RELATIVE PREFERENCE OF DIFFERENT TOMATO VARIETIES/ HYBRIDS BY MAJOR PEST IN RELATION TO ANTIXENOSIS AND DYNAMICS OF PESTS POPULATION WITH REGARDS TO ABIOTIC PARAMETERS

Thesis

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Dedicated
to my beloved
Parents

Smt. Mongra Sahu
Shri S. R. Sahu

CERTIFICATE - I

This is to certify that the thesis entitled **"RELATIVE PREFERENCE OF DIFFERENT TOMATO VARIETIES/HYBRIDS BY MAJOR PEST IN RELATION TO ANTIXENOSIS AND DYNAMICS OF PESTS POPULATION WITH REGARDS TO ABIOTIC PARAMETERS"** submitted in partial fulfilment of the requirements for the degree of **"Master of Science in Agriculture"** of the Indira Gandhi Agricultural University, Raipur, is a record of the bonafide research work carried out by **Shri ISHWARI KUMAR** under my guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

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

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This is to certify that the thesis entitled **"RELATIVE PREFERENCE OF DIFFERENT TOMATO VARIETIES/HYBRIDS BY MAJOR PEST IN RELATION TO ANTIXENOSIS AND DYNAMICS OF PESTS POPULATION WITH REGARDS TO ABIOTIC PARAMETERS"** submitted by **Shri ISHWARI KUMAR** to the Indira Gandhi Agricultural University, Raipur in partial fulfilment of the requirements for the degree of M.Sc.(Ag.) in the **Department of Entomology** has been approved by the Student's Advisory Committee after oral examination in collaboration with the externalexaminer.

28.10.02

EXTERNAL EXAMINER

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CHAPTER - I

INTRODUCTION

Tomato, *Lycopersicon esculantum* (Mill) is an important vegetable crop grown all over the world. It is rich source of several vitamin and minerals. India is the second largest vegetable producer of the world. In India, the total vegetable production was 98.50 million tonnes from an average area of 6.24 million hectare, out of it, tomato production was 8.40 million tonnes from an area of 0.50 million hectare during 2000-01 (Anonymous, 2001). In Chhattisgarh state, the tomato production was 2.320 lakh tonnes from an area of 15,480 hectare during 1998-99 (Anonymous, 2001).

Worldwide, more than a hundred different insect-pests have been recorded on tomato crops (Talekar *et al.*, 1983). At any one time and place, however only a few species are major pests of economic importance.

Considerable economical losses caused by *H. armigera* have been reported by Fary and Cuthbert (1974) and Kashyap and Batra (1987). Yield losses of 40 to 50 per cent in Tamil Nadu and 22.39 to 37.99 per cent at Bangalore due to this insect have been reported by Shrinivasan (1959) and Tiwari and Krishnamoorthy (1984), respectively. The fruit bore *H. armigera* (Hubner) is a limiting factor of the successful cultivation of tomato crop throughout the world.

American serpentine leaf miner, *Liriomyza trifolii* (Burgess) is one of the important pests which is expanding its distribution in the world. It started its journey from its native place in the United States of America (Florida) during early 1970's and has become almost cosmopolitan. The pest has been introduced in India in the year 1990-91 (Viraktamath *et al.*, 1993). This polyphagous leaf miner has increased host range to more than 400 plants (Parrella and Keil, 1984). In India it has spread widely in Karnataka, Andhra Pradesh, Maharashtra, Gujrat, Delhi, Chhattisgarh, Madhya Pradesh and other stages of the country. It attained serious pest status in all most all the vegetable crops especially on tomato and cucurbits. Insecticide application has commonly been responsible for outbreaks of *L. trifolii* because the insecticides are often more toxic to the large parasite complex holding the leaf miner in check (Oatman and Kennedy, 1976).

The tobacco whitefly, *Bemisia tabaci* is native to Indian region but now a days it is widely distributed, occurring outdoors in all tropical and subtropical countries of the world. (Avidor and Harpaz, 1969, Mount and Halsey 1978). *B. tabaci* is polyphagous, attacking more than 300 plants of different families (Avidov, 1956, Mound and Hasey, 1978), but the whitefly develops better on some plants (Van Lenteren *et al*, 1980). Due to specific microclimate (Avidov and Harpaz, 1969) or the pH of the leaf sap (Hussein *et al*., 1936, Berlinger *et al*., 1983) both adult and nymph cause direct damage to the plant by sucking from the phloem by screating honeydew. This weaken the plants by sap extraction and allows black shooty mould fungus to develop on the honeydew, thus drying them. The main damage caused by *Bemisia tabaci* to the tomato is indirect by transmitting virus diseases (Hill, 1969; Cohen and Berlinger, 1986). This is one of the most important limiting factor for tomato cultivation in warm climates.

Tomato also subjected to severe infestation by jassid, *Empoasca devastans*. The damage to the crop results in profuse draining of plant sap, development of honeydew leading to black shooty mould and leaf shedding. The most severe damage however, caused by transmitting virus diseases.

The potato thrips, *Caliothrips indicus* (Bagnall) is the most cosmopolitan pest and a limiting factor in tomato cultivation. It is found in many countries, its outbreak was noticed in warm climates and in greenhouses in colder areas (Lewis, 1973). Thrips, when numerous, may cause premature wilting, retardation of leaf development and deformation of young shoots (Avidor and Harpoz, 1969). Thrips are markedly polyphagous, found on nearly all vegetable crops which belong to different botanical families. It transmits tomato spotted wilt virus disease.

Tomato crop is attacked by various polyphagous aphids, *Myzus persicae, Aphis gossypii, Macrosiphum euphorbiae* etc., no aphids are hostspecific for tomato. Consequently, wherever tomatoes are cultivated they may be attacked by the local aphids. They feed by piercing and sucking from the plant usually on the underside of the leaves and on the young shoots. The most severe damage however is caused by transmitting virus diseases (Zimmerman-Gries *et al.*, 1976).

The tomato fruits are picked up at short and frequent intervals, therefore it is difficult to use insecticides frequently to manage the insect, as it may result in the high pesticide residue in the tomato fruits. One of the best way to avoid the use of pesticide is the use of resistant variety. On one hand they are better from economic point of view and on the other reduce the environmental pollution resulting from the excessive use of toxic chemicals.

There are some wild species of tomato which contain natural mortality factor in their leaves (Fery and Cuthbert, 1975, Kashyap and Verma, 1987). Among these *L. hirsutum, F. glabratum* contain the natural insecticide 2-tridecanone (Williams *et al.,* 1980), produced by type 6 trichomes on the leaves. This wild tomato contains about 72 times as much 2-tridecanone as cultivars. Larvae of the Colorado potato beetle, *Leptinotarsa decemlinata* and the tomato hornworn, *Manducasexta*are killed by this compound.

The factors responsible for the resistance are some morphological characters like hairyness and some chemical characters like ascorbic acid, phenolic compound 2-tridecanone which are known to impart resistance to different varieties against different pests. The compounds like glycoalkaloid and α-tomatine are found in the wild species and are toxic to the tobacco caterpillar, *Spodoptera exigua* and tomato fruit worm, *Heliothis zea* (Juvik and Stevens, 1982 a, b).

Keeping in mind the above points investigations entitled "Relative preference of different tomato varieties/hybrids by major pest in relation to antixenosis and dynamics of pests population with regards to abiotic parameters." were undertaken with the following objectives :

(i) Relative resistance/susceptibility of tomato varieties against pest complex of tomato.

(ii) Biophysical basis of resistance/susceptibility to major pest.

(iii) Dynamics of major pests of tomato in relation to abiotic parameters.

Review of Literature

CHAPTER-II

REVIEW OF LITERATURE

Tomato is known to be attacked by several insect pests during crop growth period to harvesting of these, tomato fruit borer, *Helicoverpa armigera* (Hubner), tomato leaf miner, *Liriomyza trifolii*, thrips, *Caliothrips indicus*, jassid, *Empoasca devastons*, aphid, *Aphis gossypii* and whitefly, *Bemisia tabaci* are regular pests in Chhattisgarh region.

In Chhattisgarh region no systematic work has been done on the management of these tomato pests. The literature available in India and abroad on different entomological aspects has been grouped under following headings :

1. Relative resistance/ susceptibility of tomato varieties.
2. Biophysical basis of resistance/ susceptibility to major pest
3. Dynamics of major pests of tomato in relation to abiotic parameters.

2.1 Relative resistance/ susceptibility of tomato varieties

Lal (1985) tested 28 tomato varieties against the noctuid *Helicoverpa armigera* in field resistance trails in Libya in 1977. Varieties Parker, Bonus and VIN-B were found to be highly resistant (1-2.5% infestation), while super Marmend, Bonest F_1 hybrid and No. 502 VFN4 F_1 hybrid were highly susceptible (22.6-44.7% infestation).

Kashyap and Verma (1987) studied the development and survival of *Helicoverpa armigera* on 6 tomato genotypes of wild tomato species *Lycopersicon hirsutum, f. glabratum* consisting of two pest tolerant (HT 64 and HT 50), two susceptible (HS 173 and HS 172) and one recommended varieties (HS 101) at a constant temperature of 29°C. The duration of the larval stage varied from 36.0 days on HS 173 to 414 days on HT 64, with an average of 34.6 days on *L. hirsutum*, and adult from larvae reared on this genotype died soon after emergence. The survival of larvae on the wild food plant was 16.6 per cent as compared with 90 per cent on susceptible genotypes. Susceptibility of 4 tomato varieties, HA 101, Pusa Ruby, Redchemy and Monzana and two accession of L. *hirsutum, f. glabratum* B 6013 and WIR 402 to tomato fruit borer *Helicoverpa armigera* was studied, variety B 6013 was highly resistant where as remaining four tomato varieties were moderately to highly susceptible.

Sharma *et al.* (1990) grown four varieties during rabi, 1989 to study the effect of *H. armigera* on the number and weight of fruit. The smallest mean per cent reduction in the number and yield was observed in Kanchan 3 and it was 16.31 per cent and 10.45 per cent, respectively.

Butler and Heneberry (1991) observed differences in the number of *Bemisia tabaci* attracted to different tomato varieties in Arizona, USA, in 1990. The most attractive varieties were Roma, Columbia, Patio and Better Boy.

Davino *et al.* (1992) studied different F_1 hybrids and varieties grown under green house condition against TYLCV (tomato yellow leaf curl virus) transmitted through whitefly. Varieties M46, M47, M48 were resistance to cherry type tomato variety RS 9020. Their results showed that the tomato variety RS 9020 had the lowest number of infected leaf and highest yielder.

Ramnath *et al.* (1992) reported that among five host plants, redgram (Pigeon pea) was the most preferred host for oviposition by *Helicoverpa armigera* followed by bhindi (okra). Bengal gram (chickpea), tomatoes and cotton. Biophysical character like trichome density was positively correlated with oviposition. Among hosts, chickpea was the preferred host for feeding followed by pigeonpea, okra, cotton and tomato.

Todzhaev and Ruzmetov (1993) studied the infestation level of *Heliocoverpa armigera* on eight tomato varieties in the Khorezmmskaya region of Uzbekistan. They showed that Ravshan and Yusupovskii 40 being resistant and other tomato varieties were susceptible.

Singh *el al.* (1994) reported that among the varieties evaluated against *H. armigera.* Punjab Chhuhara proved resistant in all six year of testing while U 52, J 14-12, Pant Bahar, Azad, T-2, Pusa selection and Pusa selection 4 also showed resistance whereas KS 6 and selection 18 proved highly susceptible. Out of the hybrids KT4 and Pusa hybrid 4 were the best. Among the collections only HC 253003 showed promise against the pest.

Krishnakumar *et al.* (1995) studied the antixenosis characters of *Frankliniella occidentalis* to several species of *Lycopersicon.* They observed that *L. hirsutm, L. hirsutm, f. glabratum* and *L. pennelii* had high antixenosis to thrips nymphs where as *L. chilense* had moderately antixenosis characters.

Kumar *et al* (1995) tested thirteen *Lycopersicon* accessions for landing of *Thrips tabaci* and *Trialcurodes vaporariorum* on leaves and flowers. The tomato accession "Anhu" was infested at foliage stage where as accession "Pearl Harbor" was infested at flowering stage and no infestation was observed in accession "Rey de los Temprano".

Borch (1996) studied the infestation level of *Helicoverpa armigera* and *Bemisia tabaci* on five tomato varieties during 1994-95 in summer season at Diphu, Assam. The variety Arkavikas produced the highest mean yield of 6.69 tonnes/ha and it had also higher infestation of *Bemisia tabaci* and *Helicoverpa armigera* than variety Arkalook which indicated the tolerance of the variety.

Schoot *et al.* (1996) recorded the effect of development period, fecundity and mortality of *Liriomyza trifolii* in some tomato accessions. They tested accessions of various *Lycopesicon species, L. hirsutum* accessions was found to be completely resistant which expressed the reduction of reproduction and larval survival. Whereas, among *L. cheesmanii* genotype LA 1448 showed partial resistant.

Gc *et al.* (1997) screened out four commercial varieties, six local varieties and twelve hybrids of tomato against *Helicoverpa armigera* in Nepal during 1997. They found that among the hybrids, Altair F_1 (90-5225), Mercur F_1 (90-5223), F_1 958930 were found resistant whereas in the commercial varieties Roma was found to be best. Variety Pusa Ruby showed susceptibility against *H. armigera.*

Atta-Aly *el al.* (1998) observed in a field experiment on Cuza, Egypt, with tomatoes (*Lycopersicon esculentum*) cv. Peto 86. Pest control of *Myzus persicae* and *Bemisia tabaci* was evaluated following various methods. They concluded that growing tomatoes under 1 agry P17 (a white fleecy material) produced the best pest control good quality fruits and the highest fruit yield.

Jeyakumar and Uthamasamy (1998) evaluated different host plants for oviposition preference of *Liriomyza trifolii.* They observed that the number of eggs per unit area was high in tomato followed by bittergourd, soybean, cowpea, lablab and cotton. Pumpkin was recorded significantly less number of eggs per unit area.

Nagata *et al.* (1998) conducted the resistance study in lettuce *(Lachica sativa*) against *Liriomyza trifolii* under laboratory condition. Four lettuce varieties *viz.* Tall Guzmaine, Valmaine, 'Floricos 83' and Parris Island cos were used in an initial study and another varieties like Valmaine and Tall Guzmaine were used in 2 additional studies. Significant differences in fecundity as measured by the number of pupae produced and in the total number of stipples were found, but this differences resulted from difference in adult survival. Female leafminer on Tall Gouzmaine survived significantly longer and produced more pupae than adults on Valmaine, Perris Island cos, and Florico 583 which were less preferred by leaf miner.

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Thakur *et al.* (1998) tested number of tomato varieties / hybrids for resistance to *Helicoverpa armigera* in the Chamba district of Himachal Pradesh, India, variety S-12 was found resistant with minimum percentage fruit damage (0. 66%).

