EVALUATION OF OKRA, *ABELMOSCHUS ESCULENTUS* (LINNAEUS) MOENCH VARIETIES/GENOTYPES AGAINST THEIR MAJOR PESTS IN MIDDLE GUJARAT CONDITION

A

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BY

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GUJARAT (INDIA)

2000

DEDICATED
TO MY
BELOVED PARENTS

ABSTRACT

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EVALUATION OF OKRA, *ABELMOSCHUS ESCULENTUS* (LINNAEUS) MOENCH VARIETIES/GENOTYPES AGAINST THEIR MAJOR PESTS IN MIDDLE GUJARAT CONDITION

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To evaluate the various okra varieties against their major pests in middle Gujarat conditions, a study was carried out during the year, 1999 at Gujarat Agricultural University, Anand Campus, Anand. The studies indicate that among 16 varieties, none was found free from the aphid, *Aphis gossypii* Glover, infestation. The okra variety GO-2 remained least susceptible in comparison to rest of the varieties, this may be due to the hairiness of this variety and high population of lady bird beetle *Cheilomenes sexmaculata* (Fabricius). Parbhani Kranti had high aphid population. The jassid, *Amrasca biguttula biguttula* Ishida population was found low on varieties VRO-4 and HRB-9-2. This may be due to high hair density and longer hair on the lower midrib of leaf. Whereas, the population of jassid was found high in the less hairy variety Arka Anamika. The

variety HRB-55 had low shoot damage by *Earias vittella* Fabricius, whereas, high in the variety AOL-95-13. The fruit damage by *E. vittella* was low in the variety JOL-5 and high in the variety GO-2. This may be due to hair density on the fruit. Whereas, the fruit damage due to *Helicoverpa armigera* Hubner was found low in the variety HRB-55 and high in the variety JOL-4.

The population of lady bird beetle *C. sexmaculata* was found to be high in the variety HRB-55 and low in the variety HRB-9-2. The population of green lacewing, *Chrysoperla carnea* Stephens was high in the variety HRB-55 and low in the variety AOL-95-15. Whereas, the population of syrphid fly, *Xanthogramma scutellaris* Fabricius was found high in the variety HIHB-068.

The study on the leaf hair density indicated that the okra varieties JOL-4 and DEV-91-4 had low hair density on upper surface of the leaf. Whereas, the varieties JOL-5, VRO-4 and HIHB-068 had high hair density. The leaf hair density on lower surface of the leaf was low in the varieties AOL-95-13, Padra-18-6 and Pusa Sawani. Whereas, high in the variety HIHB-068. The fruit hair density was low in the variety JOL-5 and high in the variety AOL-95-13.

The study on the leaf hair length indicated that the okra variety Arka Anamika had shorter hairs on upper surface of the leaf whereas, longer hairs in the variety VRO-4. The hair length on lower surface of the leaf was shorter in the variety Padra-18-6 and longer in the variety HRB-9-2.Whereas, on the lower midrib of leaf shorter hairs were present in the variety Arka Anamika and longer hairs in the variety VRO-4. The average hair length was found longer in the variety VRO-4 and shorter in the variety Arka Anamika. The fruit hair length was shorter in the variety DEV-91-4 and longer in the variety HIHB-068.

The correlation studies indicated that there was no significant association found between aphid with hair density and hair length, whereas, a significant negative association was found between the jassid population and hair density as well as hair length of the lower midrib of the leaf. The significant negative association was also found between fruit damage by the fruit borers (*E. vittella* and *H. armigera*) and fruit hair density whereas, no significant association was found between the fruit borers and fruit hair length.

The yield data indicated that the okra variety HRB-9-2 gave high yield whereas, the variety Pusa Sawani gave low yield.

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CERTIFICATE

This is to certify that the thesis entitled **EVALUATION OF OKRA, *ABELMOSCHUS ESCULENTUS* (LINNAEUS) MOENCH VARIETIES/GENOTYPES AGAINST THEIR MAJOR PESTS IN MIDDLE GUJARAT CONDITION** submitted by Shri Venkata Ramana Chapara in partial fulfilment of the requirements for the degree of **Master of Science (Agriculture) in Agricultural Entomology** of Gujarat 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.

D. Mehta.

Place : Anand
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INTRODUCTION

I. INTRODUCTION

Okra (bhendi) *Abelmoschus esculentus* (Linnaeus) Moench, popularly known as lady's finger, is a herbaceous hairy annual plant of the family Malvaceae. It is among the most important vegetable crop due to its nutritional, industrial and medicinal values (Nadkarni, 1927 and Chauhan, 1972). It is rich in vitamins, calcium, potassium, phosphorus and iron (Singh, 1970). It is grown extensively in tropical and subtropical parts of the world. The estimated area under this seasonal vegetable in Gujarat is 11243 hectares during the year 1998-99 with a production of 55597 metric tonnes (Anon., 2000).

The okra crop is attacked by as many as 11 species of insect pests right from germination to harvest in Gujarat (Patel *et al.*, 1970). The major insect pests include shoot and fruit borer, *Earias vittella* Fabricius; jassid, *Amrasca biguttula biguttula* Ishida; aphid, *Aphis gossypii* Glover; whitefly, *Bemisia tabaci* Gennadius and leaf roller, *Sylepta derogata* Fabricius. The insect pests of minor importance are leaf eating beetles, *Trachys* spp.; fruit borer, *Helicoverpa armigera* Hubner; weevils, *Myllocerus* spp.; semilooper, *Anomis flava* Fabricius; thrips, *Thrips tabaci* Lindermann; mealybugs, *Ferrisia virgata* Cockerell and scale insect,

Saissetia coffeae Walker. Major non-insect pests causing severe damage to this crop include root-knot nematode, *Meloidogyne* spp. and red spider mite, *Tetranychus* spp. (Butani and Jotwani, 1984).

In early stage of the crop, sucking insects *viz.*, aphid, jassid and whitefly cause heavy economic loss by sucking cell sap from tender leaves and ultimately reduce the yield. The whitefly is responsible for transmitting yellow vein mosaic disease in okra. The shoot and fruit borer (*E. vittella*) larvae bore the growing shoots before fruit formation and with the availability of floral buds and fruits starts damaging them. Whereas, *H. armigera* bore the floral buds and fruits. Thus, they cause direct loss of yield (Dhawan and Sidhu, 1984).

Various scientists have reported the losses in fruit yield of okra due to these insect pests in range of 65 to 85 per cent (Rawat and Sahu, 1973; Rai, 1983 and Dhawan and Sidhu, 1984). Owing to deterioration of okra fruits, the pest damage was upto 37.18 and 69.91 per cent in okra products during monsoon and summer seasons, respectively (Mote, 1977).

Okra being a valuable vegetable crop chemical control is generally practiced for higher gains. But due to periodical harvest practice, chemicals are not advisable. Moreover to this, use of chemicals has several adverse consequences such as development of resistance by insect pests to insecticides, resurgence of pests, outbreak of secondary pests, problem of

residues, toxicity to non-target organisms, disturbance in the natural balance of pest species, environmental pollution, etc. (Dahiya and Chauhan, 1992). To overcome these problems, Swaminathan (1977) has emphasized on the appropriate blend of chemical and non-chemical methods such as cultural and biological methods of pest management relegating the insecticides to serve as complementary/supplementary strategy.

Cultural practices such as use of resistant/tolerant varieties is primafacie to minimize the yield losses by pests. Use of resistant cultivars virtually does not involve any skill or cash investment in pest control. It can be considered as a principal component of pest management besides cultural, biological and chemical means. For development of resistant variety use of appropriate donor parents is of atmost importance. There is no single variety of the crop in the state recognised totally resistant to all the insect pests. Hence, there was an urgent need to identify cultures which are moderately tolerant, resistant/tolerant to insect pests of okra, so that they can be used in breeding programme for development of varieties resistant/tolerant to insect pests. In this context, the present study was carried out to evaluate various okra varieties/genotypes against their major pests under middle Gujarat condition (weather data enclosed – Annexure-I).

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

In the present era of intensive agriculture, pest is considered as one of the important limiting factors in crop production. Okra is an important vegetable crop cultivated throughout the country. The literature available on the present aspect is reviewed under following heads.

1. Varietal susceptibility to insect pests.
2. Natural enemies
3. Effect of hairiness

2.1 Varietal susceptibility to insect pests

2.1.1 Sucking pests

2.1.1.1 Aphid, *A. gossypii*

Uthamasamy *et al.* (1974) at Coimbatore, Tamil Nadu reported that among 25 okra varieties, Pusa Sawani was resistant variety to aphid, *A. gossypii*.

Gunathilagaraj *et al.* (1977) at Madurai, Tamil Nadu found that among different okra varieties screened for resistance against aphid, *A. gossypii*, the variety AE-112 recorded least population whereas, it was highest in the variety Clemson Spineless.

Vyas (1989) at Anand, Gujarat found high aphid *A. gossypii* population in the okra variety Pusa Sawani and low in the variety Selection-2.

Among 23 varieties of okra screened for resistance to aphid, *A. gossypii*, low aphid population was found in the varieties Padra-18-6, Pusa Sawani, M-1, Punjab-7 and M-8 (Anon., 1990).

Roy (1995) at Bhubaneshwar, Orissa reported that the okra variety Selection-2-2 was least susceptible to aphid, *A. gossypii* whereas, the variety Selection-1 was highly susceptible.

2.1.1.2 Jassid, *A. biguttula biguttula*

Uthamasamy *et al.* (1975) at Coimbatore, Tamil Nadu found higher preference of jassid, *A. biguttula biguttula* for feeding and oviposition to susceptible okra variety AE-26 than the varieties AE-52 and AE-30.

Uthamasamy and Subramanian (1980) at Coimbatore, Tamil Nadu reported that the okra variety AE-22 was resistant due to low preference of jassid, *A. biguttula biguttula* for oviposition and feeding.

Chelliah and Srinivasan (1983) at Coimbatore, Tamil Nadu found that the okra cultivars AE-22 and AE-44 were resistant to jassid, *A. biguttula biguttula*.

Vyas (1989) at Anand, Gujarat reported that the varieties Selection-2, PB-57, GO-1 and Punjab Padmini were moderately resistant.

Among 23 okra cutivars screened for resistance at Anand, Gujarat, least jassid, *A. biguttula biguttula* population was recorded in the cultivar M-11 (Anon., 1990).

Hooda and Dhankar (1992) at Hisar, Haryana evaluated wild texa of okra against jassid, *A. biguttula biguttula* and observed *Abelmoschus moschatus* Medik as highly resistant in comparison to the commercial variety *A. esculentus*.

Barroga and Bernardo (1993) at Lugune, Phillippines found that the okra variety ACC-12 exhibited antixenosis, antibiosis and tolerance as mechanisms of resistance to jassid, *A. biguttula biguttula*. Whereas, Mahal *et al.* (1993) at Ludhiana, Punjab reported that among 13 okra varieties, IC-7194, Punjab Padmini and New Selection recorded low jassid, *A. biguttula biguttula* population.

Patel (1994) at Anand, Gujarat found that the okra variety GOH-3 was more susceptible to jassid, *A. biguttula biguttula* in comparison to the varieties GOH-4, GOH-1, PB-57 and Pusa Sawani.

Khambete and Desai (1996) at Dapoli, Maharashtra reported that among 26 cultivars screened for jassid, *A. biguttula biguttula* resistance, the varieties Sela, Ankur-35, Boi, Plon-44-13, Sel-3 and HOE-301 exhibited significantly low population.

Sharma and Sharma (1997) at Hisar, Haryana reported poor survival, longer developmental period and smaller size of the nymphs of jassid, *A. biguttula biguttula* when reared on the cultivar IC-1794 as compared to the cultivars MR-12, MR 10-1 or Pusa Sawani.

Ragumoorthi and Kumar (1999) at Periyakulam, Tamil Nadu reported 23 okra lines as resistant to jassid, *A. biguttula biguttula*.

2.1.2 Borer complex

2.1.2.1 ***E. vittella***

Nawale and Sonone (1977) at Rahuri, Maharashtra found low infestation of fruit borer, *E. vittella* in the okra variety AE-22.

Gupta and Yadav (1978) at Rahuri, Maharashtra reported that among 60 okra germplasms tested 5325, 6327, 6701, 6901, 6903, 6804, 6908, 7117 and Kalyanpur Bonia were rated as moderately resistant to the shoot and fruit borers, *E. vittella* and *E. insulana*.

Rout and Sonone (1979) at Rahuri, Maharashtra reported the low susceptibility of the okra cultivar AE-71 to *E. vittella*.

Teli and Dalaya (1981) at Rahuri, Maharashtra found that the okra varieties Lucknow Special, Lucknow Rashmi, Selection-2-2, BHB and AE-3 were most susceptible to fruit and shoot borer, *E. vittella*.

Mote (1982) at Rahuri. Maharashtra reported lesser damage of fruit borer, *E. vittella* in the okra variety AE-19.

Chelliah and Srinivasan (1983) a Coimbatore, Tamil Nadu found 5 okra varieties and a wild species *Abelmoschus manihot* (L.) as resistant to fruit borer, *E. vittella* infestation. Kashyap and Verma (1982) at Hisar, Haryana reported that the variety SEL-2 was more susceptible to shoot and fruit borer, *E. vittella*. Whereas, Kishore *et al.* (1983) at Hisar, Haryana found the okra lines HB-45, HB-39 and HB-43 resistant to *Earias* spp.

Dhandapani (1985) at Coimbatore, Tamil Nadu observed okra varieties Pusa Sawani and AE-17 as susceptible and CO-1 as resistant to fruit borer. *E. vittella*. Similarly, Madhav and Dumbre (1985) at Rahuri, Maharashtra found okra varieties Pusa Sawani, AE-75 and White Velvet as tolerant and the variety Koparwadi local as resistant to shoot and fruit borer, *Earias* spp.

Ratanpara (1987) at Junagadh reported that the okra variety Pragrain was least susceptible to the okra shoot and fruit borer, *E. vittella*.

Among different okra varieties screened for resistance at Anand, Gujarat the variety Selection-2-2 was found moderately tolerant to shoot and fruit borer, *E. vittella* (Anon., 1988).

Sharma and Dhankar (1989) at Hisar, Haryana reported that the okra variety Long Green Smooth was least infested with the shoot and fruit borer, *Earias* spp. whereas Sardana and Dutta (1989) at Karnal, Haryana reported okra genotypes IC-6653 and Bhindi-6-Dhari as least susceptibility to shoot and fruit borer, *E. vittella.*

Bhalla *et al.* (1989) at New Delhi reported high yield in the okra varieties Sel-2 and Pusa Sawani despite of high shoot and fruit borer, *E. vittella* infestation.

