root transformation to draw inference in both the experiments. The periodic mean values of different cultivars on pest incidence ware taken into account for pest succession study.

3.1.2 Correlation between incidence of pest and weather parameter

In order to study the effect of weather parameters, *viz.*, maximum temperature, minimum temperature, average temperature, morning relative humidity, evening relative humidity, average relative humidity, sunshine hours, rainy days and rainfall on population of various pests, correlation coefficient and multiple/simple regression were worked out. Weekly metrological data as recorded by the office of the Farm manager, College farm, N.M. College of Agriculture, Navsari for the period during July to November 2007 were used for this purpose.

3.1.3 Correlation between insect predators and their host insects

Simple correlation between predatory insects *viz;* green lacewing and lady bird beetle with their host insects like aphid, jassid, whitefly and mite pests were worked out by using their periodical mean population.

3.1.4 Correlation among different pest populations

Correlation between various pests *viz;* aphid, jassid, whitefly, mite, spotted bollworm and *Helicoverpa* with each other were worked out using the weekly mean population of these pests.

3.2 Estimation of avoidable losses due to pest complex in okra cv. Parbhani Kranti

To estimate avoidable losses due to pest complex in Parbhani Kranti variety of okra, a field experiment was conducted in, College farm, Navsari Agricultural University, Navsari during the *kharif* season in the year 2007. The other experimental details are furnished as under.

3.2.1 Experimental Details:

1.	Location	: College farm, NAU, Navsari.
2.	Season and Year	: *Kharif*-2007
3.	Design	: Randomized Block Design (R.B.D.)
4.	No. of Replication	: 3
5.	Variety	: Parbhani Kranti
6.	Plot Size	: 4.5×2.25 m (Gross) 3.30×1.35 m (Net)
7.	Spacing	: 45 X 30 cm
8.	No. of Row per plot	: 5
9.	Method of Sowing	: Dibbling
10.	No. of Treatment	: 7

Details of treatments:

A) Protection against insect pests throughout crop season. (seed treatment +need base application of insecticides)

B) Protection against insect pests from 30 days onwards.

C) Protection against insect pests from 45 days onwards.

D) Protection against insect pests from 60 day onwards.

E) Protection against insect pests up to 45 days. i.e. seed treatment

F) Protection against insect pests up to 60 days. (seed treatment +need base application of insecticides)

G) No protection against insect pests.

3.2.2 Methods of Observations:

Weekly Observations were recorded for different insect and mite pests as described in succession of insect pest studies. To record the observations of sucking pests, five plants were randomly selected, from each plant three leaves each from the top, middle and lower part were observed for sucking pests at weekly interval. To record the observation of spotted bollworm and *Helicoverpa*, ten plants were randomly selected and numbers of larvae as well as damaged fruits were recorded at weekly interval. Yield of healthy and damaged fruits were recorded separately at each picking. The average pest population was worked out using observations of a pest for all the respective treatments. The average pest population at each observation was used to compare it with economic threshold level to decide application of insecticide. The chemical control measures were adopted as and when the insect or mite populations exceed the economic threshold level fixed for each pest.

3.2.3 Details of Insecticide Treatments:

Seed treatment: Imidacloprid (Gaucho) 70 WS 10gm/kg seeds.

Sr. No.	Insect-Pest	Chemical Control Measure	Conc. Per cent	Dose
1.	Sucking pest	Thiamethoxam 25 WG	0.005	2gm/10lit
2.	Spotted bollworm	Spinosad 2.5 SC	0.0020	8ml/10lit
3.	Semilooper	Emamectin benzoate 5 SG	0.001	2gm/10lit
4.	Prodenia	Chlorfenapyr 10 SC	0.0075	7.5ml/10lit
5.	Mite	Propargite (Omite57 EC)	0.05	20ml/10lit

Arbitrary economic threshold levels for important pest of okra

Sr. No.	Insect-Pest		ETL
1.	Sucking pest	Aphid	Alone or combined number 10/ leaf
		Jassid	Alone or combined number 10/ leaf
		Whitefly	5-10 adults/leaf
2.	Spotted bollworm		20 larvae/20 plant
3.	Semilooper		4 larvae/plant
4.	Prodenia		5 first instar larval colony/20 plant
5.	Mite		10 mites/leaf

3.2.4 Okra fruit yield

Okra fruit yield received from net plot area of each treatment was weighted and recorded separately during each picking. Total yield of all picking in each treatment was converted on hectare basis.

3.2.5 Avoidable losses

Per cent avoidable losses of okra yield in different treatments were calculated by comparing the okra yield of respective treatments with unprotected treatment by adopting following formula. (Kanwar and Ameta, 2007)

$$\text{Avoidable losses per cent} = \frac{\text{Yield in protected plot} - \text{Yield in unprotected plot}}{\text{Yield in protected plot}} \times 100$$

3.2.6 Economics

To work out Benefit to Cost Ratio (BCR) first, the cost of insecticides per hectare for each treatment was calculated based on prevailing market price. The labour cost involved for chemical control in different treatments during the experiment was taken into consideration as per minimum labour wages fixed by state government. The value of yield of okra per hectare for each treatment obtained during the investigation was calculated using prevailing market price of okra. Thereafter gross realization was worked out for each treatment after deducting the cost of insecticides plus cost of labour. For finding out the additional profit due to the use of insecticides for each treatment, the value realized in control treatment was deducted from the gross realization for each treatment. BCR was worked out based on additional profit after deducting realization in control treatment divided by total cost protection i.e. cost of insecticides plus cost of labour.

RESULTS AND DISCUSSION

IV. RESULTS AND DISCUSSION

Two field experiments were conducted during *kharif* 2007 at the College farm, Navsari Agriultural University, Navsari, to study the succession of important pests of okra in different cultivars and estimation of avoidable losses due to pest complex in okra cv. Parbhani Kranti attacking in different stages of crop growth. The results obtained from these experiments are presented and discussed in this chapter.

4.1 Succession of important pests in different cultivars of okra

A field experiment was undertaken to study the pests succession in okra. During the investigation, five cultivars were studied *viz;* Parbhani Kranti, Arka Anamika, Pusa Sawani, Go-2 and LSVT (AOL-03-1) were grown in replicated trial. Five plants were selected from each plot for sucking pests and ten plants were selected for shoot and fruit borer and periodic observations were recorded at weekly interval on different insect-pests to workout period of activity, period of peak level of population, pest succession and period of simultaneous occurrence and also the influence of population of one pest on other pests.

The result (Table-1 and Fig.-1) revealed that there was no incidence of insect-pests in early stage of crop till third weeks after sowing (WAS). However, incidence of sucking pests likes jassid, *A. biguttulla biguttulla* and whitefly, *B. tabaci* started

Table : 1 Succession of important insect – pests of okra during *kharif* – 2007

Standard week	WAS	Date of observation	Mean population per leaf				Mean population/plant	Natural predator/plant	
			Aphid	Jassid	Whitefly	Mite	S & F borer	Green lace wing	Lady bird beetle
31	4	30/07/2007	0.71(0.00)*	1.26(1.18)*	0.96(0.52)*	0.71(0.00)*	0.87(0.27)*	0.71(0.00)*	0.71(0.00)*
32	5	06/08/2007	0.96(0.44)	1.44(1.68)	1.02(0.62)	0.71(0.00)	0.94(0.41)	0.76(0.10)	0.71(0.00)
33	6	13/08/2007	1.32(1.33)	1.55(1.96)	1.18(1.02)	0.71(0.00)	0.96(0.45)	0.83(0.22)	0.71(0.00)
34	7	20/08/2007	1.48(1.78)	1.65(2.30)	1.59(2.18)	0.71(0.00)	0.99(0.51)	0.94(0.44)	0.71(0.00)
35	8	27/08/2007	1.70(2.51)	1.69(2.41)	2.04(4.18)	0.71(0.00)	1.04(0.61)	1.11(0.78)	0.71(0.00)
36	9	03/09/2007	2.02(3.69)	1.89(3.22)	1.86(3.34)	0.99(0.80)	1.17(0.98)	0.85(0.26)	0.76(0.09)
37	10	10/09/2007	2.21(4.46)	2.23(4.76)	1.71(2.70)	1.40(2.20)	1.35(1.35)	0.71(0.00)	0.81(0.18)
38	11	17/09/2007	2.54(6.10)	2.41(5.52)	1.65(2.48)	2.58(6.48)	1.26(1.11)	0.71(0.00)	0.88(0.31)
39	12	24/09/2007	4.01(16.69)	2.14(4.16)	1.61(2.36)	4.21(18.20)	1.21(1.00)	0.71(0.00)	0.95(0.46)
40	13	01/10//2007	4.19(18.50)	2.02(3.65)	1.56(2.14)	4.29(18.02)	1.14(0.83)	0.71(0.00)	1.16(0.90)
41	14	08/10//2007	3.50(12.24)	1.83(2.90)	1.41(1.72)	4.04(15.98)	1.10(0.72)	0.71(0.00)	0.82(0.90)
42	15	15/10//2007	2.98(8.70)	1.70(2.46)	1.30(1.38)	3.64(12.86)	1.04(0.59)	0.71(0.00)	0.71(0.00)

- Data in the parentheses are original value, while those outside are square root ($\sqrt{X + 0.5}$) transformed values

WAS = Week After Sowing

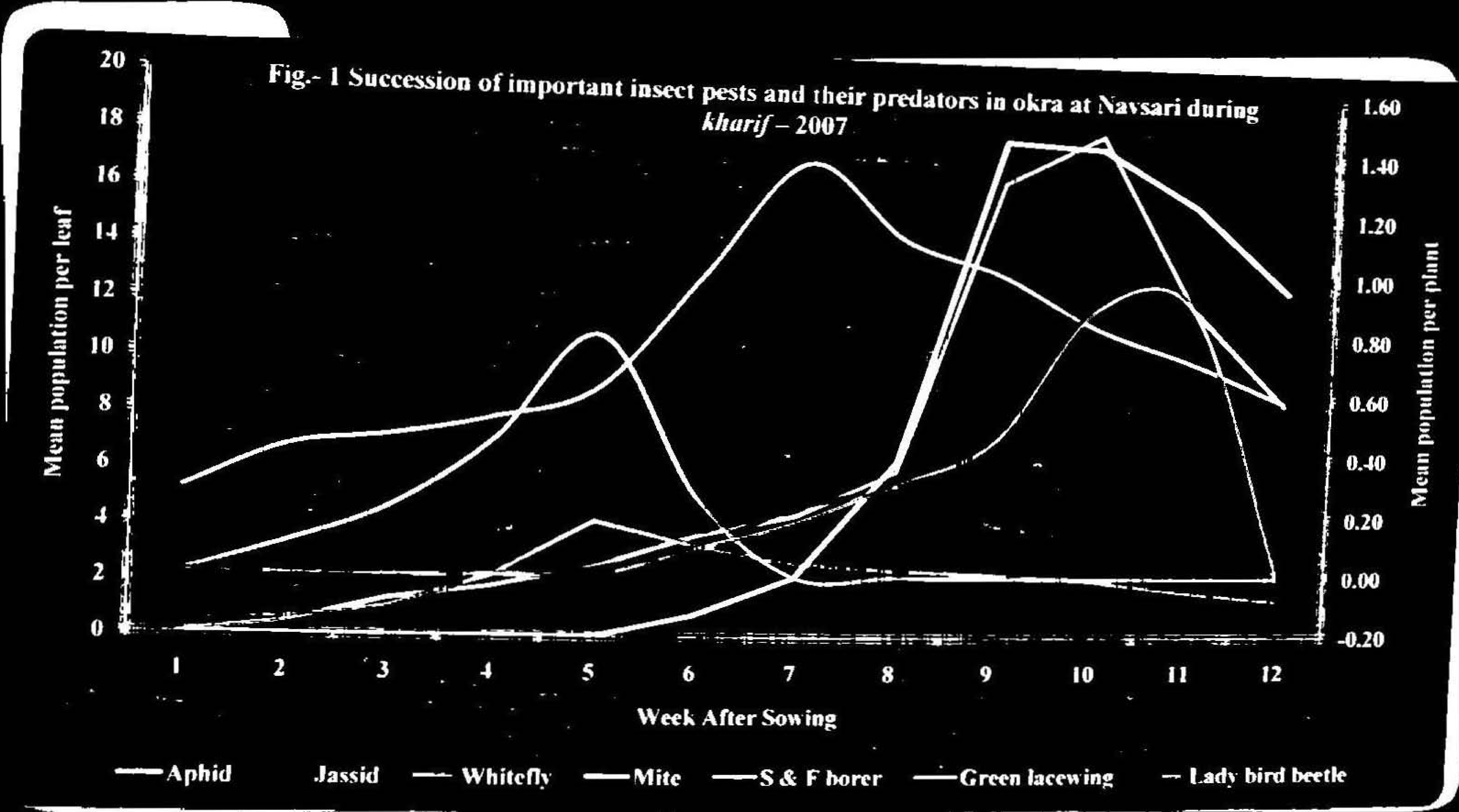


Fig.- 1 Succession of important insect pests and their predators in okra at Navsari during kharif – 2007
Mean population per leaf
Mean population per plant
20
18
16
14
12
10
8
6
4
2
0
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1
2
3
4
5
6
7
8
9
10
11
12
Week After Sowing
Aphid
Jassid
Whitefly
Mite
S & F borer
Green lacewing
Lady bird beetle

simultaneously fourth WAS i.e. last week of July and they showed their activity on the crop throughout the season. Initially, the incidence of these two pests was low. Among them, whitefly multiplied comparatively at a faster rate reaching to peak level after 8^{th} WAS (4.18 adults/leaf). Whereas, population of jassid increased gradually and attained its peak during later part of crop season (11^{th} WAS) i.e. 5.52 jassids per leaf. The whitefly population exhibited sudden decline within couple of weeks and was as its lowest level (1.38 adults/ leaf) during the harvesting of the crop and also the population of jassid suddenly declined within couple of weeks and was as its lowest level (2.52 jassids/leaf) at the end of the crop season.

Similarly aphid, *A. gossypii* population initiated 5^{th} WAS i.e. 0.44 aphid per leaf. The aphid multiplied comparatively at a faster rate reaching to peak level at 40^{th} standard week (18.50 aphids/leaf) there after the pest population declined and reached at the end of the crop season. In case of mite, *T. macfarlanei* the population initiated from 9^{th} WAS (0.80 mite/leaf) then its population gradually increased and reached to peak level at 39^{th} standard week (18.20 mites/leaf) after this population declined and reached at the harvesting stage of the crop. Population of all these sucking pests declined and disappeared from okra crop 15^{th} WAS (third week of October).

The shoot and fruit borer, *E. vittella* (Table-1) appeared on the okra crop throughout the crop season. At the early stage, it attacked the growing shoot and later on, it moved to fruits. The shoot damage was observed in the early vegetative growth stage (4^{th} WAS), when tender shoots were available in plenty to bore and feed inside. The population of shoot and fruit borer reached to its peak level (1.35 larvae/plant) during the 37^{th} standard week there after the pest population declined and reached to 0.59 larva per plant at the harvesting stage of crop.

It can be further explicated from the results that the two predators *viz*; green lacewing and lady bird beetle occurred first week of August to third week of October. Out of the two predators, chrysopid was first to appear between 4 and 9 WAS and reached its maximum intensity 8 WAS. Later on, the coccinelids swung into action 9 WAS and prevailed throughout the remaining crop season, the later one reached peak level 13 WAS. Thus, the green lacewing took the lead for enforcing natural control, while lady bird beetle took care of residual low level population of sucking pests. The two predators *viz*; green lacewing and lady bird beetle appeared at different period exerting to some extent natural check on sucking pests.

4.1.1 Sequence of occurrence of important insects and mite pests on okra

Insect-pest requires certain set of weather conditions particularly temperature and relative humidity for their survival and multiplication. Moreover, in course of evolution, they have adopted to feed and survive not only on a particular host but also on specific part of suitable host plant that satisfy their nutritional requirements. This leads to occurrence of different insect-pests at different growth stages of host plant. Besides the feeding habit and other habits like secretion of honey dew, spinning of silk web etc. are the factors responsible for difference in period of occurrence of different pests on the same host plant. Thus, the period of their occurrence in-group or in isolated manner may be dependent on stages of crop growth, population of insect-pests and prevailing weather factors. With these facts in mind, the present investigation was undertaken to work out sequence of occurrence of important insect-pests of okra in South Gujarat. The mean number of important pests observed at weekly interval during the crop season with respect to five different cultivars were used for this purpose. These findings are discussed below.

The results revealed that there was no incidence of insect pest in early stage until third WAS, however, incidence of sucking pests like jassid, whitefly and borer like shoot and fruit borer started simultaneously fourth WAS *i.e.* the last week of July. Out of these, two sucking pests occurred throughout the season. Among them, whitefly multiplied at comparatively faster rate reaching the peak level 8th WAS. It was followed by jassid which attained the peak level 11th WAS conforming positive correlation with whitefly mentioned in Table-2. The third sucking pest *i.e.* aphid multiplied relatively slowly and as such reached the peak level 13th WAS *i.e.* first week of October disclosing positive correlation with jassid. The population of these sucking

Table : 2 Correlation among important insect pests of okra during *kharif* – 2007

Insect-pests	Aphid	Jassid	Whitefly	Mite	Shoot & fruit borer
Aphid	-	0.481	0.140	0.966*	0.416
Jassid	0.481	-	0.498	0.393	0.940*
Whitefly	0.140	0.498	-	-0.018	0.579*
Mite	0.966*	0.393	-0.018	-	0.303
Shoot & fruit borer	0.416	0.940*	0.579*	0.303	-

* Significant at 5 % level (r = ± 0.574)

pests declined at the end of crop season. The fourth sucking pests *i.e.* mite population started 9th WAS which multiplied relatively slow and as such reached the peak level 12th WAS *i.e.* last week of September conforming significant positive correlation with aphid (r= 0.966) and negatively correlated with whitefly (r= -0.018). Shoot and fruit borer population started in 4th WAS which multiplied relatively slow and as such reached the peak level 10th WAS *i.e.* second week of September conforming significant positive correlation with jassid (r= 0.940) and whitefly (r= 0.579). The population of these pests gradually declined at the end of crop season.