Dawood *et al.* (1999) screened eight tomato varieties for their susceptibility to *B. tabaci* and the infection of plants with tomato yellow leaf curl virus (TYLCV). Tomato hybrids Dora, Jakal and Facolta were least susceptible to *B. tabaci* whereas varieties TY-20 and Sheva were found to be more susceptible.

2.2 Biophysical basis of resistance/ susceptibility to major pests

Jones *et al.* (1934) studied the nature of resistance in white Persian variety of onion against onion thrips, *Thrips tabaci* (Lind.) and reported that probably two or perhaps three characters namely the shape of the leaves, the angle of divergence of the two inner host leaves and the distance apart of the leaf blade on the sheath column tended to restrict the thrips population on this variety. Probably of considerable importance was the difference in the shape of the leaves. The histological character alone probably did not account for resistance because white Persian variety of onion (which was resistant to thrips) had leaves about the thickness of Australian Brown (susceptible one) but still without typical injury.

Singh *et al.* (1982) studied in Punjab, the influence of tomato plant and fruit characteristics (growth habit determinant or indeterminate) leaflet density, fruit size and shape, pericarp thickness, dry matter content, ascorbic acid content and citric acid content on infestation by *H. armigera*. Fruit damage by the pest was found to be independent at all these characters except ascorbic acid content, which was positively correlated with damage, however a low ascorbic acid content is undesirable from the view of quality and therefore of little value in breeding programmes for pest resistance.

Lal (1985) reported that number of tomato accessions with very pubescent leaves and stems compared with susceptible TK 70 and resistant 76 WP 134417 under field experiment against *Helicoverpa armigera.* All the accessions were more susceptible than TK 70. The lack of resistance in susceptible was mainly due to lack of grandular trichomes.

Kashyap and Verma (1987) reported the influence of some plant characteristics on the susceptibility of 124 tomato varieties to natural population of the noctuid *H. armigera* under field condition in Haryana, India in 1880 and 1982. There was a positive correlation between fruit infestation by the pest, both on number and weight basis, and infestation was negatively correlated with the number of flowers per inflorescence. The surface texture of the calyx also affected the susceptibility of the genotype. Analysis of 6 genotypes for 18 biochemical constituents revealed that the reducing sugar in fruits was positively correlated with the degree of infestation, while the zinc and iron content of foliage and ascorbic acid content of fruits were negatively correlated.

The co-efficient of determinations revealed that 87 per cent variability in infestation was due to zinc, iron, ascorbic acid and reducing sugar contents.

Butler and Vir (1989) observed the morphological basis of resistance in cotton to the aleyrodid *Bemisia tabaci*. The plant characters like leaf area, thickness of leaf lamina, hair density, hair length and angle of insertion of leaf hair, hair density and leaf thickness were positively correlated with the population *of Bemisia tabaci.*

The influence of different host plants on preference/ non-preference of *Caliothrips indicus* (Bagnall) was studied by Shaw *et al.* (1989). They tested ten host plants and reported that country been and soybean were preferred most due to the combined more by area, lesser length width ratio, lesser thickness of leaf cuticle and upper epidermis and other bio-chemical characters like more potassium more total amino acid, nitrogen, protein, reducing sugar and more ascorbic acid content as compared to host safflower which was least preferred by the pest.

Butler *el al.* (1991) studied the *Gossypium* spp. for resistance to leafhopper, *Empoasca devastans* and whitefly, *Bemisia tabaci* on the basis of number of trichomes. They observed that the leaf hopper populations decreased but whitefly populations increased as number of trichomes increased.

Ilyas *et al.* (1991) observed the effects of some morphophysiological characters of leaf on the incidence of cotton whitefly, *Bemisia tabaci.* They reported that the trichome density and its length, midrib thickness, nitrogen content and the pH of leaves were positively correlated with the incidence of *Bemisia tabaci*, whereas the chlorophyll content of leaves was negatively correlated with incidence of *Bemisia tabaci*. Trichome length was equally important characters influencing the number *of Bemisia tabaci*.

Shaw *et al.* (1991) conducted experiment to study the mechanism of susceptibility in different pea varieties against *Caliothrips indices* (Bagnall) and reported that pea variety JM-1 was most susceptible due to many associated factors of more leaf area, lesser length width ratio, lesser thickness of leaf cuticle and upper epidermis and other biochemical characters as compared to resistant varieties BB-1 and BB-5.

Hilderbrand *et al.* (1993) reported that the tomato leaves had the capacity to produce volatile compounds like 6-carbon aldehydes and alcohols in leaves that affected the population of *Bemisia (abaci*, with the volatiles produced from crushed leaves having a much greater effect. They concluded that the 6 carbon aldehydes and alcohols may be components which reduced fecundity. These results could be significant for the genetic alteration of plants for improving resistance to aphids.

Liu and Yang (1993) observed varying resistance in different cotton varieties to *Aphis gossypii.* They reported that the increase in concentration of tanin, proline and soluble sugars which resulted in suppression of aphid population..

Chu *et al.* (1995) studied relationship between cotton leaf morphology and whitefly (*Bemisia tabaci)* population densities. They observed that broader leaf varieties had fewer whitefly adult, eggs and nymphs compared to normal leaf varieties. The vascular bundles of underleaf was negatively correlated with whitefly adult, egg and nymphal densities of leaves.

Naveed *et al.* (1995) observed that cotton varieties with low density of hairs and a shorter hair length had a larger population of aphids.

Chandrakar *et al.* (1997) tested the twenty four tomato varieties screened against *Helicorpa armigera* during the spring 1995-96 in Chhattisgarh, varieties Pusa Early Dwarf, Arka Vikas and Pusa Gaurava had more hair on peduncles were less susceptible to the pest damage than those with less hairs on the peduncles. Negative correlation between ascorbic acid content of the fruit and fruit damage was observed.

Ashraf *et al.* (1999) reported that epicuticular wax content and hairness of leaves were responsible for the resistance against white fly *B. tabaci* on cotton.

Nombela *el al.* (2000) screened the two commercial varieties of tomato, Alta and Peto 95, the accession line number LA 716 of *Lycopesicon pennellii* and lines 946 H-006 and 94 GH-033, with different leaf acyl sugar contents against *Bemisia tabaci.* There was no oviposition on LA 716 because of the highest acyl sugar content, while the greatest fecundity and fertility values were observed on the varieties Alfa having no acyl sugar content.

The commercial tomato varieties Motella, VEN 8 and Ronita all of these carry Mi gene resistance to aphid *Macrosiphum euphorbiae* than on the Mi lacking varieties Manimaker, Rio Fuego and Roma. When data of Mi bearing plants were pooled, the mean values for daily infestation and pupal production of *Bemisiatabaci* were significantly lower than those of Mi-lacking plants. This reflected a level of antixenosis and antibiosis based of resistance in commercial tomato and indicate that Mi, or another closely linked gene, might implicated in a partial resistance which was not associated either with the presence of glandular trichomes or their exudates. This findings support the resistance mechanism to whiteflies and aphid in commercial tomato plants.

2.3 Dynamics of major pests of tomato in relation to abiotic parameters:

Lewis (1973) observed that warm sunny dry summers in temperate regions encouraged reproduction and survival of most species of thrips leading on flowering plants until drought caused plants to wither and food become scare. Cloudy wet weather when foliage was often moist discouraged breeding leading to reduction of population.

Gerling and Horowitz (1984) reported that the seasonality of whitefly infestations has been studies extensively *B. tabaci* over winters of low population densities on cultivated and wild plants in warmer localities. In spring when the temperature rises above 14.4°C, egg laying and population growth commences. The population build up and more from crop to crop, from spring potatoes and sunflower to cotton and later to tomatoes.

Bughio *et al.* (1986) conducted the experiments to study the incidence and population of *Empoasca devastans, Thrips tabaci* and *Bemisia tabaci* on cotton varieties. The *Empoasca devastans* populations remained above the economic threshold (one insect/leaf) from the 4th week of May to the end of June. The population of *Thrips tabaci* reached economic thresholds (8-10 thrips/leaf) during the third week of June. The population of *Bemisia tabaci* remained negligible throughout the course of the study and did not reach economic injury level.

Parihar and Singh (1986) studied the larval population of *Helicoverpa armigera* on tomato and losses caused by this pest in the Meerut district of Uttar Pradesh, India in 1983-84 and 1984-85. The larval population was low till the first week of February in both years and increased rapidly. Therefore reaching a peak in the last week of March. In the last week of April the population declined to 4 larvae/ plants. Percentage fruit infestation was low up to the end of February, while the second week of April 50.08 and 83.04 per cent of fruits were infested in 1984 and 1985, respectively. By the second week of May 1.44 per cent of fruits were infested in 1984 and 2.84 per cent in 1985.

Kashyap and Bishnoi (1988) observed the appearance and build up of *Myzus persicae* populations with the abiotic parameters during 1976-85 in Haryana, India. They were reported that the relative humidity 166 + 2.8%) and saturation deficit (2.53 + 0.65 mm of Hg) were found to follow a normal curve for the population build up of *M. persicae.* Aphid population decreased sharply with increase of relative humidity (6.5%) and also with the linear increase in mean temperature. Aphid response pockets with optimum temperature (11-14^{0}C) and relative humidity (68-75%) were clearly demarcated.

Mohan *et al.* (1988) studied the incidence of *Trialeurodes vaporariorum* on tomato in Nilgiris region, Tamil Nadu, India during 1987 and reported that the maximum incidence of *T. vaporariorum* was observed during January to August.

The influence of weather parameters on population dynamics of *Caliothrips indicus* (Bagnall) on pea was studied by Shaw *et al.* (1991) and depicted that the thrips was active from November to June and most active during December-January. Among the meteorological factors only the rainfall was found to have significant negative relationship with its numbers. Clear sunny days appeared to increase the population. Temperature did not appear to be of much importance during of field population of the pest from July to January end.

Bagmare *et al.* (1995) recorded the effect of weather parameters on the populations of *Liriomyza trifolii* on tomato and other hosts, in Jabalpur, Madhya Pradesh, India. Correlation analysis of the variables showed that mean temperature and sunshine hours had a positive correlation with the population of *L. trifolii.* Rainfall and relative humidity had a negative correlation with populations of *L. trifolii.*

Jongdae (1996) reported that the feeding activity of larvae of *Liriomyza trifolii* was greatest at 20°C.

Brewster *et al.* (1997) studied that two peaks of whitefly population were observed on tomato at late September to October.

Men *et al.* (1997) determined the influence of weather on the abundance of *Bemisia tabaci* on sunflower during the *rabi* season 1984-91 in Maharashtra. The peak abundance of *Bemisia tabaci* occurred during December - January of each year. There was a negative correlation between the maximum and minimum temperature, sunshine hours and pest abundance. A non significant positive correlation was found between morning and evening relative humidity and pest abundance.

Abdel *et al.* (1998) observed the population dynamics of *Bemisia tabaci* and their relation with abiotic parameters in tomato, in Egypt during 1995-96. Temperature had a significant effect on both egg and nymphal populations. While relative humidity had no significant effect.

Alicai *et al.* (1999) found the significant differences ($P < 0.05$) in monthly whitefly numbers, overall whitefly populations increased with temperature and decreased with rainfall within a month, peak whitefly populations occurred in the hot dry season but whitefly numbers were generally greatest on crops of 3-4 months old.

Ozawa *et al.* (1999) observed the population growth rate of *Liriomyza trifolii*, on tomato was highest at 25°C, and female fecundity was varied from 15°C to 25°C.

Rongai *et al.* (1999) observed that populations of *Aphis gossypii* increased at maximum temperatures of 30 C. Laboratory tests confirmed that survival of this pest at high temperatures.

Sewity *et al.* (1999) reported the seasonal abundance of the whitefly *Bemisia tabaci* on 16 species of weeds (4 perennial, 9 winter and 3 summer weeds) in Giza, Egypt, during 1993-94. They reported that, *B. tabaci* occurred all years around on the weeds selected for this study reaching its highest abundance during the period from August to November on perennial, winter and summer weeds.

Suenaga *et al.* (1999) investigated the effect of low and high temperatures on the longivity and fecundity of pupae and adults of *Liriomyza trifolii.* Longevity and fecundity of the adults emerging from the pupae exposed to 15 to 30^0C were reduced at 25°C compared with those of the adults emerging from the pupae exposed to 20 or 25°C. The survival rate of the pupae and the adults were more reduced at 30°C than at 25°C.

Xia *et al* (1999) studied the life table parameters of *Aphis gossypii* on cotton at six temperatures (10, 15, 20, 25 and 35 + 0.5°C) in the laboratory. Development was fasted at 30°C with a pre-larva position period. Survival to adults was greatest at 25°C (18%). Fecundity was highest at 25°C.

Materials and Methods

CHAPTER-III

MATERIALS AND METHODS

This chapter deals with the description of the soil, weather conditions, materials used and techniques adopted during the course of investigation. The present study entitled "Relative preference of different tomato varieties/ hybrids by major pest in relation to antixenosis and dynamics of pests population with regards to abiotic parameters" was carried out during spring-summer season of 2001-2002 at the Horticulture Research Farm, Department of Entomology, I.G.A.U., Raipur (C.G.). The experiment was conducted with the collaboration of Department of Horticulture, I.G.A.U., Raipur (C.G.).

3.1 Geographical situation

Raipur is situated in Central-Eastern part of Chhattisgarh and lies between 21^{o}16' North latitude and 18^{o}36' East longitude with an attitude of 289.56 meters above the mean sea level.

3.2 Climate

Raipur falls under the tropical region of India. The climate of Raipur is dry sub-humid to semi-arid with the average annual rainfall of 1000-1350 mm mostly concentrated from middle of June to September with occasional shower in winter. The maximum temperature goes as high as 46 C during the summer months. The meteorological data were recorded at meteorological observatory I.G.A.U. Raipur, which are presented in Table 6.

3.3 Field preparation

The experimental field was prepared to a fine tilth. The layout of the experimental plant was done as per the specification mentioned.

3.4 Experimental details

The experimental trial was conducted with thirteen genotypes in RBD, with three replications against the major insect pests of tomato.

The details of the genotypes and experiments are as under.

Open pollinated	**Hybrid**
1. Pusa Rubi	9. Kuber Geeta
2. S-22	10. Ganpati
3. Punjab Keshri	11. Sadabahar
4. Sanjewani BWT 101	12. Paras Dadi
5. Sun 5715	13. Akash
6. Navodaya	
7. Manimaker	
8. NS 101	

Other details

Crop		Tomato
Variety		Both open pollinated and hybrids
Plot size		2.10 x 2.40 square meter for open pollinated
		2.40 x 3.20 square meter for hybrids
Replication spacing	:	1.0 meter

Plot spacing	50 cm between open pollinated and 1 meter between hybrids
Experimental area	865.20 square meter (21.00 x 41.20)
Date of Nursery sowing	25-11-01
Date of transplanting	6-1-02
Fertilizer recommended	120 N:80 P_2O_5:80 K_2O kg/ha for open pollinated 250 N:200 P_2O_5:150 K_2O kg/ha for hybrids
Interculture operation	15 days after transplanting, 45 days after transplanting and 65 days after transplanting.