Sojitra (1991) at Anand, Gujarat found Pusa Sawani susceptible to spotted bollworm, *E. vittella.* Vyas and Patel (1991) at Anand, Gujarat found Selection-2 least infested with the shoot and fruit borer, *E. vittella.*

Khambete and Desai (1996) at Dapoli, Maharashtra found Wonderful Pink as a tolerant variety to *E. vittella.* Patil *et al.* (1996) at Dharwad, Karnataka reported 10 genotypes of okra as less susceptible to *E. vittella.*

2.1.2.2 *H. armigera*

Harender *et al.* (1993) at Jachh, Himachal Pradesh reported least incidence of the fruit borer, *H. armigera* in the okra variety Punjab-7.

2.2 Natural enemies

Since the literature on the activity of natural enemies on different okra varieties is not available, the occurrence of natural enemies of various okra pests has been reviewed.

Tawfik *et al.* (1973) at Cairo, Egypt reported a predatory coccinellid, *Scymnus interruptus* Goeze on okra aphid, *A. gossypii*. Again Tawfik *et al.* (1974) at Cairo, Egypt reported a syrphid, *Sphaerophoria flavicauda* Zett. as a predator of okra aphid, *A. gossypii*.

Venugopal *et al.* (1975) at Coimbatore, India found 3 species of predatory coccinellids viz., *Cheilomenes sexmaculata* F.; *Coccinella septempunctata* L. and *Coccinella repanda* Thnb. on okra aphid, *A. gossypii*.

Thontadarya *et al.* (1978) at Dharwad, Karnataka reported the egg parasitoid, *Trichogramma australicum* Gir. from the eggs of *H. armigera* infesting okra.

Nettles (1979) at Louisiana, USA reported the tachinid parasitoid, *Eucelatoria* spp. from *Heliothis virescens* B. on okra and cotton.

Swamiappan and Balasubramanian (1980) at Coimbatore, Tamil Nadu found the egg larval parasitoid *Chelonus blackburni* Cam. as an effective bio-control agent of *E. vittella* on okra.

Naganagoud and Thontadarya (1984) at Dharwad, Karnataka found high rate of egg parasitism by *Trichogramma acheae* Nagaraja on *Earias* spp. and by *Trichogramma chilonis* Ishi on *H. armigera.*

Salim et al. (1987) at Islamabad, Pakistan reported *Orius albidipennis* Reut. an anthocorid bug as a predator of immature stages of soft bodied insects and the eggs and neonate larvae of the lepidopteran insects infesting okra.

Jalali *et al.* (1988) at Banglore, Karanataka reported *Cotesia kazak* Kurd as the major parasite of *H. armigera* on the crops cotton, okra, and tomato.

Sathe (1990) at Kolhapur, Maharashtra reported that the parasitic wasp, *Eriborus* spp. was stimulated by the food plants such as pigeonpea, chickpea, okra, cauliflower, tomato and cabbage to search its host *H. armigera.*

Dubey *et al.* (1993) at Jabalpur, Madhya Pradesh reported the larval parasitoid *Campoletis chloridae* Uchida as an effective check of *H. armigera* population in the crops like okra, chickpea, pigeonpea,

hollyhock, soyabean, fodder grain, sorghum etc. Singh *et al.* (1993) at Banglore, Karnataka found that the *Anagrus spp; Anagrus flaveolus* Waterh, *Arescon enocki* Subba Rao and Kaur and *Oligosita* spp. as the effective egg parasitoids of jassid, *A. biguttula biguttula* whereas, the predators of it were *Cheilomenes sexmaculata, Termatophyllum spp.* and *Mallada boninensis* Okamoto on crops like okra, castor, cereals, grain legumes, oilseed crops, fibre crops, fruit and forage crops.

Kapadia and Mittal (1995) at Junagadh, Gujarat reported 2 mymariads, *Arescon enocki*, S. and *Stethynium empoascae* Subba Rao as egg parasitoids of okra jassid, *A. biguttula biguttula.*

Ambrose (2000) at Palayankottai, Tamil Nadu reported that the reduviid predator, *Rynocoris kumarii* Ambrose and Livingstone effectively suppressed the infestation of *H. armigera* on okra.

2.3 Effect of hairiness

Since the literature available on the effect of hairiness of okra on various pests and natural enemies is limited, the relevant information on cotton crop also reviewed.

2.3.1 Effect of hairiness on insect pests

2.3.1.1 Sucking pests

2.3.1.1.1 Aphid, *A. gossypii*

Khan and Agarwal (1990) at New Delhi found that moderately hairy varieties were more preferred by aphid, *A. gossypii* as compared to the smooth or densely pubescent varieties of cotton.

Weathersbee and Hardee (1994) at Mississipii, USA observed that lower aphid, *A. gossypii* population was found on cotton cultivar exhibiting the smooth leaf characters.

Naveed *et al.* (1995) at Multan, Pakistan reported that the cotton variety CIM-70 with low hair density had a high population of Aphid, *A. gossypii*.

Jiang and Guo (1996) at Beijing, China found that the density of hairiness and aphid resistant level of cotton significantly affected its feeding behaviour.

2.3.1.1.2 Jassid, *A. biguttula biguttula*

Bindra and Mahal (1979) at Ludhiana, Punjab found less infestation and low damage of jassid in the okra varieties New Selection, Selection-2-2 and Selection 6-2, which had high hair density on midvein of the leaf.

Ambekar and Kalbhor (1981) at Rahuri, Maharashtra reported that the cotton varieties Buri-1007, DHY-286 and Khandwa-2 had high degree of resistance to jassid, *A. biguttula biguttula* due to more numbers of hair count.

Teli and Dalaya (1981) at Rahuri, Maharashtra found that the okra varieties having more hair density and hair length on leaf lamina were less preferred for oviposition.

Rote *et al.* (1982) at Surat, Gujarat reported average jassid, *A. biguttula biguttula* nymphs per plant was lower in the cotton variety G.Cot. 10 and found resistance due to hairiness.

Sharma and Agarwal (1983) at New Delhi found that the cotton jassid, *A. biguttula biguttula* population was negatively correlated with leaf hairiness.

Khan and Agarwal (1984) at Dholi, Bihar reported that jassid, *A. biguttula biguttula* resistant cotton entries had more number of hairs as compared to the highly susceptible ones.

Uthamasamy and Subramanian (1985) at Coimbatore, Tamil Nadu reported that the okra varieties possessing more and longer hairs on the midrib and lamina of the leaves were resistant to jassid, *Amrasca devastans* Distant.

Singh (1989) at New Delhi reported that the difference in the behaviour of the jassid, *A. biguttula biguttula* population in various okra varieties was attributable to high hair density and hair length on the lower leaf surface.

Lancon *et al.* (1989) at Ivory Coast, Zambia improved the chorzea (*G. hirsutum)* a cotton variety for resistance against jassid, *A. devastans* through increased hairiness.

Sivasubramanian *et al.* (1991) at Coimbatore, Tamil Nadu reported that the cotton varieties cooker 100 webber and 1814 were highly susceptible to *A. devastans,* due to less number of hairs on leaf.

Sharma and Sharma (1997) at Hisar, Haryana reported that hair density of different veins of cotton leaf showed significant negative correlation with egg laying by *A. biguttula biguttula.*

Bhatt (2000) at Anand, Gujarat observed significant negative association between hair density of midrib on lower surface of leaf and jassid, *A. biguttula biguttula* population.

2.3.1.2 Borer complex

2.3.1.2.1 *E. vittella*

Bhat *et al.* (1984) at Nagpur, Maharashtra reported that variety with moderate hairiness of the leaf was least susceptible to cotton bollworms, *E. vittella* and *H. armigera.*

Kumbhar *et al.* (1991) at Rahuri, Maharashtra found that among 40 okra varieties, AE-79, AE-69 and AE-22 had high resistance to shoot damage by shoot and fruit borer, *E. vittella* and the variety AE-79 had fair resistance only to fruit damage. The resistance was correlated with increased fruit hair density.

Saini and Singh (1999) at Hisar, Haryana reported significant positive correlation between trichome density and oviposition by spiny bollworm, *E. insulana.*

2.3.1.2.2 ***H. armigera***

Robinson *et al.* (1980) at Texas, USA reported that smooth leaf cottons suppress the population of *Heliothis virescens* F. by reducing the total number of eggs deposited by adults.

Ramalho *et al.* (1984) at Mississippi, USA observed that the hairy varieties provide resistance against larvae of *H. virescens* by interfering their movement and increasing mortality.

Navasero and Ramaswamy (1993) at Mississippi, USA reported that the leaf hairiness is one of the important factors affecting the oviposition by *H. armigera.*

Abhishek and Yadav (1998) at Jabalpur, Madhya Pradesh reported that leaf morphology acted as a proposed mechanism for the development of resistance to *H. armigera.*

2.3.2 Effect of hairiness on the natural enemies

Treacy *et al.* (1986) at Texas, USA reported that the egg parasitoid, *Trichogramma pretiosum* Riley parasitised more eggs of *H. virescens* on smooth leaf cotton than on hairy cotton.

Treacy *et al.* (1987) at Texas, USA reported that the predation by *Chrysoperla rufilabaris* Burmeister on the eggs of *Heliothis zea* B. was greater on smooth leaf cotton than on the hairy leaf cotton.

MATERIALS AND METHODS

III. MATERIALS AND METHODS

With a view to screen the varieties/genotypes of okra, *A. esculentus* for their susceptibility to major pests in middle Gujarat condition, an experiment was conducted during *kharif*, 1999 at Plant Breeding Farm, Gujarat Agricultural University, Anand Campus, Anand.

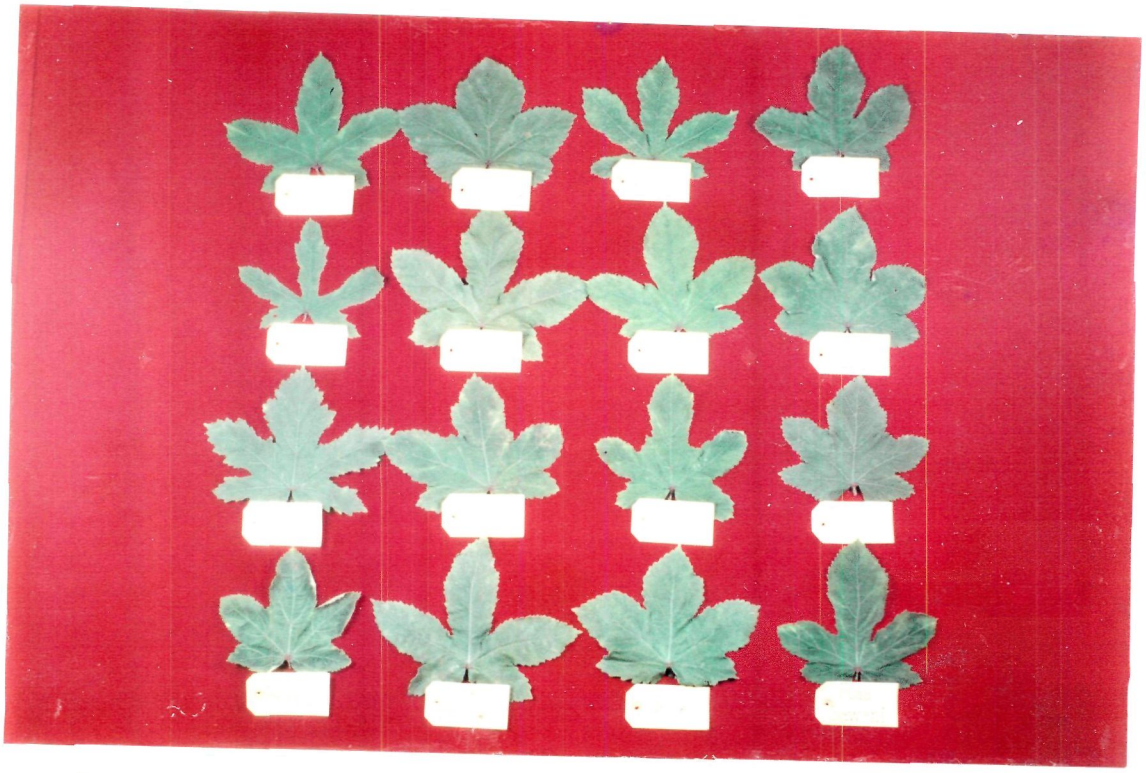
3.1 Experimental details

3.1.1 Treatments

Sixteen different varieties/genotypes (Table-1 and Plate-1) of okra were evaluated to study their effect on their major pests.

Table 1 : The varieties/genotypes selected for their evaluation against their major pests

Sr. No.	Varieties/Genotypes
1.	HRB-55
2.	JOL-5
3.	HRB-9-2
4.	VRO-4
5.	HIHB-068
6.	SEL-2
7.	AOL-95-15
8.	JOL-4
9.	AOL-95-13
10.	Parbhani Kranti
11.	VRO-3
12.	DEV-91-4
13.	Padra-18-6
14.	Arka Anamika
15.	GO-2
16.	Pusa Sawani



I Leaves of different okra varieties

3.1.2 Experimental design

The experiment was conducted in Randomised Block Design with three replications.

3.1.3 Plot size

1.5 x 3.0 m

3.2 Agronomic details

i.	Soil type	:	Sandy loam		
ii.	Date of sowing	:	30-06-1999		
iii.	Spacing	:	60 x 30 cm		
iv.	Fertilizer (kg/ha)	:	**N**	**P**	**K**
	Basal dose	:	50	50	50
	Top dressing	:	50	0	0
	Total	:	100	50	50
v.	Irrigation	:	As and when required		
vi.	Interculturing and weeding	:	As and when required		
vii.	Period of picking	:	17-08-'99 to 23-09-'99		
viii.	Number of pickings	:	12 at 2-3 days interval		

3.3 Observations recorded

3.3.1 Sucking pests

The weekly observations (P) on the count of aphid, *A. gossypii* and jassid, *A. biguttula biguttula* were recorded from 3 weeks after germination. From each plot, 5 plants were tagged and 3 leaves from each tagged plant (one each from top, middle and bottom portions) were selected at random for recording the observations (Plates II and III).

3.3.2 Borer complex

3.3.2.1 *E. vittella*

3.3.2.1.1 Shoot damage

Shoots damaged by *E. vittella* were observed at weekly periods (P) and per cent damage was worked out.

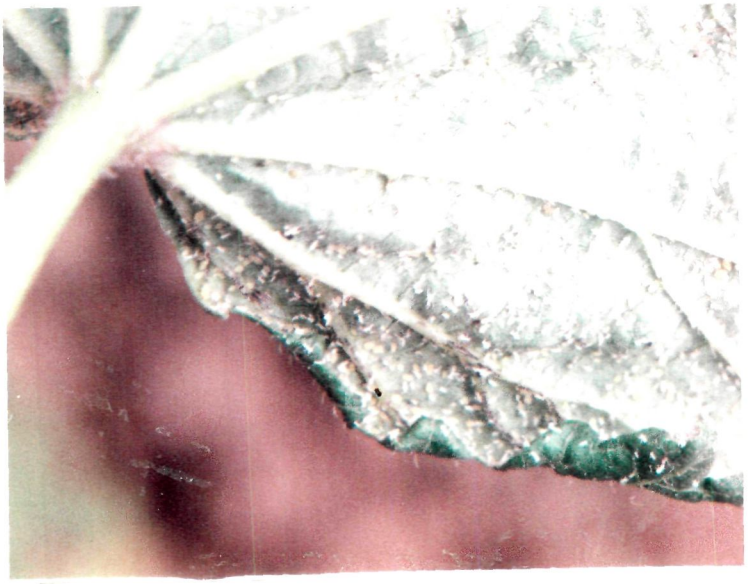
3.3.2.1.2 Fruit damage

Fruits damage by *E. vittella* were observed at each picking (P) and converted in to per cent damage (Plate IV).