The two predators viz; *C. scelestes* and *C. septempunctata* occurred at distinct periods of crop growth. The chrysopid appeared in the early stage of crop suppressing jassid and whitefly population. The incidence of coccinelid predator started during later part of crop stage and prevailing throughout the remaining crop season.

4.1.2 Varietal Screening

4.1.2.1 Periodic incidence of important pests on different cultivar of okra during *kharif* -2007

A. Sucking pests

(a) Aphid: *A. gossypii*

The periodic incidence of aphid on okra during the crop season is given in Table 3 and Fig.-2. The result indicated

Table : 3 Periodic incidence of aphid, *A. gossypii* on different cultivars of okra during *kharif* - 2007

Standard Week	WAS	Date of observation	Mean number of aphid per leaf					Period mean
			Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)	
31	4	30/07/2007	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*
32	5	06/08/2007	0.81(0.20)	0.92(0.40)	0.89(0.40)	1.19(1.00)	0.82(0.20)	0.93(0.44)
33	6	13/08/2007	1.63(3.20)	1.07(0.80)	1.11(0.80)	1.26(1.20)	1.05(0.65)	1.22(1.33)
34	7	20/08/2007	1.69(3.60)	1.37(1.60)	1.37(1.40)	1.33(1.40)	1.15(0.90)	1.38(1.78)
35	8	27/08/2007	2.23(5.00)	1.63(2.20)	1.69(2.40)	1.49(1.80)	1.27(1.15)	1.66(2.51)
36	9	03/09/2007	2.31(5.40)	1.96(3.40)	2.20(4.40)	1.98(3.60)	1.45(1.65)	1.98(3.69)
37	10	10/09/2007	2.50(6.20)	2.18(4.40)	2.37(5.20)	2.05(4.00)	1.72(2.50)	2.16(4.46)
38	11	17/09/2007	3.06(9.20)	2.48(5.80)	2.69(7.00)	2.36(5.20)	1.94(3.30)	2.51(6.10)
39	12	24/09/2007	3.28(10.40)	4.81(25.40)	5.11(28.00)	2.59(6.40)	3.58(13.25)	3.27(16.69)
40	13	01/10//2007	6.22(40.00)	3.92(15.80)	3.75(14.00)	4.05(16.00)	2.59(6.70)	4.11(18.50)
41	14	08/10//2007	4.53(20.60)	3.48(12.40)	3.33(10.80)	3.52(12.00)	2.33(5.40)	3.44(12.24)
42	15	15/10//2007	3.79(14.00)	2.84(7.80)	3.03(8.80)	3.10(9.20)	1.95(3.70)	2.94(8.70)
Cultivar Mean			3.73(9.82)	2.28(6.67)	2.10(6.93)	2.14(5.15)	1.71(3.28)	2.19 (6.37)

	S. Em. ±	C.D. (0.05)	CV %
Cultivar (C)	0.088	0.244	
Period (P)	0.136	0.378	27.19
C X P	0.305	0.845	

* Data in the parentheses are original value, while those outside are square root (vX + 0.5) transformed values

WAS = Week After Sowing

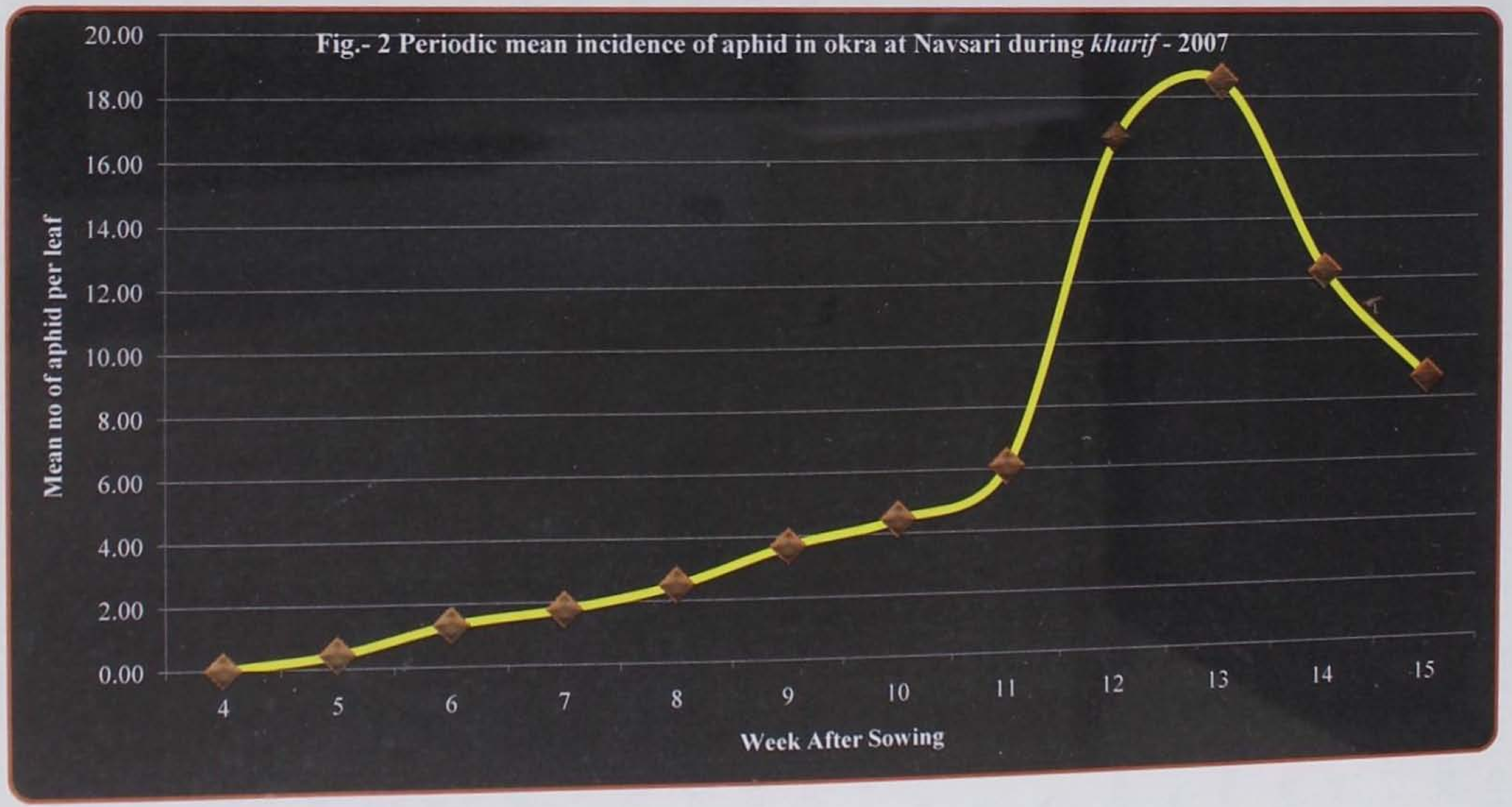


Fig.- 2 Periodic mean incidence of aphid in okra at Navsari during *kharif* - 2007
Mean no of aphid per leaf
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
4
5
6
7
8
9
10
11
12
13
14
15
Week After Sowing

significant differences in the incidence of aphid at different period of crop growth. The period mean revealed that the aphid population commenced fifth weeks after sowing (WAS) i.e. the first week of August, when 0.44 aphid was recorded per leaf. Thereafter, the population gradually increased up to 11[th] WAS i.e. third weeks of September and reached to the peak level (18.50 aphids/leaf) 13[th] WAS coinciding with first week of October. Thereafter, aphid population gradually declined at the harvesting of the crop i.e. third week of October.

The results revealed significant differences in aphid population among different okra cultivars. The cultivar LSVT (AOL-03-1) recorded least population i.e. 3.28 aphids per leaf which was at par with GO-2 (5.15 aphids/leaf), whereas, highest population (9.82 aphids/leaf) was recorded in Parbhani Kranti followed by Pusa Sawani and Arka Anamika cultivars. The interaction effect due to cultivar × period was also significant. This indicated that various okra cultivars differed in their reaction to aphid population at different period of crop growth.

From the results, it can be inferred that the aphid population occurred throughout the crop season with higher level during the last week of September and first week of October. The pest crossed economic threshold level (ETL) between last week of September to first week of October. Earlier to this, similar finding have been reported by Dhamdhere *et al.* (1984) reported peak population of *A. gossypii* in last week of September. Thus, the present findings are in close conformity to the earlier reports on seasonal activity of aphid.

(b) Jassid : *A. biguttula biguttula*

The jassid population differed significantly at different period of crop growth irrespective of cultivar (Table 4 and Fig.-3). Perusal of results further indicated that the incidence of jassid started fourth WAS (the last week of July) (1.18 jassids/leaf), initially increased slowly up to ten WAS (2^{nd} week of September). However, its population reaches to the peak level in 38^{th} standard week (5.52 jassids/ leaf). Thereafter, the population started steady decline and reached at low level of 2.46 jassids per leaf at the end of the crop season.

The results further revealed significant differences in jassid population on different cultivars. The cultivar Arka Anamika supported minimum population (2.03 jassids/leaf) which was at par with GO-2 (2.05 jassids/leaf) and LSVT (AOL-03-1) (2.07 jassids/leaf) cultivars, while, the maximum jassid population (4.71 jassids/leaf) was observed in Parbhani Kranti, which was at par with Pusa Sawani (4.23 jassids/leaf). The descending order of susceptibility of different cultivars to this pest was Parbhani Kranti, Pusa Sawani, LSVT (AOL -03-1), GO-2 and Arka Ananika. The interaction effect due to cultivar × period on incidence of jassid was found to be non-significant which indicated that the susceptibility of different cultivars was not affected by the age of okra cultivars under study.

Table : 4 Periodic incidence of jassid, *A. biguttula biguttula* on different cultivars of okra during *kharif* - 2007

Standard Week	WAS	Date of observation	Mean number of jassid per leaf					Period mean
			Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)	
31	4	30/07/2007	1.62(2.32)*	1.23(1.30)*	1.39(1.60)*	0.91(0.38)*	0.88(0.30)*	1.21(1.18)*
32	5	06/08/2007	1.72(2.72)	1.31(1.30)	1.79(2.80)	1.10(0.75)	1.13(0.83)	1.41(1.68)
33	6	13/08/2007	1.77(2.82)	1.39(1.50)	1.83(3.00)	1.24(1.08)	1.36(1.43)	1.52(1.96)
34	7	20/08/2007	1.94(3.50)	1.44(1.60)	1.96(3.50)	1.27(1.15)	1.46(1.73)	1.61(2.30)
35	8	27/08/2007	1.92(3.40)	1.44(1.60)	1.96(3.50)	1.43(1.58)	1.55(1.98)	1.66(2.41)
36	9	03/09/2007	2.32(5.62)	1.66(2.40)	2.18(4.50)	1.44(1.60)	1.55(2.00)	1.83(3.22)
37	10	10/09/2007	3.05(9.72)	1.66(2.40)	2.25(4.90)	2.25(4.58)	1.64(2.23)	2.17(4.76)
38	11	17/09/2007	2.91(8.72)	1.94(3.40)	2.93(8.30)	2.02(3.60)	2.02(3.60)	2.36(5.52)
39	12	24/09/2007	2.36(5.42)	1.85(3.00)	2.52(6.00)	1.87(3.00)	1.97(3.40)	2.11(4.16)
40	13	01/10//2007	2.31(5.12)	1.74(2.60)	2.35(5.20)	1.86(2.75)	1.75(2.60)	1.99(3.65)
41	14	08/10//2007	2.02(3.92)	1.54(2.00)	2.03(3.80)	1.80(2.20)	1.74(2.58)	1.79(2.90)
42	15	15/10//2007	1.26(3.22)	1.26(1.30)	2.00(3.70)	1.63(1.95)	1.61(2.15)	1.65(2.46)
Cultivar Mean			2.15(4.71)	1.54(2.03)	2.10(4.23)	1.55(2.05)	1.60(2.07)	1.78(3.02)

	S. Em. ±	C.D. (0.05)	CV %
Cultivar (C)	0.0591	0.164	23.05
Period (P)	0.0916	0.254	
C X P	0.205	NS	

* Data in the parentheses are original value, while those outside are square root (√X + 0.5) transformed values

WAS = Week After Sowing

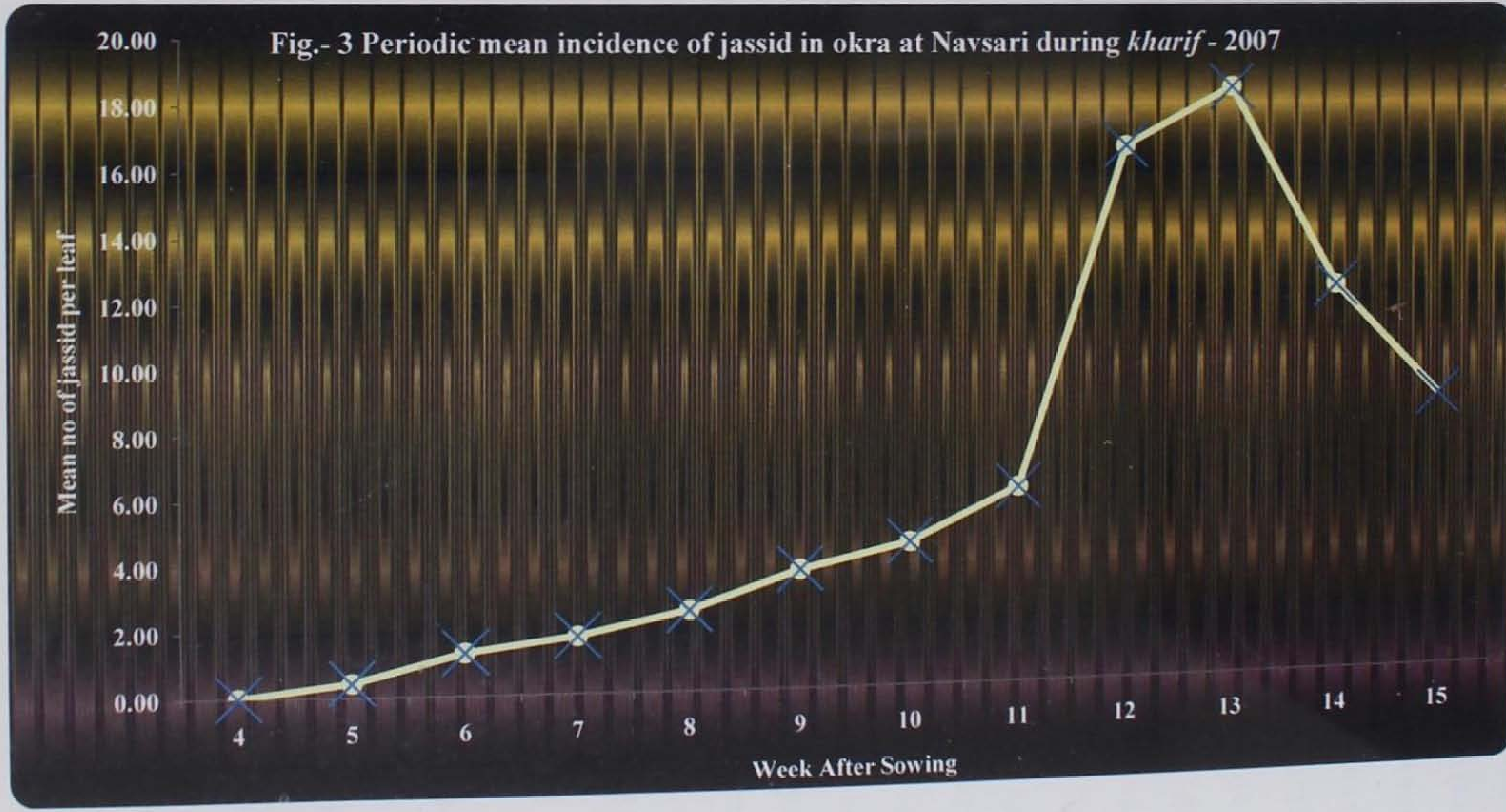


Fig.- 3 Periodic mean incidence of jassid in okra at Navsari during *kharif* - 2007
Mean no of jassid per leaf
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
4
5
6
7
8
9
10
11
12
13
14
15
Week After Sowing

From the results, it can be summarized that the jassid population occurred throughout the crop season with the peak level of population during the third week of September. The results further indicated that the jassid population crossed the ETL during the 3rd week of September. The results obtained in present investigation are thus in close agreement with the earlier reports of Atwal *et al.* (1969) who observed higher incidence of jassid in the month of September. Srinivasa and Sugeetha (2001) reported cultivar Parbhani Kranti was more preferred by jassid during the *kharif* season. Rawat and Sahu, 1973; Senapati and Khan, 1978 reported that seven to eleven weeks old okra plants were more susceptible to attack by jassids. The higher incidence of jassid population during August-September in central states was obvious because higher atmospheric temperature prevailing in these state during this period as compared to southern states. The facts that the jassid population is favoured by higher temperature have been also supported by correlation studies.