Sowing was done in the Easth-West direction with row to row spacing 80 cm for hybrids and 60 cm for open pollinated whereas plant to plant spacing was 60 cm for hybrids and 35 cm for open pollinated. One meter distance between two replication was maintained. Plots were fertilized with recommended dose of fertilizer i.e. 250 kg nitrogen (for hybrids) and 120 kg nitrogen (for open pollinated) in form of urea, 200 kg P_2O_5 (for hybrids) and 80 kg P_2O_5 (for open pollinated) in the form of single super phosphate and 150 kg K_2O (for hybrids) and 80 kg K_2O (for open pollinated) in the form of murate of potash. All dose of phosphorus, potash and 40 per cent dose of urea applied as a basal dose and remaining nitrogen was applied in 2 split doses, i.e. first at 45 days and second at 65 days after transplanting. Flood irrigation was applied at weakly interval. The crop was completely free from insecticidal application.

3.5 Method of recording observation

3.5.1 Fruit borer infestation

Fruit borer, *Helicoverpa armigrea* (Hubner) infestation was recorded at the time of each picking. The healthy and infested fruits were separated and counted. Thus on the basis of per cent infestation level the percentage loss was worked out and it was correlated with leaf area, length-width ratio of leaf and number of trichomes. The final yield of marketable fruit was also calculated as per hectare basis. The formulae followed for recording various observations were as follows.

3.5.1.1 Per cent fruit damage

The per cent fruit damage was worked out with the help of following formula:

$$\text{Per cent fruit damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits (healthy + damaged)}} \times 100$$

3.5.1.2 Weight of damaged fruit

The weight of per cent fruit damage was worked out with the help of following formula:

$$\text{Weight of damaged fruits (\%)} = \frac{\text{Weight of damaged fruits}}{\text{Total weight of fruits (healthy + damaged)}} \times 100$$

3.5.2 Sucking pests

The population of sucking pest like, whitefly, *Bemisia tabaci*, aphid, *Aphis gossypii*, thrips, *Caliothrips indicus* and jassid, *Empoasca devastans* was recorded at ten days intervals.

3.5.3 Mine length and percentage damaged leaves by leaf miner

The length of mines formed by leaf miner was recorded with the help of thread. The thread was spread on mine length starting from the tending point to end point i.e. pupation site and thereafter the full length of thread was spread on measuring scale and thus length of mine was measured it was measured by measuring scale. The length of mine was observed from randomly selected three plants concentrating on upper, middle and lower leaves from each plant. Thus total number of healthy and infested leaves was recorded and percentage damage leaves was worked out by following formula:

$$\text{Percentage of damaged leaves} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves (healthy + damaged)}} \times 100$$

3.5.4 Leaf area

The leaf area was calculated as per the method described by Achnlither (1978). The leaf area was calculated with the help of measuring scale. Measuring scale was spread on whole length and width of leaves (starting of end point) and thereafter these were multiplied with constant factor i.e. 0.9. The leaf area was recorded from randomly selected five plants consisting of upper, middle and lower leaves and as such ten leaves were observed.

3.5.5 Length-width ratio

The length-width ratio was calculated with the help of mathematical calculation. The length of each variety leaves was divided to width of each variety leaves. This was also calculated for upper, middle and lower leaves.

3.5.6 Number of trichomes

The number of trichomes of each variety was recorded with the help of bionocular microscope. One sq cm leaf was cut out form leaf surface randomly, thereafter it was placed under bionocular microscope and counted the number of trichomes. The number of trichomes was recorded from randomly selected three leaves on upper, middle and lower leaves on both surfaces of these leaves.

3.5.7 Statistical analysis

The data obtained were statistically analysed using appropriate transformation wherever needed. The data on population of whitefly, aphid, thrips, jassid and leaf miner were transformed into V x + 0.5 by using square root transformation, whereas, data on percentage were transformed to arcsine. The mean populations of each insect-pests was correlated with leaf area, length-width ratio and number of trichomes on upper, middle and lower leaves of different varieties and over all populations (each observation) of different pests were correlated with the abiotic parameters, like temperature (maximum and minimum), rainfall and relative humidity (morning and evening). However, the regression equation was worked out on significantly correlated values. The differences between open pollinated and hybrid varieties were also worked out applying 't' test.

Experimental Findings

CHAPTER-IV

EXPERIMENTAL FINDINGS

The result of different experiments in the present investigation are briefly depicted objective wise as reported below.

4.1,2 Relative preference of different tomato varieties / hybrids to different pests and biophysical basis of resistance / susceptibility

The findings of the present study revealed that tomato fruit borer, *Helicoverpa armigera*, leaf miner, *Liriomyza trifolii,* white fly, *Bemisia tabaci*, aphid, *Aphis gossypii*, thrips, *Caliothrips indicus* and jassid, *Empoasca devastans* caused loss of varying level to tomato crop throughout the study period. The incidence of *H. armigera* was observed on the basis of percentage damaged fruit and weight of damaged fruit, the incidence of leaf miner was observed on the basis of length of mine formed by leaf miner and percentage affected leaves, whereas, the whitefly, aphid, thrips and jassid incidence was observed on the basis of their populations, the observations taken at ten days intervals on thirteen tomato varieties viz., Pusa Ruby, S-22, Punjab Keshri Sanjeewani BWT 101, Sun 5715, Navodaya, Manimaker, NS 101 (Open pollinated), Kubergeeta, Ganpati, Sadabahar, Paras Dadi and Akash (hybrids). Besides these, the leaf area, length width ratio of leaves and number of trichomes (per square cm) were also recorded.

4.1, 2.1 Relative preference to *H. armigera*

The data on relative preference of tomato varieties are presented in table 1. The results revealed that none of the tomato varieties was found free from damage to *H. armigera* and this phenomena in tomato against *H. armigera* has also been reported earlier (Canerday *et al.,* 1969). The percentage fruit damage varied from 16.29 to 34.77 in different varieties. The least fruit damage (16.29%) was recorded in Manimaker followed by S-22 (17.26%), NS 101 (17.43%) and Paras Dadi (18.86%) with no significant difference among them. Whereas, the percentage damaged fruit on weight basis in different varieties ranged from 13.61 to 28.33, Manimaker had significantly least weight loss (13.61%) followed by Navodaya (13.82%) and NS101 (13.96%). The differences among these varieties were also non significant.

The moderate fruit damage was recorded in Navodaya (23.21%) followed by Kubergeeta (28.17%) and Pusa Ruby (28.31%) based on the number whereas S-22 (15.27 %) as well as Paras Dadi (16.01%) had moderate loss on weight basis. Significantly maximum fruit damage on number basis was recorded on varieties Sanjeewani BWT 101 (34.77%) followed by Sun 5715 (37.73%) and Akash (30.35%), where as the losses on weight basis was maximum in varieties like Sanjeewani BWT 101 (28.33 %) and Punjab Keshri (27.18 %).

There was no significantly differences between open pollinated and hybrid varieties with respect to fruit damage and weight loss.

Table 1 : Relative preference of different tomato varieties/ hybrids by fruit borer, *H. armigera* and biophysical parameters

Variety	No. of damaged fruit per cent	Wt. of damaged fruit per cent	Leaf area (sq. cm)	Length-width ratio	No. of trichomes (per sq. cm)	Marketable yield (q/ha)
Pusa Ruby	29.31 (32.18)	21.35 (26.89)	10.54	2.00:1	141.44	198.01
S-22	17.26 (24.51)	15.27 (22.98)	5.25	1.90:1	239.56	204.56
Punjab Keshri	34.46 (35.84)	27.18 (31.05)	8.45	1.90:1	417.84	203.69
Sanjeewani BWT 101	34.77 (36.07)	28.23 (31.97)	7.19	1.96:1	169.84	67.57
Sun 5715	34.73 (36.06)	25.51 (30.29)	6.95	1.66:1	606.68	112.56
Navodaya	23.21 (28.72)	13.82 (21.52)	6.11	1.90:1	183.12	140.67
Manimaker	16.29 (23.75)	13.61 (21.62)	7.19	1.86:1	643.08	197.42
NS 101	17.43 (24.63)	13.96 (21.93)	5.65	1.85:1	456.44	135.51
Kubergeeta	28.17 (32.01)	19.87 (26.45)	7.62	1.95:1	720.00	100.59
Ganpati	29.37 (32.37)	19.57 (25.91)	10.22	1.96:1	582.72	50.91
Sadabahar	29.04 (32.49)	18.96 (25.75)	6.89	1.89:1	569.76	119.83
Paras Dadi	18.86 (25.70)	16.01 (23.56)	7.89	1.86:1	463.12	93.79
Akash	30.35 (33.35)	24.61 (29.54)	8.76	1.90:1	282.64	83.33
SEm	(2.29)	(2.49)	-	-	-	-
CD (5%)	(6.7)	(7.30)	-	-	-	-

Figures in parentheses are arcsine transform values

Biophysical basis of resistance/susceptibility

Various biophysical characters like leaf area, length width ratio of leaves and number of trichomes per sq. cm. were recorded and these were correlated with dependable variable i.e. percentage fruit damage based on number as well as on weight basis. There was a great variation in the leaf area of different varieties as it ranged from 5.25 sq.cm. in S-22 to 10.54 sq. cm. in Pusa Ruby. There was positive correlation between the leaf area and percentage fruit damage both on number and weight basis but the relation was found to be non significant.

The correlation between the length-width ratio of leaves with fruit borer infestation was found to be positive but non significant.

The other biophysical parameters like number of trichomes also varied greatly in different varieties, the average number of trichomes per sq.cm. ranged from 141.44 in Pusa Ruby to 720.00 in Kubergeeta. The parameter had negative relationship with percentage fruit damage both on number and weight basis but it was found to be non significant.

4.1, 2.2 Relative preference to *Liriomyza trifolii*(on the basis of damaged leaves)

The affected leaves by leaf miner was higher on lower leaves followed by middle and upper leaves. The data on these parameters are presented in (Table 2a and 3). In upper leaves the mean per cent of affected leaves among the tested varieties varied from 4.27 to 16.55 per cent, the variety NS 101 had

Table 2a : Relative preference of different tomato varieties/ hybrids by major pests

Varieties	Mean per cent affected leaves by leaf miner			Mean length formed by leaf miner (cm)			Mean population of whitefly		
	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
Pusa Ruby	14.58	29.81	54.68	1.53	2.55	3.18	5.37	4.11	1.17
	(22.34)	(33.07)	(47.67)	(1.42)	(1.77)	(1.92)	(2.38)	(2.14)	(1.27)
S-22	6.77	21.56	36.78	0.60	1.74	2.55	6.33	2.71	1.00
	(14.96)	(27.64)	(37.23)	(1.04)	(1.50)	(1.74)	(2.60)	(2.04)	(1.20)
Punjab Keshri	4.44	22.36	46.27	0.77	2.23	3.04	5.75	4.62	1.00
	(11.94)	(28.21)	(42.84)	(1.12)	(1.65)	(1.96)	(2.49)	(2.86)	(1.21)
Sanjeewani BWT 101	14.38	30.15	50.14	1.82	2.19	3.01	2.70	1.86	0.89
	(22.26)	(33.29)	(45.06)	(1.52)	(1.81)	(1.87)	(1.78)	(1.53)	(1.17)
Sun 5715	7.88	25.46	43.51	0.58	2.14	2.89	2.95	2.18	0.89
	(16.24)	(30.48)	(41.25)	(1.04)	(1.62)	(1.84)	(1.85)	(1.62)	(1.16)
Navodaya	13.38	30.04	48.38	1.47	2.35	3.28	3.33	2.28	1.17
	(21.38)	(33.08)	(44.05)	(1.40)	(1.68)	(1.94)	(1.96)	(1.67)	(1.27)
Manimaker	6.64	23.73	44.98	0.85	2.17	3.17	6.78	4.18	0.72
	(14.67)	(29.12)	(42.10)	(1.16)	(1.63)	(1.92)	(2.69)	(2.16)	(1.10)
NS 101	4.27	20.94	43.16	0.44	1.62	3.02	2.62	2.13	0.67
	(11.42)	(27.22)	(41.04)	(0.97)	(1.46)	(1.87)	(1.76)	(1.62)	(1.08)
Kubergeeta	13.01	29.78	45.33	1.12	2.36	3.09	5.99	3.95	1.99
	(21.06)	(33.05)	(42.30)	(1.27)	(1.69)	(2.03)	(2.54)	(2.11)	(1.05)
Ganpati	16.55	33.56	52.89	1.68	2.70	3.65	5.74	3.76	1.67
	(23.99)	(35.36)	(42.79)	(1.48)	(1.78)	(1.92)	(2.49)	(2.05)	(1.44)
Sadabahar	12.02	31.28	54.31	1.26	2.28	3.20	3.12	3.18	1.22
	(19.71)	(33.96)	(47.45)	(1.32)	(1.66)	(1.92)	(1.90)	(1.91)	(1.30)
Paras Dadi	11.69	30.70	52.63	0.99	2.30	3.35	2.62	2.47	0.94
	(19.97)	(33.60)	(46.49)	(1.22)	(1.67)	(1.96)	(1.75)	(1.69)	(1.17)
Akash	12.02	26.78	50.31	0.95	2.15	2.78	5.62	4.18	0.72
	(17.35)	(31.12)	(45.16)	(1.20)	(1.63)	(1.81)	(2.47)	(2.12)	(1.10)
SEm	1.06	1.15	1.57	0.063	0.076	0.057	0.09	0.12	0.12
CD (5%)	(3.10)	(3.34)	(4.59)	(0.91)	NS	NS	(0.28)	(0.36)	NS

Note: Percent effected leaves are transformed into arcsine and other figures are transformed into $\sqrt{n+0.5}$ are given in parentheses; NS = Non significant

Table 2b : Relative preference of different tomato varieties/ hybrids by major pests