3.3.2.2 *H. armigera*

3.3.2.2.1 Fruit damage

Fruit damage by *H. armigera* were observed at each picking (P) and converted in to per cent damage (Plate V).



II Aphid, *A. gossypii*

III Jassid, *A. biguttula biguttula*

Iv *E. vittella* damage

V *H. armigera* damage

3.3.3 Natural enemies

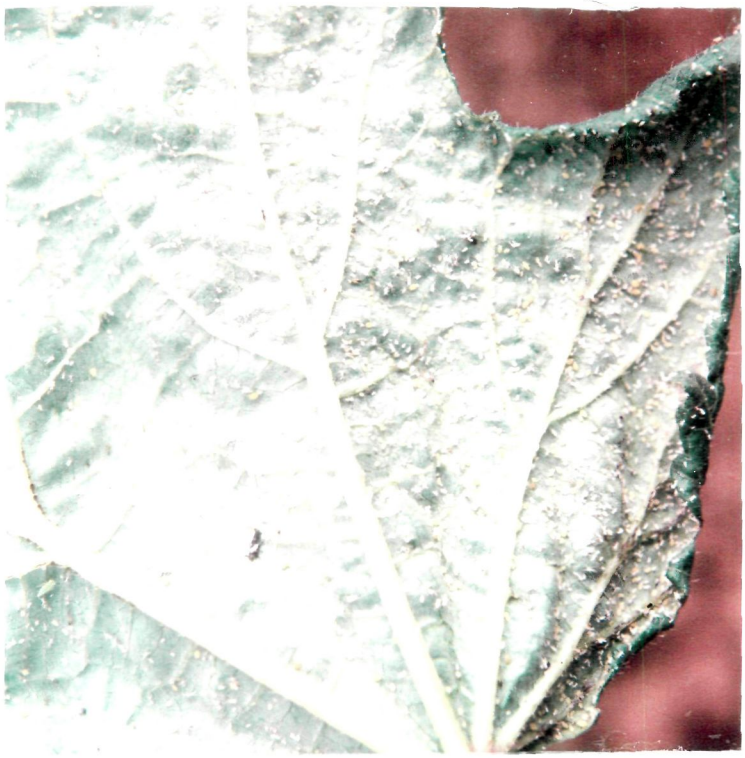
Each selected tagged plants were carefully examined to determine the occurrence of natural enemies *viz.*, green lace wing, *Chrysoperla carnea* Stephens; lady bird beetle, *Cheilomenes sexmaculata* Fabricius; Syrphid fly, *Xanthogramma scutellaris* Fabricius and unidentified staphylinids on standing crop. Various stages of natural enemies per plant were recorded (Plate VI and VII).

3.3.4 Hair density

To study the impact of hair density on the pest incidence, hair density i.e. number of hairs per 0.5 cm^2 area on the leaf, number of hairs per 0.5 cm length of midrib and number of hairs per 0.2 cm^2 area on fruit were recorded with zoom objective using a binocular lens of 0.7 – 4.5 and eye piece of 10 X.

3.3.5 Hair length

Ten hairs each from upper and lower surfaces, mid rib on lower surface and from fruit of each variety were plucked from various quadrates where the hair density had been recorded. These were measured with a precalibrated ocular micrometer fitted in the eye piece (HWF 10 X)



VI Lady bird beetle, *C. sexmaculatus* feeding on aphid

VII Green lacewing, *C. carnea* feeding on aphids

of monocular microscope. Single ocular micrometer unit (O) for the given optical conditions was calculated by using the following formula.

$$O = \frac{\text{Number of stage divisions coinciding with ocular divisions}}{\text{Number of ocular divisions}} \times 0.01$$

The value of 'O' was calibrated as 0.011 mm by which the number of divisions (N) covered by the specimen hair were multiplied to obtain the length of the specimen hair (Desai and Desai, 1980).

3.3.6 Yield

Total yield of different varieties was recorded from the experimental plot.

3.4 Statistical methodology

Data pertaining to sucking pests and shoot damage were collected at weekly intervals and that on the damage by fruit borers, *E. vittella* and *H. armigera* were collected at 2-3 day intervals. The analysis for individual period as well as over the period were carried out as per the procedure described by Steel and Torrie (1980) and Snedecor and Cochran (1968).

Table 2 : The analysis of variance structure for individual period analysis

Source	df	SS	MS	Cal F.
Replication	(r-1)	SSr	MSr	MSr/MSE
Treatment	(t-1)	SSt	MSt	MSt/MSE
Error	(r-1) (t-1)	-	-	-
Total	(rt-1)	-	-	-

Table 3 : Combined analysis over period

Source	df	SS	MS	Cal F.
Replication (r)	(r-1)	SSr	MSr	MSr/MSE(a)
Treatment (t)	(t-1)	SSt	MSt	MSt/MSE(a)
Error (a)	(r-1)(t-1)	SS(a)	MSE(a)	-
Period (p)	(p-1)	SSp	MSp	MSp/MSE(b)
T x P	(t-1)(p-1)	SStxp	MStp	MStp/MSE(b)
Error (b)	t(r-1)(p-1)	SS(b)	MSE(b)	-
Total	rtp-1	-	-	-

RESULTS AND DISCUSSION

IV. RESULTS AND DISCUSSION

4.1 Varietal susceptibility of okra to insect pests

4.1.1 Sucking pests

4.1.1.1 Aphid, *A. gossypii*

Results presented in Table-4 indicated that none of the okra varieties was found completely free from aphid infestation. The okra variety GO-2 had least aphid population and remained significantly least susceptible in 4 out of 8 periods in pooled over period analysis. Whereas, the variety Parbhani Kranti had recorded significantly highest aphid population in all the 8 periods.

The okra variety GO-2 remained least susceptible (0.29 aphids/leaf, Table-5) in comparison to rest of the varieties. This may be due to the less hair density (2.6/0.5 cm^2, Table-6) and smaller hair (0.35 mm, Table-7) and also due to high population of lady bird beetle, *C. sexmaculata* (1.38/plant, Table-8). Uthamasamy *et al.* (1974) and Bhatt (2000) also found low aphid population on smooth leaf varieties of okra and cotton.

The aphid population in the variety Pusa Sawani was 0.73/leaf and was found at par with the varieties Arka Anamika (0.94/leaf) and HRB-55 (1.08/leaf). The variety HRB-55 was found at par with the variety Padra-18-6. The aphid population in the variety Padra-18-6 was

Table 4 : Average number of aphids, *A. gossypii* in different okra varieties/genotypes

Sr. No.	Varieties/Genotypes	Population of aphids/leaf at weekly interval								Pooled over period
		P1	P2	P3	P4	P5	P6	P7	P8	
1.	HRB-55	2.20 (4.34)	1.07 (0.64)	1.73 (2.49)	1.11 (0.73)	0.85 (0.22)	1.00 (0.5)	1.06 (0.62)	1.09 (0.68)	1.26 (1.08)
2.	JOL-5	1.61 (2.09)	1.22 (0.98)	1.14 (0.79)	2.35 (5.02)	1.15 (0.82)	2.02 (3.58)	2.40 (5.26)	1.52 (1.81)	1.68 (2.32)
3.	HRB-9-2	5.35 (28.12)	1.99 (3.46)	2.42 (5.35)	2.32 (4.88)	2.61 (6.31)	2.17 (4.20)	2.90 (7.91)	2.91 (7.96)	2.83 (7.50)
4.	VRO-4	3.74 (13.48)	3.61 (12.53)	3.72 (13.33)	4.82 (22.73)	3.39 (10.99)	4.84 (22.92)	4.90 (23.51)	4.86 (23.12)	4.23 (17.40)
5.	IIIHB-068	3.76 (13.63)	4.89 (23.41)	4.74 (21.96)	2.94 (8.14)	4.28 (17.81)	3.72 (13.33)	5.72 (32.21)	7.73 (59.25)	4.72 (21.80)
6.	SEL-2	4.48 (19.57)	4.40 (18.86)	4.46 (19.39)	3.45 (11.40)	3.45 (11.40)	6.34 (39.69)	3.73 (13.41)	4.89 (23.41)	4.40 (18.90)
7.	AOL-95-15	6.76 (45.15)	4.42 (19.03)	4.49 (19.66)	4.10 (16.31)	4.69 (21.49)	4.10 (16.31)	5.63 (31.19)	5.42 (28.87)	4.95 (24.00)
8.	JOL-4	5.87 (33.95)	4.04 (15.82)	5.00 (24.50)	4.70 (21.59)	4.20 (17.14)	5.55 (30.30)	4.44 (19.21)	6.13 (37.07)	4.99 (24.40)
9.	AOL-95-13	6.12 (36.95)	4.64 (21.02)	4.90 (23.51)	4.83 (22.82)	5.25 (27.06)	4.34 (18.33)	4.79 (22.44)	5.49 (29.64)	5.05 (25.00)
10.	Parbhani Kranti	6.26 (36.68)	4.10 (16.31)	4.62 (20.84)	4.96 (24.10)	4.93 (23.80)	4.96 (24.10)	4.17 (16.88)	7.52 (56.05)	5.19 (26.40)
11.	VRO-3	5.37 (28.33)	4.31 (18.07)	5.50 (29.75)	5.82 (33.37)	5.09 (25.40)	4.18 (16.97)	4.88 (23.31)	5.27 (27.27)	5.05 (25.00)
12.	DEV-9i-4	6.35 (39.82)	3.87 (14.47)	4.46 (19.39)	4.29 (17.90)	4.28 (17.81)	4.54 (20.11)	3.76 (13.63)	7.56 (56.65)	4.89 (23.40)
13.	Padra-18-6	2.58 (6.15)	1.20 (0.94)	0.98 (0.46)	0.79 (0.12)	1.72 (2.45)	1.08 (0.66)	1.36 (1.34)	1.52 (1.81)	1.40 (1.46)
14.	Arka Anamika	2.70 (6.79)	1.15 (0.82)	1.37 (1.37)	0.71 (0.004)	1.13 (0.77)	0.92 (0.46)	0.71 (0.004)	0.92 (0.34)	1.20 (0.94)
15.	GO-2	1.02 (0.54)	0.71 (0.004)	1.00 (0.05)	0.94 (0.38)	1.12 (0.75)	0.90 (0.31)	0.71 (0.04)	0.71 (0.004)	0.89 (0.29)
16.	Pusa Sawani	1.98 (3.42)	0.89 (0.29)	0.86 (0.24)	0.71 (0.004)	0.94 (0.38)	0.71 (0.004)	1.36 (1.34)	1.43 (1.54)	1.11 (0.73)
	Mean	4.13	2.91	3.21	3.05	3.07	3.21	3.28	4.06	-
	S.Em. (V)	-	-	-	-	-	-	-	-	0.07
	(P)	-	-	-	-	-	-	-	-	0.03
	(V x P)	-	-	-	-	-	-	-	-	0.12
	CD at 5% (V)	-	-	-	-	-	-	-	-	0.20
	(P)	-	-	-	-	-	-	-	-	0.09
	(V x P)	-	-	-	-	-	-	-	-	0.34
	CV% (V)	-	-	-	-	-	-	-	-	9.85
	(V x P)	-	-	-	-	-	-	-	-	6.39

Figures in parentheses are $\sqrt{x + 0.5}$ retransformed values

Table 5 : Average susceptibility of various okra varieties/genotypes to the aphid, *A. gossypii* and the jassid, *A. biguttula biguttula*

Sr. No.	Varieties/ Genotypes	Aphid population per leaf (Average over period)	Jassid nymphs per leaf (Average over period)
1.	HRB-55	1.26 (1.08)	0.88 (0.27)
2.	JOL-5	1.68 (2.32)	0.87 (0.25)
3.	HRB-9-2	2.83 (7.50)	0.82 (0.17)
4.	VRO-4	4.23 (17.40)	0.82 (0.17)
5.	HIHB-068	4.72 (21.80)	0.86 (0.23)
6.	SEL-2	4.40 (18.90)	1.08 (0.67)
7.	AOL-95-15	4.95 (24.00)	1.46 (1.63)
8.	JOL-4	4.99 (24.40)	1.76 (2.60)
9.	AOL-95-13	5.05 (25.00)	1.62 (2.12)
10.	Parbhani Kranti	5.19 (26.40)	1.93 (3.22)
11.	VRO-3	5.05 (25.00)	2.44 (5.45)
12.	DEV-91-4	4.89 (23.40)	2.65 (6.52)
13.	Padra-18-6	1.40 (1.46)	2.97 (8.32)
14.	Arka Anamika	1.20 (0.94)	3.49 (11.69)
15.	GO-2	0.89 (0.29)	1.66 (2.25)
16.	Pusa Sawani	1.11 (0.73)	2.43 (5.4)
	S.Em. (V)	0.07	0.08
	CD at 5% (V)	0.2	0.24
	CV% (V)	9.85	26.51

Figures in parentheses are $\sqrt{x + 0.5}$ retransformed values

Table 6 : Leaf hair density in different okra varieties/genotypes

Sr. No.	Varieties/ Genotypes	Leaf hair density		
		Upper surface/ 0.5 cm^2	Lower surface/ 0.5 cm^2	Midrib/ 0.5 cm length
1.	HRB-55	5.0	5.0	4.3
2.	JOL-5	6.0	6.3	6.0
3.	HRB-9-2	5.3	5.3	5.0
4.	VRO-4	6.0	3.7	6.0
5.	HIHB-068	6.0	6.7	7.0
6.	SEL-2	4.7	5.0	3.3
7.	AOL-95-15	3.3	3.3	3.3
8.	JOL-4	2.0	4.0	2.0
9.	AOL-95-13	2.7	3.0	2.6
10.	Parbhani Kranti	3.7	3.7	3.3
11.	VRO-3	3.0	3.0	4.0
12.	DEV-91-4	2.0	3.0	2.0
13.	Padra-18-6	2.3	2.7	2.0
14.	Arka Anamika	2.7	3.0	2.67
15.	GO-2	3.3	3.3	3.3
16.	Pusa Sawani	3.0	2.7	2.3
	S.Em.	0.31	0.35	0.50
	CD at 5%	0.89	1.00	1.45
	CV%	14.13	15.11	22.99