(c) Whitefly: *B.tabaci*

The results on periodic fluctuation of whitefly on okra are presented in Table-5 and Fig.-4. The results showed significant differences in population build up of whitefly at different stages of crop growth. The period mean indicated that the pest started fourth WAS (the last week of July) (0.52 adult/ leaf) and reached a peak level during the last week of August (4.18 adults/leaf). The whitefly population gradually

Table : 5 Periodic incidence of whitefly, *B. tabaci* on different cultivars of okra during *kharif* - 2007

Standard Week	WAS	Date of observation	Mean number of whitefly per leaf					Period mean
			Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)	
31	4	30/07/2007	1.51(2.00)*	0.71(0.00)*	0.82(0.20)*	0.89(0.40)*	0.71(0.00)*	0.93(0.52)*
32	5	06/08/2007	1.51(2.00)	0.77(0.10)	0.82(0.20)	1.00(0.60)	0.82(0.20)	0.98(0.62)
33	6	13/08/2007	1.86(3.00)	0.95(0.50)	1.06(0.70)	1.00(0.60)	0.88(0.30)	1.15(1.02)
34	7	20/08/2007	2.07(3.80)	1.80(2.80)	1.12(0.80)	1.77(2.70)	1.12(0.80)	1.58(2.18)
35	8	27/08/2007	3.45(11.40)	1.48(1.80)	1.67(2.50)	1.69(2.40)	1.77(2.80)	2.01(4.18)
36	9	03/09/2007	3.09(9.10)	1.42(1.60)	1.41(1.60)	1.53(2.00)	1.67(2.40)	1.82(3.34)
37	10	10/09/2007	2.73(7.00)	1.42(1.60)	1.38(1.50)	1.42(1.60)	1.49(1.80)	1.69(2.70)
38	11	17/09/2007	2.65(6.60)	1.36(1.40)	1.31(1.30)	1.31(1.30)	1.49(1.80)	1.62(2.48)
39	12	24/09/2007	2.61(6.40)	1.31(1.30)	1.26(1.20)	1.31(1.30)	1.43(1.60)	1.58(2.36)
40	13	01/10//2007	2.43(5.50)	1.31(1.30)	1.26(1.20)	1.31(1.30)	1.36(1.40)	1.53(2.14)
41	14	08/10//2007	2.35(5.10)	1.25(1.10)	1.20(1.00)	1.06(0.70)	1.06(0.70)	1.38(1.72)
42	15	15/10//2007	2.16(4.20)	1.06(0.70)	1.20(1.00)	1.00(0.60)	0.94(0.40)	1.27(1.38)
Cultivar Mean			2.37(5.51)	1.24(1.18)	1.21(1.10)	1.27(1.29)	1.23(1.18)	1.46(2.05)

	S. Em. ±	C.D. (0.05)	CV %
Cultivar (C)	0.0465	0.129	22.02
Period (P)	0.720	0.199	
C X P	0.161	0.446	

* Data in the parentheses are original value, while those outside are square root (√X + 0.5) transformed values

WAS = Week After Sowing

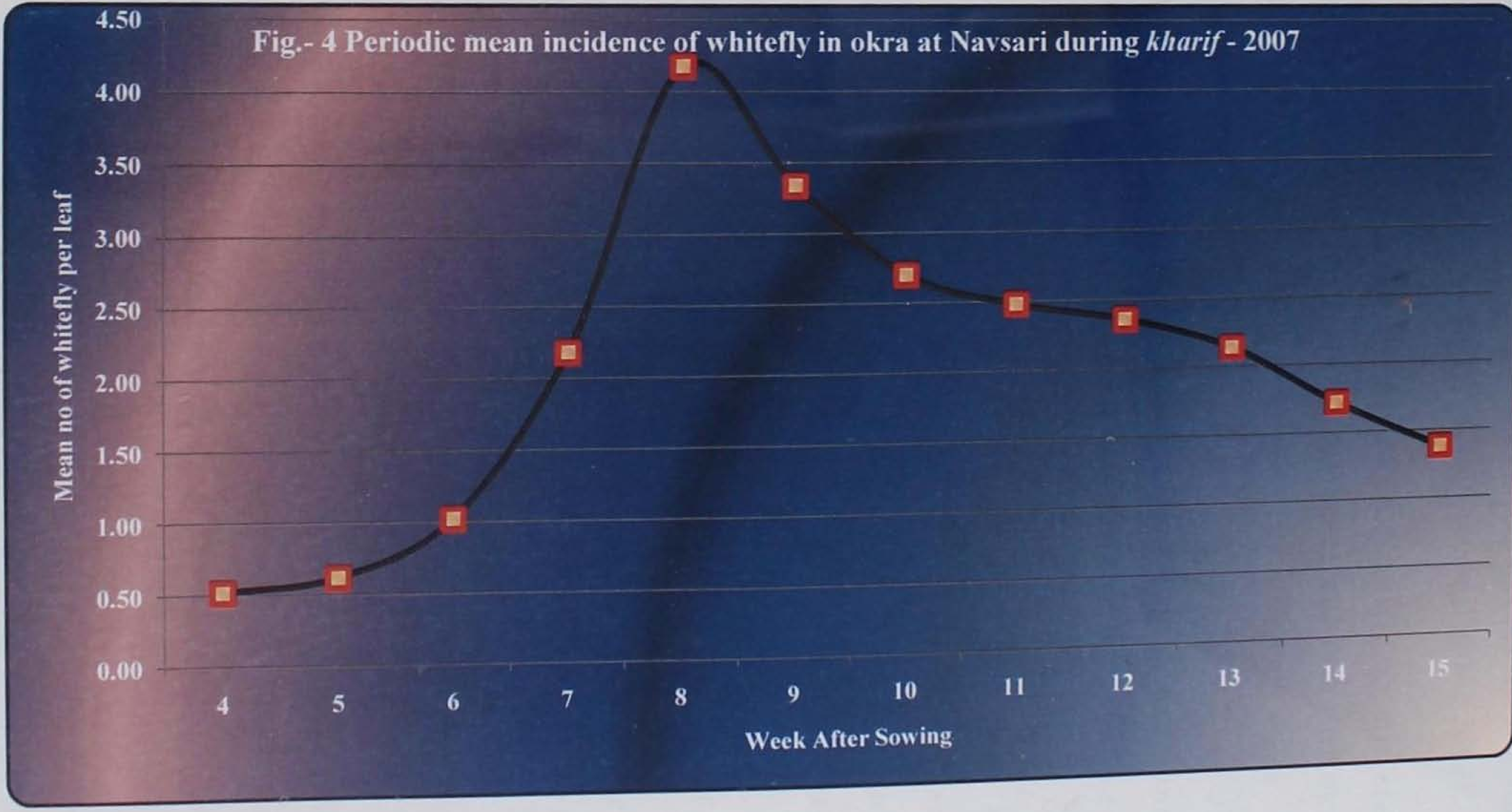


Fig.- 4 Periodic mean incidence of whitefly in okra at Navsari during *kharif* - 2007 declined reaching the low level (1.38 adults/leaf) during the third week of October, after which it reached to negligible level.

Perusual of results revealed significant difference in relative abundance of whitefly in different cultivars of okra. The minimum population was observed in cultivar Pusa Sawani (1.10 adults/leaf) which was at par with LSVT (AOL-03-1) (1.18 adults/leaf), Arka Anamika (1.18 adults/leaf) and GO-2 (1.29 adults/leaf). The highest population was observed in Parbhani Kranti (5.51 adults/leaf). The descending order of susceptibility of different cultivars to this pest was Parbhani Kranti, GO-2, Arka Anamika, LSVT (AOL-03-1) and Pusa Sawani. The interaction effect due to the cultivar × period on incidence of whitefly was significant. This indicated that various okra cultivars differed in their reaction to whitefly at different periods of crop growth.

From the results, it can be concluded that the whitefly appeared from the last week of July to the third week of October with the period of peak population during the last week of August. Earlier to this, Sidhu and Dhavan (1981) reported that activity of whitefly *B. tabaci* was maximum during July to August while Patel (1988) found the activity of whitefly reaching its peak level after seven to eight weeks of sowing. Thus, the present findings tally with the reports of Patel (1988) while it differs with the reports of Sidhu and Dhawan (1981). Who reported that the variation in whitefly activity may be due to location, date of sowing of okra crop and environmental conditions in the particular area.

(d) Mite: *T. macfarlanei*

Significant differences were observed in population build up of mite at different growth periods of okra crop (Table-6 and Fig.-5). On the basis of period mean, it was found that the incidence of mite started nine WAS (first week of September) (0.80 mite/leaf), increased rapidly and reached a peak level at 12^{th} WAS, coinciding with the last week of September (18.20 mites/leaf). Later on, it gradually declined reaching the lower level at the end of the crop season.

The results further indicated significant differences in the mean population of mite per leaf among different cultivars. The cultivar LSVT (AOL-03-1) showed the lowest mite population (4.71 mites/leaf) which was at par with GO-2 (4.98 mites/leaf), Arka Anamika (5.20 mites/leaf) and Pusa Sawani (7.23 mites/leaf). Reversely, the highest mite population (8.94 mites/leaf) was observed in Parbhani Kranti. The descending order of susceptibility of different cultivars to this acarine pest was Parbhani Kranti, Pusa Sawani, Arka Anamika, GO-2 and LSVT (AOL-03-1). The interaction effect due to cultivar × period on the incidence of mite population was found to be significant which indicated that the susceptibility of various okra cultivars to mite population was inconsistent at different stages of crop growth.

Table : 6 Periodic incidence of mite, *T. macfarlanei* on different cultivars of okra during *kharif* - 2007

Standard Week	WAS	Date of observation	Mean number of mite per leaf					Period mean
			Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)	
31	4	30/07/2007	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*
32	5	06/08/2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
33	6	13/08/2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
34	7	20/08/2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
35	8	27/08/2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
36	9	03/09/2007	1.81(4.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.93(0.80)
37	10	10/09/2007	2.20(6.60)	0.71(0.00)	1.88(4.40)	0.71(0.00)	0.71(0.00)	1.24(2.20)
38	11	17/09/2007	3.10(10.70)	1.78(3.80)	2.62(8.60)	1.77(3.00)	2.53(6.30)	2.36(6.48)
39	12	24/09/2007	5.37(28.41)	3.24(10.00)	5.08(25.60)	2.69(8.20)	4.36(18.80)	4.15(18.20)
40	13	01/10//2007	4.72(22.20)	4.39(18.80)	4.31(19.10)	4.28(17.80)	3.46(12.20)	4.23(18.02)
41	14	08/10//2007	4.49(20.30)	4.00(15.60)	4.00(16.40)	4.11(16.40)	3.31(11.20)	3.98(15.98)
42	15	15/10//2007	3.66(15.09)	3.51(14.20)	3.51(12.60)	3.84(14.40)	2.86(8.00)	3.48(12.86)
Cultivar Mean			2.41(8.94)	1.82(5.20)	2.14(7.23)	1.80(4.98)	1.79(4.71)	1.99(6.21)

	S. Em. ±	C.D. (0.05)	CV %
Cultivar (C)	0.091	0.253	31.67
Period (P)	0.141	0.392	
C X P	0.316	0.876	

* Data in the parentheses are original value, while those outside are square root (vX + 0.5) transformed values

WAS = Week After Sowing

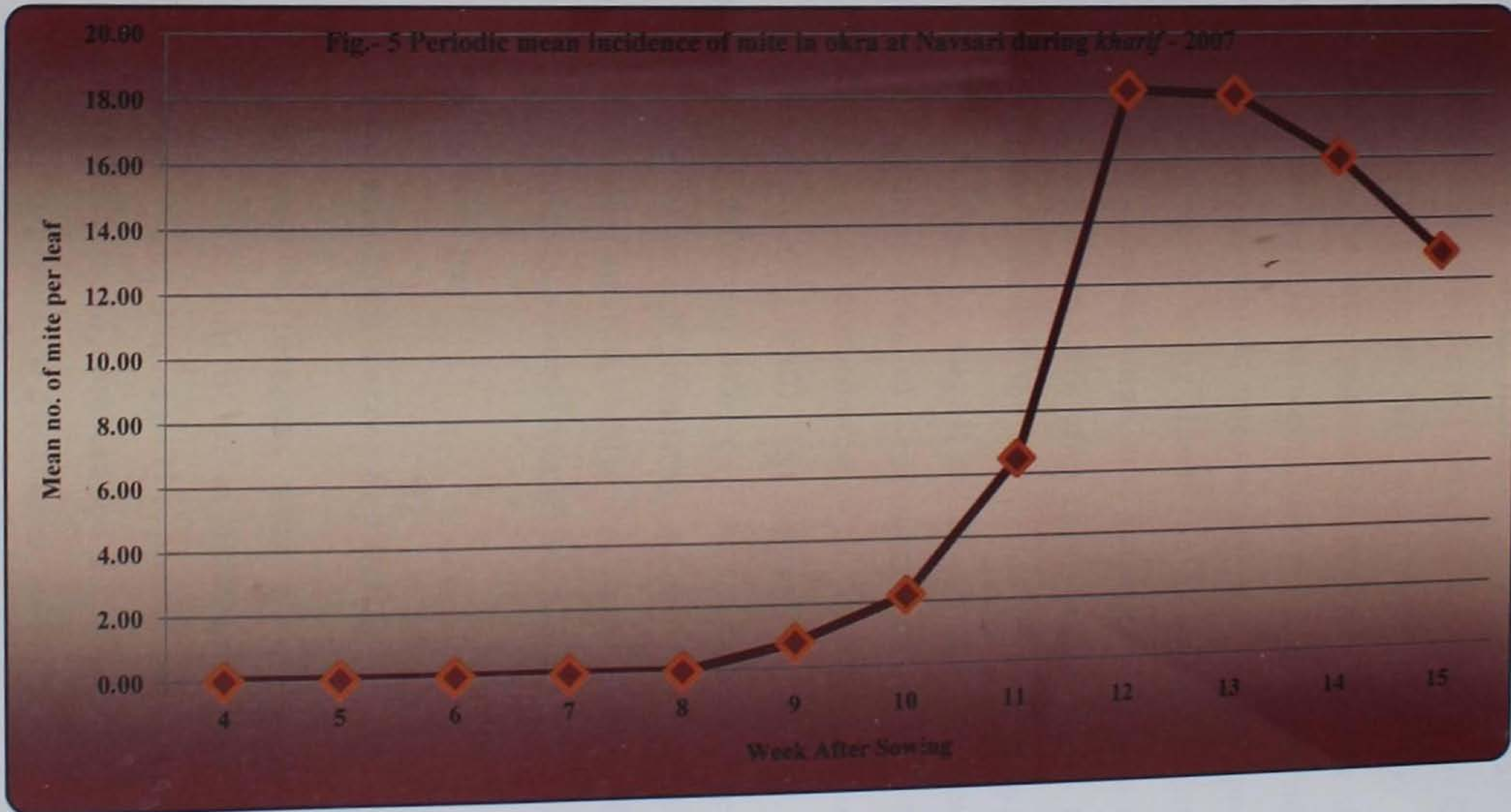


Fig.- 5 Periodic mean incidence of mite in okra at Navsari during kharif - 2007
Mean no. of mite per leaf
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
4
5
6
7
8
9
10
11
12
13
14
15
Week After Sowing

Table : 7 Periodic incidence of shoot and fruit borer, *E. vittella* on different cultivars of okra during *kharif* - 2007

Standard Week	WAS	Date of observation	Mean number of larvae per plant					Period mean
			Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)	
31	4	30/07/2007	1.07(0.68)*	0.77(0.10)*	0.89(0.33)*	0.77(0.10)*	0.80(0.15)*	0.86(0.27)*
32	5	06/08/2007	1.11(0.78)	0.85(0.25)	1.09(0.70)	0.82(0.18)	0.80(0.15)	0.93(0.41)
33	6	13/08/2007	1.11(0.78)	0.85(0.25)	1.15(0.83)	0.82(0.18)	0.85(0.23)	0.96(0.45)
34	7	20/08/2007	1.13(0.83)	0.87(0.28)	1.22(1.00)	0.84(0.20)	0.85(0.23)	0.98(0.51)
35	8	27/08/2007	1.19(0.98)	0.90(0.33)	1.29(1.18)	0.88(0.28)	0.88(0.28)	1.03(0.61)
36	9	03/09/2007	1.52(1.88)	0.93(0.38)	1.57(1.98)	0.91(0.33)	0.91(0.33)	1.17(0.98)
37	10	10/09/2007	1.48(1.80)	1.23(1.05)	1.53(1.85)	1.29(1.18)	1.15(0.85)	1.34(1.35)
38	11	17/09/2007	1.37(1.45)	1.12(0.78)	1.50(1.78)	1.16(0.85)	1.09(0.70)	1.25(1.11)
39	12	24/09/2007	1.34(1.35)	1.08(0.70)	1.45(1.63)	1.07(0.65)	1.06(0.65)	1.20(1.00)
40	13	01/10//2007	1.27(1.18)	1.04(0.60)	1.33(1.28)	1.02(0.55)	1.02(0.55)	1.14(0.83)
41	14	08/10//2007	1.20(1.03)	0.97(0.45)	1.22(1.03)	1.01(0.53)	1.02(0.55)	1.08(0.72)
42	15	15/10//2007	1.13(0.88)	0.94(0.40)	1.14(0.83)	0.97(0.45)	0.93(0.38)	1.02(0.59)
Cultivar Mean			1.24(1.13)	0.96(0.46)	1.28(1.20)	0.96(0.45)	0.95(0.42)	1.08(0.73)