Varieties	Mean population of aphid (per plant)			Mean population of thrips (per plant)			Mean population of Jassid (per plant)		
	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
Pusa Ruby	5.05	4.71	1.75	2.58	2.36	2.11	1.98	1.56	1.63
	(2.34)	(2.27)	(1.42)	(1.74)	(1.69)	(1.59)	(1.57)	(1.42)	(1.39)
S-22	5.00	5.11	1.70	1.42	2.24	1.71	1.91	1.39	0.81
	(2.34)	(2.36)	(1.28)	(1.71)	(1.65)	(1.48)	(1.55)	(1.37)	(1.15)
Punjab Keshri	4.16	3.89	1.67	2.11	2.18	1.62	1.78	1.27	0.79
	(2.15)	(2.09)	(1.46)	(1.61)	(1.63)	(1.44)	(1.50)	(1.33)	(1.13)
Sanjeewani BWT 101	4.94	4.22	1.58	2.11	2.23	1.82	1.93	1.36	0.79
	(2.33)	(2.17)	(1.36)	(1.61)	(1.68)	(1.52)	(1.55)	(1.36)	(1.14)
Sun 5715	1.77	2.55	1.17	2.06	2.08	1.49	1.80	1.23	0.65
	(1.51)	(1.73)	(1.27)	(1.56)	(1.61)	(1.41)	(1.51)	(1.31)	(1.07)
Navodaya	4.11	4.27	2.00	2.46	2.36	1.69	1.77	1.43	0.81
	(2.14)	(2.18)	(1.58)	(1.71)	(1.69)	(1.45)	(1.51)	(1.38)	(1.14)
Manimaker	2.16	2.44	1.33	2.02	1.89	1.49	1.65	1.32	0.79
	(1.63)	(1.70)	(1.35)	(1.58)	(1.54)	(1.40)	(1.46)	(1.34)	(1.13)
NS 101	2.55	2.77	1.17	1.51	1.84	1.31	1.63	1.08	0.68
	(1.73)	(1.81)	(1.27)	(1.56)	(1.52)	(1.31)	(1.45)	(1.26)	(1.08)
Kubergeeta	5.27	2.83	2.50	2.82	2.78	2.36	1.84	1.41	0.95
	(2.39)	(2.08)	(1.67)	(1.80)	(1.81)	(1.67)	(1.52)	(1.38)	(1.20)
Ganpati	2.16	2.88	1.08	2.78	2.56	2.26	1.78	1.37	0.91
	(1.62)	(1.83)	(1.25)	(1.80)	(1.74)	(1.64)	(1.50)	(1.37)	(1.18)
Sadabahar	6.22	5.11	2.33	2.51	2.53	1.98	1.71	1.35	0.76
	(2.58)	(2.35)	(1.67)	(1.74)	(1.74)	(1.56)	(1.48)	(1.35)	(1.12)
Paras Dadi	2.94	3.22	1.33	2.24	2.51	1.91	1.75	1.17	0.69
	(1.85)	(1.92)	(1.32)	(1.65)	(1.63)	(1.55)	(1.50)	(1.29)	(1.09)
Akash	4.95	4.99	1.42	2.20	1.91	1.58	1.71	1.09	0.59
	(2.30)	(2.34)	(1.32)	(1.64)	(1.53)	(1.44)	(1.48)	(1.26)	(1.03)
SEm	0.12	0.10	0.19	0.11	0.08	0.10	0.056	0.045	0.093
CD (5%)	(0.35)	(0.30)	NS	NS	NS	NS	NS	NS	NS

Note: Percent effected leaves are transformed into arcsine and other figures are transformed into $\sqrt{n+0.5}$ are given in parentheses

Table 3 : Biophysical parameters of different varieties/ hybrids of tomato

Varieties	Leaf area (sq. cm.)			Length:width ratio			No. of trichomes (per sq. cm.)		
	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
Pusa Ruby	8.75	13.68	9.68	2.08:1	2.01:1	1.92:1	785.36	762.64	745.40
S-22	3.71	7.06	5.24	2.04:1	1.85:1	1.84:1	1100.00	859.16	974.68
Punjab Keshri	5.16	10.73	10.05	2.16:1	1.79:1	1.86:1	852.00	1041.32	784.00
Sanjeewani BWT 101	2.54	7.84	9.04	2.21:1	2.05:1	1.77:1	917.32	1149.32	1056.68
Sun 5715	4.65	7.26	6.30	1.92:1	1.83:1	1.77:1	1368.00	1600.00	1578.68
Navodaya	5.46	11.80	11.94	2.24:1	1.84:1	1.78:1	1072.00	1020.00	1101.32
Manimaker	5.28	9.07	7.46	1.98:1	1.92:1	1.71:1	1573.32	1621.32	1832.00
NS101	3.53	6.33	7.40	2.06:1	1.87:1	1.70:1	2032.00	1989.32	1880.00
Kubergeeta	6.75	9.25	6.85	2.06:1	1.97:1	1.85:1	1040.00	1061.36	993.32
Ganpati	8.35	10.77	11.63	1.92:1	1.87:1	1.55:1	2018.68	1742.64	1780.00
Sadabahar	4.71	8.90	7.30	2.23:1	1.85:1	1.71:1	1110.68	1156.00	1174.64
Paras Dadi	5.83	9.46	9.00	2.07:1	1.76:1	1.87:1	1980.00	1338.64	1576.00
Akash	6.11	10.08	10.56	2.03:1	1.89:1	1.82:1	956.00	1169.00	909.00

least damaged leaf (4.27%) followed by Punjab Keshri (4.44%), Manimaker (6.64%) and S-22 (6.77%) where as remaining varieties received less infestation. The differences among these varieties were non significant. Significantly maximum per cent of affected leaves were recorded in Ganapati (16.55%) followed by Pusa Ruby (14.50%) and Sanjeewani BWT-101 (14.38%), with no significant differences among them.

In middle leaves the least per cent of affected leaves were recorded in NS101 (20.94%) followed by S-22 (21.56%) and Punjab Keshri (22.36%) and they were at par to each other. The highest per cent of affected leaves were observed on Ganpati (33.56%) and Sadabahar (31.28%) with no significant differences between them.

In case of lower leaves the mean per cent of affected leaves was found to be significant and it ranged from 36.78 per cent in S-22 to 54.68 per cent in Pusa Ruby. The maximum per cent of affected leaves were observed in variety Pusa Ruby and it was at par with Sadabahar (54.31%), Ganpati (52.89%) and Paras Dadi (52.63%). Significantly lowest per cent affected leaves was observed in variety S-22.

The differences on the incidence of leaf miner between open pollinated and hybrid varieties was significant with middle leaves (t = 2.60) and non significant with upper and lower leaves.

Biophysical basis of resistance/susceptibility

The correlation between leaf area of upper and middle leaves and per cent affected leaves was positive but non significant. However, the leaf area of lower leaves was positively correlated with the per cent affected leaves the "r" value being 0.627. A linear relationship between leaf area and per cent affected leaves was observed. The regression equation (Fig. 1) being $Y_2 = 34.287 + 1.579 X_3$; whereas X_3 is the leaf area and Y_2 is per cent affected leaves by leaf miner. This indicates that with every one square cm increase in leaf area there will be an increase in 1.579 per cent affected leaves.

There was positive relationship between the length width ratio of all three leaves and per cent affected leaves but the relation was found to be non significant.

There was negative relationship between number of trichomes of upper and lower leaves of different varieties with per cent affected leaves in upper as well as lower leaves but the relationship was found to be non significant. However, the number of trichomes in middle leaves was negatively correlated with the per cent affected leaves, the "r" value being -0.684. The regression equation (Fig. 2) being $Y_1 = 29.63 - 0.0018 X_7$; whereas, Y_1 is the per cent affected leaves by leaf miner and X_7 is the number of trichomes per sq. cm. This indicates that every one increase in number of trichomes there will be decrease in leaf miner infestation 0.0018 per cent.

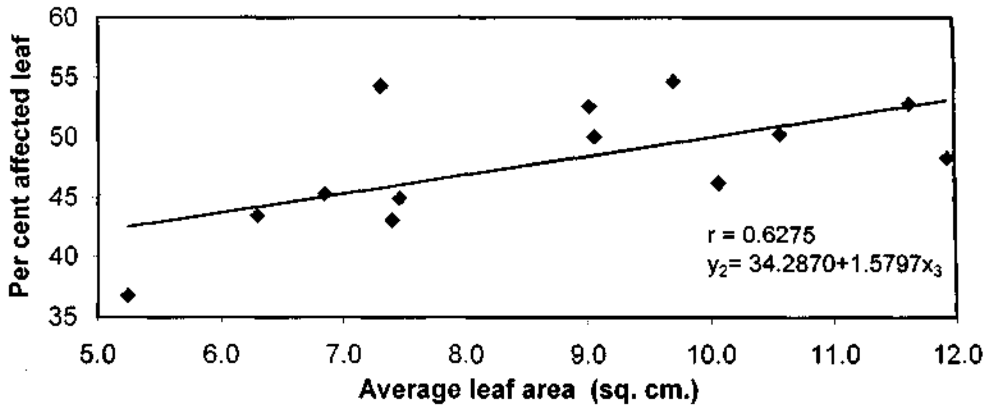

Fig. 1 : Regression of percentage affected leaf on leaf area of lower leaf

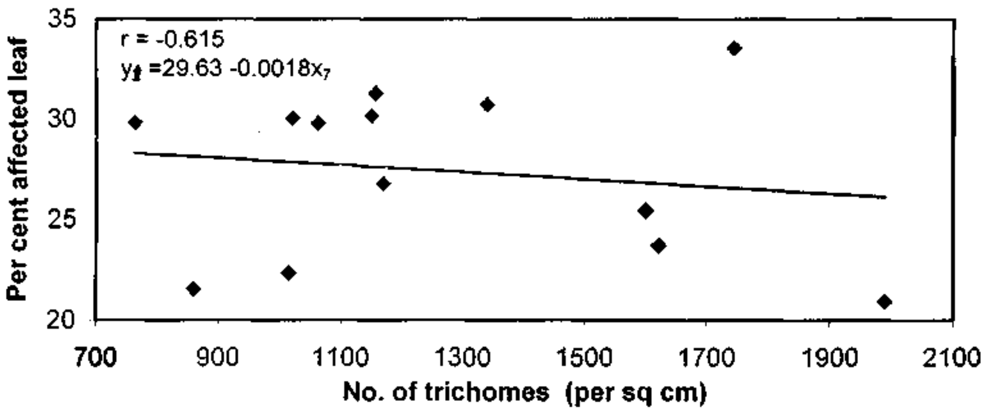

Fig. 2. : Regression of percentage affected leaf by leaf miner on number of trichomes on middle leaf

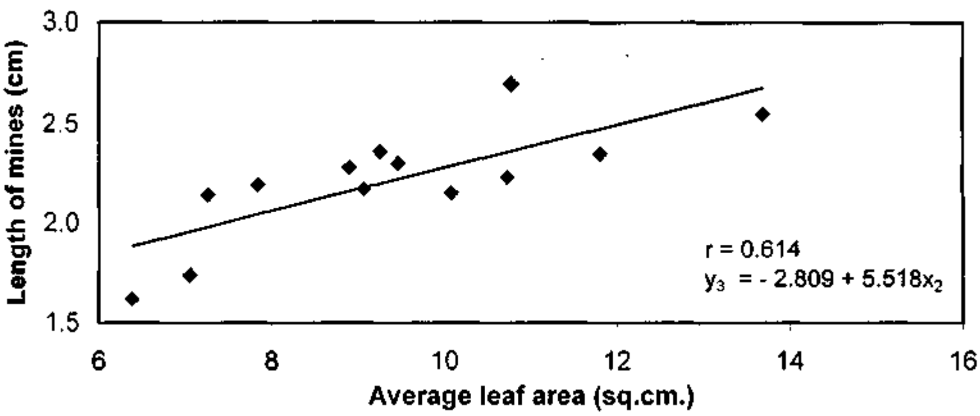

Fig. 3 : Regression of length of mines on leaf area of middle leaf

4.1, 2.3 Relative preference to *Liriomyza trifolii*(on the basis of length of mines)

The data presented in Table 2a and 3, revealed that, there was no difference in length of mines in upper, middle and lower leaves of different varieties. All the varieties had the infestation of leaf miner with varying level throughout the period of investigation. In upper leaves, the average length of mines among the tested varieties varied from 0.44 cm to 1.82 cm. The varieties with minimum length of mine were NS 101 (0.44 cm) followed by Sun 5715 (0.58 cm) and S-22 (0.60 cm). However, differences among these varieties were found to be non significant. Significantly maximum length of mines was recorded in Sanjeewani BWT 101 (1.82 cm) and Ganpati (1.68 cm) the differences among them were non significant.

In middle leaves the least average length of mines was recorded in varieties NS 101 (1.62 cm) and S-22 (1.71 cm) whereas the highest length of mines was recorded in variety Ganpati (2.70 cm) followed by Pusa Ruby (2.55 cm) with no significant difference between them.

In case of lower leaves the average length of mines among the tested varieties ranged from 2.55 cm to 3.65 cm. The variety NS-101 (2.55 cm) had least length of mines followed by Sun 5715 (2.89 cm) and Akash (2.78 cm) as comparision to other varieties. The variety Ganpati had highest length of mines (3.65 cm) followed by Paras Dadi (3.35 cm), with no significant difference between them.

The differences in mine length in all the open pollinated and hybrid varieties were found to be non significant.

Biophysical basis of resistance/susceptibility

There was positive relationship between average leaf area and length of mines in upper leaves but correlation coefficient was found to be non significant. The leaf area in middle leaves of different varieties was positively correlated with length of mines (r = 0.614). A linear relationship (Fig. 3) between leaf area and average length of mines was observed, the regression equation being $Y_3 = -2.809 + 5.518\ X2$, whereas Y_3 is the length of mines and X2 is the leaf area. This indicates that with every one sq. cm. increase in leaf area there will be increase in length of mine by 5.518 cm. Similarly the linear and positive relationship was observed between leaf area and length of mines in lower leaves (r = 0.581), the regression equation being $Y_4 = 2.435 + 0.076\ \mathbf{X_3}$**,** whereas Y_4 is the length of mines and X_3 is the leaf area. This indicates that with every one sq. cm. increase in leaf area there will be increase of 0.076 cm. length of mines (Fig. 4).

There was positive relationship between the length width ratio of all three leaves and length of mines in all three leaves but the data were found to be non significant.