Table 7 : Leaf hair length in different okra varieties/genotypes

Sr. No.	Varieties/ Genotypes	Leaf hair length (mm)			Mean
		Upper surface	Lower surface	Midrib on lower surface	
1.	HRB-55	0.55	0.57	0.57	0.55
2.	JOL-5	0.58	0.60	0.58	0.59
3.	HRB-9-2	0.70	0.72	0.72	0.71
4.	VRO-4	0.72	0.72	0.74	0.72
5.	HIHB-068	0.57	0.57	0.63	0.59
6.	SEL-2	0.50	0.49	0.51	0.50
7.	AOL-95-15	0.47	0.47	0.48	0.47
8.	JOL-4	0.42	0.42	0.43	0.42
9.	AOL-95-13	0.46	0.43	0.45	0.45
10.	Parbhani Kranti	0.41	0.44	0.39	0.42
11.	VRO-3	0.36	0.39	0.40	0.39
12.	DEV-91-4	0.37	0.40	0.35	0.37
13.	Padra-18-6	0.32	0.31	0.30	0.31
14.	Arka Anamika	0.31	0.32	0.29	0.30
15.	GO-2	0.35	0.35	0.36	0.35
16.	Pusa Sawani	0.45	0.43	0.44	0.44
	S.Em.	0.01	0.01	0.01	0.01
	CD at 5%	0.03	0.03	0.03	0.03
	CV%	3.27	3.58	3.98	3.27

Table 8 : Average number of natural enemies per plant on different varieties/genotypes of okra

Sr. No.	Varieties/ Genotypes	Lady bird beetle	Green lacewing	Syrphid
1.	HRB-55	2.27 ± 1.51	1.16 ± 0.21	0.22 ± 0.06
2.	JOL-5	0.88 ± 0.25	0.49 ± 0.10	0.40 ± 0.22
3.	HRB-9-2	0.55 ± 0.27	0.66 ± 0.23	0
4.	VRO-4	1.05 ± 0.42	0.41 ± 0.08	0.44 ± 0.11
5.	HIHB-068	0.88 ± 0.22	0.49 ± 0.16	1.1 ± 0.14
6.	SEL-2	1.16 ± 0.20	0.91 ± 0.16	0.29 ± 0.20
7.	AOL-95-15	1.18 ± 0.35	0.08 ± 0.08	0.22 ± 0.11
8.	JOL-4	0.99 ± 0.20	0.33 ± 0.33	0.99 ± 0.69
9.	AOL-95-13	1.28 ± 0.51	0.49 ± 0.09	0.33 ± 0.19
10.	Parbhani Kranti	0.88 ± 0.29	0.49 ± 0.17	0
11.	VRO-3	1.10 ± 0.25	0.49 ± 0.09	0.29 ± 0.20
12.	DEV-91-4	1.05 ± 0.28	0.33 ± 0.33	0.33 ± 0.19
13.	Padra-18-6	0.88 ± 0.25	0.41 ± 0.15	0
14.	Arka Anamika	0.99 ± 0.26	0.49 ± 0.21	0
15.	GO-2	1.38 ± 0.62	0.58 ± 0.16	0
16.	Pusa Sawani	1.33 ± 0.44	0.16 ± 0.16	0

1.46/leaf which was followed by JOL-5 (2.32/leaf), HRB-9-2 (7.5/leaf), VRO-4 (17.4/leaf). However, the variety VRO-4 was found at par with the variety SEL-2 (18.9/leaf) which was followed by HIHB-068 (21.8/leaf) and DEV-91-4 (23.4/leaf)

The highest aphid population was found in the variety Parbhani Kranti (26.4/leaf) despite of low hair density (3.5/0.5 cm^2) and shorter hair (0.42 mm). This may be due to non-significant association between hairiness and aphid population. Similar trend was also observed on cotton by Bhatt (2000).

The variety Parbhani Kranti was found to be at par with the varieties VRO-3 and AOL-95-13 (25 aphids/leaf) each, which were closely followed by the varieties JOL-4 (24.4 aphids/leaf) and AOL-95-15 (24 aphids/leaf).

The order of susceptibility of different okra varieties to *A. gossypii* was found as GO-2 < Pusa Sawani ≤ Arka Anamika ≤ HRB-55 ≤ Padra18-6 < JOL-5 < HRB-9-2 < VRO-4 ≤ SEL-2 < HIHB-068 < DEV-91-4 ≤ AOL-95-15 ≤ JOL-4 ≤ AOL-95-13 = VRO-3 ≤ Parbhani Kranti.

4.1.1.2 Jassid, *A. biguttula biguttula*

Results presented in Table-9 indicated that the okra varieties HRB-9-2 and VRO-4 remained significantly less susceptible to jassid in 6

out of 10 periods in pooled over period analysis. Whereas, the okra variety Arka Anamika remained significantly more susceptible in 8 periods.

The okra varieties HRB-9-2 and VRO-4 with high hair density, 5.3/0.5 cm^2 and 4.8/0.5 cm^2 (Table-6) and longer hair 0.72 and 0.74 mm, respectively (Table-7) on lower midrib of leaf were having low (0.82/leaf) jassid population (Table-5) and were found less susceptible in comparison to rest of the varieties. This is due to significant negative association of jassid population with hair density (r=-0.71742) and hair length (r=-0.87057, Table-10 and Fig. 1 and 2) on the lower midrib of leaf. Further, it may also be due to interference of high hair density and longer hair on the midrib with the jassid oviposition activity (Plates VIII and IX). The ovipositor length measured by Khan and Agarwal (1984) was 0.786 $\pm$ 0.003 mm. This clearly indicate that longer hair of okra leaf interfere with the oviposition which ultimately resulted in low jassid population. Khan and Agarwal (1984), Uthamasamy and Subramanian (1985), Singh (1988), Mahal *et al.*(1993) and Bhatt (2000) also found low jassid population on okra and cotton varieties having high hair density and longer hair.

The jassid population in the varieties HRB-9-2 and VRO-4 (0.17/leaf) were at par with HIHB-068 (0.23/leaf), JOL-5 (0.25/leaf), HRB-55 (0.27/leaf). The variety HRB-55 was found at par with SEL-2 (0.67/leaf) and was followed by the variety AOL-95-15 (1.63/leaf) which

Table 9 : Average number of jassid, *A. biguttula biguttula* in different okra varieties/genotypes

Sr. No.	Varieties/ Genotypes	Population of jassid /leaf at weekly interval										Pooled over period
		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	
1.	HRB-55	0.82 (0.17)	0.82 (0.17)	0.83 (0.18)	0.83 (0.18)	0.82 (0.17)	0.95 (0.40)	0.81 (0 15)	0.88 (0.27)	1.02 (0.54	0.98 (0.46)	0.88 (0.27)
2.	JOL-5	1.09 (0.68)	0.92 (0.34)	0.94 (0.38)	0.90 (0.31)	0.92 (0.34)	0.93 (0.36)	0.79 (0.12)	0.71 (0.004)	0.80 (0.14)	0.74 (0.04)	0.87 (0.25)
3.	HRB-9-2	0.79 (0.12)	0.74 (0.04)	0.77 (0.09)	0.78 (0.10)	0.83 (0.18)	0.78 (0.10)	1.01 (0.52)	0.80 (0.14)	0.85 (0.22)	0.88 (0.27)	0.82 (0.17)
4.	VRO-4	0.77 (0.09)	0.74 (0.04)	0.86 (0.23)	0.77 (0.09)	0.87 (0.25)	0.81 (0.15)	0.77 (0.09)	0.78 (0.10)	0.82 (0.17)	0.97 (0.44)	0.82 (0.17)
5.	HIHB-068	0.88 (0.27)	0.77 (0.09)	0.89 (0.29)	0.77 (0.09)	0.81 (0.15)	0.84 (0.20)	0.79 (0.12)	0.80 (0.14)	1.07 (0.64)	1.01 (0.52)	0.86 (0.23)
6.	SEL-2	0.99(0.48)	1.20 (0.94)	0.92 (0.34)	1.07 (0.64)	1.17 (0.86)	1.05 (0.60)	1.07 (0.64)	1.04 (0.58)	1.07 (0.64)	1.23 (1.01)	1.08 (0.67)
7.	AOL-95-15	1.09 (0.68)	1.30 (1.19)	1.05 (0.52)	0.98 (0.46)	1.70 (2.39)	1.54 (1.87)	1.67 (2.28)	1.90 (3.11)	1.77 (2.63)	1.62 (2.12)	1.46 (1.63)
8.	JOL-4	1.55 (1.90)	1.72 (2.45)	1.74 (0.87)	1.58 (1.99)	1.68 (2.32)	1.75 (2.56)	1.82 (2.81)	2.00 (3.50)	2.02 (3.58)	1.77 (2.63)	1.76 (2.60)
9.	AOL-95-13	1.67 (2.28)	1.52 (1.81)	1.60 (0.8)	1.78 (2.66)	1.74 (2.52)	1.46 (1.63)	1.56 (1.93)	1.67 (2.28)	1.67 (2.28)	1.53 (1.84)	1.62 (2.12)
10.	Parbhani Kranti	1.54 (1.87)	1.58 (1.99)	1.77 (2.63)	1.82 (2.81)	2.04 (3.66)	1.43 (1.54)	2.30 (4.79)	2.08 (3.82)	2.42 (5.35)	2.32 (4.88)	1.93 (3.22)
11.	VRO-3	2.70 (6.79)	1.99 (3.46)	3.03 (8.68)	2.13 (4.03)	2.61 (6.31)	1.82 (2.81)	2.52 (5.85)	2.64 (6.46)	2.37 (1.18)	2.59 (6.20)	2.44 (5.45)
12.	DEV-91-4	2.26 (4.60)	2.14 (4.07)	2.63 (6.41)	2.33 (4.92)	2.73 (6.95)	2.69 (6.73)	2.78 (7.22)	2.90 (7.90)	3.49 (11.68)	2.59 (6.20)	2.65 (6.52)
13.	Padra-18-6	2.98 (8.38)	2.61 (6.31)	3.11 (9.17)	2.92 (8.02)	2.94 (8.14)	2.69 (6.73)	3.15 (9.42)	2.97 (8.32)	3.28 (10.25)	3.09 (9.04)	2.97 (8.32)
14.	Arka Anamika	3.01 (8.56)	3.33 (10.58)	3.83 (14.16)	3.68 (13.04)	3.74 (13.48)	3.24 (9.99)	3.68 (13.04)	3.50 (11.75)	3.48 (11.61)	3.39 (10.99)	3.49 (11.69)
15.	GO-2	3.54 (12.03)	3.33 (10.58)	3.78 (13.78)	3.15 (9.42)	1.61 (2.09)	1.49 (1.72)	1.74 (2.52)	1.81 (2.77)	1.91 (3.14)	1.98 (3.42)	1.66 (5.40)
16.	Pusa Sawani	1.78 (2.66)	1.66 (2.25)	1.51 (1.78)	1.66 (2.25)	1.53 (1.84)	1.78 (2.66)	1.98 (3.42)	1.73 (2.49)	1.60 (2.06)	1.35 (1.32)	2.43 (2.25)
	Mean	1.72	1.65	1.83	1.70	1.73	1.58	1.78	1.76	1.85	1.75	
	S.Em. (V)	-	-	-	-	-	-	-	-	-	-	0.08
	(P)	-	-	-	-	-	-	-	-	-	-	0.03
	(V x P)	-	-	-	-	-	-	-	-	-	-	0.15
	CD at 5% (V)	-	-	-	-	-	-	-	-	-	-	0.24
	(P)	-	-	-	-	-	-	-	-	-	-	0.10
	(V x P)	-	-	-	-	-	-	-	-	-	-	0.42
	CV% (V)	-	-	-	-	-	-	-	-	-	-	26.51
	(V x P)	-	-	-	-	-	-	-	-	-	-	15 15

Figures in parentheses are $\sqrt{x + 0.5}$ retransformed values

Table 10 : Correlation between hairiness and different insect pests of okra

Sr. No.	Character	Hair density	Hair length
		Leaf	**Leaf**
1.	Aphid	0.00270	0.10313
2.	Jassid	-0.71742*	-0.87057*
	Fruit borers	**Fruit**	**Fruit**
1.	*E. vittella*	-0.69706*	-0.08165
2.	*H. armigera*	-0.54534*	-0.32365

* Value at 5% level of significant critical value (2 tail, 0.05) = +/- 0.49580

Fig. 1 : Effect of midrib hair density on Jassid, ***A. biguttula biguttula***

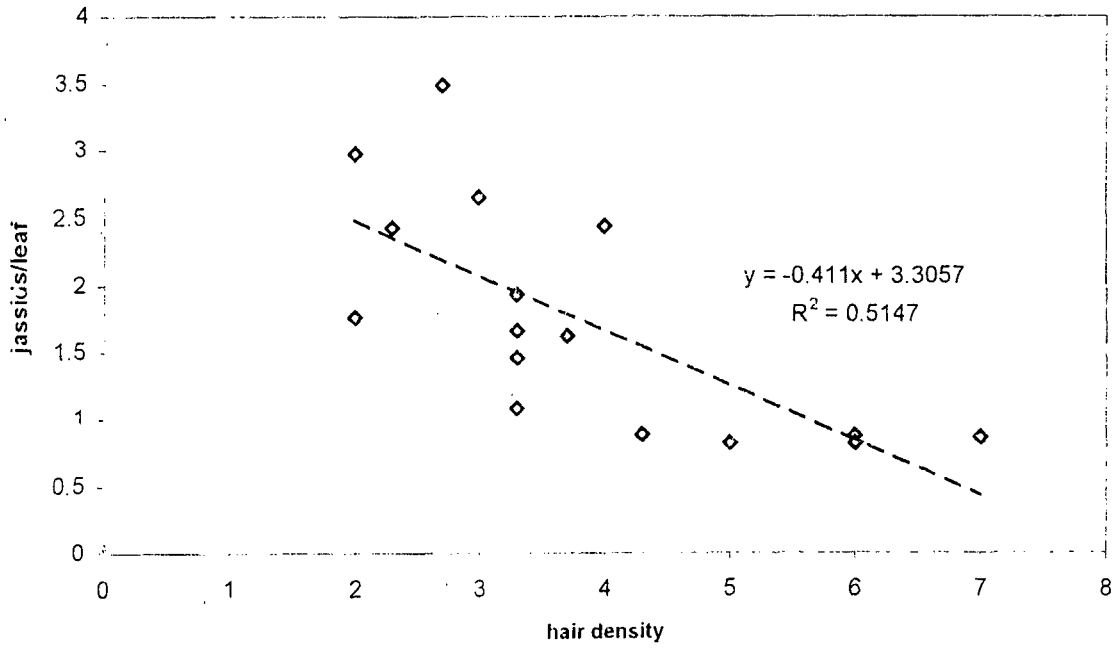
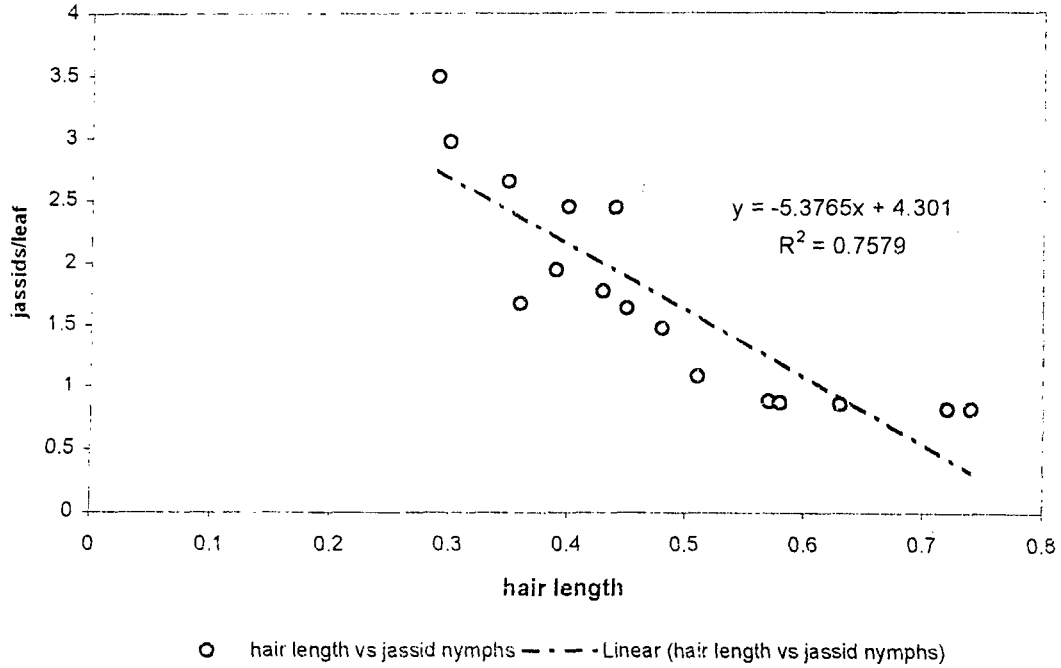