	S. Em. ±	C.D. (0.05)	CV %
Cultivar (C)	0.024	0.072	15.56
Period (P)	0.038	0.104	
C X P	0.084	NS	

* Data in the parentheses are original value, while those outside are square root ($\sqrt{X + 0.5}$) transformed values

WAS = Week After Sowing

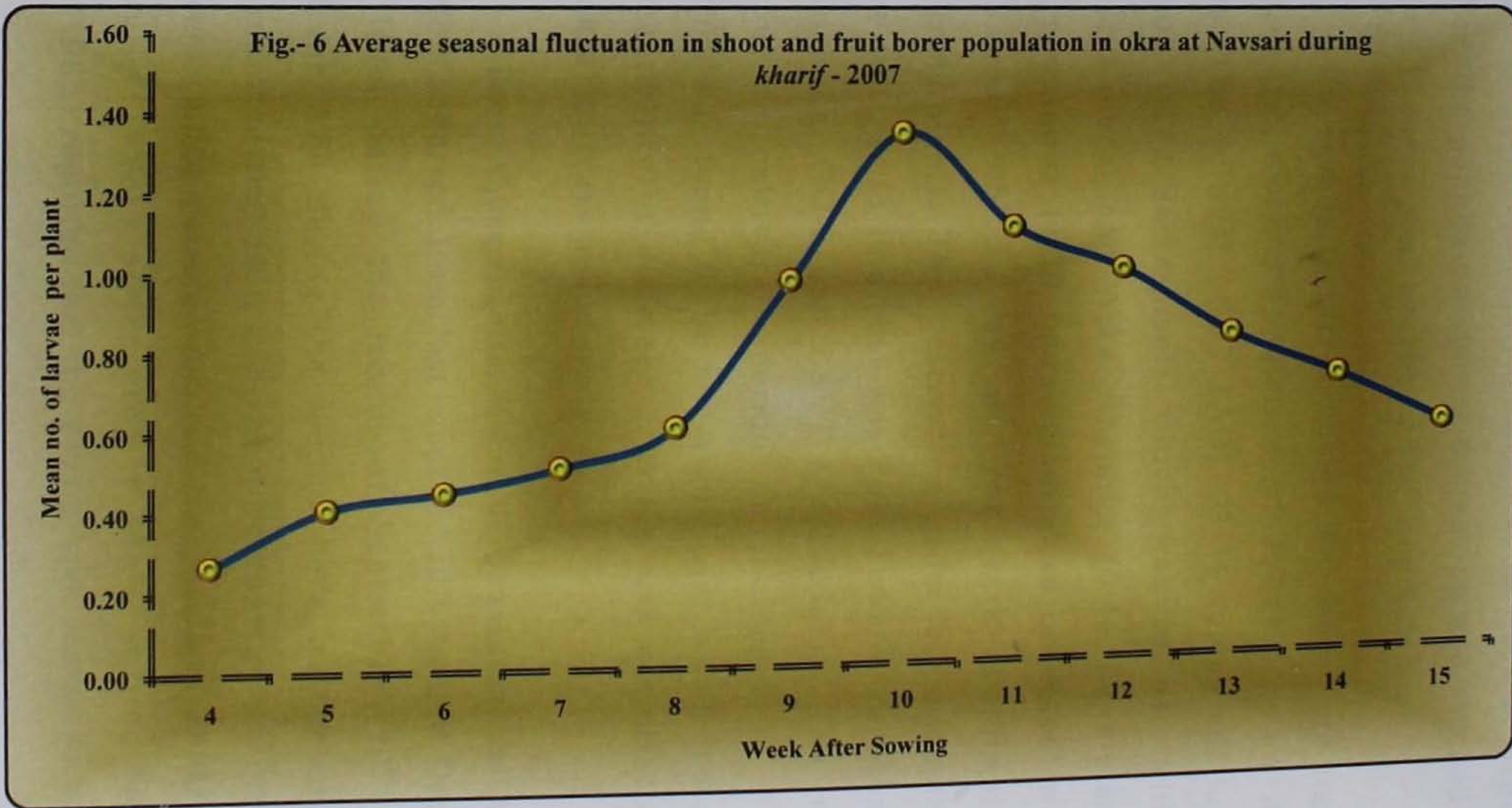


Fig.- 6 Average seasonal fluctuation in shoot and fruit borer population in okra at Navsari during *kharif* - 2007 peak level (1.35 larvae/plant) during second week of September. Thereafter, the population started decreasing and reached at low level of (0.59 larva/plant) at the end of crop season.

The results further indicated that there were significant differences in average population of *E. vittella* on different cultivars. The cultivar LSVT (AOL-03-1) supported the lowest population (0.42 larva/plant) which was at par with GO-2 (0.45 larva/plant) and Arka Anamika (0.46 larva/plant). The highest population (1.20 larvae/plant) was observed in cultivar Pusa Sawani which was at par with Parbhani Kranti (1.13 larvae/plant). The descending order of susceptibility of different cultivar to this pest was Pusa Sawani, Parbhani Kranti, Arka Anamika, GO-2 and LSVT (AOL-03-1). The interaction effect due to cultivar × period on incidence of *E. vittella* population was found to be non-significant which indicated that the susceptibility of different cultivars was not affected by the age of okra cultivars under study.

From these results, it can be concluded that the *Earias* population occurred from last week of July to mid October with higher level during the month of September (10^{th} WAS), It crossed the ETL during the second week of September. Mote (1977) reported that fruit and shoot borer increased gradually up to 10 weeks after germination and the pest was found to decline suddenly 11 weeks of the crop in *kharif* season. Kashyap and Verma (1982) reported that the *Earias* spp. remained active in the months of August, September and October. Mandel *et al.* (2006) reported that shoot and fruit borer infestation was highest in Pusa Sawani cultivar. Thus, the present findings are in close conformity to the earlier reports.

b) Heliothis: *Helicoverpa armigera*

H. armigera does not occur throughout the crop season hence, the results regarding the same were not discussed.

4.1.2.2 Periodic occurrence of natural predators of insect-pests of okra

Green lacewing (GLW) and lady bird beetle (LBB) are effective predators of soft bodied sap sucking insects like aphid, jassid, whitefly etc. Therefore, periodic incidence of these predators was also studied simultaneously to have an idea about its role in checking populations of the sucking pests of okra.

a) Green lacewing: *C. Scelestes*

The periodic incidence of *chrysoperla* population in different cultivars of okra during the crop season is given in Table-8 and Fig.-7. Significant differences were observed in population build up of *chrysoperla* during different periods of crop growth. The period mean indicated that the chrysopid population started 4^{th} WAS i.e. the first week of August (0.10 larva/plant), increased rapidly and reached the peak level (0.78 larva/plant) during the fourth week of August. Later on, its

Table : 8 Periodic incidence of green lacewing, *C. scelestes* on different cultivars of okra during *kharif* - 2007

Standard Week	WAS	Date of observation	Mean number of larva per plant					Period mean
			Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)	
31	4	30/07/2007	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*
32	5	06/08/2007	0.91(0.38)	0.71(0.00)	0.77(0.10)	0.71(0.00)	0.71(0.00)	0.76(0.10)
33	6	13/08/2007	0.96(0.48)	0.78(0.13)	0.93(0.40)	0.74(0.05)	0.74(0.05)	0.83(0.22)
34	7	20/08/2007	1.18(0.90)	0.88(0.30)	1.11(0.75)	0.77(0.10)	0.78(0.13)	0.94(0.44)
35	8	27/08/2007	1.26(1.10)	1.06(0.68)	1.22(1.00)	1.10(0.75)	0.91(0.38)	1.11(0.78)
36	9	03/09/2007	1.04(0.63)	0.79(0.15)	0.97(0.48)	0.74(0.05)	0.71(0.00)	0.85(0.26)
37	10	10/09/2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
38	11	17/09/2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
39	12	24/09/2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
40	13	01/10//2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
41	14	08/10//2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
42	15	15/10//2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.79(0.15)
Cultivar Mean			0.86(0.29)	0.76(0.10)	0.83(0.23)	0.75(0.08)	0.73(0.05)	

	S. Em. ±	C.D. (0.05)	CV %
Cultivar (C)	0.015	0.042	13.28
Period (P)	0.023	0.065	
C X P	0.052	0.145	

* Data in the parentheses are original value, while those outside are square root (√X + 0.5) transformed values

WAS = Week After Sowing

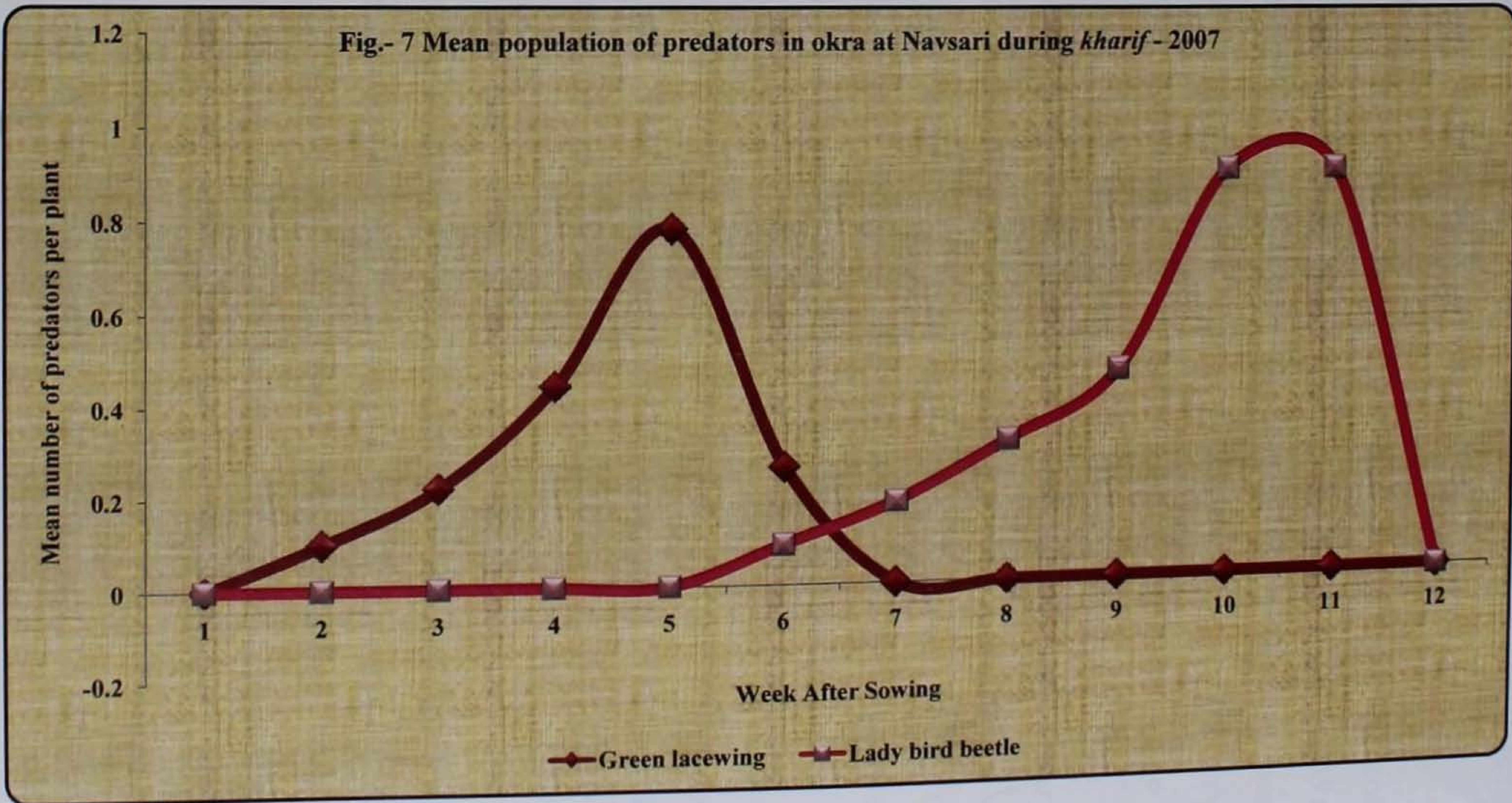


Fig.- 7 Mean population of predators in okra at Navsari during *kharif* - 2007
Mean number of predators per plant
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
1
2
3
4
5
6
7
8
9
10
11
12
Week After Sowing
Green lacewing
Lady bird beetle

population declined gradually and reached the lowest level (0.26 larva/plant) in first week of September.

The results further revealed significant differences in population build up of chrysopid on different okra cultivars. The cultivar LSVT (AOL-03-1) supported the minimum population (0.05 larva/plant) which was at par with GO-2 (0.08 larva/plant) and Arka Anamika (0.10 larva/plant) cultivars. The highest population (0.29 larva/plant) was observed in cultivar Parbhani Kranti which was at par with Pusa Sawani (0.23 larva/plant) cultivar. Incidently, the jassid and whitefly population were also higher in Parbhani Kranti and Pusa Sawani. Thus, the GLW population was more in the cultivars, which supported higher population of jassid and whitefly than the cultivars, which were relatively less susceptible to these pests. The interaction effect due to cultivar × period on incidence of *Chrysoperla* was significant. This indicated that various okra cultivars differed in their reaction to *Chrysoperla* population at different period of crop growth.

From the results, it can be concluded that the incidence of green lacewing started during the first week of August and remained active till first week of September with maximum number during the fourth week of August indicating that it is active for a shorter period of only five weeks coinciding with higher population density of whitefly. The differences in period of activity of this chrysopid predator may be attributed largely due to differences in date of sowing and the crop composition during the particular year of study that ultimately would have affected the population build up of the host insects of this predator. The incidence of green lacewing started during October and lasted upto the first fortnight of November at Sardar Krushinagar in cotton (Anon.,1985). Gadhia (1988) reported that incidence of *chrysoperla* commenced from October with minimum number during January at the same location. Thus, the present findings are different with the reports of Gadhia (1988). Who reported the variation in *chrysoperla* activity may be due to the location, date of sowing and environmental conditions in the particular area.

b) Lady bird beetle: *C. Septempunctata*

The results on population of lady bird beetle (LBB) on different cultivars of okra are presented in Table-9 and Fig-7. Perusal of results indicated that the coccinelid population differed significantly at different periods. The population of this predator appeared 9th WAS i.e. the first week of September (0.09 adult/ plant), reaching the peak level (0.90 adult/plant) during the first week of October and thereafter, it declined gradually and reached the low level during the third week of October.

Significant differences were also observed in population build up of this coleopterous predator among different cultivars of okra. The cultivar LSVT (AOL-03-1) supported the

Table : 9 Periodic incidence of lady bird beetle, *C. septempunctata* on different cultivars of okra during *kharif* - 2007

Standard Week	WAS	Date of observation	Mean number of adult per plant					Period mean
			Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)	
31	4	30/07/2007	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*	0.71(0.00)*
32	5	06/08/2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
33	6	13/08/2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
34	7	20/08/2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
35	8	27/08/2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
36	9	03/09/2007	0.85(0.25)	0.71(0.00)	0.81(0.18)	0.72(0.03)	0.71(0.00)	0.76(0.09)
37	10	10/09/2007	0.98(0.50)	0.74(0.05)	0.90(0.33)	0.72(0.03)	0.71(0.00)	0.81(0.18)
38	11	17/09/2007	1.03(0.60)	0.83(0.20)	1.04(0.60)	0.74(0.05)	0.77(0.10)	0.88(0.31)
39	12	24/09/2007	1.17(0.90)	0.91(0.38)	1.15(0.83)	0.75(0.08)	0.78(0.13)	0.95(0.46)
40	13	01/10//2007	1.32(1.25)	1.12(0.80)	1.30(1.20)	1.09(0.75)	0.97(0.50)	1.16(0.90)
41	14	08/10//2007	0.99(0.53)	0.76(0.08)	0.89(0.30)	0.75(0.08)	0.72(0.03)	0.82(0.90)
42	15	15/10//2007	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
Cultivar Mean			0.88(0.34)	0.78(0.13)	0.86(0.29)	0.75(0.08)	0.74(0.06)	0.80(0.18)

	S. Em. ±	C.D. (0.05)	CV %
Cultivar (C)	0.015	0.041	
Period (P)	0.023	0.065	13.03
C X P	0.052	0.145	

* Data in the parentheses are original value, while those outside are square root (vX + 0.5) transformed values

WAS = Week After Sowing

minimum population of lady bird beetle (0.06 adult/plant) which was at par with cultivar GO-2 (0.08 adult/plant) and Arka Anamika (0.13 adult/plant). The highest population (0.34 adult/plant) was observed in cultivar Parbhani Kranti which was at par with Pusa Sawani (0.29 adult/leaf). Incidently, the aphid population was also higher in Parbhani Kranti, Arka Anamika, Pusa Sawani and GO-2 cultivars. Thus, the LBB population was more in the cultivars, which supported higher population of aphid than the cultivars, which were relatively less susceptible to these pests. The interaction effect due to cultivar × period on incidence of coccinellid predators was significant. This indicated that various okra cultivars differed in their reaction to lady bird beetle population at different period of crop growth.

From the results, it can be concluded that the coccinelid predators were active from the first week of August to the second week of October with peak level during the first week of September. Venugopal *et al.* (1975) reported that *M. Sexmaculatus* was found predating on *A.gossypii* during September to October in okra. The present findings thus by and large corroborate the earlier findings.