There was a great variation in the number of trichomes in leaves of the different varieties. The average number of trichomes per square cm. ranged from 785 in Pusa Ruby to 2032 in NS 101 in upper leaves where as number of

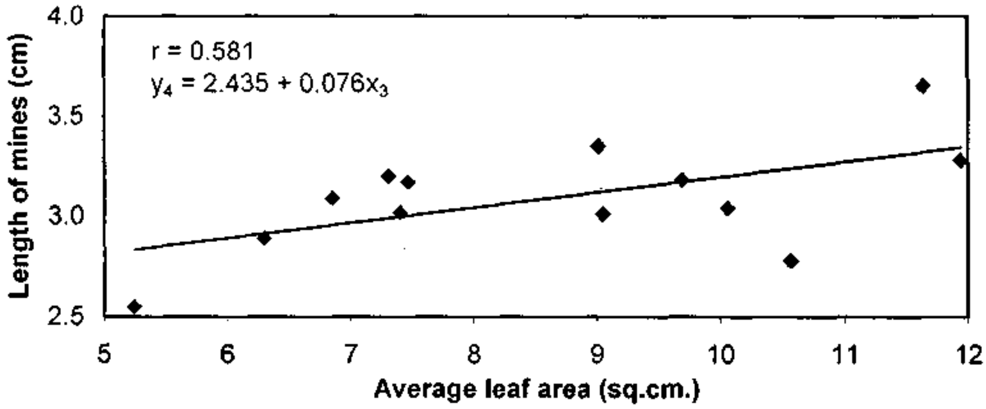

Fig. 4 : Regression of length of mines on leaf area of lower leaf

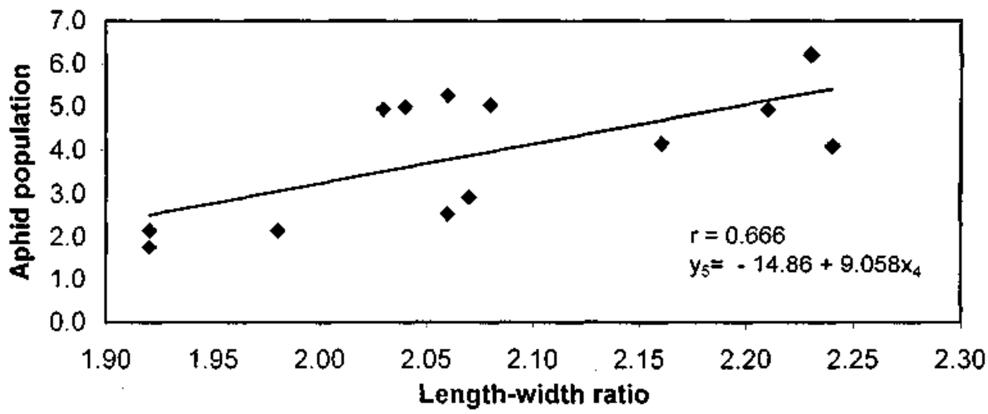

Fig. 5. : Regression of aphid population on length-width ratio of upper leaf

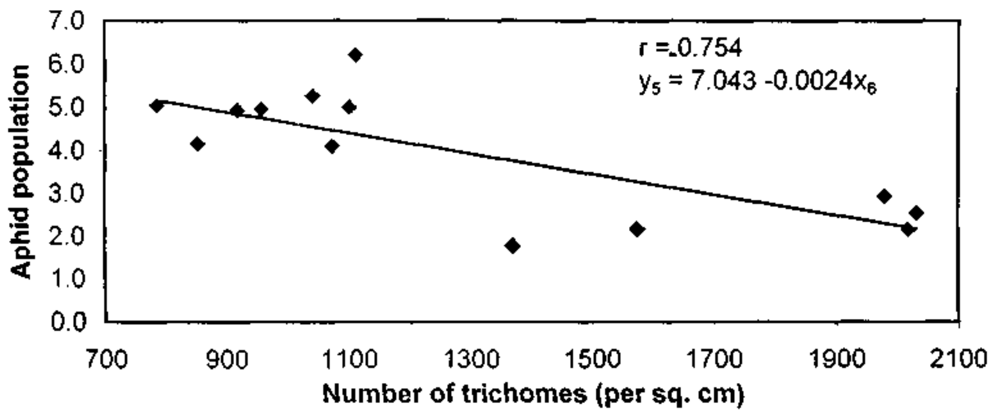

Fig. 6 : Regression of aphid population on number of trichomes on upper leaf

trichomes 762.64 in Pusa Ruby to 1989.32 in NS 101 in middle leaves and 745.40 in Pusa Ruby to 1880 in NS 101 in lower leaves, however it was non significant but negatively correlated with length of mines at upper, middle and lower leaves.

4.1, 2.4 Relative preference to *Bemisia tabaci*

The mean population of whitefly on different varieties recorded at upper, middle and lower leaves are presented in Table 2a and 3. In upper leaves, the mean population of whitefly on different varieties ranged from 2.62 to 6.78 per leaf. The varieties NS 101 and Paras Dadi had 2.62 whitefly population per plant followed by Sanjeewani BWT 101 (2.70) and Sun 5715(2.95) compared to other varieties. Maximum population of whitefly was recorded in Manimaker (6.78) and S-22 (6.33), with significant difference between them.

In middle leaves, the minimum population of whitefly per plant was observed in Sanjeevani BWT 101 (1.86) followed by NS 101 (2.13), Sun 5715 (2.18) and Navodaya (2.28) with no significant difference among them. Maximum population of whitefly was observed in variety Akash (4.18) and Pusa Ruby (4.11) with no significant difference between them.

In case of lower leaves the population of whitefly among the tested varieties varied from 0.67 in NS 101 to 1.99 in Kubergeeta. The minimum population of whitefly was observed in variety NS 101. However, it did not differ significantly from variety Manimaker (0.72). The maximum population of whitefly was observed in Kubergeeta it differ significantly from NS 101 and Manimaker.

The differences in whitefly population in all the open pollinated and hybrid varieties were found to be non significant.

Biophysical basis of resistance/susceptibility

There was a great variation in the leaf area of different varieties and it varied from 2.54 sq.cm. to 8.75 sq.cm., 6.33 sq.cm to 13.68 sq.cm. and 5.24 sq.cm to 11.98 sq.cm. respectively in upper, middle and lower. The correlation of leaf area of upper, middle and lower portion with whitefly population was found to be positive but non significant.

There was positive relationship between the length-width ratio of upper leaves with white fly population, but negative relation with length-width ratio of leaves belong to middle and lower leaves and whitefly population was observed. The level of significance was found to be non significant.

There was a great variation in the number of trichomes on leaves of different varieties. The average number of trichomes per sq.cm ranged from 785 in Pusa Ruby to 2032 in NS 101 in upper leaves whereas the number in middle and lower leaves varied respectively from 762.64 in Pusa Ruby to 1989.32 in NS 101 and 745.40 in Pusa Ruby to 1880 in NS 101.

4.1, 2.5. Relative preference to *Aphis gossypii*

The mean population of aphid on different varieties recorded at upper, middle and lower leaves are presented in Table 2b and 3. In upper leaves the mean population of aphid per plant varied from 1.77 to 6.22. Minimum population was recorded in varieties like Sun 5715 (1.77), Manimaker (2.16), Ganpati (2.16) and NS 101 (2.55) with no significant differences among them. Significantly maximum population of aphid was recorded in Sadabahar (6.22) followed by Pusa Ruby (5.05) and S-22 (5.00) with no significant different among them.

In middle leaves minimum population of aphid was recorded in Manimaker (2.44) followed by Sun 5715 (2.55) and NS 101 (2.77), with no significant difference among them, whereas maximum population of aphid was recorded in S-22 (5.11), Paras Dadi (5.11) and Akash (4.99) without significant difference among them.

In case of lower leaves, the population of aphid varied from 1.08 in Ganpati to 2.50 in Kubergeeta. The maximum population of aphid was recorded in Kubergeeta, however, it did not differ significantly from Sadabahar (2.33). The minimum population of aphid was observed in variety Ganpati, which differ significantly from Kubergeeta and Sadabahar.

The differences in aphid population in all the open pollinated and hybrid varieties were found to be non significant.

Biophysical basis of resistance/susceptibility

There was a great variation in the leaf area of different varieties and it ranged from 2.54 sq. cm. in Sanjeewani BWT 101 to 8.75 sq.cm. in Pusa Ruby in upper leaves, whereas, in middle and lower leaves it respectively varied from

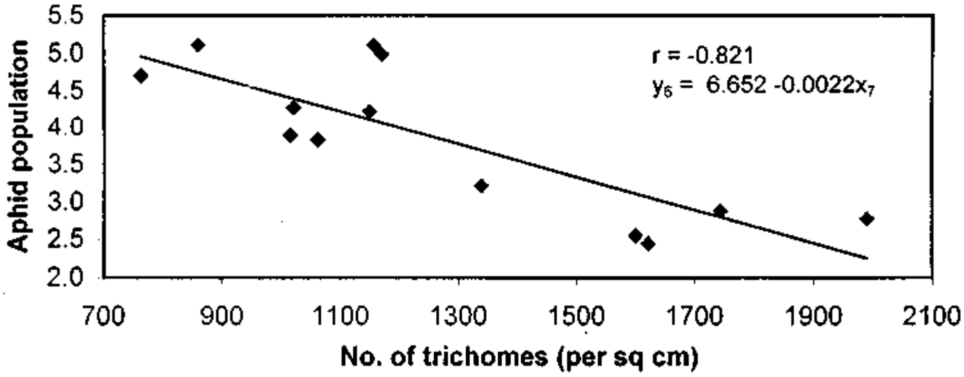

Fig. 7 : Regression of aphid population on number of trichomes on middle leaf

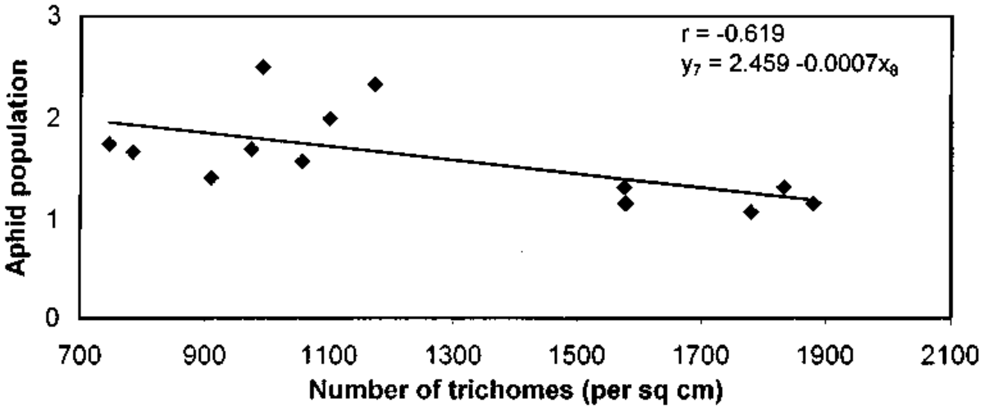

Fig. 8. : Regression of aphid population on number of trichomes on lower leaf

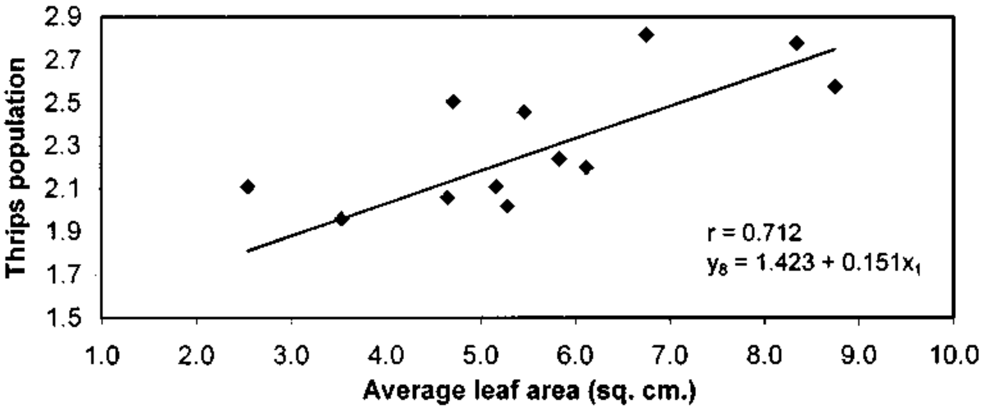

Fig. 9 : Regression of thrips population on leaf area of upper leaf

6.33 sq. cm. in NS 101 to 13.68 sq.cm. in Pusa Ruby and 5.24 sq. cm. in S-22 to 11.94 sq.cm. in Navodaya. The correlation of leaf area of upper and lower leaves was found to be negative with aphid population whereas, the correlation of leaf area of middle leaves with aphid population was found to be positive but non significant.

The length-width ratio of all leaves of different varieties had a positive and linear relationship with the mean population of aphid, the “r” value being 0.666 (Fig. 5). The regression equation being Y_5 = 14.868 + 9.058 X4; where X4 is the length-width ratio of leaves and Y_5 is the mean population of aphid per plant. This indicates that with every one unit increase in the length-width ratio there will be increase in aphid population by 9.0581 per plant, whereas such correlation was not observed in middle and lower leaves.

The number of trichomes in leaves was a negatively correlated with the mean population of aphid in upper leaves, the "r" value being -0.754, the regression equation (Fig.6) being $Y_5 = 7.0438 - 0.0024 X_6$; where X_6 is the number of trichomes on leaves and Y_5 is the mean population of aphid per plant. This indicates that with every one increase in number of trichomes of leaves there will be decrease in 0.0024 aphid per plant. The number of trichomes on middle leaves was also negatively correlated with the mean population of aphid in middle leaves, the "r" value being -0.8216, the regression equation (Fig.7) being $Y_6 = 6.652-0.0022 X_7$; where Y_6 is the mean population of aphid and X_7 is the number of trichomes in per sq. cm. on leaves.

This indicates that with every one increase in number of trichomes on leaves there will be decrease in 0.0022 aphid per plant. Similarly the number of trichomes on lower leaves was also negatively correlated with the mean population of aphid in lower leaves, the "r" value being -0.6192, the regression equation (Fig. 8) being Y_7 = 2.459 - 0.0007Xg; where, Y_7 is the mean population of aphid and X_8 is the number of trichomes on leaves. This indicates that with every one increase in number of trichome of leaves there will be decrease in 0.0007 aphid per plant.

4.1, 2.6 Relative preference to *Caliothrips indicus*

The mean population of thrips on different varieties recorded at upper, middle and lower leaves, are presented in Table 2b and 3. In upper leaves the mean population of thrips varied from 1.42 to 2.82, variety S-22 (1.42) had minimum thrips population followed by NS 101 (1.51) with no significant difference between them. Maximum population of thrips was recorded in Kubergeeta (2.82) and Ganpati (2.78) with non significant difference between them.

In middle leaves the least population of thrips was recorded in NS 101 (1.84) followed by Manimaker (1.89) with no significant difference between them. Maximum population of thrips was recorded in Kubergeeta (2.38) followed by Ganpati (2.56) with non significant differences between them.

In case of lower leaves the population of thrips among the tested varieties varied from 1.31 in NS 101 to 2.36 in Kubergeeta. The maximum population of thrips was observed in Kubergeeta, however, it did not differ significantly from Ganpati (2.26). The minimum population of thrips was observed in variety NS 101 and it differ significantly from Kubergeeta and Ganpati.

There was significantly difference between open pollinated and hybrids of upper leaves (t = 2.23) and non significant in middle and lower leaves.

Biophysical basis of resistance/susceptibility

The leaf area of different varieties in upper leaves was positively correlated with the mean population of thrips in upper leaves, the "r" value being 0.712, the regression equation being Yg = 1.423 + 0.151 X_1; (Fig. 9) where, Yg is the mean population of thrips and X_1 is the leaf area. This indicates that with every one sq. cm. increase in leaf area there will be increase in population of thrips by 0.1519. The correlation of leaf area of middle and lower leaves with thrips population was found to be non-significant.

There was non significant but negative relationship between the number of trichomes in per sq.cm. in upper and middle leaves with thrips population. The number of trichomes of lower leaves was negatively correlated with the mean population of thrips, the "r" value being -0.655, the regression equation (Fig. 10) being Y_9 = 2.43-0.0005 X_8; where, Y_9 is the mean population of thrips and Xg is the number of trichomes per sq. cm. of leaves. This indicates that with every one sq. cm. increase in number of trichomes of leaves there will be decrease in 0.005 thrip per plant.