Fig. 2 : Effect of midrib hair length on Jassid, ***A. biguttula biguttula***



VIII Leaf hair density on the variety HRB-9-2

IX Leaf hair density on the variety JOL - 4

was at par with AOL-95-13 (2.12/leaf) and GO-2 (2.25/leaf) and these were closely followed by the varieties JOL-4 (2.6/leaf) and Parbhani Kranti (3.22/leaf).

The highest jassid population was found in the variety Arka Anamika (11.69/leaf), which was followed by the variety Padra-18-6 (8.32/leaf) and DEV-91-4 (6.52/leaf). However, the variety DEV-91-4 was found at par with the varieties VRO-3 (5.45/leaf) and Pusa Sawani (5.4/leaf).

The order of susceptibility of different okra varieties to *A. biguttula biguttula* was found to be HRB-9-2 = VRO-4 ≤ HIHB-068 ≤ JOL-5 ≤ HRB-55 ≤ SEL-2 < AOL-95-15 ≤ AOL-95-13 ≤ GO-2 ≤ JOL-4 ≤ Parbhani Kranti < Pusa Sawani ≤ VRO-3 ≤ DEV-91-4 < Padra-18-6 < Arka Anamika.

4.1.2 Borer complex

4.1.2.1 *E. vittella*

4.1.2.1.1 Shoot damage

Results presented in Table-11 indicate that the shoot damage due to *E. vittella* in the okra variety HRB-55 was low and remained significantly less in 2 out of 4 periods. Whereas, the shoot damage in the variety AOL-95-13 was high and maximum over 2 periods.

Table 11 : Per cent shoot damage by *E. vittella* on different okra varieties /genotypes

Sr. No.	Varieties/ Genotypes	Periods (P)				Pooled over period
		P1	P2	P3	P4	
1.	HRB-55	0.81 (0.02)	7.31 (1.61)	3.94 (0.47)	0.81 (0.020	3.22 (0.32)
2.	JOL-5	4.61 (0.64)	0.81 (0.02)	7.44 (1.67)	10.42 (3.27)	5.82 (1.03)
3.	HRB-9-2	10.42 (3.27)	7.31 (1.61)	0.81 (0.02)	0.81 (0.02)	4.84 (0.71)
4.	VRO-4	7.31 (1.62)	7.47 (1.66)	7.61 (1.75)	7.31 (1.62)	7.42 (1.67)
5.	HIHB-068	0.81 (0.02)	7.67 (1.78)	7.36 (1.64)	7.31 (1.62)	5.79 (1.01)
6.	SEL-2	12.77 (4.88)	7.76 (1.82)	7.49 (1.69)	4.35 (0.57)	8.09 (1.98)
7.	AOL-95-15	7.31 (1.61)	4.24 (0.54)	7.28 (1.60)	7.53 (1.71)	6.59 (1.32)
8.	JOL-4	10.49 (3.31)	0.81 (0.02)	12.77 (4.88)	10.49 (3.31)	8.64 (2.26)
9.	AOL-95-13	9.10 (2.50)	16.74 (8.29)	7.38 (1.64)	17.05 (8.59)	12.57 (4.74)
10.	Parbhani Kranti	18.39 (9.95)	13.29 (5.28)	10.44 (3.28)	0.81 (0.02)	10.73 (3.47)
11.	VRO-3	14.07 (5.91)	7.79 (1.83)	10.62 (3.39)	7.31 (1.61)	9.94 (2.98)
12.	DEV-91-4	12.90 (4.98)	3.78 (0.43)	2.98 (0.27)	3.64 (0.40)	5.82 (1.03)
13.	Padra-18-6	13.29 (5.28)	6.92 (1.45)	13.19 (5.20)	14.85 (6.56)	12.06 (4.37)
14.	Arka Anamika	4.56 (0.63)	10.36 (3.23)	4.13 (0.51)	10.96 (3.61)	7.50 (1.70)
15.	GO-2	7.40 (1.67)	2.64 (0.21)	2.22 (0.15)	2.70 (0.22)	5.60 (0.95)
16.	Pusa Sawani	4.56 (0.63)	2.64 (0.21)	7.79 (1.83)	7.41 (1.66)	3.74 (0.42)
	Mean	8.67	6.72	7.09	7.11	
	S.Em. (V)	-	-	-	-	0.50
	(P)	-	-	-	-	0.21
	(V x P)	-	-	-	-	0.85
	CD at 5% (V)	-	-	-	-	1.46
	(P)	-	-	-	-	0.20
	(V x P)	-	-	-	-	0.82
	CV% (V)	-	-	-	-	23.57
	(V x P)	-	-	-	-	20.04

Figures in parentheses are arc sine $\sqrt{\text{per cent}}$ retransformed values

Table 12 : Susceptibility of various okra varieties/genotypes to *E. vittella* and *H. armigera*

Sr. No.	Varieties/ Genotypes	Per cent shoot damage by *E. vittella* (pooled over period)	Per cent fruit damage (Pooled over period)		Yield (kg/ha)
			E. vittella	*H. armigera*	
1.	HRB-55	3.22 (0.32)	12.83 (4.93)	2.58 (0.20)	5220
2.	JOL-5	5.82 (1.03)	10.95 (3.60)	2.79 (0.24)	5098
3.	HRB-9-2	4.84 (0.71)	18.99 (10.58)	6.74 (1.38)	5286
4.	VRO-4	7.42 (1.67)	23.12 (15.42)	6.10 (1.13)	2877
5.	HIHB-068	5.79 (1.01)	21.85 (13.85)	8.55 (2.21)	3421
6.	SEL-2	8.09 (1.98)	23.12 (15.42)	13.85 (5.73)	3651
7.	AOL-95-15	6.59 (1.32)	22.54 (14.69)	12.41 (4.62)	3182
8.	JOL-4	8.64 (2.26)	23.14 (15.44)	17.95 (9.50)	5101
9.	AOL-95-13	12.57 (4.74)	24.14 (16.72)	12.69 (4.82)	2677
10.	Parbhani Kranti	10.73 (3.47)	16.26 (7.84)	11.51 (3.98)	23.31
11.	VRO-3	9.94 (2.98)	22.93 (15.18)	12.04 (4.35)	2291
12.	DEV-91-4	5.82 (1.03)	19.35 (10.98)	16.12 (7.70)	23.21
13.	Padra-18-6	12.06 (4.37)	22.28 (14.37)	13.22 (5.22)	2934
14.	Arka Anamika	7.5 (1.70)	23.51 (15.91)	15.22 (6.90)	2243
15.	GO-2	3.74 (0.42)	24.99 (17.84)	10.49 (3.31)	1674
16.	Pusa Sawani	5.6 (0.95)	22.79 (15.00)	10.06 (3.05)	1474
	S.Em. (V)	0.50	0.56	0.49	227.49
	CD at 5% (V)	1.46	1.63	1.42	657.90
	CV% (V)	23.57	15.57	22.35	12.17

Figures in parentheses are arc sine $\sqrt{\text{per cent}}$ retransformed values

The okra variety HRB-55 had low (0.32%) shoot damage (Table-12) and was found significantly less susceptible as compared to rest of the varieties except GO-2 (0.42%). The variety HRB-9-2 was found at par with GO-2, Pusa Sawani (0.95%), HIHB-068 (1.01%), JOL-5 and DEV-91-4 (1.03% each) which were closely followed by the variety AOL-95-15 (1.32%).

The shoot damage was found high (4.74%) in the variety AOL-95-13 and remained highly susceptible in comparison to rest of the varieties. This variety was found at par with the variety Padra-18-6 (4.37%). Whereas, the variety Padra-18-6 was closely followed by the varieties Parbhani Kranti (3.47%), VRO-3 (2.98%) and JOL-4 (2.26%). and these were closely followed by SEL-2 (1.98%), Arka Anamika (1.7%) and VRO-4 (1.67%).

The order of susceptibility of different okra varieties to shoot borer *E. vittella* was found as HRB-55 ≤ GO-2 ≤ HRB-9-2 ≤ Pusa Sawani ≤ HIHB-068 ≤ JOL-5 = DEV-91-4 ≤ AOL-95-15 ≤ VRO-4≤ Arka Anamika ≤ SEL-2 ≤ JOL-4 ≤ VRO-3 < Parbhani Kranti ≤ Padra-18-6 ≤ AOL-95-13.

4.1.2.1.2 Fruit damage

Results presented in Table-13 indicated that the fruit damage due to *E. vittella* in the okra variety JOL-5 was low and remained

Table 13 : Per cent fruit damage by *E. vittella* on different okra varieties/genotypes

Sr. No	Varieties/ Genotypes	Fruit damage as recorded at weekly interval											Pooled over period
		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	
1.	HRB-55	7.83 (1.85)	13.96 (5.81)	13.71 (5.61)	0.81 (0.02)	0.81 (0.02)	0.81 (0.02)	22.80 (15.01)	11.97 (4.30)	20.53 (12.29)	18.46 (10.02)	29.40 (24.09)	12.83 (4.93)
2.	JOL-5	24.94 (17.78)	17.10 (8.64)	0.81 (0.02)	18.05 (9.60)	0.81 (0.02)	26.14 (19.40)	29.35 (24.02)	0.81 (0.02)	0.81 (0.02)	0.81 (0.02)	0.81 (0.02)	10.95 (3..60)
3.	HRB-9-2	24.38 (17.03)	24.93 (17.76)	23.87 (16.37)	21.92 (13.93)	27.84 (21.80)	11.40 (3.90)	16.99 (8.53)	0.81 (0.02)	29.94 (17.78)	13.56 (5.49)	18.26 (9.81)	18.99 (10.58)
4.	VRO-4	33.30 (30.14)	15.94 (7.54)	13.66 (5.57)	10.96 (3.61)	20.41 (12.16)	30.85 (26.29)	24.48 (17.17)	33.37 (30.25)	18.91 (10.50)	25.92 (19.12)	26.54 (19.96)	23.12 (15.42)
5.	HIHB-068	28.17 (22.28)	25.35 (18.33)	21.36 (13.26)	14.26 (6.06)	19.16 (10.77)	26.17 (19.45)	17.62 (9.16)	21.38 (13.28)	24.40 (17.06)	23.04 (15.31)	19.47 (11.10)	21.85 (13.85)
6.	SEL-2	21.47 (13.39)	23.28 (15.62)	18.77 (10.35)	26.94 (20.52)	28.85 (23.28)	21.47 (13.39)	24.88 (17.70)	25.21 (18.14)	18.09 (9.64)	19.16 (10.77)	26.17 (19.45)	23.12 (15.42)
7.	AOL-95-15	17.50 (9.04)	21.52 (13.45)	24.40 (17.06)	23.51 (15.91)	19.38 (11.01)	21.74 (13.71)	23.82 (16.31)	18.69 (10.26)	26.85 (20.39)	28.86 (23.29)	21.69 (13.65)	22.54 (14.69)
8.	JOL-4	24.61 (17.34)	25.21 (18.14)	18.16 (9.71)	23.03 (15.03)	23.64 (16.07)	30.33 (25.50)	20.45 (12.20)	20.17 (11.88)	21.02 (12.86)	23.51 (15.91)	24.39 (17.05)	23.14 (15.44)
9.	AOL-95-13	20.45 (12.20)	25.63 (18.71)	35.26 (33.32)	24.59 (17.31)	24.64 (17.38)	21.30 (13.19)	30.33 (25.5)	31.75 (27.69)	20.16 (11.87)	20.23 (11.96)	13.42 (5.38)	24.14 (16.72)
10.	Parbhani Kranti	17.29 (8.83)	20.45 (12.20)	19.75 (11.41)	23.89 (16.40)	19.31 (10.93)	14.86 (6.57)	0.81 (0.02)	19.12 (10.72)	25.44 (18.45)	17.10 (8.64)	0.81 (0.02)	16.26 (7.84)
11.	VRO-3	37.29 (36.70)	13.63 (5.55)	21.44 (13.36)	19.08 (10.68)	18.82 (10.40)	18.55 (10.12)	30.86 (26.31)	20.98 (12.82)	22.41 (14.53)	17.32 (8.86)	31.83 (27.81)	22.93 (15.18)
12.	DEV-91-4	22.90 (15.14)	21.04 (12.88)	27.74 (21.66)	15.22 (6.89)	13.81 (5.69)	8.35 (2.10)	22.26 (14.35)	18.31 (9.86)	20.66 (12.44)	27.70 (21.60)	14.83 (6.55)	19.35 (10.96)
13.	Padra-18-6	18.85 (10.43)	27.72 (21.63)	17.69 (9.23)	17.32 (8.86)	22.79 (15.00)	13.52 (5.46)	16.71 (8.26)	39.38 (40.25)	20.46 (12.21)	26.78 (20.31)	23.89 (16.40)	22.28 (14.37)
14.	Arka Anamika	25.07 (17.95)	23.82 (16.31)	22.81 (15.02)	22.72 (14.91)	29.16 (23.74)	31.50 (27.30)	13.56 (5.49)	26.45 (19.83)	19.83 (11.50)	26.73 (20.23)	16.98 (8.52)	23.51 (15.91)
15.	GO-2	28.52 (22.79)	15.46 (7.10)	20.36 (12.10)	28.01 (22.05)	25.64 (18.72)	29.41 (24.11)	32.52 (28.9)	29.55 (24.32)	29.03 (23.54)	19.94 (11.63)	16.43 (8.00)	24.99 (17.84)
16.	Pusa Sawani	26.93 (20.51)	13.78 (5.67)	30.06 (25.09)	17.46 (9.00)	17.56 (9.10)	21.40 (13.31)	26.39 (19.75)	23.79 (16.27)	25.64 (18.72)	20.28 (12.01)	27.41 (24.19)	22.79 (15.00)
	Mean	23.7	20.55	20.62	19.24	19.54	20.49	22.11	21.36	21.20	20.59	19.52	
	S.Em. (V)	-	-	-	-	-	-	-	-	-	-	-	0.56
	(P)	-	-	-	-	-	-	-	-	-	-	-	0.40
	(V x P)	-	-	-	-	-	-	-	-	-	-	-	1.62
	CD at 5% (V)	-	-	-	-	-	-	-	-	-	-	-	1.63
	(P)	-	-	-	-	-	-	-	-	-	-	-	1.12
	(V x P)	-	-	-	-	-	-	-	-	-	-	-	4.50
	CV% (V)	-	-	-	-	-	-	-	-	-	-	-	15.57
	(V x P)	-	-	-	-	-	-	-	-	-	-	-	13.49