4.1.3 Correlation between incidence of pests and weather parameter

4.1.3.1 Insect-pests of okra

In nature, the population of insect-pest is never truely stable. The rise and fall of population density of any organism depends on abiotic factor like temperature and humidity and biotic factors that are host plants. To know the effect of various weather parameters on the population fluctuation of insect-pests of okra, simple correlation was worked out between period and mean incidence of each pest obtained in pest sequence study and weekly mean value of different weather parameters.

A. Sucking pests :

(a) Aphid : *A. gossypii*

The result presented in Table-10 revealed that the aphid population in Parbhani Kranti cultivar was positively correlated with maximum temperature (r=0.687). Whereas, evening relative humidity (r=-0.646), average relative humidity (r=-0.592) and rainy days (r=-0.604) were negatively correlated with aphid population. The other weather parameters *viz;* minimum temperature, average temperature, morning relative humidity, wind velocity, sunshine hours, rainfall and evaporation had no marked effect on population fluctuation of aphid in Parbhani Kranti cultivar.

In case of Arka Anamika, Pusa Sawani and LSVT (AOL-03-1) cultivar the weather parameters *viz;* maximum temperature, average temperature, sunshine hours and evaporation were having positive influence whereas, minimum temperature, morning relative humidity, evening relative humidity, average relative humidity, wind velocity, rainfall and rainy days had

Table : 10 Correlation matrix of the relationship between weather parameters with aphid, *A. gossypii* population on different cultivars of okra during *kharif* – 2007

Sr. No.	Weather parameters	Mean number of aphid per leaf				
		Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)
1	Maximum Temperature °C	0.687*	0.335	0.271	0.783*	0.266
2	Minimum Temperature °C	-0.518	-0.257	-0.229	-0.633*	-0.199
3	Average Temperature °C	0.355	0.166	0.101	0.336	0.139
4	Morning Relative Humidity (%)	-0.354	-0.112	-0.067	-0.495	-0.056
5	Evening Relative Humidity (%)	-0.646*	-0.326	-0.270	-0.758*	-0.258
6	Average Relative Humidity (%)	-0.592*	-0.283	-0.228	-0.713*	-0.216
7	Wind Velocity (km/hr)	-0.560	-0.460	-0.437	-0.635*	-0.420
8	Sunshine Hours (hr/day)	0.516	0.222	0.173	0.596*	0.170
9	Rainfall (mm)	-0.521	-0.491	-0.458	-0.592*	-0.466
10	Rainy Days	-0.604*	-0.390	-0.314	-0.640*	-0.332
11	Evaporation (mm)	0.408	0.041	0.005	0.414	0.002

* Significant at 5 % level (r = ± 0.574)

negative influence with aphid population, however, all these correlations were non-significant. In case of GO-2 cultivar the aphid population was significant, positively correlated with maximum temperature (r=0.783) and sunshine hours (r=0.596) whereas, minimum temperature (r=-0.633), evening relative humidity (r=-0.758), average relative humidity (r=-0.713), wind velocity (r=-0.635), rainfall (r=-0.592) and rainy days (r=-0.640) were significant negatively correlated with aphid population. The other weather parameters *viz;* average temperature, morning relative humidity and evaporation had no marked effect on population fluctuation of aphid. Kadivar (1996) found that the population of aphid had positive correlatation with maximum temperature whereas; it had significant negative correlation with minimum temperature. However, the results obtained in present studies are in close agreement with that of Kadivar (1996) limited to the temperature effect.

b) Jassid: *A.biguttulla biguttulla*

The correlation coefficients obtained between jassid population and weather parameters revealed (Table-11) that in relation with jassid population in Parbhani Kranti cultivar, the weather parameters *viz;* maximum temperature, minimum temperature, average temperature, morning relative humidity, sunshine hours, rainy days and evaporation were positively correlated whereas, evening relative humidity, average relative humidity, wind velocity and rainfall showed negative correlation

Table : 11 Correlation matrix of the relationship between weather parameters with jassid, *A. biguttula biguttula* population on different cultivars of okra during *kharif* – 2007

Sr. No.	Weather parameters	Mean number of jassid per leaf				
		Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)
1	Maximum Temperature °C	0.185	0.103	0.215	0.424	0.408
2	Minimum Temperature °C	0.101	0.138	-0.040	-0.136	-0.192
3	Average Temperature °C	0.472	0.391	0.302	0.505	0.390
4	Morning Relative Humidity (%)	0.239	0.350	0.226	0.016	-0.009
5	Evening Relative Humidity (%)	-0.079	0.005	-0.112	-0.321	-0.303
6	Average Relative Humidity (%)	-0.007	0.086	-0.036	-0.249	-0.241
7	Wind Velocity (km/hr)	-0.466	-0.461	-0.459	-0.573	-0.561
8	Sunshine Hours (hr/day)	0.255	0.044	0.120	0.422	0.272
9	Rainfall (mm)	-0.254	-0.267	-0.283	-0.437	-0.479
10	Rainy Days	0.053	0.064	0.040	-0.219	-0.201
11	Evaporation (mm)	0.296	0.079	0.182	0.370	0.280

* Significant at 5 % level (r = ± 0.574)

with jassid population. In case of Arka Anamika cultivar, maximum temperature, minimum temperature, average temperature, morning relative humidity, evening relative humidity, average relative humidity, sunshine hours, rainy days and evaporation were positive influence whereas, wind velocity and rainfall showed negative correlation with jassid population. However, all these correlations were non-significant.

In case of Pusa Sawani cultivar maximum temperature, average temperature, morning relative humidity, sunshine hours, rainy days and evaporation has positive correlation whereas, minimum temperature, evening relative humidity, average relative humidity, wind velocity and rainfall were negatively correlated with jassid population; however, all these correlations were non-significant.

Incase of GO-2 maximum temperature, average temperature, morning relative humidity, sunshine hours and evaporation were positively correlated whereas, minimum temperature, evening relative humidity, average relative humidity, wind velocity, rain fall and rainy days showed negative correlation with jassid population, however, all these correlations were non-significant.

In LSVT (AOL-03-1) cultivar maximum temperature, average temperature, sunshine hours and evaporation were having positive influence whereas, minimum temperature, morning relative humidity, evening relative humidity, average relative humidity, wind velocity, rain fall and rainy days showed negative correlation with jassid population, however, all these correlations were non-significant.

Patel (1988) reported the jassid populations were non-significantly correlated with all weather parameters during summer season. However, significant correlation of jassid population was observed with minimum temperature while other parameters showed non-significant during *kharif* season. Thus, the present findings of positive effect of temperature of jassid population confirm the earlier results (Patel, 1988).

C. Whitefly: *B. tabaci*

The results indicated (Table-12) that in case of Parbhani Kranti and LSVT (AOL-03-1) the weather parameters *viz;* minimum temperature, average temperature, morning relative humidity, evening relative humidity, average relative humidity, rainfall, rainy days and evaporation had positive correlation whereas, maximum temperature, wind velocity and sunshine hours showed negative correlation with whitefly population, however, all these correlations were non-significant. In Arka Anamika cultivar evaporation (r= 0.603) was positively correlated with whitefly population and their correlation co-efficient was significant. The other weather parameters *viz*; maximum temperature, minimum temperature, average temperature, morning relative humidity, average relative humidity, sunshine hours exhibited positive influence whereas evening relative humidity,

Table : 12 Correlation matrix of the relationship between weather parameters with whitefly, *B. tabaci* population on different cultivars of okra during *kharif* – 2007

Sr. No.	Weather parameters	Mean number of whitefly per leaf				
		Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)
1	Maximum Temperature °C	-0.042	0.124	0.084	-0.174	-0.126
2	Minimum Temperature °C	0.123	0.193	0.022	0.354	0.235
3	Average Temperature °C	0.121	0.510	0.176	0.258	0.154
4	Morning Relative Humidity (%)	0.332	0.174	0.218	0.410	0.475
5	Evening Relative Humidity (%)	0.157	-0.002	0.039	0.277	0.246
6	Average Relative Humidity (%)	0.201	0.039	0.082	0.314	0.305
7	Wind Velocity (km/hr)	-0.392	-0.415	-0.398	-0.243	-0.376
8	Sunshine Hours (hr/day)	-0.118	0.306	-0.006	0.017	-0.157
9	Rainfall (mm)	0.088	-0.344	-0.001	-0.034	0.083
10	Rainy Days	0.348	-0.121	0.203	0.191	0.400
11	Evaporation (mm)	0.072	0.603*	0.191	0.378	0.072

* Significant at 5 % level (r = ± 0.574)

wind velocity, rain fall and rainy days showed negative correlation with whitefly population, however, all these correlations were non-significant.

In case of Pusa Sawani wind velocity, sunshine hours and rainfall showed negative correlation whereas rest of cultivars showed positive influence with whitefly population. While, GO-2 cultivar showed negative correlation with maximum temperature, wind velocity and rainfall whereas remaining was having positive influence with whitefly population, however, all these correlations were non-significant. Ghose (1999) reported that minimum temperature was positively correlated with whitefly population. Thus, the result obtained in present investigation is in consonance with the results obtained by earlier workers.

d) Mite: *T. macfarlanei*

It can be stated from the results (Table-13) that the population of mite was positively correlated with maximum temperature, average temperature, sunshine hours and evaporation whereas, minimum temperature, morning relative humidity, evening relative humidity, average relative humidity, wind velocity, rainfall and rainy days showed negative correlation with mite population in Parbhani Kranti and LSVT (AOL-03-1) cultivars. However, all these correlations were non-significant.

The mite population in Arka Anamika cultivar was positively correlated with maximum temperature (r= 0.766).

Table : 13 Correlation matrix of the relationship between weather parameters with mite, *T. macfarlanei* population on different cultivars of okra during *kharif* – 2007

Sr. No.	Weather parameters	Mean number of mite per leaf				
		Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)
1	Maximum Temperature °C	0.546	0.766*	0.518	0.796*	0.437
2	Minimum Temperature °C	-0.452	-0.714*	-0.440	-0.738*	-0.393
3	Average Temperature °C	0.218	0.182	0.189	0.195	0.126
4	Morning Relative Humidity (%)	-0.297	-0.575*	-0.275	-0.628*	-0.225
5	Evening Relative Humidity (%)	-0.535	-0.772*	-0.507	-0.803*	-0.429
6	Average Relative Humidity (%)	-0.491	-0.743*	-0.464	-0.780*	-0.391
7	Wind Velocity (km/hr)	-0.574*	-0.565	-0.529	-0.563	-0.469
8	Sunshine Hours (hr/day)	0.390	0.555	0.359	0.585*	0.259
9	Rainfall (mm)	-0.556	-0.552	-0.527	-0.553	-0.467
10	Rainy Days	-0.501	-0.681*	-0.510	-0.700*	-0.442
11	Evaporation (mm)	0.152	0.309	0.117	0.331	0.030

* Significant at 5 % level ($r = \pm 0.574$)

Whereas, minimum temperature (r= -0.714), morning relative humidity (r= -0.575), evening relative humidity (r= -0.772), average relative humidity (r= -0.743) and rainy days (r= -0.681) were significant negatively correlated while, the other weather parameters were positively correlated with mite population.

In case of Pusa Sawani cultivar maximum temperature, average temperature, sunshine hours and evaporation were positively correlated while, minimum temperature, morning relative humidity, evening relative humidity, average relative humidity, wind velocity, rainfall and rainy days showed negative correlation with mite population. However, all these correlations were non-significant. In case of mite population in cultivar GO-2, significant positive correlation was found with maximum temperature (r = 0.796) and sunshine hours (r= 0.585). Whereas, minimum temperature (r= -0.738), morning relative humidity (r= -0.628), evening relative humidity (r= -0.803), average relative humidity (r= -0.780) and rainy days (r= -0.700) showed significant negative correlation with mite population. The other weather parameters *viz,* average temperature and evaporation was positively correlated while wind velocity and rainfall showed negative correlation with mite population. Gulati (2004) reported the mite population was positively correlated with maximum temperature and relative humidity. Thus, the present finding of positive effect of temperature of mite population confirmed the earlier results.

B) Shoot and fruit borer: *E. Vittella*

Results of correlation between *E. vittella* population and weather parameters (Table-14) revealed that maximum temperature, minimum temperature, average temperature, morning relative humidity, evening relative humidity, average relative humidity, sunshine hours, rainy days and evaporation were positively correlated whereas, wind velocity and rainfall were negatively correlated in Parbhani Kranti and Pusa Sawani cultivar. However, all these correlations were non-significant.

Population of *E. vittella* in Arka Anamika cultivar were positively correlated with maximum temperature, average temperature, morning relative humidity, sunshine hours and evaporation whereas, minimum temperature, evening relative humidity, average relative humidity, wind velocity, rainfall and rainy days showed negative correlation with *E. vittella* population. In LSVT (AOL-03-1) was significant negative correlation with wind velocity (r= -0.608). In GO-2 and LSVT(AOL-03-1) cultivars, positive correlation with maximum temperature, average relative humidity and sunshine hours whereas, minimum temperature, morning relative humidity, evening relative humidity, average relative humidity, wind velocity, rainfall and rainy days showed negatively correlated with *Earias* population. However, all these correlations were non-significant. Mandel (2006) reported that significant negative correlation with the maximum temperature and positive

Table : 14 Correlation matrix of the relationship between weather parameters with shoot and fruit borer, *E. vittella* population on different cultivars of okra during *kharif* – 2007

Sr. No.	Weather parameters	Mean number of larvae per plant				
		Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)
1	Maximum Temperature °C	0.040	0.341	0.029	0.422	0.457
2	Minimum Temperature °C	0.152	-0.068	0.187	-0.143	-0.141
3	Average Temperature °C	0.306	0.471	0.341	0.491	0.553
4	Morning Relative Humidity (%)	0.234	0.073	0.292	-0.012	-0.021
5	Evening Relative Humidity (%)	0.010	-0.252	0.049	-0.328	-0.352
6	Average Relative Humidity (%)	0.062	-0.181	0.107	-0.261	-0.282
7	Wind Velocity (km/hr)	-0.428	-0.511	-0.403	-0.565	-0.608*
8	Sunshine Hours (hr/day)	0.125	0.373	0.081	0.440	0.433
9	Rainfall (mm)	-0.255	-0.414	-0.300	-0.396	-0.470
10	Rainy Days	0.197	-0.171	0.187	-0.204	-0.277
11	Evaporation (mm)	0.213	0.325	0.240	0.345	0.321

* Significant at 5 % level (r = ± 0.574)

relationship with the minimum temperature, relative humidity, vapour pressure and rainfall with *E. vittella* population. Thus, the present findings tally with the earlier reports.

4.1.3.2 Insect predators of okra pests

a) Green lacewing: *C. Scelestes*

Perusal of the pest correlation coefficient (Table-15) revealed that no significant correlations existed between incidence of *Chrysoperla* and weather parameters. However, maximum temperature, average temperature, morning relative humidity, sunshine hours and evaporation had positive correlation, while minimum temperature, evening relative humidity, average relative humidity, wind velocity, rainfall and rainy days had negative correlation with population of green lacewing. Kalariya (1993) also observed negative correlation of lacewing with relative humidity. Thus, the present findings are in agreement with the earlier results to some extent.

b) Lady bird beetle: *C. Septempunctata*

The result (Table-16) revealed that no significant correlations existed between incidence of lady bird beetle and weather parameters. However, minimum temperature, relative humidity, wind velocity, rainfall and rainy days had positive influence while, maximum temperature, average temperature, sunshine hours and evaporation had negative influence with lady bird beetle population. Moreover, all these correlations were non-

Table : 15 Correlation matrix of the relationship between weather parameters with green lacewing, *C. scelestes* population on different cultivars of okra during *kharif* – 2007

Sr. No.	Weather parameters	Mean number of larva per plant				
		Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)
1	Maximum Temperature °C	0.341	0.291	0.288	0.374	0.322
2	Minimum Temperature °C	-0.101	-0.178	-0.106	-0.250	-0.221
3	Average Temperature °C	0.420	0.214	0.323	0.242	0.200
4	Morning Relative Humidity (%)	0.099	0.096	0.155	-0.037	0.053
5	Evening Relative Humidity (%)	-0.269	-0.252	-0.224	-0.345	-0.286
6	Average Relative Humidity (%)	-0.189	-0.176	-0.140	-0.280	-0.213
7	Wind Velocity (km/hr)	-0.520	-0.377	-0.472	-0.347	-0.351
8	Sunshine Hours (hr/day)	0.250	0.179	0.185	0.275	0.203
9	Rainfall (mm)	-0.430	-0.328	-0.371	-0.312	-0.289
10	Rainy Days	-0.313	-0.333	-0.266	-0.396	-0.340
11	Evaporation (mm)	0.153	0.136	0.121	0.262	0.191

* Significant at 5 % level ($r = \pm 0.574$)

Table : 16 Correlation matrix of the relationship between weather parameters with lady bird beetle, *C. septempunctata* population on different cultivars of okra during *kharif* – 2007

Sr. No.	Weather parameters	Mean number of adult per plant				
		Parbhani Kranti	Arka Anamika	Pusa Sawani	GO-2	LSVT (AOL-03-1)
1	Maximum Temperature °C	-0.487	-0.319	-0.399	-0.271	-0.261
2	Minimum Temperature °C	0.441	0.299	0.402	0.194	0.232
3	Average Temperature °C	-0.135	-0.074	-0.048	-0.155	-0.080
4	Morning Relative Humidity (%)	0.330	0.332	0.303	0.345	0.319
5	Evening Relative Humidity (%)	0.514	0.407	0.453	0.368	0.363
6	Average Relative Humidity (%)	0.483	0.398	0.428	0.371	0.361
7	Wind Velocity (km/hr)	0.376	0.134	0.279	0.060	0.108
8	Sunshine Hours (hr/day)	-0.389	-0.322	-0.319	-0.371	-0.310
9	Rainfall (mm)	0.301	0.360	0.252	0.476	0.403
10	Rainy Days	0.402	0.342	0.327	0.390	0.296
11	Evaporation (mm)	-0.013	-0.014	0.059	-0.163	-0.066

* Significant at 5 % level (r = ± 0.574)

significant. Upadhyay (1984) reported the coccinellid population showed positive correlation with minimum temperature and relative humidity as well as negative correlation with maximum temperature. Thus, the present findings are in agreement to that of earlier workers.