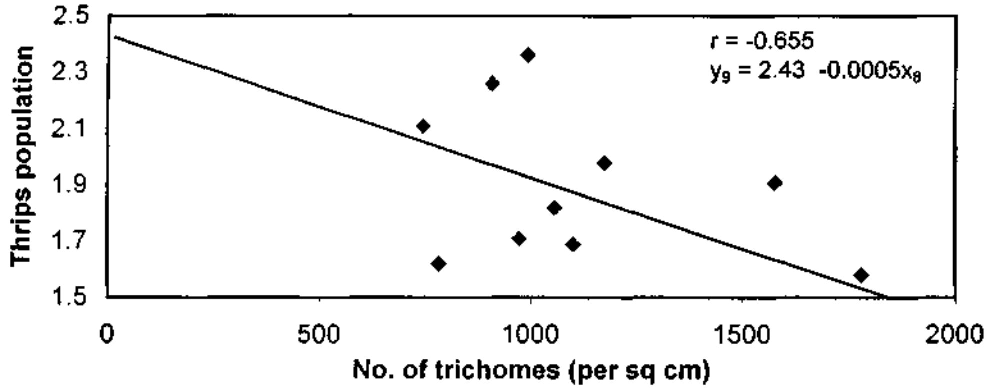

Fig. 10 : Regression of thrips population on number of trichomes of lower leaf

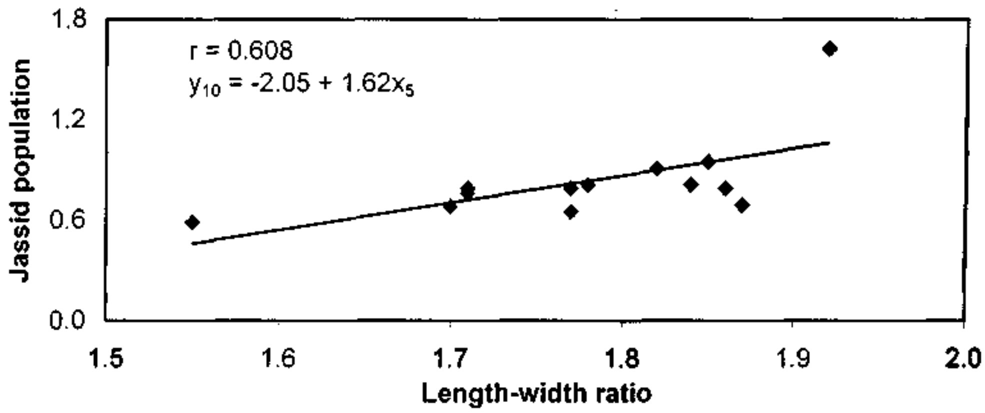

Fig. 11. : Regression of jassid population on length-width ratio of lower leaf

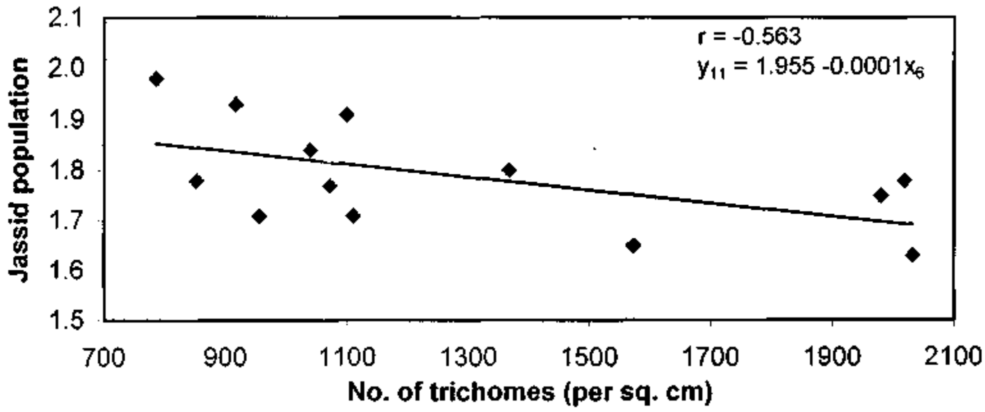

Fig. 12 : Regression of jassid population on number of trichomes of upper leaf

4.1, 2.7 Relative preference to *Empoasca devastans*

The mean population of jassid was recorded at upper, middle and lower leaves of different varieties and are presented in Table 2b and 3. In upper leaves the mean population of jassid among the tested varieties ranged from 1.63 in NS 101 to 1.98 in Pusa Ruby. The differences among these varieties were found to be non significant.

In middle leaves the mean population of jassid ranged from 1.09 in Akash to 1.56 in Pusa Ruby. The differences among these varieties were found to be non significant.

In case of lower leaves the mean population of jassid among the tested varieties ranged from 0.59 in Akash to 1.63 in Pusa Ruby. The differences among these varieties were non significant.

The differences in jassid population in all the open pollinated and hyrbid varieties were also found to be non significant.

Biophysical basis of resistance/susceptibility

The correlation between the leaf area of upper leaf with jassid population was positive but non significant whereas, the correlation between the leaf area of middle and lower leaf with jassid population was negative and non significant.

The correlations between length width ratio of upper leaves and middle leaves were found to be non significant whereas, the length-width ratio of

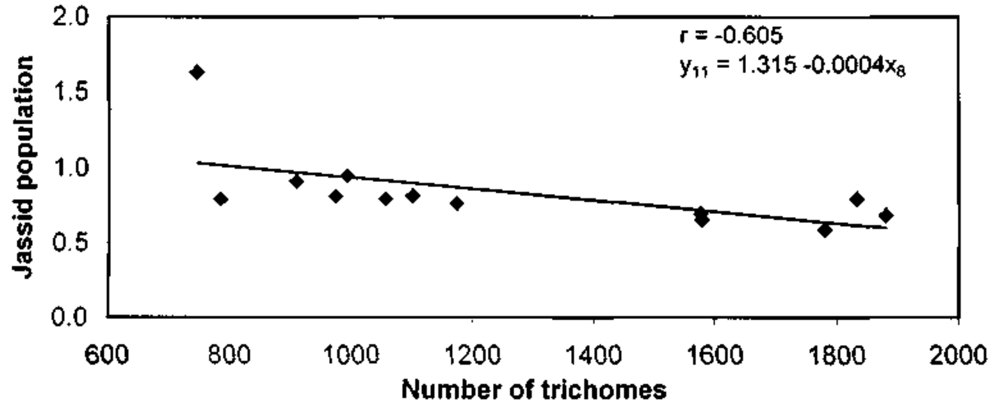

Fig. 13. : Regression of jassid population on number of trichomes on lower leaf

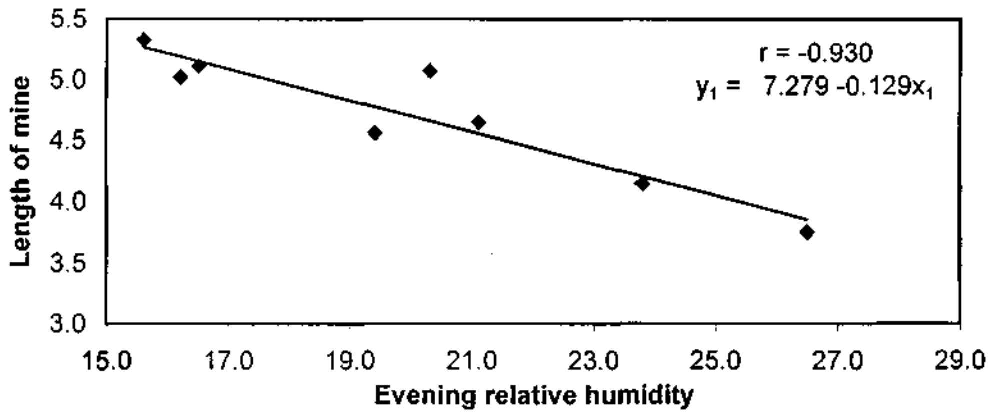

Fig. 14. : Regression of length of mines on evening relative humidity

lower leaves of different varieties had a positive correlation with the mean population ofjassid, the "r" value being 0.608, the regression equation (Fig. 11) being $Y_{10} = 2.05 + 1.62 X_5$; where, X_5 is the length - width ratio of leaves and Y_{10} is the mean population of jassid. This indicates that with every one unit increase in the length - width ratio there will be increase in jassid population by 1.62.

The number of trichomes of upper leaves was negatively correlated with the mean population of jassid, the "r" value being -0.563, the regression equation (Fig. 12) being $Y_{11} = 1.955-0.0001 X_6$; where, X_6 is the number of trichomes in upper leaves and Y_{11} is the mean population of jassid. This indicates that with every one sq.cm. increase in number of trichomes of leaves there will be decreased in 0.0001 jassid population. The relationship between number of trichomes, and middle leaves with jassid population was found to be non significant. The number of trichomes on lower leaves was negatively correlated with mean population of jassid, the "r" value being -0.605, the regression equation (Fig. 13) being $Y_{11} = 1.315 - 0.0004 Xg$; where, Y_{11} is the mean population of jassid and Xg is the number of trichomes. This indicates that with every one increase in number of trichomes there will be decrease jassid population 0.0004 number.

Yield

The marketable yield of tomato varied from 67.57 q/ha in Sanjeewani BWT 101 to 204.56 q/ha in S-22 among pollinated varieties whereas the yield level in hybrid tomato varied from 50.91 q/ha in Ganpati to 119.83 q/ha in Sadabahar.

There was great variation in the yield level in different varieties and in hybrids. The marketable yield varied from 50.91 q/ha to 204.56 q/ha. This variation in yield parameter was mainly due to potential of varieties/ hybrids and the resistance/ susceptibility characters. The variety S-22, Manimaker and NS 101 were found to be good yielder and fairly resistant to all the pest. Among the varieties NS 101 was found to be resistant to all the pest with fairly good yielder. The resistant characters in NS 101 might be due to some biophysical characters which needs detail study.

4.3 Dynamics of Major pests of tomato in relation to abiotic parameters

Influence of different weather parameters viz. temperature (maximum, minimum) rainfall and relative humidity (morning, evening) on the seasonal incidence of different pest (fruit borer, leaf miner, whitefly, aphid, thrips and jassid) of tomato was observed and are presented in Table 4 to 6 and Fig. 16 .

4.3.1 Population dynamics of *Helicoverpa armigera* in relation to abiotic parameters

The population of *Helicoverpa armigera* was observed on the basis of damaged fruit per cent from March to May, 2002 (Table 4 and Fig. 15).

Effect of maximum temperature

The association between maximum temperature and mean percentage damaged fruit was found to be positive but non significant. However, three

Table 4 : Meteorological observations and damaged fruit by *H. armigera* during March-May-2002

S. No.	Date and Month	Mean percentage fruit damage	Mean temperature		Total rainfall (mm)	Mean relative humidity (%)	
			Maximum	Minimum		Morning	Evening
1	March 18-27	9.46	36.55	18.60	0.00	62.40	18.44
2	March-April 28-06	10.28	38.01	20.74	0.00	73.20	23.80
3	April 07-15	13.43	39.24	22.86	0.00	55.67	17.33
4	April 16-22	28.12	42.64	26.84	0.00	41.43	14.71
5	April 23-29	34.40	42.36	24.97	3.00	46.28	15.57
6	April-May 30-06	6.67	42.27	26.54	2.50	47.00	20.28