Figures in parentheses are arc sine $\sqrt{\text{per cent}}$ retransformed values

Table 14: Hair density and hair length on fruit in different okra varieties/genotypes

Sr. No.	Varieties/ Genotypes	Fruit hair density per 0.2 cm^2	Fruit hair length (mm)
1.	HRB-55	10.75 (115)	0.59
2.	JOL-5	11.07 (122)	0.60
3.	HRB-9-2	10.46 (109)	0.48
4.	VRO-4	9.62 (92)	0.57
5.	HIHB-068	10.32 (106)	0.72
6.	SEL-2	9.24 (85)	0.49
7.	AOL-95-15	9.82 (96)	0.50
8.	JOL-4	7.02 (49)	0.49
9.	AOL-95-13	6.50 (42)	0.44
10.	Parbhani Kranti	10.53 (110)	0.53
11.	VRO-3	9.62 (92)	0.60
12.	DEV-91-4	10.41 (108)	0.39
13.	Padra-18-6	10.07 (101)	0.54
14.	Arka Anamika	7.02 (49)	0.69
15.	GO-2	6.22 (38)	0.41
16.	Pusa Sawani	9.94 (98)	0.58
	S.Em.	1.10	0.09
	CD at 5%	3.12	0.03
	CV%	25.66	5.52

Figures in parentheses are $\sqrt{x + 0.5}$ retransformed values

significantly less susceptible in 6 out of 11 periods. Whereas, the fruit damage in the variety GO-2 was high and remained highly susceptible in 2 periods.

The okra variety JOL-5 with high (11.07/0.2 cm^2) fruit hair density and longer hair (0.60 mm, Table-14) was found significantly less (3.6%) susceptible as compared to rest of the varieties (Table-12). This is due to significant negative association of *E. vittella* fruit damage with hair density and hair length (Fig. 3 and Plate X). Similar results were also found by Kumbhar *et al.* (1991).

The fruit damage by *E. vittella* was low (3.6%) in the variety JOL-5 which was followed by the varieties HRB-55 (4.93%), Parbhani Kranti (7.84%) and HRB-9-2 (10.58%). The variety HRB-9-2 was found at par with the variety DEV-91-4 (10.98%).

The okra variety GO-2 with low (38/0.2 cm^2) fruit hair density and smaller hair (0.41 mm, Plate XI) was found significantly more (17.84%) susceptible as compared to rest of the varieties.

The variety GO-2 was found to be at par with the varieties AOL-95-13 (16.72%) and Arka Anamika (15.91%) and these varieties were closely followed by the varieties JOL-4 (15.44%), SEL-2 (15.42%), VRO-4 (15.42%), VRO-3 (15.18%), Pusa Sawani (15%), AOL-95-15 (14.69%), Padra-18-6 (14.37%) and HIHB-068 (13.85%).

Fig. 3 : Effect of hair density on fruit damage by *E. vittella*

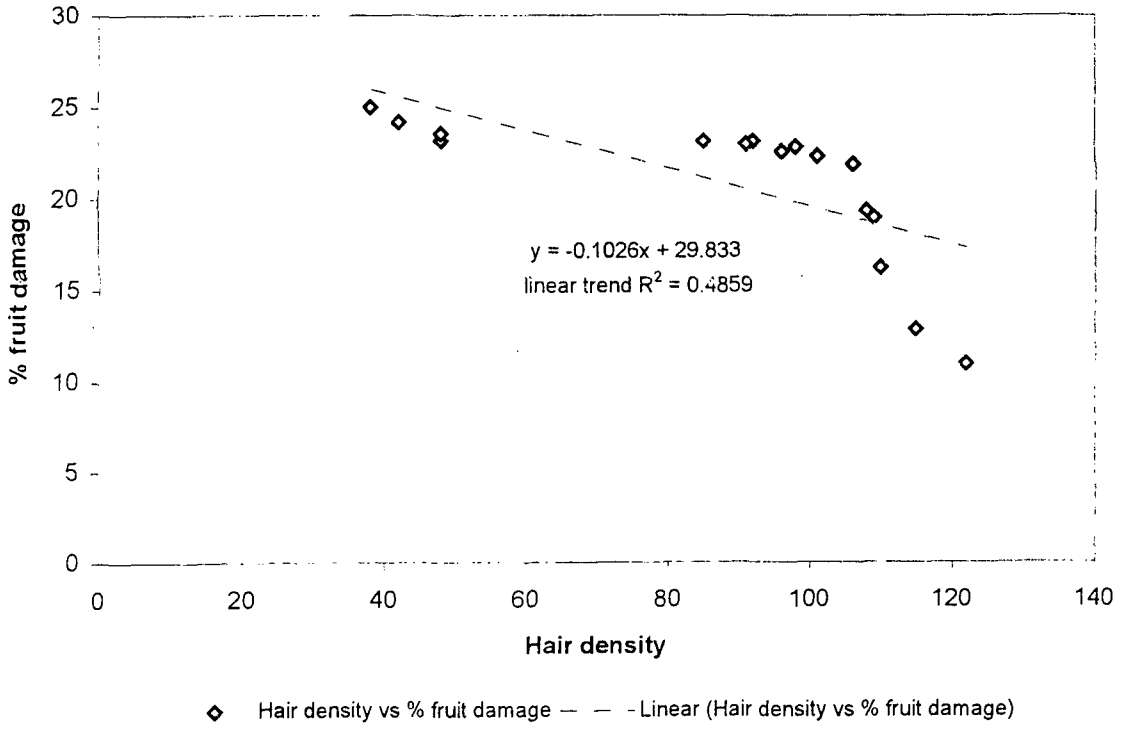
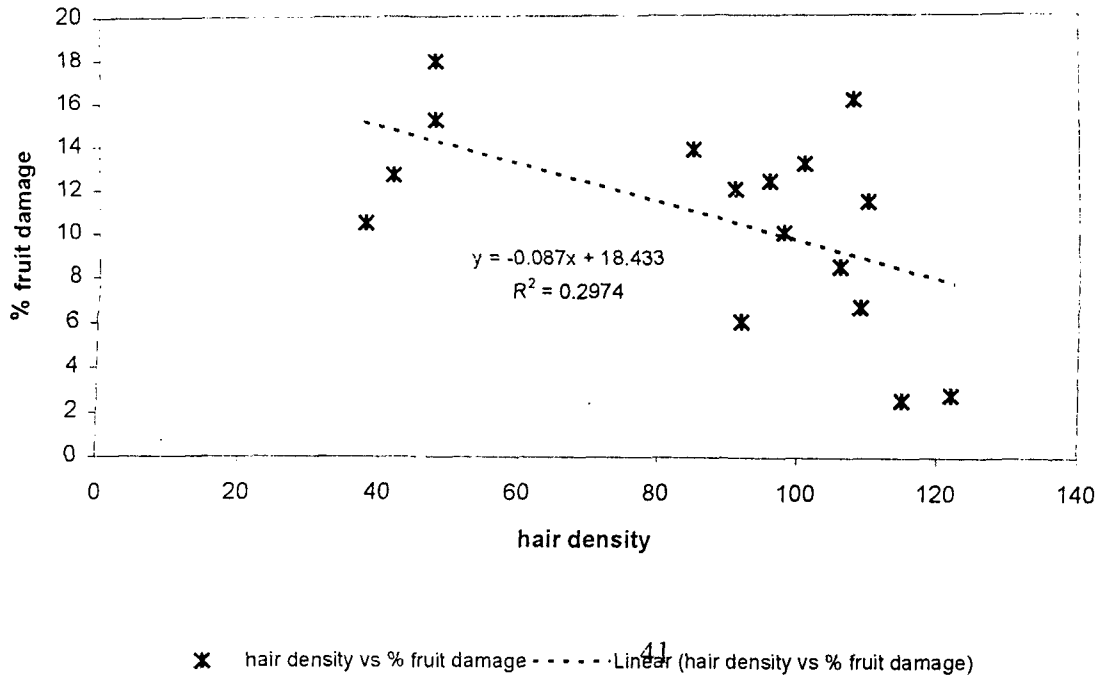
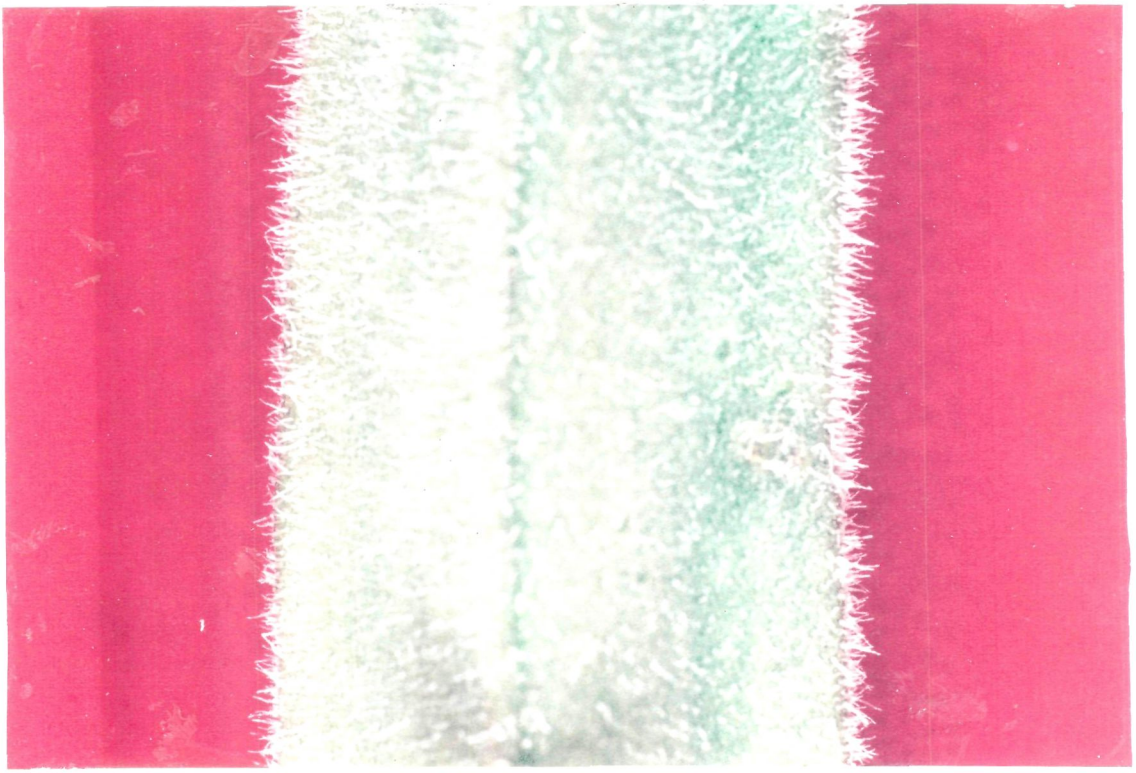
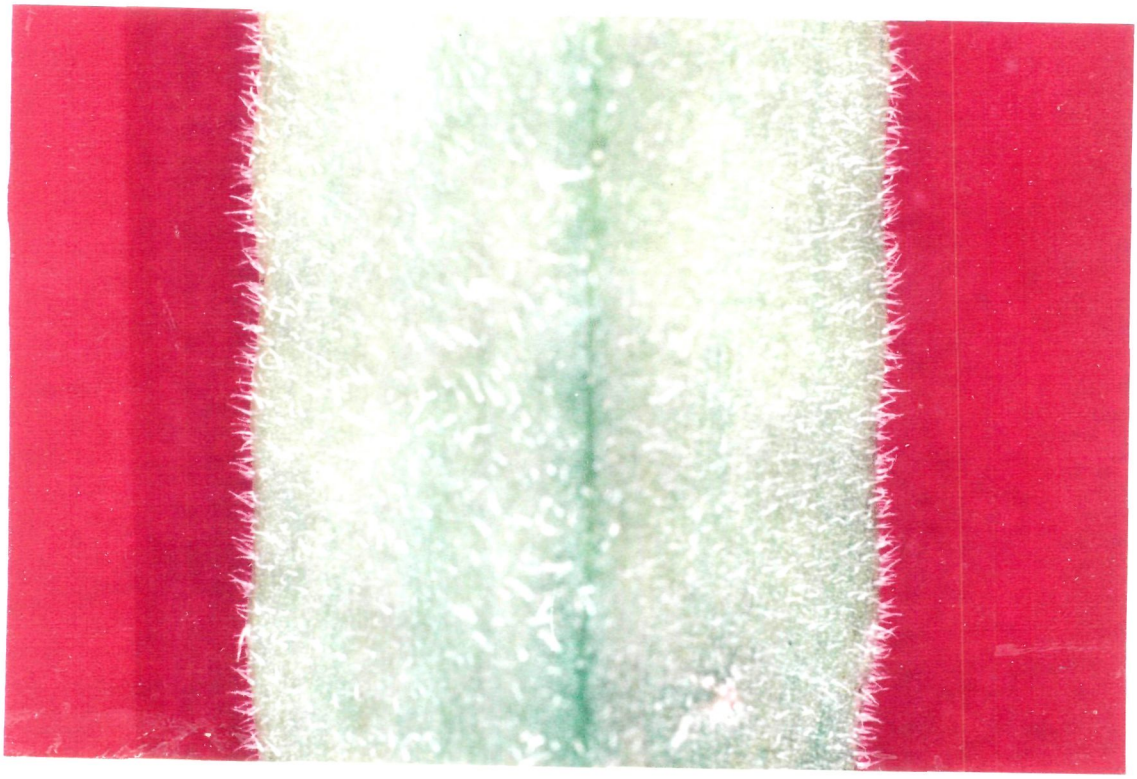


Fig. 4 : Effect of hair density on fruit damage by *H. armigera*





X Fruit hair density on the variety JOL- 5



XI Fruit hair density on the variety GO-2

The order of susceptibility of different okra varieties to fruit damage by *E. vittella* was found as JOL-5 < HRB-55 < Parbhani Kranti < HRB-9-2 ≤ DEV-91-4 < HIHB-068 ≤ Padra-18-6 ≤ AOL-95-15 ≤ Pusa Sawani ≤ VRO-3 ≤ VRO-4 = SEL-2 ≤ JOL-4 ≤ Arka Anamika ≤ AOL-95-13 ≤ GO-2.