4.1.4 Correlation between insect predators and their host insects

a) Green lacewing: *C. Scelestes*

The results (Table-17 and Fig.-8) revealed that the *chrysoperla* predator was significant positively correlated with aphid (r= 0.862), jassid (r= 0.699) and mite (r= 0.763) population. However, the chrysopid predator did not exhibit removable effect on whitefly populations.

b) Lady bird beetle: *C. Septempunctata*

It can be seen from the results that the population of predatory beetle was negatively correlated with jassid and whitefly population. The other host insect *viz*; aphid and mite were positively correlated with this predators, although their correlation coefficient were non-significant. The negative correlation between the predators and jassid and whitefly population indicated that its predators might suppress the pest population. Gravena *et al.* (1976), Chandra and Kushwaha (1987) and Ghetiya (1992) also reported positive correlation of

Table : 17 Correlation between insect predator and their host insects during *kharif* – 2007

Insect-pests	Green lacewing	Lady bird beetle
Aphid	0.862*	0.011
Jassid	0.699*	-0.181
Whitefly	0.308	-0.227
Mite	0.763*	0.090

* Significant at 5 % level (r = ± 0.574)

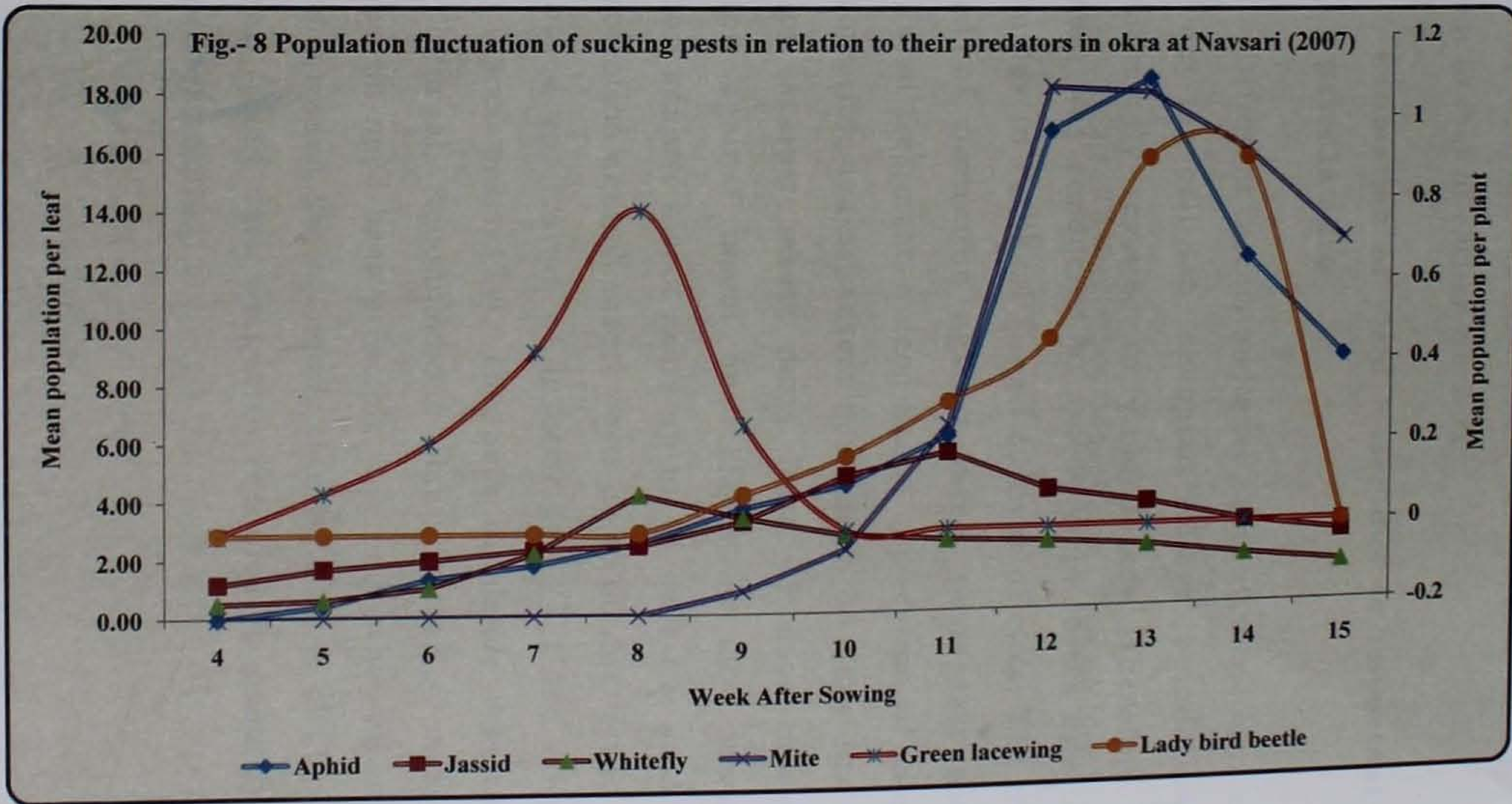


Fig.- 8 Population fluctuation of sucking pests in relation to their predators in okra at Navsari (2007)
Mean population per leaf
Mean population per plant
Week After Sowing
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
4
5
6
7
8
9
10
11
12
13
14
15
Aphid
Jassid
Whitefly
Mite
Green lacewing
Lady bird beetle

coccinellids with the aphids. Thus, the present findings are in agreement to that of earlier workers.

4.2 Estimation of yield losses due to important insect-pests in okra

Different insects and mite pests attacked okra crop that drained out the cell sap, devoured foliage, bored flowers and fruits ultimately resulted in yield losses. Therefore, a field experiment was conducted to assess yield losses due to insect-pest complex in Parbhani Kranti cultivar of okra. The treatments consisted of protection against insect pests throughout crop season (seed treatment + need based application of insecticides) (T_1), protection against insect pests from 30 days onwards (T_2), protection against insect pests from 45 days onwards (T_3), protection against insect pests from 60 day onwards (T_4), protection against insect pests up to 45 days i.e. seed treatment (T_5), protection against insect pests up to 60 days (seed treatment +need based application of insecticides) (T_6) and no protection against insect pests (T_7). The pest incidence was recorded at weekly interval. Recommended plant protection measures were employed on need base principle *i.e.*, only when mean incidence of a pest crossed the economic threshold level (ETL) in a given treatment. Yield data were also recorded to quantify losses in different treatments.

4.2.1 Incidence of insect-pest

A) Sucking pests:

a) Aphid: *A.gossypii*

The results presented in Table-18 explicated that the aphid population crossed the ETL two times in the treatments of protection against the insect-pest throughout the crop season (T_1) (9 and 13 WAS), protection against insect-pest from 30 days onwards (T_2) (9 and 12 WAS), protection against insect pest from 45 days onwards (T_3) (9 and 11 WAS) and protection against insect-pest from 60 days onwards (T_4) (10 and 13 WAS) warranting two sprays of insecticides of thiamethoxam, however, in the treatment of protection against insect-pest up to 60 days (T_6) aphid population crossed ETL three times (8,11 and 13 WAS). Thus, only one spray of insecticide was warranted to bring down aphid population below ETL up to 60 days as per the treatment criteria. In the treatment of T_5, aphid population crossed ETL two times (10 and 13 WAS), but as in this treatment no protection after 45 days onwards, hence no application of insecticide was made. In case of no protection against insect-pest (T_7), it remained above ETL between 9 and 14 WAS.

Aphid population showed significant differences regarding its build up among different levels of protection of okra crop. The treatment T_1 recorded the least population (4.84 aphids/leaf) which was at par with T_6 (5.27 aphids/leaf) and

Table : 18 Comparative mean incidence of Aphid, *A. gossypii* in okra Cv. Parbhani Kranti under different protection levels during *kharif* - 2007

Sr. No.	Treatments	WAS Aphid population crossed ETL	Insecticide application made WAS	Average no. of Aphid per leaf	Reduction in population over control (%)
T_1	Protection against insect pests throughout crop season. (seed treatment + Need base application of insecticides)	9,13	9,13	2.29(4.84)*	62.93
T_2	Protection against insect pests from 30 days onwards.	9,12	9,12	2.87(7.73)	40.82
T_3	Protection against insect pests from 45 days onwards.	9,11	9,11	3.18(9.76)	25.33
T_4	Protection against insect pests from 60 day onwards.	10,13	10,13	3.16(9.65)	26.17
T_5	Protection against insect pests up to 45 days. i.e. seed treatment	10,13	-	3.33(10.75)	17.70
T_6	Protection against insect pests up to 60 days. (seed treatment +Need base application of insecticides)	8,11,13	8	2.39(5.27)	59.69
T_7	No protection against insect pests.	9,10,11,12, 13,14	-	3.66(13.07)	0.00
	S. Em. ±			0.21	
	C.D. (0.05)			0.659	
	CV %			12.42	

* Data in the parentheses are original value, while those outside are square root ($\sqrt{X + 0.5}$) transformed values
WAS = Week After Sowing

T_2 (7.73 aphids/leaf). The highest population (13.07 aphids/leaf) was recorded in the treatment T_7 followed by T_5 (10.75 aphids/leaf), T_3 (9.76 aphids/leaf) and T_4 (9.65 aphids/leaf). The per cent reduction in population of aphid was highest in the treatment of T_1 (62.93 %) followed by T_6 (59.76) and it was lowest in the treatment of T_5 (17.70 %).

According to Dhamdhere (1984) reported the aphid population remained active from last week of August to first week of October with peak population in last week of September. Thus, the present findings tally with the earlier reports.

From the results, it can be summarized that if need based protection measures were adopted in okra, two sprays of insecticides were required to reduce aphid population below ETL level of the crop season. Seed treatment of imidacloprid was given in the treatments of T_1, T_5 and T_6.

b) Jassid: *A. biguttulla biguttulla*

The result revealed (Table-19) that the jassid population crossed the ETL two times in the treatment of T_1 (8 and 11 WAS) and T_2 (6 and 9 WAS) warranting two sprays of insecticides of thiamethoxam , however in the treatment of T_3 jassid population crossed ETL three time (6, 8 and 11 WAS), the insecticide applied (8 and 11 WAS) as per treatment criteria. In treatment T_4, jassid population crossed ETL two times during the crop season (7 and 10 WAS), insecticide was applied 10 WAS as

Table : 19 Comparative mean incidence of jassid, *A. biguttulla biguttulla* in okra Cv. Parbhani Kranti under different protection levels during *kharif* - 2007

Sr. No.	Treatments	WAS Jassid population crossed ETL	Insecticide application made WAS	Average no. of Jassid per leaf	Reduction in population over control (%)
T_1	Protection against insect pests throughout crop season. (seed treatment + Need base application of insecticides)	9,11	9,11	1.90(3.11)*	71.41
T_2	Protection against insect pests from 30 days onwards.	8,12	8,12	2.00(3.51)	67.76
T_3	Protection against insect pests from 45 days onwards.	8,11	8,11	2.71(7.11)	34.63
T_4	Protection against insect pests from 60 day onwards.	10,12	10,12	3.05(8.87)	18.48
T_5	Protection against insect pests up to 45 days. i.e. seed treatment	9,13	-	2.72(7.02)	35.49
T_6	Protection against insect pests up to 60 days. (seed treatment +Need base application of insecticides)	8,12	8	1.98(3.44)	68.34
T_7	No protection against insect pests.	8,9,10,11, 12, 13	-	3.36(10.88)	0.00
	S. Em. ±			0.19	
	C.D. (0.05)			0.598	
	CV %			13.28	

* Data in the parentheses are original value, while those outside are square root ($\sqrt{X + 0.5}$) transformed values
WAS = Week After Sowing

per treatment. In case of treatment T_5, jassid population crossed ETL two times during the crop season (8 and 11 WAS), however, insecticide was not applied as per the treatment criteria. In case of treatment T_6, jassid population crossed ETL two times during crop season (8 and 11 WAS). Thus, only one spray of insecticide was warranted to bring down jassid population below ETL up to 60 days as per treatment criteria. In treatment T_7, jassid population remained above ETL between 6 and 9 WAS.

The result further showed that graded levels of protection provided on need base principle resulted in significant differences regarding average jassid population in different treatments. The least number of jassid was observed in the treatment of T_1 (3.11 jassids/leaf) which was at par with T_6 (3.44 jassids/leaf) and T_2 (3.51 jassids/leaf), while the highest population was observed in the T_7 (10.88 jassids/leaf) followed by T_4 (8.87 jassids/leaf). The highest reduction in jassid population was observed in treatment of T_1 (71.41 %) followed by T_6 (68.34 %) and T_2 (67.76 %) while it was lowest in T_4 (18.48 %). Kumawat *et al.* (2000) reported jassid population reached at peak in the second week of September. Thus, the present findings tally with the earlier reports.

From the above result it is evident that only two sprays of insecticides were required to reduce jassid population below ETL. In treatment T_1, T_5 and T_6 seed treatment of imidacloprid was given.

B) Whitefly: *B. tabaci*

The results presented in Table-20 revealed that the whitefly population crossed the ETL (5 adults/leaf) only once in the treatments T_1 and T_6 (8 WAS) warranting one spray of insecticide during the crop season. It crossed ETL two times in treatment T_2 (6 and 9 WAS), T_3 (6 and 9 WAS) and T_4 (7 and 9 WAS). Thus, two spray of thiamethoxam were given in treatment T_2 while, in T_3 and T_4 treatment only one spray of insecticide was applied as per the treatment criteria. In treatment T_5, whitefly population crossed ETL once (8 WAS) however, insecticide was not applied as per treatment criteria. In treatment T_7 whitefly population remained above ETL between 6 and 9 WAS.

Whitefly population showed significant differences among different treatments. The treatment T1 recorded the least population (0.89 adult/leaf) which was at par with T_6, while the highest population (7.88 adult/leaf) was recorded in treatment T_7 followed by T_3, T_4 and T_5 treatments. The per cent reduction in population of whitefly was highest in the treatment T_1 (88.75 %) followed by T_6 (86.89 %) treatment and it was lowest in the treatment of T_3 (53.47 %). Patel (1988) reported that activity of whitefly reached its peak level eight week after sowing of okra. Thus, the present findings are in agreement to that of earlier workers.

From the above results, it can be inferred that if need based protection measures are adopted in okra, one spray of

Table : 20 Comparative mean incidence of whitefly, *B. tabaci* in okra Cv. Parbhani Kranti under different protection levels during *kharif* - 2007

Sr. No.	Treatments	WAS whitefly population crossed ETL	Insecticide application made WAS	Average no. of whitefly per leaf	Reduction in population over control (%)
T_1	Protection against insect pests throughout crop season. (seed treatment + Need base application of insecticides)	8	8	1.17(0.89)*	88.75
T_2	Protection against insect pests from 30 days onwards.	9	9	1.83(2.89)	63.37
T_3	Protection against insect pests from 45 days onwards.	9	9	2.03(3.67)	53.47
T_4	Protection against insect pests from 60 day onwards.	9	9	1.97(3.42)	56.60
T_5	Protection against insect pests up to 45 days. i.e. seed treatment	8	-	1.91(3.29)	58.29
T_6	Protection against insect pests up to 60 days. (seed treatment +Need base application of insecticides)	8	8	1.24(1.03)	86.89
T_7	No protection against insect pests.	8,9	-	2.89(7.88)	0.00
	S. Em. ±			0.13	
	C.D. (0.05)			0.411	
	CV %			12.38	

* Data in the parentheses are original value, while those outside are square root (vX + 0.5) transformed values
WAS = Week After Sowing

Table : 20 Comparative mean incidence of whitefly, *B. tabaci* in okra Cv. Parbhani Kranti under different protection levels during *kharif* - 2007

Sr. No.	Treatments	WAS whitefly population crossed ETL	Insecticide application made WAS	Average no. of whitefly per leaf	Reduction in population over control (%)
T_1	Protection against insect pests throughout crop season. (seed treatment + Need base application of insecticides)	8	8	1.17(0.89)*	88.75
T_2	Protection against insect pests from 30 days onwards.	9	9	1.83(2.89)	63.37
T_3	Protection against insect pests from 45 days onwards.	9	9	2.03(3.67)	53.47
T_4	Protection against insect pests from 60 day onwards.	9	9	1.97(3.42)	56.60
T_5	Protection against insect pests up to 45 days. i.e. seed treatment	8	-	1.91(3.29)	58.29
T_6	Protection against insect pests up to 60 days. (seed treatment +Need base application of insecticides)	8	8	1.24(1.03)	86.89
T_7	No protection against insect pests.	8,9	-	2.89(7.88)	0.00
	S. Em. $\pm$			0.13	
	C.D. (0.05)			0.411	
	CV %			12.38	

* Data in the parentheses are original value, while those outside are square root (√X + 0.5) transformed values
WAS = Week After Sowing

insecticide was required to reduce whitefly population below ETL up to 60 days of the crop season. In treatment T_1, T_5 and T_6 seed treatment of imidacloprid was given.

b) Mite: *T. macfarlanei*

The results presented in Table-21 explicated that the mite population crossed ETL (10 mites/leaf) twice (11 and 14 WAS) in the treatment T_1, T_3, and T_6. Thus, two sprays of propargite were applied in T_1 and T_3 treatment; however acaricide was not applied in treatment T_6 as per treatment criteria. This acarina pest crossed ETL one time in treatment T_2 (12 WAS) while, in treatment T_4 and T_5 crossed ETL twice (11 and 13 WAS), however acaricide was not applied as per treatment. In treatment T_7 mite population crossed ETL between 11 and 14 WAS.