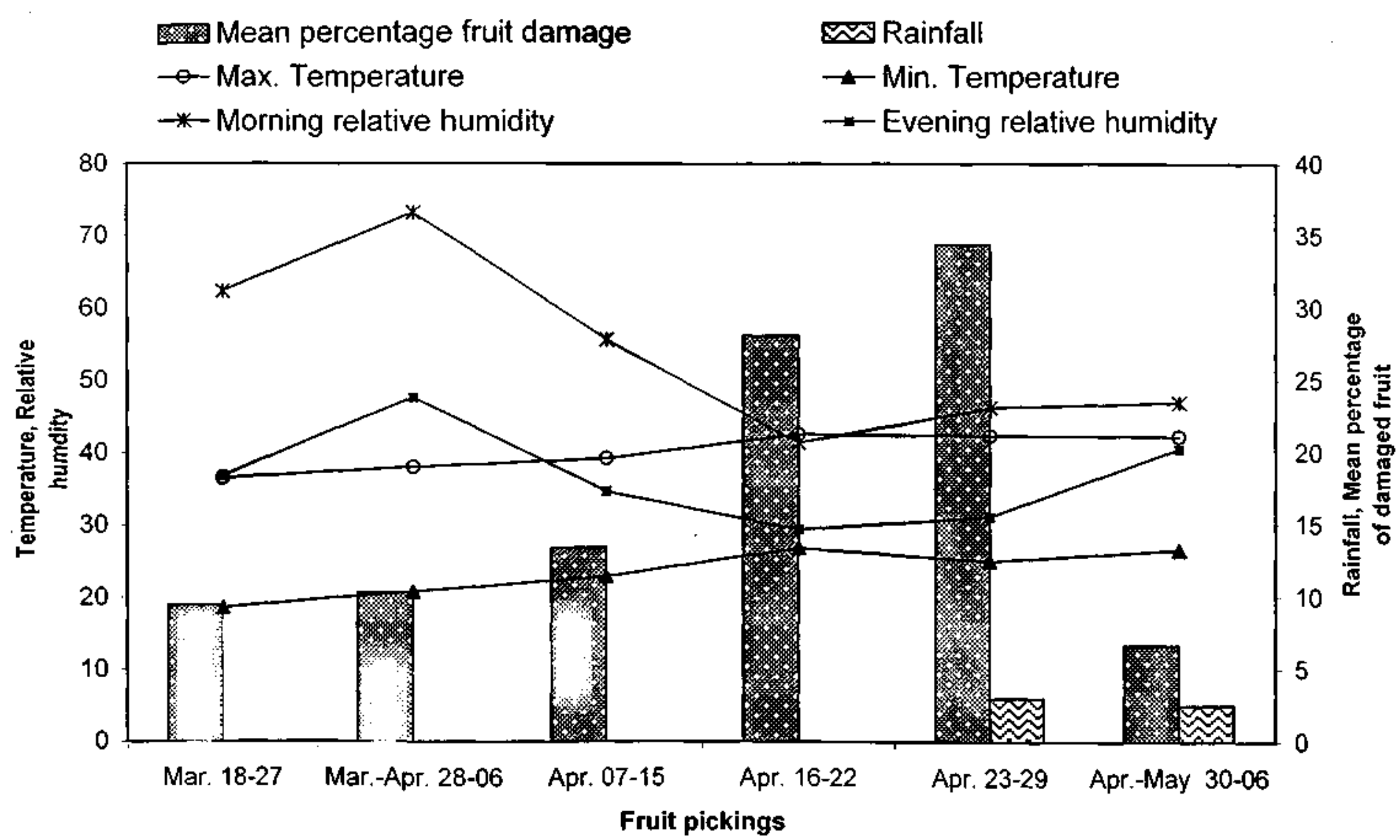

Fig 15 : Season incidence of *H. armigera* alongwith weather parameters

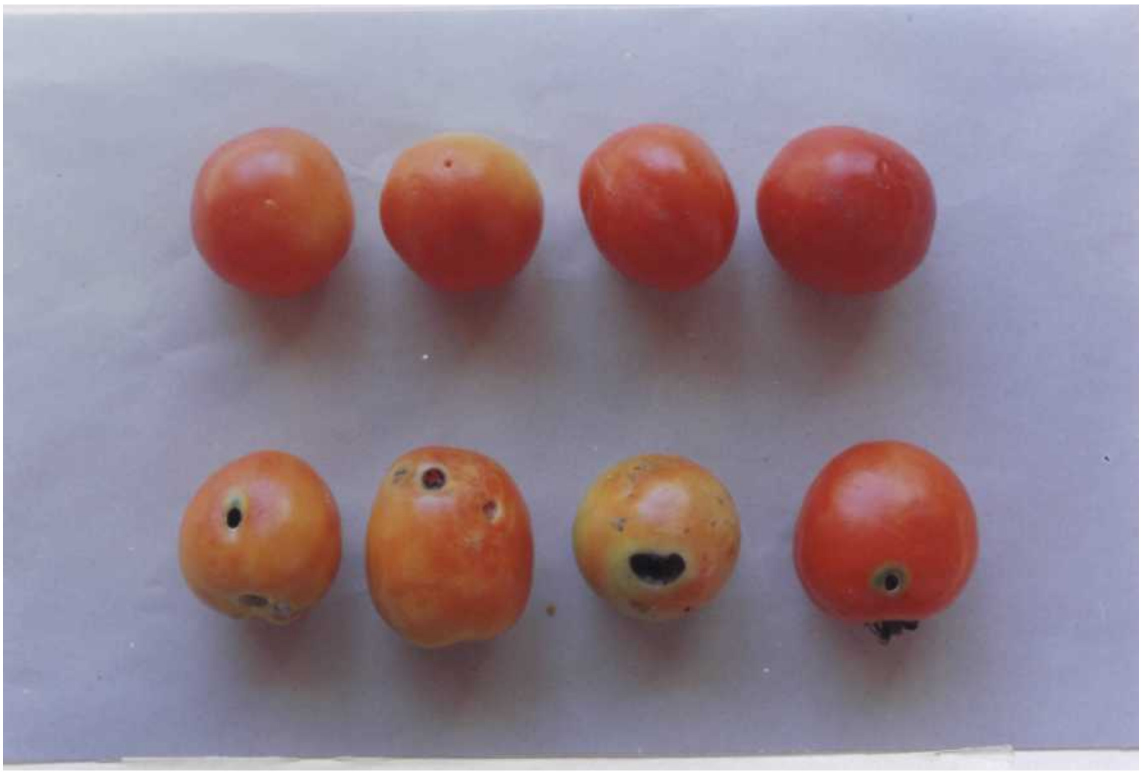

Plate I : Showing healthy fruits and damaged fruits peaks of maximum damaged fruits were observed on 22^{n} April, 29 April and 6th May, during the observation period when the maximum temperatures was 42.64°C, 42.36°C and 42.27°C, respectively.

Effect of minimum temperature

The relationship between the minimum temperature and percentage damaged fruit was found to be positively but non significant. During the study three peaks of maximum damage fruits were observed and these peaks were on 29th April, 22nd April and 6th May. During these period the mean temperature ranged from 24.97°C to 26.84°C.

Effect of rainfall

The correlation coefficient between rainfall and percentage damaged fruit was found to be non significant. During the observation period total 5.5 mm rainfall was recorded between 29th (3.00 mm) April and 06th May (2.5) indicating no effect of rainfall on the infestation of fruit borer.

Effect of relative humidity

The correlation coefficient between the evening relative humidity and percentage damaged fruit was found to be negative but non significant. This indicate that the relative humidity had some negative effect on the incidence of fruit borer.

4.3.2 Dynamics of leaf miner infestation (based on percentage damaged leaf) in relation to abiotic parameters

The percentage damaged leaves by leaf miner was observed throughout the study period i.e. from January to May, 2002 (Table 5and 6).

Effect of Maximum temperature

The relationship between maximum temperature and percentage damaged leaves was found to be positive but non significant. However, there were three peaks of percentage damaged leaves observed from 18th March to 17th April. During these periods the maximum temperatures were ranged from 37.99°C to 39.73° C.

Effect of minimum temperature

The relationship between minimum temperature and percentage damaged leaves was found to be positive but not significant. During the study periods three peaks of percentage damaged leaves were observed on 18 March, 7 ' April and 17 April. During these periods the minimum temperature were ranged from 18.60°C to 23.14°C.

Effect of rainfall

The correlation coefficient between rainfall and percentage damaged leaves was found to be negative but non significant. During the observation period total 20 mm rainfall was recorded. Which indicated that these was no effect of rainfall on the incidence of leaf miner.

Table 5 : Population dynamics of major pests of tomato during January-May 2002

S. No.	Mean percentage damaged leaves	Mean length of mine (cm)	Mean population of whitefly per plant	Mean population of aphid per Plant	Mean population of thrips per plant	Mean population of jassid per plant
1	22.43	0.00	4.48	5.75	0.00	0.00
2	30.65	0.00	4.30	4.15	3.79	0.00
3	29.22	3.76	5.07	5.66	5.11	0.00
4	25.25	4.15	5.45	6.09	5.28	3.46
5	24.83	4.65	6.35	3.63	3.68	2.86
6	25.95	5.07	5.71	3.03	3.20	3.37
7	25.68	5.11	3.32	0.00	0.00	5.06
8	26.65	5.33	1.49	0.00	0.00	4.32
9	23.77	5.02	0.00	0.00	0.00	0.00
10	20.95	4.56	0.00	0.00	0.00	0.00

Table 6 : Meteorological observations during January to May (2002)

S. No.	Date and Month	Mean temperature (°C)		Total rainfall (mm)	Mean relative humidity (%)	
		Maximum	Minimum		Morning	Evening
1	28-06 January-February	26.98	11.04	0.0	80.5	31.8
2	07-16 February	29.17	15.52	5.2	83.6	45.4
3	17-26 February	33.14	15.83	0.0	76.9	26.5
4	27-08 February-March	33.39	16.33	0.0	69.9	23.8
5	09-18 March	33.50	17.43	0.0	68.3	21.1
6	19-28 March	37.90	18.60	3.0	62.8	16.5
7	29-07 March-April	38.26	21.04	2.5	65.7	20.3
8	08-17 April	39.73	23.14	0.0	53.7	15.6
9	18-27 April	42.60	26.37	3.0	45.8	16.2
10	28-07 April-May	43.03	26.02	6.3	49.1	19.4

20 mm rainfall recorded on 28th January to 7th May (2002)

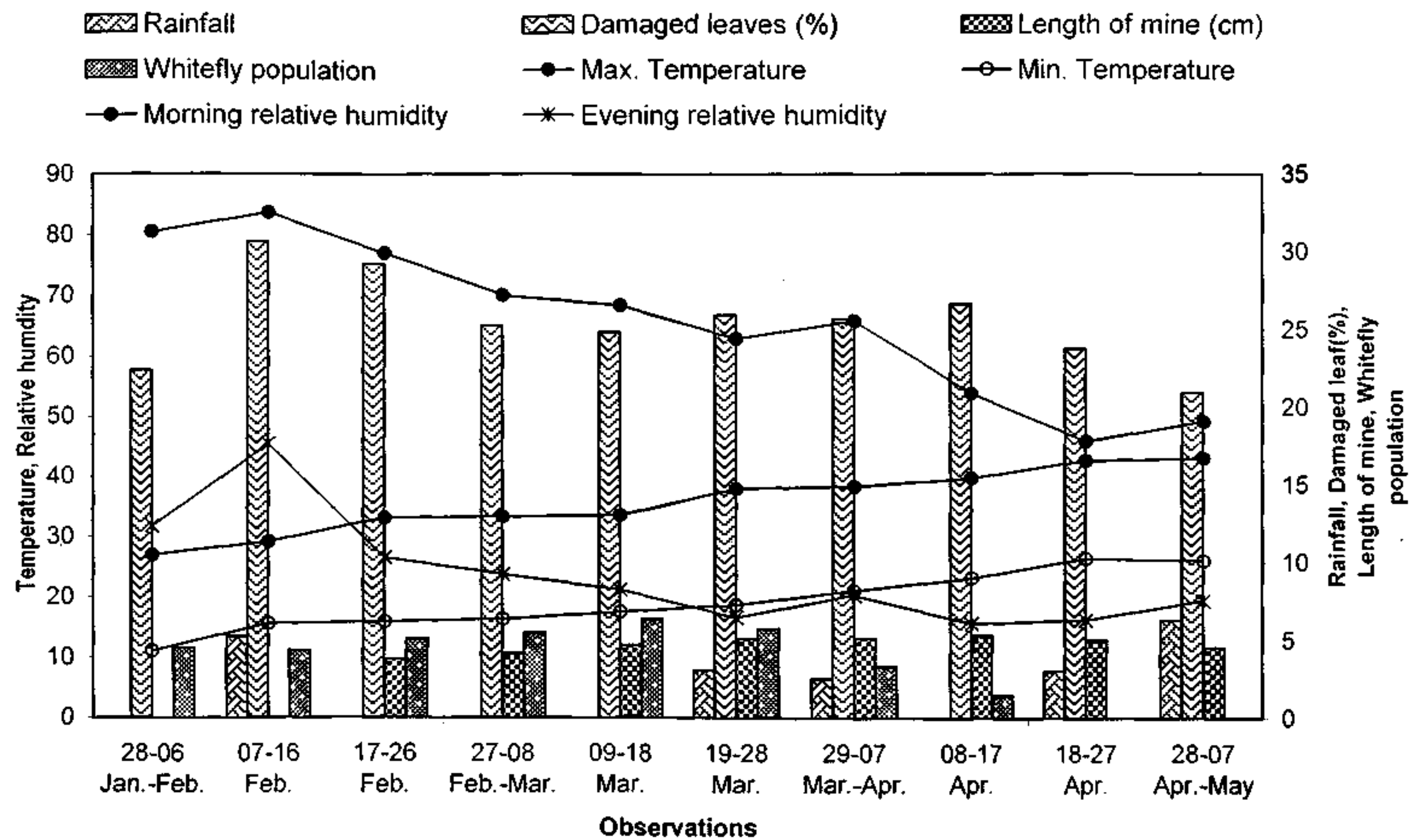

Fig 16 : Season incidence of different pests of tomato along with weather parameters

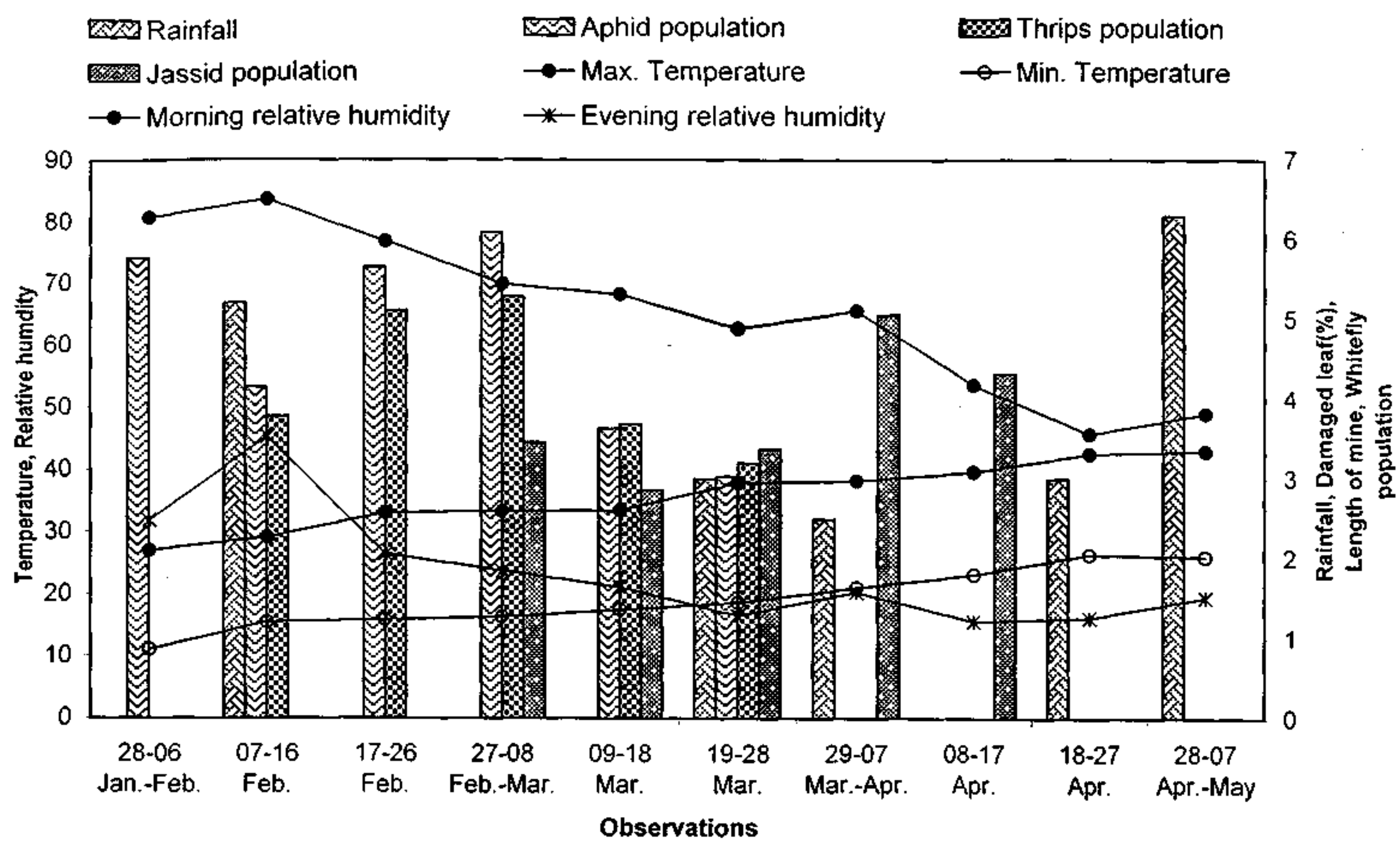

Fig 16 : Season incidence of different pests of tomato along with weather parameters

Plate **II :** Showing damaged leaf by leaf miner

Effect of Relative humidity

The morning relative humidity was negatively correlated with percentage damaged leaves but the data were found to be non significant. During observation period morning relative humidity ranged from 45.80 per cent to 83.60 per cent. Similarly the evening relative humidity had also negative correlation with the percentage damaged leaves but the data were found to be non significant. During observation period evening relative humidity ranged from 15.60 per cent to 45.40 per cent.