4.1.2.2 *H. armigera*

Results presented in Table-15 indicated that the fruit damage due to *H. armigera* in the okra variety HRB-55 was low and remained significantly less susceptible in 6 out of 8 periods. Whereas, the fruit damage in the variety JOL-4 was high and remained highly susceptible in 5 periods.

The okra variety HRB-55 with high (10.75/0.2 cm^2) fruit hair density and longer hair (0.59 mm, Table-14) was found significantly less susceptible (0.2%) as compared to rest of the varieties other than JOL-5 (0.24%) (Table-12). This was due to significant negative association of *H. armigera* fruit damage with hair density and hair length (Fig. 4).

The fruit damage by *H. armigera* was low (0.2%) in the variety HRB-55 and was found at par with the variety JOL-5 (0.24%). These varieties were followed by VRO-4 (1.13%) which was found at par with HRB-9-2 (1.38%) and followed by the variety HIHB-068 (2.21 %).

Table 15 : Per cent fruit damage by *H. armigera* on different okra varieties/genotypes

Sr. No.	Varieties/Genotypes	Fruit damage as recorded at weekly interval								Pooled over period
		P1	P2	P3	P4	P5	P6	P7	P8	
1.	HRB-55	0.81 (0.02)	0.81 (0.02)	9.45 (2.69)	0.81 (0.02)	0.81 (0.02)	6.31 (1.20)	0.81 (0.02)	0.81 (0.02)	2.58 (0.20)
2.	JOL-5	4.19 (0.53)	0.81 (0.02)	7.86 (1.87)	0.81 (0.02)	6.24 (1.18)	0.81 (0.02)	0.81 (0.02)	0.81 (0.02)	2.79 (0.24)
3.	HRB-9-2	9.03 (2.46)	0.81 (0.02)	11.02 (3.65)	0.81 (0.02)	0.81 (0.02)	12.30 (4.53)	6.46 (1.26)	12.64 (4.78)	6.74 (1.38)
4.	VRO-4	7.73 (1.80)	7.46 (1.68)	9.84 (2.92)	0.81 (0.02)	7.76 (1.82)	0.81 (0.02)	7.81 (1.84)	6.59 (1.31)	6.10 (1.13)
5.	HIHB-068	9.18 (2.54)	0.81 (0.02)	13.45 (5.41)	0.81 (0.02)	0.81 (0.02)	16.63 (8.19)	10.51 (3.32)	16.17 (7.75)	8.55 (2.21)
6.	SEL-2	17.77 (9.31)	14.88 (6.59)	19.44 (11.07)	1.44 (0.06)	16.08 (7.67)	12.32 (4.55)	18.03 (9.57)	0.81 (0.02)	13.85 (5.73)
7.	AOL-95-15	9.57 (2.76)	13.32 (5.30)	22.72 (14.91)	0.81 (0.02)	14.39 (6.17)	13.40 (5.37)	13.27 (5.26)	11.77 (4.16)	12.41 (4.62)
8.	JOL-4	20.24 (11.96)	11.44 (3.93)	23.96 (16.49)	25.36 (18.34)	17.52 (9.06)	11.80 (4.18)	19.73 (11.39)	13.59 (5.52)	17.95 (9.50)
9.	AOL-95-13	13.27 (5.26)	8.81 (2.34)	14.43 (6.21)	15.56 (7.19)	12.15 (4.42)	10.88 (3.56)	15.21 (6.88)	11.20 (3.77)	12.69 (4.82)
10.	Parbhani Kranti	12.34 (4.56)	7.89 (1.88)	0.81 (0.02)	24.63 (17.36)	11.39 (3.9)	0.81 (0.02)	19.35 (10.97)	14.82 (6.54)	11.51 (3.98)
11.	VRO-3	12.96 (5.02)	11.64 (4.07)	13.52 (5.46)	14.84 (6.55)	15.22 (6.89)	4.80 (0.70)	14.91 (6.62)	8.46 (2.16)	12.04 (4.35)
12.	DEV-91-4	15.03 (6.72)	24.60 (17.32)	21.24 (13.12)	20.59 (12.36)	15.06 (6.75)	11.79 (4.17)	9.91 (2.96)	10.78 (3.49)	16.12 (7.70)
13.	Padra-18-6	12.96 (5.02)	11.67 (4.09)	13.50 (5.45)	15.06 (6.75)	16.74 (8.29)	5.11 (0.79)	22.29 (14.38)	8.45 (2.15)	13.22 (5.22)
14.	Arka Anamika	12.31 (4.54)	14.24 (6.05)	29.45 (24.17)	20.75 (12.55)	15.06 (6.75)	9.51 (2.72)	9.59 (2.77)	10.82 (3.52)	15.22 (6.90)
15.	GO-2	14.90 (6.61)	18.39 (9.95)	11.39 (3.90)	13.42 (5.38)	16.11 (7.69)	0.81 (0.02)	8.12 (1.99)	0.81 (0.02)	10.49 (3.31)
16.	Pusa Sawani	6.84 (1.42)	15.05 (6.74)	0.81 (0.02)	13.99 (5.77)	14.12 (5.95)	7.46 (1.68)	11.06 (3.68)	11.25 (3.80)	10.06 (3.05)
	Mean	11.20	10.16	13.93	11.28	11.27	7.85	11.74	8.74	
	S.Em. (V)	-	-	-	-	-	-	-	-	0.49
	(P)	-	-	-	-	-	-	-	-	0.22
	(V x P)	-	-	-	-	-	-	-	-	0.88
	CD at 5% (V)	-	-	-	-	-	-	-	-	1.42
	(P)	-	-	-	-	-	-	-	-	0.61
	(V x P)	-	-	-	-	-	-	-	-	2.45
	CV% (V)	-	-	-	-	-	-	-	-	22.35
	(V x P)	-	-	-	-	-	-	-	-	14.25

Figures in parentheses are arc sine $\sqrt{\text{per cent}}$ retransformed values

The okra variety JOL-4 with low (7.02/0.2 cm^2) fruit hair density and smaller hair (0.49 mm) was found significantly highly susceptible(9.5%).

The variety JOL-4 was followed by less susceptible variety i.e. DEV-91-4 (7.7%) and was closely followed by the variety Arka Anamika (6.9%). The variety Arka Anamika was found to be at par with the variety SEL-2 (5.73%) and the variety SEL-2 was found at par with the varieties Padra-18-6 (5.22%) and AOL-95-13 (4.82%). These were closely followed by the varieties AOL-95-15 (4.62%), VRO-3 (4.35%) and Parbhani Kranti (3.98%). The variety Parbhani Kranti was followed by GO-2 (3.31%) and Pusa Sawani (3.06%).

The order of susceptibility of different okra varieties to fruit damage by *H. armigera* was found as HRB-55 ≤ JOL-5 < VRO-4 ≤ HRB-9-2 < HIHB-068 < Pusa Sawani ≤ GO-2 ≤ Parbhani Kranti ≤ VRO-3 ≤ AOL-95-15 ≤ AOL-95-13 ≤ Padra-18-6 ≤ SEL-2 ≤ Arka Anamika ≤ DEV-91-4 < JOL-4.

4.2 Natural enemies

4.2.1 Lady bird beetle, *C. sexmaculata*

Results presented in Table-8 indicated that the okra variety HRB-55 had a maximum (2.27 ± 1.51) *C. sexmaculata* population per plant

and was followed by the varieties GO-2, Pusa Sawani, AOL-95-13, AOL-95-15, SEL-2, VRO-3, DEV-91-4, VRO-4, Arka Anamika, JOL-4, Padra-18-6, Parbhani Kranti, HIHB-068, JOL-5 and HRB-9-2 in which population of *C. sexmaculata* was ranged from 0.55 to 1.38 per plant.

4.2.2 Green lacewing, *C. carnea*

Results presented in Table-8 indicated that the okra variety HRB-55 had a maximum (1.16 ± 0.21) *C. carnea* population per plant and in other varieties it was 0.08 to 0.91 per plant.

4.2.3 Syrphid fly, *X. scutellaris*

Results presented in Table-8 indicated that the okra variety HIHB-068 had maximum (1.1 ± 0.14) *X. scutellaris* population per plant and was followed by the varieties JOL-4, VRO-4, JOL-5, Pusa Sawani, DEV-91-4, AOL-95-13, SEL-2, VRO-3, AOL-95-15, HRB-55 with a range of population 0.22 to 0.99 per plant.

4.3 Leaf hairiness

4.3.1 Hair density in different okra varieties

4.3.1.1 Upper surface

Results presented in Table-6 indicate the hair density per 0.5 cm^2 leaf area on different okra varieties. The data revealed that the okra varieties JOL-4 and DEV-91-4 had a significantly low (2.0) hair density as

compared to rest of the varieties. These 2 varieties were found at par with the varieties Padra-18-6 (2.3), AOL-95-13 (2.7) and Arka Anamika (2.7). Further, it was observed that these varieties were closely followed by the varieties VRO-3 (3.0), Pusa Sawani (3.0), AOL-95-15 (3.3), GO-2 (3.3) and Parbhani Kranti (3.7).

The okra varieties JOL-5, VRO-4 and HIHB-068 had a significantly high (6.0) hair density. These were followed by the variety HRB-9-2 (5.3) which was at par with the varieties HRB-55 (5.0) and SEL-2 (4.7).

The order of hair density in different okra varieties on the upper surface of the leaf was JOL-4 = DEV-91-4 $\leq$ Padra-18-6 $\leq$ AOL-95-13 = Arka Anamika $\leq$ VRO-3 = Pusa Sawani $\leq$ AOL-95-15 = GO-2 $\leq$ Parbhani Kranti < SEL-2 $\leq$ HRB-55 $\leq$ HRB-9-2 $\leq$ JOL-5 = VRO-4 = HIHB-068.

4.3.1.2 Lower surface

Results presented in Table-6 indicate the hair density per 0.5 cm^2 leaf area of different okra varieties. The data revealed that the okra varieties AOL-95-13, Padra-18-6 and Pusa Sawani had a significantly low (2.7) hair density. These varieties were at par with the varieties JOL-4 (3.0), DEV-91-4 (3.0), VRO-3 (3.0), Arka Anamika (3.0), GO-2 (3.3), AOL-95-15 (3.3),VRO-4 (3.7) and Parbhani Kranti (3.7).

The okra variety HIHB-068 had a significantly high (6.7) hair density and was at par with the variety JOL-5 (6.0). However, JOL-5 was at par with HRB-9-2 (5.3), HRB-55 (5.0) and SEL-2 (5.0).

The order of hair density in different okra varieties on the lower surface of the leaf was AOL-95-13 = Padra-18-6 = Pusa Sawani ≤ VRO-3 = JOL-4 = DEV-91-4 = Arka Anamika ≤ GO-2 = AOL-95-13 ≤ VRO-4 = Parbhani Kranti ≤ SEL-2 = HRB-55 ≤ HRB-9-2 ≤ JOL-5 ≤ HIHB-068

4.3.1.3 Midrib

Results presented in Table-6 indicate the hair density per 0.5 cm of the midrib in different okra varieties. The data revealed that the varieties Padra-18-6 and JOL-4 had a significantly low (2.0) hair density and was found at par with the varieties Pusa Sawani (2.3), Arka Anamika (2.67), DEV-91-4 (3.0), SEL-2 (3.3), AOL-95-15 (3.3), Parbhani Kranti (3.3) and GO-2 (3.3).

The okra variety HIHB-068 had a significantly high (7.0) hair density and was at par with the varieties VRO-4 (6.0) and JOL-5 (6.0). These 2 varieties were closely followed by the variety HRB-9-2 (5.0) and was found at par with the varieties HRB-55 (4.3), VRO-3 (4.0) and AOL-95-13 (3.7).

The order of hair density in different varieties on the midrib of lower surface of leaf was Padra-18-6 = JOL-4 = DEV-91-4 ≤ Pusa Sawani ≤ AOL-95-13 ≤ Arka Anamika ≤ SEL-2 = AOL-95-15 = Parbhani Kranti = GO-2 ≤ VRO-3 ≤ HRB-55 ≤ HRB-9-2 ≤ JOL-5 = VRO-4 ≤ HIHB-068.

4.3.2 Leaf hair length in different okra varieties

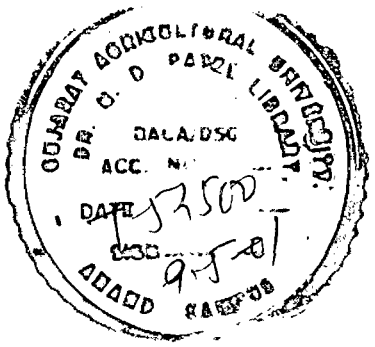
4.3.2.1 Upper surface

Results presented in Table-7 indicated that the okra variety Arka Anamika had shortest hairs (0.31 mm). This was at par with the variety Padra-18-6 (0.32 mm) and was followed by the varieties GO-2 (0.35 mm) and VRO-3 (0.36 mm). However, these varieties were closely followed by the varieties Parbhani Kranti (0.41 mm), JOL-4 (0.42 mm), Pusa Sawani (0.45 mm), AOL-95-13 (0.46 mm) and AOL-95-15 (0.47 mm).

The okra variety VRO-4 had a longest hairs (0.72 mm) and was found to be at par with the variety HRB-9-2 (0.70 mm). Moreover, this variety was followed by the varieties JOL-5 (0.58 mm), HIHB-068 (0.57 mm), HRB-55 (0.55 mm) and SEL-2 (0.50 mm).

The order of hair length in different okra varieties on the upper surface of the leaf was Arka Anamika ≤ Padra-18-6 ≤ GO-2 ≤

VRO-3 ≤ DEV-91-4 ≤ Parbhani Kranti ≤ JOL-4 ≤ Pusa Sawani ≤ AOL-95-13 ≤ AOL-95-15 ≤ SEL-2 < HRB-55 < HIHB-068 ≤ JOL-5 < HRB-9-2 ≤ VRO-4.



4.3.2.2 Lower surface

Results presented in Table-7 indicated that the okra variety Padra-18-6 had shortest hairs (0.31 mm). This was followed by the varieties Arka Anamika (0.32 mm), GO-2 (0.35 mm), VRO-3 (0.39 mm), DEV-91-4 (0.40 mm). However, the variety DEV-91-4 was found at par with the varieties JOL-4 (0.42 mm), AOL-95-13 (0.43 mm) and Pusa Sawani (0.43 mm).