The results further showed that graded level of protection provided on need base principle resulted in significant differences regarding average mite population in different treatments. The least number of mites were observed in the treatment T_1 (2.60 mites/leaf) which was at par with T_2 (3.38 mites/leaf), while the highest mite population was observed in the unprotected treatment T_7 (14.37 mites/leaf). The highest reduction in the mite population over control was observed in the treatment of T_1 (81.90 %) followed by T_2 (79.72 %) and T_4 (76.50 %). The lowest reduction was recorded T_5 (35.36 %) followed by T_6 (37.05 %). Gurdipsingh and Saini (1971) reported

Table : 21 Comparative mean incidence of mite, *T. macfarlanei* in okra Cv. Parbhani Kranti under different protection levels during *kharif* - 2007

Sr. No.	Treatments	WAS mite population crossed ETL	Insecticide application made WAS	Average no. of mite per leaf	Reduction in population over control (%)
T_1	Protection against insect pests throughout crop season. (seed treatment + Need base application of insecticides)	11,14	11,14	1.75(2.60)*	81.90
T_2	Protection against insect pests from 30 days onwards.	12	12	1.84(2.91)	79.72
T_3	Protection against insect pests from 45 days onwards.	11,14	11,14	2.81(7.48)	47.96
T_4	Protection against insect pests from 60 day onwards.	11,13	11,13	1.96(3.38)	76.50
T_5	Protection against insect pests up to 45 days. i.e. seed treatment	11,13	-	3.10(9.29)	35.36
T_6	Protection against insect pests up to 60 days. (seed treatment +Need base application of insecticides)	11,14	-	3.06(9.04)	37.05
T_7	No protection against insect pests.	11, 12, 13,14	-	3.84(14.37)	0.00
	S. Em. ±			0.22	
	C.D. (0.05)			0.676	
	CV %			14.49	

* Data in the parentheses are original value, while those outside are square root $(\sqrt{X + 0.5})$ transformed values
WAS = Week After Sowing

that the major activity of the acarine pest was reported during September-October in castor. Singh *et al.* (1990) reported the incidence of *T. telarius* peaked in third week of September in soybean. Thus, the present findings are in close agreement with earlier workers.

From the above results, it can be concluded that only two sprays of acaricide were needed to check mite population, which crossed ETL during 60 days onwards of the crop season.

B) Fruit and Shoot borer: *E. vittella*

The results presented in Table-22 disclosed that the incidence of *E. vittella* crossed ETL (20.00 larvae/20 plant) three times throughout the crop season (T_1) (6, 9 and 13 WAS). Thus, two sprays of spinosad were given 6 and 9 WAS to reduce *E. vittella* population below ETL. In treatment T_2 *E. vittella* population crossed ETL three times (7, 10 and 13 WAS) in which two sprays were applied to reduce *E. vittella* population while, in treatment T_3 it crossed ETL three times (6, 8 and 12 WAS) in which two sprays were applied (8 and 12 WAS) to reduce *E. vittella* population. In case of treatment T4, *E. vittella* population crossed ETL thrice (6, 9 and 13 WAS) in which two sprays of insecticide applied 9 and 13 WAS. In treatment T_6 *E. vittella* population crossed ETL two times (7 and 10 WAS) in which insecticide was applied 7 WAS. However, second spray was not applied as per treatment criteria.

Table : 22 Comparative mean incidence of shoot and fruit borer, *E. vittella* in okra Cv. Parbhani Kranti under different protection levels during *kharif* - 2007

Sr. No.	Treatments	WAS shoot & fruit borer population crossed ETL	Insecticide application made WAS	Average no. of larvae per plant	Reduction in population over control (%)
T_1	Protection against insect pests throughout crop season. (seed treatment + Need base application of insecticides)	6,9,13	6,9,13	0.72(0.02)*	98.45
T_2	Protection against insect pests from 30 days onwards.	7,10,13	7,10,13	0.75(0.06)	95.08
T_3	Protection against insect pests from 45 days onwards.	6,8,12	8,12	1.12(0.77)	40.41
T_4	Protection against insect pests from 60 day onwards.	6,9,13	9,13	0.77(0.10)	92.23
T_5	Protection against insect pests up to 45 days. i.e. seed treatment	6,8,13	6	1.22(1.02)	20.47
T_6	Protection against insect pests up to 60 days. (seed treatment +Need base application of insecticides)	7,10	7	1.30(1.19)	7.34
T_7	No protection against insect pests.	6,7,8,9,10, 12	-	1.33(1.29)	0.00
S. Em. ±				0.06	
C.D. (0.05)				0.196	
CV %				10.67	

* Data in the parentheses are original value, while those outside are square root ($\sqrt{X + 0.5}$) transformed values
WAS = Week After Sowing

The result further explicated significant differences in mean population of *E. vittella* in different protection levels of okra crop. The treatment T_1 exhibited lowest mean pest incidence (0.02 larva/plant) which was at par with T_2 (0.06 larva/plant) and T_4 (0.10 larva/plant). The highest pest incidence was recorded in the treatment T_7 (1.29 larvae/plant) which was at par with T_6 (1.19 larvae/plant) and T_5 (1.02 larvae/plant). The reduction in *E. vittella* population over control treatment was maximum in T_1 treatment (98.45 %) followed by T_2 (95.08 %) and T_4 (92.23 %) and it was minimum in treatment T_6 (7.34 %). Kashyap and Verma (1982) reported that the population of *Earias* spp. was found between August and October. Mote (1977) reported shoot and fruit borer increased gradually upto 10^{th} week after sowing in *kharif* season. Thus, the present findings differ due to the different location and different environmental conditions.

From the above results, it can be concluded that two sprays of spinosad (6 and 9 WAS) may be needed to curtail *E. vittella* population below the ETL throughout the crop season.

4.2.2 Okra fruit yield

Picking wise fruit yield of okra was recorded in different treatments during *kharif*-2007 and presented in Table-23 and Fig.- 9 and 10. The results revealed that significant differences in okra yield among different levels of protection. The highest yield was recorded in treatment of the protection against insect-pests throughout the crop season (T_1) (1548 kg/ha)

Table : 23 Okra yield in different treatments during *kharif* – 2007

Sr. No.	Treatment	Yield (kg/ha)	Avoidable losses in yield (%)	Per cent yield increase over control
T_1	Protection against insect pests throughout crop season. (seed treatment + Need base application of insecticides)	1548	29.59	41.94
T_2	Protection against insect pests from 30 days onwards.	1326	17.80	21.62
T_3	Protection against insect pests from 45 days onwards.	1220	10.65	11.91
T_4	Protection against insect pests from 60 day onwards.	1211	10.00	11.09
T_5	Protection against insect pests up to 45 days. i.e. seed treatment	1226	11.09	12.47
T_6	Protection against insect pests up to 60 days. (seed treatment +Need base application of insecticides)	1537	29.08	40.94
T_7	No protection against insect pests.	1090	0.00	0.00
	S. Em. ±	55.03		-
	C.D. (0.05)	166.91		-
	CV %	7.28		-

Fig.- 9 Okra fruit yield of Parbhani Kranti cultivar due to different levels of protection at Navsari (2007)

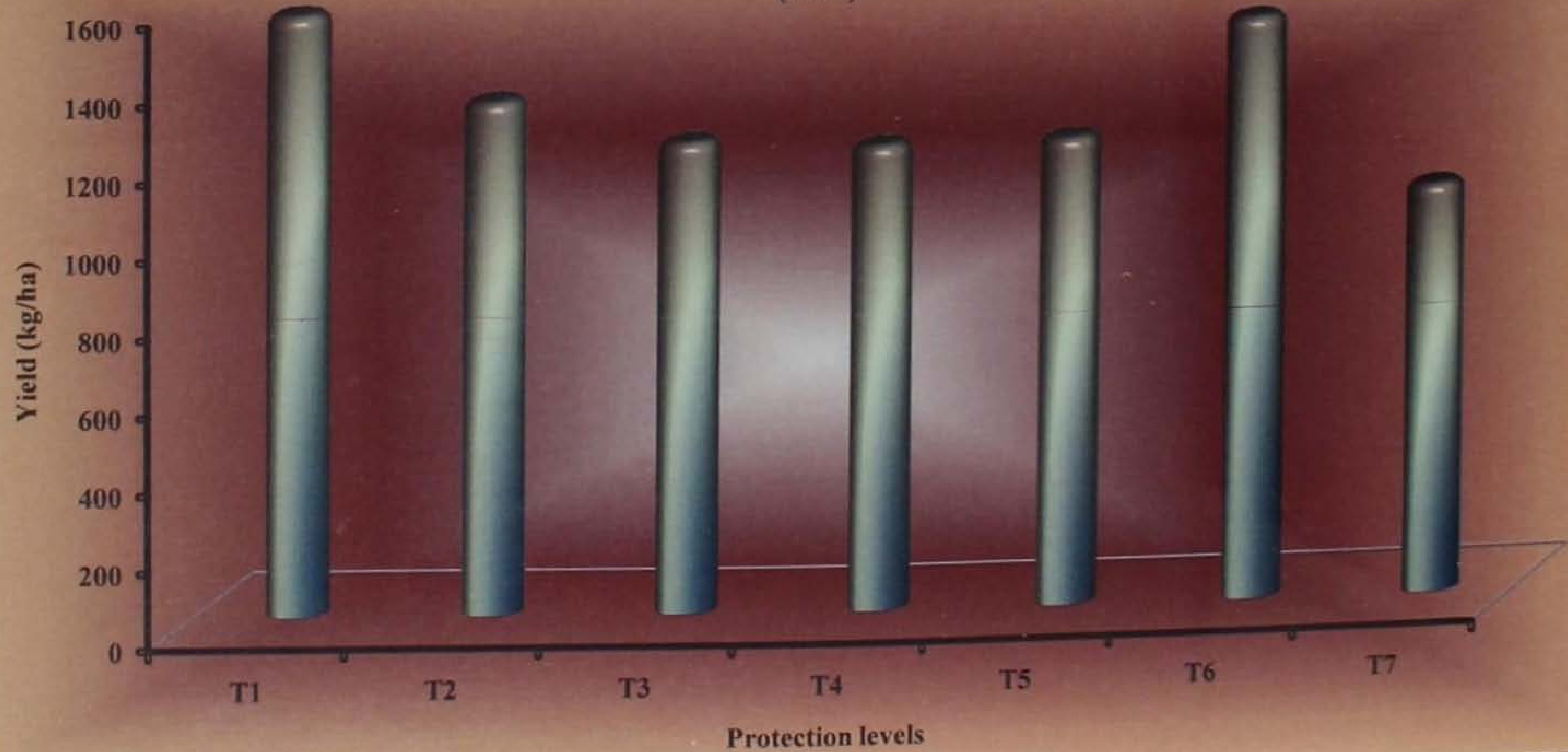
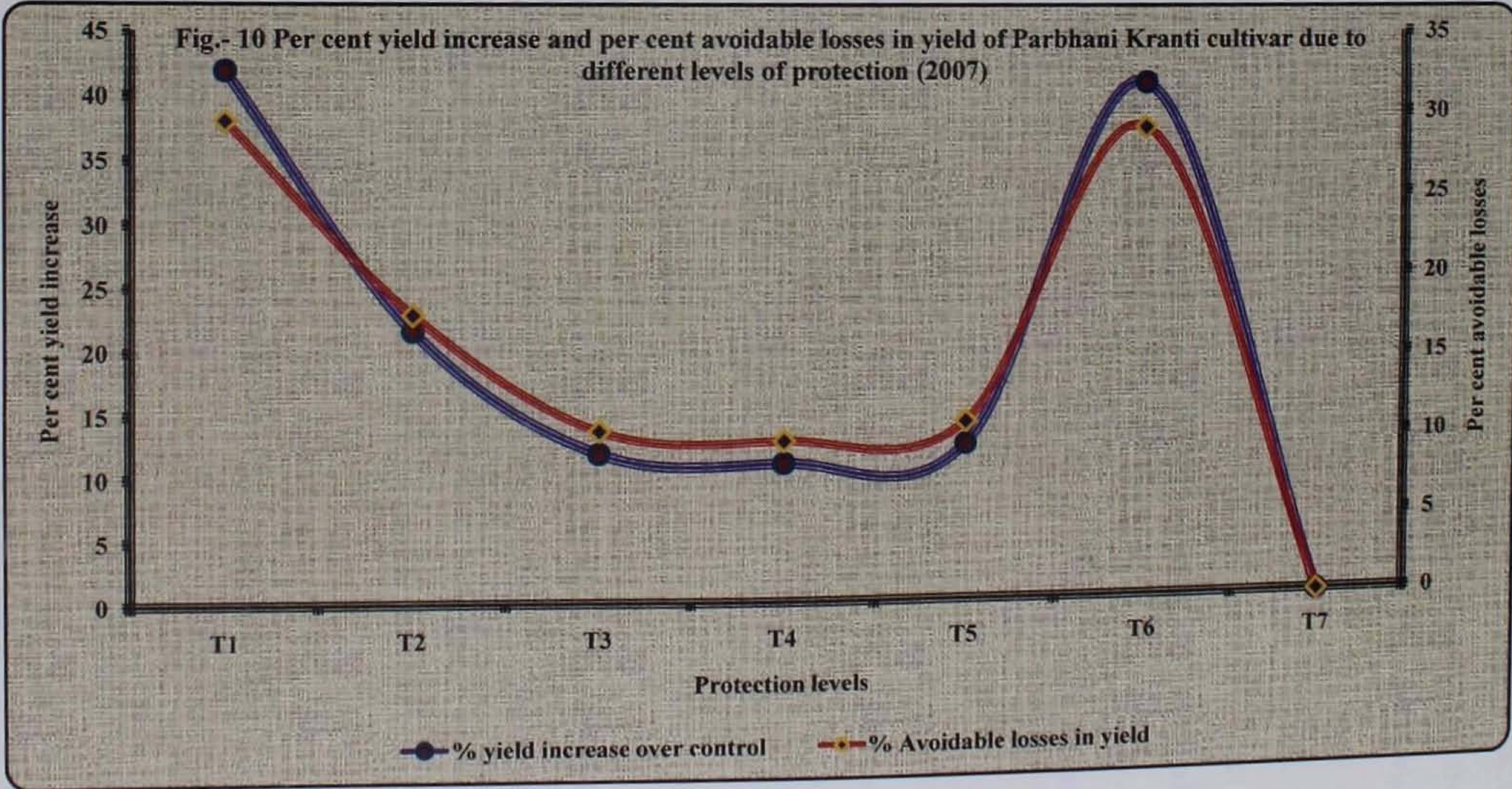


Fig.- 10 Per cent yield increase and per cent avoidable losses in yield of Parbhani Kranti cultivar due to different levels of protection (2007)



which was at par with protection against insect-pest upto 60 days (T_6) (1537 kg/ha). The lowest yield was recorded in the treatment of no protection against insect-pest (T_7) (1090 kg/ha) which was at par with protection against insect-pest from 60 days onwards (T_4) (1211 kg/ha), protection against insect-pest from 45 days onwards (T_3) (1220 kg/ha) and protection against insect-pest up to 45 days (T_5) (1226 kg/ha). The descending order of okra yield was (T_1) (1548 kg/ha) > (T_6) (1537 kg/ha) > (T_2) (1326 kg/ha) > (T_5) (1226 kg/ha) > (T_3) (1220 kg/ha) > (T_4) (1211 kg/ha) > (T_7) (1090 kg/ha).

Looking to the extent of increase in yield over control, the treatment T_1 remained on top (41.94 %) followed by T_6 (40.94 %). The treatments T_2, T_5, T_3 and T_4 were in the descending order of effectiveness.

4.2.3 Avoidable losses in yield

The highest avoidable loss in okra fruit yield (Table-23) was recorded (29.59%) in treatment T_1 followed by T_6 (29.08 %) and T_2 (17.80 %). The lowest avoidable loss (10.00 %) was recorded in T_4 followed by T_3 (10.65 %) and T_5 (11.09 %) treatments.

4.2.4 Economics of insecticidal application in different protection levels

Economics of insecticidal treatments in different protection levels of okra was worked out on the basis of prevailing cost of inputs and okra fruit yield are presented in Table-24. The BCR was worked out separately for the levels of protection.

The results revealed that the maximum gross income of 37152 Rs/ha was obtained when the crop was protected against insect pest throughout crop season (T_1), followed by the treatment of T6 (36888 Rs/ha). Minimum gross income was observed in unprotected treatment (T_7). Further, it can be seen from the above results that the highest BCR (1: 9.63) was recorded in the treatment of T_6 followed by the treatment T_1 (1: 4.04). The lowest BCR (1: 0.42) was obtained in the treatment of T_4.

From the present findings, in can be inferred that need based application of pesticides against pest complex of okra up to 60 days of the crop season (T_6) gave the higher BCR. Secondly, the need based application of chemical pesticides on the basis of threshold level helped to reduce the number of pesticide application to one time in T_6 along with seed treatment while, two times in T_1, T_2, T_3 and T_4 treatments. Treatment T_5 received seed treatment only and no pesticide application throughout the crop period.

Table : 24 Economics of different protection levels against insect pest complex of okra Cv. Parbhani Kranti during *kharif* - 2007

Treatment	Total Spray	Cost of insecticide (Rs/ha)	Labour Cost (Rs/ha)	Total cost of plant protection (Rs/ha)	Yield (kg/ha)	Gross income (Rs/ha)	Net gain (Rs/ha)	Net profit over control	BCR
T_1	2	1980	200	2180	1548	37152	34973	8813	1:4.04
T_2	2	1950	200	2150	1326	31824	29674	3514	1:1.63
T_3	2	1950	200	2150	1220	29280	27130	970	1:0.45
T_4	2	1850	200	2050	1211	29064	27014	854	1:0.42
T_5	1	909	100	1009	1226	29424	28415	2255	1:2.23
T_6	1	909	100	1009	1537	36888	35879	9719	1:9.63
T_7	0	-	-	-	1090	26160	26160	-	-

Price :

Fruit yield = 12 Rs/500 gm

Labour charge = 100 Rs/spray

SUMMARY AND CONCLUSION

V. SUMMARY AND CONCLUSION

Two field experiments were conducted at Navsari during kharif, 2007 to study succession of important insect and mite pests and estimation of yield losses due to various pests attacking okra at different stages of crop growth. The results are summarized and concluded as under.

5.1 Succession of important insect and mite pests in okra

The pest sequence study was understand in five different cultivars viz; Parbhani Kranti, Arka Anamika, Pusa Sawani, GO-2 and LSVT (AOL-03-1) and weekly observations were recorded on important pests. The periodical mean value of pest incidence based on all cultivars was taken into account for pest sequence study.

The incidence of sucking pests like jassid and whitefly commenced fourth WAS i.e last week of July and fluctuated through out the crop season. Among them whitefly multiplied comparatively at a faster rate reaching to peak level (4.18 adults/leaf) during last week of August where as population of jassid increased gradually and attended its peak during third week of September (5.52 jassid/leaf). Similarly, aphid population initiated first week of August and reached peak level (18.50 aphids/leaf) at first week of October. Whereas, mite population started first week of September and reach peak level (18.20 mites/leaf) during the last week of September. In case of shoot and fruit borer, initiated fourth week after sowing (last week of July) and population reached the peak level (1.35 larvae/plant) during the second week of September.

The two predators *viz*; green lacewing and lady bird beetle occurred in first week of August to third week of October. Out of the two predators, chrysopid was first to appear between 4 and 9 WAS and reached its maximum intensity 8 WAS. Later on, the coccinellids swung into action 9 WAS and prevailed throughout the remaining crop season, the later one reached peak level 13 WAS. The two predators *viz*; green lacewing and lady bird beetle appeared at different period exerting to some extent natural check on sucking pests.

5.1.1 Sequence of occurrence of important insect and mite pests on okra

The term pest sequence can be defined as "chronological colonization of a host crop by various pests." Individual or group of pests may colonize a crop at same, distinct, or sometimes overlapping period of same crop. The sequence of important insect and mite pest was worked out on the basis of mean incidence of a pest over period is as under.

There was no incidence of insect pest in early seedling stage till third week after sowing; however, incidence of sucking pest like jassids, whitefly and borer like shoot and fruit borer started fourth week after sowing. i.e. during the last week of July, out of these, two sucking pest *viz.*, jassids and whitefly occurred throughout the crop season. Whitefly multiplied comparatively at faster rate, reaching the peak level during last week of August, followed by jassids which attained the peak level during third week of September conforming positive correlation with whitefly. The third sucking pest like aphid, initiated fifth week after sowing (first week of August) and reached the peak level during first week of October disclosing positive correlation with jassid, while, fourth sucking pests like mite, population started ninth week after sowing (first week of September) and reached the peak during last week of September confirming significant positive correlation with aphid and negative correlated with whitefly.

Population of shoot and fruit borer started fourth week after sowing (last week of July) and reached the peak during second week of September conforming significant positive correlation with jassid and whitefly.

From the studies, it can be generalized, that the incidence of sucking pest like jassids and whitefly started simultaneously during last week of July and it may be closely followed by aphid in first week of August. The incidence of aphid and mite initiated first week of August and first week of September, respectively. Whereas, the shoot and fruit borer started during last week of July.

The two predators viz; *C. scelestes* and *C. septempunctata* occurred at distinct periods of crop growth. The chrysopid appeared in the early stage of crop suppressing jassid and whitefly population. The incidence of coccinelid predator started during later part of crop stage and prevailing throughout the remaining crop season.

5.1.2 Varietal screening

Among the five cultivars evaluated under field conditions for their susceptibility to different pest during kharif season, cultivars, Arka Anamika exhibited low jassid population and proved to be resistant, whereas GO-2 cultivar found moderately resistant. Cultivar, Parbhani Kranti proved to be highly susceptible against this pest.

The okra cultivar when evaluated against whitefly, Pusa Sawani and LSVT (AOL-03-1), Arka Anamika and GO-2 were supported low population of this pest and proved to be resistant, while Parbhani Kranti found to be susceptible against whitefly.

The cultivars LSVT (AOL-03-1) and GO-2 and Pusa Sawani found to be moderately resistant to aphid, whereas, the highest population of aphid was registered on cultivar Parbhani Kranti and found to be highly susceptible.

Among the five cultivars evaluated against mite, LSVT (AOL-03-1), GO-2 and Arka Anamika supported low population of this pest and proved to be resistant. The highest population of mite was observed in Parbhani Kranti and found to be highly susceptible.

The cultivars LSVT (AOL-03-1), GO-2 and Arka Anamika proved to be resistant by recording low fruit damage whereas, Parbhani Kranti was found moderately resistant. Higher fruit damage was observed in Pusa Sawani and showed susceptible reaction against this pest.

5.1.3 Periodic occurrence of natural predators

Out of the two predators, the population of green lacewing appeared first in the first week of August, whereas, lady bird beetle was seen last in the second week of September. They attained peak intensity during the fourth week of August (0.78/plant) and first week of October (0.90/plant), respectively. The population of green lacewing and lady bird beetle was maximum in cultivar Parbhani Kranti which supported higher population of aphid, jassid and whitefly, the host insects of these above two predators.

5.1.4 Correlation between incidence of pests and weather parameters

Simple correlation was worked out taking into consideration the period mean of various pests to evaluate the instantaneous effect of meteorological variables on the incidence of important pests.

A) Sucking pest:

a) Aphid:

Maximum temperature exhibited significant influenced with aphid population in Parbhani Kranti cultivar, whereas, evening relative humidity, average relative humidity and rainy days exhibited significant negative influence on aphid population. In case of Go-2 cultivar, maximum temperature and sunshine hours exhibited significant positive influence whereas, minimum temperature, evening relative humidity, average relative humidity, wind velocity, rainfall and rainy days showed significant negative influence with aphid population.

In Arka Anamika, Pusa Sawani and LSVT (AOL-03-1) cultivars, maximum temperature, average temperature, sunshine hours and evaporation showed positive influence whereas, minimum temperature, morning relative humidity, evening relative humidity, average relative humidity, wind velocity, rainfall and rainy days had negative influence with aphid population.

b) Jassid:

Jassid population in Parbhani Kranti cultivar, maximum temperature, minimum temperature, average temperature, morning relative humidity, sunshine hours, rainy days and evaporation were positively correlated whereas, another weather factors were negatively correlated with jassid population. In Arka Anamika cultivar, maximum temperature, minimum temperature, average temperature, morning relative humidity, evening relative humidity, average relative humidity, sunshine hours, rainy days and evaporation exhibited positive influence whereas, wind velocity and rainfall showed negative correlation with jassid population.

In case of Pusa Sawani cultivar, maximum temperature, average temperature, morning relative humidity, sunshine hours, rainy days and evaporation exhibited positive influence whereas, GO-2 cultivar, maximum temperature, average temperature, morning relative humidity, sunshine hours and evaporation were positively correlated with jassid population. In LSVT (AOL-03-1) cultivar, maximum temperature, average temperature, sunshine hours and evaporation showed positive influence whereas, remaining weather factors showed negative influence with jassid population.

c) Whitefly:

Minimum temperature, average temperature, morning relative humidity, evening relative humidity, average relative humidity, rainfall, rainy days and evaporation had positive correlation with whitefly population in Parbhani Kranti and LSVT (AOL-03-1) cultivars, whereas, evaporation has significant positive correlation with whitefly population in Arka Anamika cultivar.

In case of Pusa Sawani cultivar wind velocity, sunshine hours and rainfall showed negative correlation; While, GO-2 cultivar maximum temperature, wind velocity and rainfall showed negative correlation whereas remaining weather factors had positive influence with whitefly population.

d) Mite:

Population of mite was positively correlated with maximum temperature, average temperature, sunshine hours and evaporation in Parbhani Kranti and LSVT (AOL-03-1) cultivars. Whereas, in case of Arka Anamika, significant positive influence with maximum temperature, while minimum temperature, morning relative humidity, evening relative humidity, average relative humidity and rainy days showed significant negative influence on mite population.

In case of Pusa Sawani cultivar, maximum temperature, average temperature, sunshine hours and evaporation were positively correlated, whereas, in GO-2 cultivar significant positive correlation with maximum temperature and sunshine hours. While, minimum temperature, morning relative humidity, evening relative humidity, average relative humidity and rainy days showed significant negative correlation with mite population. The other weather parameters *viz,* average temperature and evaporation was positively correlated whereas remaining weather factors had negative correlation with mite population.

B) Shoot and fruit borer:

Maximum temperature, minimum temperature, average temperature, morning relative humidity, evening relative humidity, average relative humidity, sunshine hours, rainy days and evaporation were positively correlated whereas, wind velocity and rainfall having negative influence with *E.vittella* population in Parbhani Kranti and Pusa Sawani cultivars.

Population of *E.vittella* in Arka Anamika cultivar was positively correlated with maximum temperature, average temperature, morning relative humidity, sunshine hours and evaporation whereas; LSVT (AOL-03-1) cultivar showed significant negative correlation with wind velocity. In GO-2 and LSVT (AOL-03-1) cultivars, positive correlation with maximum temperature, average relative humidity and sunshine hours whereas remaining weather factors had negatively correlated with *E. vittella* population.

5.1.5 Insect predators of okra pests

a) Green lacewing: *C. scelestes*

Maximum temperature, average temperature, morning relative humidity, sunshine hours and evaporation exhibited positive correlation, while minimum temperature, evening relative humidity, average relative humidity, wind velocity, rainfall and rainy days exhibited negative correlation with population of green lacewing.

b) Lady bird beetle: *C. septempunctata*

Minimum temperature, relative humidity, wind velocity, rainfall and rainy days exhibited positive influence while, maximum temperature, average temperature, sunshine hours and evaporation exhibited negative influence with lady bird beetle population.

5.1.6 Correlation between insect predators and their host insects

The green lacewing was significant, positively correlated with aphid, jassid and mite population, whereas, lady bird beetle was negatively correlated with jassid and whitefly population and positively correlated with aphid and mite population.

5.2 Estimation of yield losses due to important insect-pests in okra

Second field experiment was conducted to estimate yield losses due to important insect-pest in Parbhani Kranti cultivar. The treatments consisted of protection against insect pests throughout crop season. (Seed treatment + need based application of insecticides) (T_1), protection against insect pests from 30 days onwards (T_2), protection against insect pests from 45 days onwards (T_3), protection against insect pests from 60 day onwards (T_4), protection against insect pests up to 45 days i.e. seed treatment (T_5), protection against insect pests up to 60 days (Seed treatment +need based application of insecticides) (T_6) and no protection against insect pests (T_7). Recommended plant protection measures were adopted as and when one or more pest population crossed their respective economic threshold level (ETL) in a given treatments. The results are summarized as under.

5.2.1 Incidence of insect-pest in different protection levels

A. Sucking pests:

The need-based application of insecticides in different treatments showed the lowest average population of aphid (4.84 aphids/leaf), jassid (3.11 jassids/leaf) and whitefly (0.89 adult/ leaf) in the treatment of T_1 that required two sprays of chemical pesticides. The corresponding highest mean number of these pests was 13.07, 10.88 and 7.88 observed in the treatment of T_7 (no protection). The maximum per cent reduction due to need based protection over control in aphid (62.93 %), jassid (71.41 %) and whitefly (88.75 %) was found in treatment T_1.

Similarly, minimum average population of mite (2.60 mites/leaf) was found in the treatment of T_1 (two spray), while it was maximum in the treatment of T_7 of these pests. The treatment of T_1 enforced the highest mortality of mite population (81.90 %) over control, whereas it was least in the treatment of T_5 (35.36 %).

B. Shoot and fruit borer:

The need based application of insecticide in different protection levels to keep shoot and fruit borer below their ETL level caused the least incidence of *E. vittella* (0.02 larva/plant) in T_1 treatment. The highest average incidence of *E. vittella* (1.29 larvae/plant) was recorded in the untreated control. The maximum per cent reduction over control in the population of *E. vittella* (98.45 %) was recorded in the treatment of T_1, whereas it was minimum in treatment of T_6 (7.34 %).

5.2.2 Okra fruit yield

The highest okra fruit yield was recorded in treatment of protection throughout the crop season (T_1) (1548 kg/ha), whereas yield was lowest (1090 kg/ha) in the treatment of no protection. Thus, the treatment T_1 proved to be best among all the levels of protection.

The maximum per cent increase in fruit yield over control was recorded in the treatment of T_1 (41.94 %) and proved to be the best treatment in protecting okra crop against different pests. The corresponding lowest increase in okra yield over control was recorded in T_4 (11.09 %) and T_3 (11.91 %) treatments.

The avoidable losses in okra fruit yield was highest (29.59 %) in T_1 followed by T_6 and T_2 with and extent of 29.08 and 17.80 per cent, respectively. Least avoidable losses (10.00 %) were observed in T_4 followed by T_3 (10.65 %) and T_5 (11.09 %) treatments.

5.2.3 Economics of insecticidal application in different protection levels

The highest BCR (1:9.63) was found in the treatment of protection against insect pests up to 60 days (Seed treatment +Need base application of insecticides) (T_6), warranting one pesticidal spray to keep pest complex of okra below their respective economic threshold level while the lowest (1:0.42) in the treatment of protection against insect pest from 60 days onwards (T_4). The treatment of protection against insect pest throughout crop season proved to be the second best with BCR 1:4.04.

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* Original not seen

APPENDICES

Appendix : I Meteorological data recorded during the course of investigations (weekly mean) *kharif* - 2007

Month (2007)	Week No.	Temperature °C			Relative Humidity (%)			Wind Velocity (km/hr)	Sunshine (hours/day)	Rain fall (mm)	Rainy Days	Evaporation (mm)
		Max.	Min.	Aver.	Mor.	Eve.	Aver.					
June	23	33.7	27.7	30.70	84	62	73.0	8.5	8.4	20.0	1	5.7
	24	33.6	27.9	30.75	79	63	71.0	9.3	7.0	10.0	1	6.6
	25	33.7	25.6	29.65	87	68	77.5	8.0	5.8	49.0	4	5.9
	26	29.7	25.3	27.50	92	82	87.0	9.6	3.2	74.8	6	3.3
July	27	30.0	26.9	28.45	85	81	83.0	15.5	0.4	140.4	4	3.4
	28	30.0	26.5	28.25	89	80	84.5	10.2	3.0	51.8	4	3.3
	29	30.8	25.9	28.35	90	72	81.0	6.7	9.6	23.5	3	3.5
	30	31.2	25.5	28.35	92	76	84.0	5.1	6.5	195.1	3	3.1
	31	29.5	24.8	27.15	94	81	87.5	6.0	3.3	290.0	4	2.2
August	32	28.1	25.0	26.55	94	88	91.0	9.9	1.1	249.0	6	1.9
	33	29.8	25.7	27.75	88	77	82.5	12.1	2.9	28.0	2	2.8
	34	30.9	25.4	28.15	91	71	81.0	5.6	7.5	11.9	1	4.1
	35	29.4	25.0	27.20	97	89	93.0	5.8	1.5	289.2	6	2.5
September	36	29.3	25.3	27.30	93	80	86.5	5.4	3.4	100.0	6	3.0
	37	32.0	24.8	28.40	91	62	76.5	4.0	8.3	22.0	2	3.7
	38	31.4	24.3	27.85	96	72	84.0	4.0	4.1	157.0	5	2.9
	39	29.5	25.1	27.30	95	80	87.5	5.3	3.0	36.0	3	2.3
October	40	33.4	22.5	27.95	90	48	69.0	3.2	7.4	0.0	0	3.6
	41	34.0	23.2	28.60	83	46	64.5	3.4	7.7	0.0	0	3.1
	42	35.0	18.5	26.75	77	25	51.0	3.5	9.6	0.0	0	3.8
	43	35.1	19.1	27.10	70	27	48.5	3.3	9.7	0.0	0	3.7
	44	34.3	21.8	28.05	80	49	64.5	3.4	8.5	0.0	0	3.7
November	45	33.6	22.4	28.00	91	51	71.0	2.9	7.8	0.0	0	2.5
	46	33.3	17.6	25.45	80	29	54.5	3.4	8.8	0.0	0	3.6
	47	32.5	14.5	23.50	57	17	37.0	4.2	9.4	0.0	0	3.6
	48	32.1	15.8	23.95	71	28	49.5	3.5	8.4	0.0	0	3.5

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CERTIFICATE

This is to certify that I have no objection for supplying to any scientist any one copy or any part of this thesis at a time through reprographic process, if necessary for rendering reference services in a library or documentation centre.

Place : Navsari.

Date : 21st February, 2009

(Patel K. B.)