The okra varieties VRO-4 and HRB-9-2 had longest hair length (0.72 mm). These were followed by JOL-5 (0.60 mm) which was at par with the varieties HRB-55 (0.57 mm) and HIHB-068 (0.57 mm). These varieties were followed by the variety SEL-2 (0.49 mm) and it was found at par with the variety AOL-95-15 (0.47 mm). This was closely followed by the variety Parbhani Kranti (0.44 mm).

The order of hair length in different okra varieties on the lower surface of the leaf was Padra-18-6 ≤ Arka Anamika ≤ GO-2 < VRO-3 ≤ DEV-91-4 ≤ JOL-4 ≤ AOL-95-13 = Pusa Sawani ≤ Parbhani Kranti ≤ AOL-95-15 ≤ SEL-2 < HIHB-068 = HRB-55 < JOL-5 < HRB-9-2 = VRO-4.

4.3.2.3 Midrib of lower surface

Results presented in Table-7 indicated that the okra variety Arka Anamika had significantly shorter (0.29 mm) hairs as compared to rest of the varieties and was found at par with the variety Padra-18-6 (0.3 mm). This was followed by the varieties DEV-91-4 (0.35 mm), GO-2 (0.36 mm), Parbhani Kranti (0.39 mm), VRO-3 (0.40 mm), Pusa Sawani (0.44 mm), AOL-95-13 (0.45 mm) and AOL-95-15 (0.48 mm).

The okra variety VRO-4 had significantly longer (0.74 mm) hairs as compared to rest of the varieties. This variety was found at par with the variety HRB-9-2 (0.72 mm) and was followed by the varieties HIHB-068 (0.63 mm), JOL-5 (0.58 mm), HRB-55 (0.57 mm) and SEL-2 (0.51 mm).

The order of hair length in different okra varieties on the midrib of lower surface of the leaf was Arka Anamika ≤ Padra-18-6 < DEV-91-4 ≤ GO-2 ≤ Parbhani Kranti ≤ VRO-3 < JOL-4 ≤ Pusa Sawani ≤

AOL-95-13 ≤ AOL-95-15 ≤ SEL-2 < HRB-55 ≤ JOL-5 < HIHB-068 < HRB-9-2 ≤ VRO-4.

4.3.2.4 Average

Results presented in Table-7 indicated that the okra variety Arka Anamika had significantly shorter (0.30 mm) hairs as compared to rest of the varieties. This was found at par with the variety Padra-18-6 (0.31 mm) and was followed by the varieties GO-2 (0.35 mm), DEV-91-4 (0.37 mm), VRO-3 (0.39 mm), Parbhani Kranti (0.42 mm), JOL-4, (0.42 mm), Pusa Sawani (0.44 mm), AOL-95-13 (0.45 mm) and AOL-95-15 (0.47 mm).

The okra variety VRO-4 had a significantly longer (0.72 mm) hairs as compared to rest of the varieties. This was found at par with the variety HRB-9-2 (0.71 mm) and was followed by the varieties HIHB-068 (0.59 mm), JOL-5 (0.59 mm), HRB-55 (0.56 mm) and SEL-2 (0.50 mm).

The order of average hair length on the leaf in different okra varieties was Arka Anamika ≤ Padra-18-6 < GO-2 ≤ DEV-91-4 ≤ VRO-3 ≤ Parbhani Kranti = JOL-4 ≤ Pusa Sawani ≤ AOL-95-13 < AOL-95-15 ≤ SEL-2 < HRB-55 ≤ JOL-5 = HIHB-068 < HRB-9-2 ≤ VRO-4.

4.4 Fruit hairiness

4.4.1 Hair density in different okra varieties

Results presented in Table-14 indicate the hair density per 0.2 cm^2 of the fruit of different okra varieties. The data revealed that the variety GO-2 had a significantly low (38) fruit hair density as compared to rest of the varieties. This variety was found at par with the varieties AOL-95-13 (42), JOL-4 (49), Arka Anamika (49) and SEL-2 (85).

The okra variety JOL-5 had a significantly high (122) hair density as compared to rest of the varieties. However, it was found at par with the varieties HRB-55 (115), Parbhani Kranti (110), HRB-9-2 (109), DEV-91-4 (108), HIHB-068 (106), Padra-18-6 (101), Pusa Sawani (98), AOL-95-15 (96), VRO-4 (92) and VRO-3 (92).

The order of fruit hair density in different okra varieties was GO-2 $\leq$ AOL-95-13 $\leq$ JOL-4 = Arka Anamika $\leq$ SEL-2 $\leq$ VRO-3 = VRO-4 $\leq$ AOL-95-15 $\leq$ Pusa Sawani $\leq$ Padra-18-6 $\leq$ HIHB-068 $\leq$ DEV-91-4 $\leq$ HRB-9-2 $\leq$ Parbhani Kranti $\leq$ HRB-55 $\leq$ JOL-5.

4.4.2 Hair length in different okra varieties

Results presented in Table-14 indicated that the okra variety DEV-91-4 had a significantly shorter (0.39 mm) fruit hair as compared to rest of the varieties. However, it was found at par with the variety GO-2 (0.41 mm) which was then followed by the varieties AOL-95-13 (0.44

mm), HRB-9-2 (0.48 mm), SEL-2 (0.49 mm), JOL-4 (0.49 mm) and AOL-95-15 (0.50 mm).

The okra variety HIHB-068 had a significantly longer (0.72 mm) fruit hair as compared to rest of the varieties. However, it was found at par with the variety Arka Anamika (0.69 mm) which was followed by the varieties JOL-5 (0.60 mm), VRO-3 (0.60 mm), HRB-55 (0.59 mm), Pusa Sawani (0.58 mm), VRO-4 (0.57 mm), Padra-18-6 (0.54 mm) and Parbhani Kranti (0.53 mm).

The order of fruit hair length in different okra varieties was DEV-91-4 ≤ GO-2 ≤ AOL-95-13 < HRB-9-2 ≤ SEL-2 = JOL-4 ≤ AOL-95-15 ≤ Parbhani Kranti ≤ Padra18-6 ≤ VRO-4 ≤ Pusa Sawani ≤ HRB-55 ≤ VRO-3 = JOL-5 < Arka Anamika < HIHB-068.

4.5 Correlation studies of leaf hairiness with various insect pests

4.5.1 Hair density

4.5.1.1 Aphid, *A. gossypii*

Results presented in Table-10 indicate that there is no significant association between the aphid population and leaf hair density. This finding was in agreement with Uthamasamy *et al.* (1974) and Bhatt (2000).

4.5.1.2 Jassid, *A. biguttula biguttula*

Results presented in the Table-10 and Fig. 1 indicate significant negative correlation between the hair density on lower mid rib of leaf and jassid total nymphal population. Similar result was observed by Teli and Dalaya (1981), Uthamasamy and Subramanian (1985) and Singh (1988) on okra and Khan and Agarwal (1984) and Bhatt (2000) on cotton.

4.5.2 Hair length

4.5.2.1 Aphid, *A. gossypii*

Results presented in Table-10 indicate non-significant association between leaf hair length and aphid population.

4.5.2.2 Jassid, *A. biguttula biguttula*

Results presented in Table-10 and Fig. 2 indicate significant negative association between the hair length on lower midrib of leaf and jassid population. Teli and Dalaya (1981) and Singh (1988) also found similar results on okra.

4.6 Correlation studies of fruit hairiness with population of various insect pests

4.6.1 Hair density

4.6.1.1 *E. vittella*

Results presented in Table-10 and Fig. 3 indicate significant association between the fruit hair density and fruit damage by *E. vittella*. Kumbhar *et al.* (1991) also found similar results.

4.6.1.2 *H. armigera*

Results presented in Table-10 and Fig. 4 indicate significant negative association between the fruit hair density and fruit damage by *H. armigera*.

4.6.2 Hair length

4.6.2.1 *E. vittella*

Results presented in Table-10 indicate non-significant association between the fruit hair length and fruit damage by *E. vittella*.

4.6.2.2 *H. armigera*

Results presented in Table-10 indicate non-significant association between the fruit hair length and fruit damage by *H. armigera*.

4.7 Yield

Results presented in Table-12 indicate that the okra variety HRB-9-2 gave significantly high (5286 kg/ha) yield than rest of the varieties and was found at par with the varieties HRB-55 (5220 kg/ha), JOL-4 (5101 kg/ha), JOL-5 (5098 kg/ha). These were followed by the varieties SEL-2 (3651 kg/ha), HIHB-068 (3421 kg/ha), AOL-95-15 (3182 kg/ha), Padra-18-6 (2934 kg/ha), VRO-4 (2877 kg/ha), AOL-95-13 (2677 kg/ha), Parbhani Kranti (2331 kg/ha), DEV-91-4 (2321 kg/ha), VRO-3 (2291 kg/ha), Arka Anamika (2243 kg/ha), GO-2 (1674 kg/ha) and significant low yield was observed in the variety Pusa Sawani (1474 kg/ha).

SUMMARY AND CONCLUSION

V. SUMMARY AND CONCLUSION

Amongst the vegetable crops okra is one of the most important crop. It suffers heavily due to the attack of various pests which reduce the yield and quality of the fruit. In this context, the present study was carried out to evaluate various okra varieties/genotypes against their major pests under middle Gujarat condition. A field experiment was conducted during the year 1999 at Plant Breeding Farm, Gujarat Agricultural University, Anand Campus, Anand. Sixteen different varieties were evaluated.

5.1 Varietal susceptibility of okra to insect pests

5.1.1 Sucking pests

The study on the evaluation of various okra varieties indicates that among 16 varieties, none of the varieties were found free from the aphid infestation. The okra variety GO-2 remained least susceptible in comparison to rest of the varieties, this may be due to the hairiness of this variety and high population of lady bird beetle, *C. sexmaculata*. Whereas, the variety Parbhani Kranti was found highly susceptible.

The varieties HRB-9-2 and VRO-4 remained less susceptible to jassid. This may be due to high hair density and longer hair on the lower

midrib of the leaf which may interfere the oviposition of jassid and resulted in low jassid population, whereas, the high population of jassid was found in the variety Arka Anamika.

5.1.2 Borer complex

The study on evaluation of 16 okra varieties indicate low shoot damage by *E. vittella* in the variety HRB-55 and high in the variety AOL-95-13. Whereas, the study on the fruit damage by *E. vittella* indicate low fruit damage in the variety JOL-5. This may be due to high fruit hair density of this variety. However, high fruit damage was found in the variety GO-2.

The variety HRB-55 had low fruit damage of *H. armigera.* This may be due to high fruit hair density of this variety. Whereas, high fruit damage was found in the variety JOL-4.

5.2 Natural enemies

The study on the population of natural enemies on various okra varieties indicate that the population of lady bird beetle, *C. sexmaculata* was high in variety HRB-55 and low in the variety HRB-9-2. Whereas, the population of green lacewing, *C. carnea* was high in the variety HRB-55 and low in the variety GO-2. The high population of syrphid fly, *X. scutellaris* was found in the variety HIHB-068.

5.3 Leaf hairiness

Hair density in different okra varieties

The study on the leaf hair density of different okra varieties indicates that the varieties JOL-4 and DEV-91-4 had low hair density on the upper surface and high in the varieties JOL-5, VRO-4 and HIHB-068. Whereas, the leaf hair density on lower surface was low in the varieties AOL-95-13, Padra-18-6 and Pusa Sawani and high in the variety HIHB-068. The hair density on the midrib was low in the varieties Padra-18-6 and JOL-4 and high in the variety HIHB-068.

Hair length in different okra varieties

The study on the leaf hair length of different okra varieties indicates that the variety Arka Anamika had the shorter hairs on the upper surface whereas, the variety VRO-4 had the longer hairs. On the lower surface, the variety Padra-18-6 had the shorter hairs and the varieties HRB-9-2 and VRO-4 had the longer hairs. Whereas, on the midrib the variety Arka Anamika had the shorter hairs and the variety VRO-4 had the longer hairs. The average leaf hair length was shorter in the variety Arka Anamika and longer in the variety VRO-4.

5.4 Fruit hairiness

Hair density in different okra varieties

The study on the fruit hair density in various okra varieties indicates that the variety GO-2 had the low hair density whereas, high in the variety JOL-5.

Hair length in different okra varieties

The study on the fruit hair length in various okra varieties indicates that the variety DEV-91-4 had the shorter hairs whereas, longer in the variety HIHB-068.

5.5 Correlation studies of okra hairiness with various insect pests

The correlation studies indicate significant negative association between jassid population and leaf hairiness (hair density and hair length). Similarly significant negative association was also found between fruit hair density and fruit borers, *E. vittella* and *H. armigera.* Whereas, association between aphids and leaf hairiness was found non-significant.

5.6 Yield

The studies on the yield indicate that the okra variety HRB-9-2 gave high yield. Whereas, the variety Pusa Sawani gave low yield.

5.7 Conclusion

On the basis of above findings it can be concluded that leaf hairiness (hair density and hair length) had negative association with jassid and fruit hair density had negative association with fruit borers, *E. vittella* and *H. armigera*. This can be an important morphological character for selecting, developing and for breeding the resistant/tolerant okra varieties to the above pests.

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*Original not seen

Annexure-I : Meteorological data of crop season during the year 1999-2000

Date and month	Std Week	RF mm	MAX T °C	MIN T °C	Mean °C	Bright Sunshine hours	EP mm	Mean RH
21-27 June	26	0.0	34.7	26.6	30.6	8.2	6.8	68
28 Jun-4 July	27	5.0	34.5	26.3	30.4	5.5	6.1	70
5 – 11 July	28	33.0	32.2	25.9	29.1	4.1	4.6	80
12 – 18 July	29	138.5	30.2	25.6	27.9	0.3	2.2	88
19 – 25 July	30	3.0	30.8	25.8	28.3	1.5	3.3	81
26 Jul–1 Aug	31	9.6	30.7	25.3	28.0	1.8	3.8	81
2- 8 Aug	32	20.2	29.6	25	27.3	0.6	2.4	86
9-15 Aug	33	0.0	32.6	25.4	29.0	5.1	5.0	74
16-22 Aug	34	0.0	33.2	25.0	29.1	5.4	5.2	69
23-29 Aug	35	0.0	33.5	24.9	29.2	6.5	6.0	70
30Aug-4Sept	36	0.0	33.7	25.6	29.6	6.6	6.3	68
5-12 Sept	37	7.4	33.5	24.9	28.7	5.4	4.7	77
13-19 Sept	38	0.0	33.1	24.6	28.8	5.4	5.1	80
20-26 Sept	39	2.8	34.5	25.0	29.7	7.4	5.7	71
27sept-3 Oct	40	4.0	34.4	24.4	28.9	6.1	4.1	75
4-10 Oct	41	18.4	32.5	26.3	27.9	3.5	3.0	81
11-17 Oct	42	0.0	34.8	19.4	27.1	9.9	4.8	61
18-24 Oct	43	0.0	35.3	18.0	26.6	9.8	5.2	53