4.3.3 Dynamics of leaf miner (based on length of mines) in relation to abiotic parameters

The incidence of leaf miner based on the mines length was observed throughout the study period i.e. from February to May, 2002. (Table 5and 6).

Effect of maximum temperature

The association between maximum temperature and length of mines was found to be positive but non significant. However, there were two maximum and one minimum length of mines observed on 7th April (5.11 cm), 17th April (5.33 cm) and 26th; February (3.76 cm), respectively. During these periods the maximum temperature was 37.99°C, 38.26°C and 33.14°C, respectively.

Effect of minimum temperature

The minimum temperature was positively correlated with the length of mines but the level of significance was not significant. The maximum length of mines was recorded on 7th April followed by 17th April. During these periods the minimum temperature was 21.04°C and 23.14°C, respectively. However, there was indication that minimum temperature had some influence on length of mines of leaf miner.

Effect of Rain fall

The correlation between rainfall and length of mines was found to be non significant. Total 14.80 mm rainfall was received during the observation period. This indicated that rainfall had no influence on the incidence of the leaf miner.

Effect of relative humidity

The morning relative humidity was negatively correlated with length of mines in all three leaves but the data were found to be non significant. During the observation period morning relative humidity ranged from 45.80 per cent to 76.90 per cent.

Similarly evening relative humidity had negative correlation with length of mines, the “r” value being -0.930, the regression (Fig. 14) equation being $Y_1 = 7.279 - 0.129X_1$; where, X_1 is the evening relative humidity and Y_1 is the length of mines. This indicates that with every one per cent increase in evening relative humidity there was decrease in 0.129 cm length of mine.

4.3.4 Population dynamics of *Bemisia tabaci* in relation to abiotic parameters

The whitefly population was observed throughout the study period i.e. from January to April 2002. (Table 5and 6)

Effect of maximum temperature

The relationship between maximum temperature and population of whitefly was negative but non significant. However, the maximum whitefly population was observed on three dates i.e. on 18t March (6.35), 28 March (5.71) and 8th March (5.45). During these periods the maximum temperature was 35.50°C, 37.99°C and 33.39°C, respectively.

Effect of minimum temperature

The minimum temperature was negatively correlated with whitefly population but the level of significance was non significant. The three peaks of whitefly population observed on 18 March, 28t March and 8 March. During these periods the minimum temperature was ranged from 16.39°C to 18.60°C.,

Effect of rainfall

The correlation between rainfall and whitefly population was found to be negative but non significant. Total 10.70 mm rainfall was received during observation period i.e. on 16th February (5.20 mm), 28th March (3.00 mm) and on 7th April (2.50 mm).

Effect of relative humidity

Morning relative humidity was positively correlated with whitefly population but statistically the data were found to be non significant. During the observation period morning *relative humidity* was *ranged from 53.70 per cent* to 83.60 per cent.

Similarly the evening relative humidity was positively correlated with *the whitefly population* but data were found to be non significant.

4.3.5 Population dynamics of *Aphis gossypii* in relation to abiotic parameters

The aphid population was observed throughout the study period i.e. from January to March, 2002. (Table 5 and 6)

Effect of maximum temperature

The relationship between maximum temperature and aphid population was found to be negative but non significant. However, the two peaks in aphid population were observed on 8^{th} March (6.09) and 26^{th} February (5.66). During these periods the maximum temperature was 33.39°C and 33.14°C, respectively.

Effect of minimum temperature

The minimum temperature was negatively correlated with aphid population but the data were found to be non significant. The maximum

Plate **III :** Showing affected plant by aphid population of aphid was observed on 8 March and 26^{t} February. During these periods the minimum temperature was 16.33°C and 15.83°C, respectively.

Effect of rainfall

The correlation between rainfall and aphid population was found to be negative but non significant indicating some adverse affect on the population of aphid. In all 8.20 mm rainfall was recorded.

Effect of relative humidity

The correlation between morning relative humidity and aphid population was positive but the data were found to be non significant. During the observation period morning relative humidity ranged from 62.80 per cent to 83.80 per cent.

Similarly, evening relative humidity was positively correlated with aphid population but it was also found to be non significant indicating that there was no influence of morning as well as evening relative humidity on population of aphid.

4.3.6 Population dynamics of *Caliothrips indicus* in relation to abiotic parameters

The thrips population was observed throughout the study period i.e. from February to April 2002 (Table 5 and 6)

Effect of maximum temperature

The relationship between maximum temperature with thrips population was found to be negative but non significant. However, the maximum population of thrips was observed two times i.e. on 8 March (5.28) and 26 February (5.11). During these periods maximum temperature was 33.39°C and 33.14°C, respectively.

Effect of minimum temperature

The correlation between minimum temperature and thrips population was found to be negative but non-significant. The maximum population of thrips was observed on 8^{th} March and 26^{th} February. During these periods the prevailing minimum temperature was 16.33°C and 15.83°C, respectively.

Effect of rainfall

The correlation between rainfall and thrips population was found to be negative but non significant. Total 8.20 mm rainfall was recorded during observation period. Rainfall received on 16^{th} February (5.20 mm) and 28^{th} March (3.00 mm) had adverse effect on population of thrips. Since there was sudden fall in the population of thrips.

Effect of relative humidity

The morning relative humidity was positively correlated with thrips population but it was found to be non significant. During observation period morning relative humidity ranged from 62.80 per cent to 83.60 per cent.

Similarly evening relative humidity was positively correlated with thrips population but it was found to be non significant. During observation period evening relative humidity ranged from 16.50 per cent to 45.40 per cent. Thus morning as well as evening relative humidity had no effect on the population of thrips.

4.3.7 **Population dynamics of *Empoasca devastans* in relation to abiotic parameters**

The jassid population was observed throughout the study period i.e. from March to April 2002 (Table 5 and 6)

Effect of maximum temperature

The maximum temperature was positively correlated with jassid population but it was found to be non significant. The maximum population of jassid was observed on 7th April (5.06) and again on 28th March (4.37). During these periods maximum temperature was 39.73°C and 37.99°C, respectively.

Effect of minimum temperature

The relationship between minimum temperature and jassid population was found to be positive but non significant. However, maximum population of jassid was observed on 7th April and again on 28th March. During these periods the minimum temperature was 21.04°C and 18.60°C, respectively.

Effect of rainfall

The correlation between rainfall and jassid population was found to be positive but non significant. Total 5.50 mm rainfall was received during the observation period i.e. on 28^{t} March (3.00 mm) and 7^{t} April (2.5 mm).

Effect of relative humidity

The morning relative humidity was negatively correlated with jassid population but it was found to be non significant. During observation period morning relative humidity ranged from 53.70 per cent to 69.90 per cent.

Similarly evening relative humidity was negatively correlated with jassid population but it was also non significant indicating that the relative humidity had no effect on the regulation ofjassid population.

Discussion

CHAPTER-V

DISCUSSION

The discussion on the study entitled "Relative preference of different tomato varieties/ hybrids by major pest in relation to antixenosis and dynamics of pests population with regards to abiotic parameters" are discussed below.

5.1,2 Relative preference of different tomato varieties/ hybrids by different pests and biophysical basis of resistance/ susceptibility

The minimum per cent fruit damage by *H. armigera* was recorded in Manimaker, S-22, NS 101 and Paras Dadi on the number basis and on the weight basis the minimum fruit damage was recorded in Manimaker, Navodaya and NS 101, however it was moderate in case of Navodaya Kubergerta and Pusa Ruby based on number whereas, S-22 and Paras Dadi had moderate level of infestation on weight basis. Kashyap and Verma (1987) reported that Pusa Ruby was found to susceptibility against *H. armigera* among the various genotypes screened. Gc *et al.* (1997) have also reported the susceptibility of Pusa Ruby against *H. armigera.*

The biophysical parameters like leaf area, length-width ratio of leaves as well as number of trichomes had no relationship with fruit borer infestation based on both the number and weight basis. This indicated that biophysical characteristics of leaves did not contribute any resistance to *H. armigera.* On the contrary Lal (1985) observed the lack of glandular trichomes on tomato varieties attributed the infestation of *H. armigera*. Chandrakar *et al.* (1997) also reported the tomato varieties which had high hairy peduncles were less susceptible to the damage than those with less hairs on the peduncles.

The minimum percentage of infested upper leaves by leaf miner was recorded in NS 101, Punjab Keshri, Manimaker and S-22 whereas in middle leaves it was minimum in varieties NS 101, S-22 and Punjab Keshri and variety, S-22 had lowest leaf miner infestation in lower leaves. However, maximum percentage affected upper leaves were observed in Ganpati, Pusa Ruby and Sanjeewani, BWT 101 showing their susceptibility whereas it was maximum in middle leaves of Ganpati and Sadabahar varieties. The varieties like Pusa Ruby, Sadabahar, Ganpati and Paras Dadi had maximum affected lower leaves. Among the varieties, S-22 variety showed minimum affected leaves showing its least preference by the pest where as variety Pusa Ruby showed maximum affected leaves in all three leaves. Moreira *et al.* (1998) have reported that Manimaker was found resistance to *Liriomyza trifolii.*

No relationship between the leaf area of upper and middle leaves with per cent affected leaves of the same leaf category was observed. This indicated that there was some other factor responsible for the variation in the per cent damaged leaves by leaf miner in different varieties/ hybrids of tomato. The leaf area of lower leaves was positively correlated with per cent affected lower leaves (r = 0.627), indicating that with increase of one sq.cm leaf area, which resulted in increase in 1.579 per cent affected leaves. There was no relationship between length width ratio and per cent affected leaves of all three leaves. This showed that narrowness or broadness of leaves had no relation with the infestation of leaf miner. This indicated that there was some other factor responsible for the variation in the per cent damaged leaves. Similarly, the number of trichomes of upper and lower leaves of different varieties had no correlation with the per cent infestation. This indicated that trichome along had no significant role of the infestation by leaf miner but some other factors like angle of ascertion might play important role which needs to be worked out. The number of trichomes on middle leaves had negative (r = -0.684) relationship with the per cent affected leaves, indicating that with the increase in number of trichomes per unit area resulted in decrease 0.0018 per cent affected leaves. No work on this aspect has been reported so far.

The least length of mines on upper leaves by leaf miner was observed in NS-101, Sun 5715 and S-22 whereas the varieties NS 101 and S-22 had minimum mines length in middle leaves. Lower leaves of NS 101, Sun5715 and Akash variety were less preferred. However, the maximum length of mines on upper leaves was recorded in varieties Sanjeewani BWT 101 and Ganpati whereas middle leaves of Ganpati and Paras Dadi were found to have maximum length of mines indicating their susceptibility to this pest. The variety, NS 101 showed least length of mines in all three leaves showed its least preference by the pest whereas variety Ganpati was most preferred indicating its susceptibility to the leaf miner based on the length of mines by leaf miner.

The correlation between leaf area of middle and lower leaves with length of mines was positive and significant (r - 0.614 and r = 0.581) indicating that, the leaf area had positive effect on the length of mines. Leaf miner had the maximum opportunity for its expansion based on the availability of leaf surface which was responsible for variation in the length of mines on different varieties of tomato. The leaf area of upper leaves length-width ratio and number of trichomes in all three leaves did not had any correlation. This indicated that only the leaf area has positive impact on the development of leaf miner found on different tomato varieties/ hybrids. There was no report on this line.

The minimum population of whitefly on upper leaves was observed in variation NS 101, Paras Dadi, Sanjeewani BWT 101 and Sun 5715 whereas in middle leaves variation like, Sanjeewani BWT 101, NS 101, Sun 5715 and Navodaya had least population of whitefly. Variety NS 101 had least population of whitefly as its lower leaves. The highest population of whitefly on upper leaves was recorded in Manimaker and S-22. Varieties, Akash and Pusa Ruby had maximum population on middle leaves. Variety Kubergeeta had maximum whitefly population on lower leaves. This indicated that there was no clear cut indication of preference of varieties/ hybrids by whitefly irrespective of any leaf position.

There was no relationship between leaf area and whitefly population on all three leaves. Some histological basis of preference was oberved by Chu (1999) who observed that the vascular bundles in under leaves was negatively correlated with whitefly adult, egg and nymphal densities of leaves. The length width ratio of leaves had no correlation with whitefly populations on upper, middle and lower leaves whereas contradictory to our finding. Chu (1999) reported that broader leaves of cotton variety had lower whitefly adult egg and nymph population as compared to normal leaves. Number of trichomes had no correlation with whitefly population found on upper, middle and lower leaves. But, contrary to this Buttler *et al.* (1991) and Ilyas *et al.* (1991) reported that the whitefly population increased with increase in number of trichomes. Similarly Butter and Vir (1989) observed that the hair density of leaf was positively correlated with whitefly population. In the present study number of trichomes did not have any relation with whitelfy population. The trichome density might be important in the selection of tomato varieties/hybrids. This indicated that there was some other antixenosis factor or factors responsible for variation in whitefly population on different varieties of tomato. However, bio-chemical basis of preference was reported by Hiderbrand *et al.* (1993) and they reported that, tomato leaves produce some volatile compounds like 6-carbon aldehydes and alcohols which have affected the population of *B. tabaci.* Ashraf *et al.* (1999) have observed that on cotton, epicultioular wax content was responsible for resistant against *B. tabaci.* Nombela *et al.* (2000) reported that tomato varieties with high acyl sugar content did not prefer for oviposition by *B. tabaci.*

Minimum population of aphid was observed on upper leaves in varieties Sun 5715, Manimaker, Ganpati and NS 101 whereas in middle leaves the varieties like Manimaker, Sun 5715 and NS 101 had lowest population. Variety Ganapati had lowest population on lower leaves. However, the maximum population of aphid was recorded on upper leaves of varieties Sadabahar, Pusa Ruby and S-22. Varieties S-22, Paras Dadi and Akash had highest aphid population in middle leaves whereas varieties Kubergeeta, Sadabahar had maximum population on lower leaves.

The leaf area had no correlation with aphid population on upper, middle and lower leaves. This indicated that crop canopy as well as some other factor might be responsible for the variation in population of aphid found on different leaves. Hiderbrand *et al.* (1993) reported that tomato leaves produce some volatile compounds like *6* carbon aldehyde and alcohols which influenced the population of aphid. Liu and Young (1993) observed that the population of *Aphis gossypii* decreased with the increasing concentration of tanin, proline and soluble sugar. The length-width ratio of upper leaves was positively correlated with population of aphid on upper leaves (r - 0.66) which showed population of increased with aphid increase in length-width ratio of leaves.

The number of trichomes was negatively correlated with the aphid population found on upper, middle and lower leaves (r = -0.754, r = -0.821, r = -0.619) which indicated that presence of trichome on leaf surface had adverse affect on the population of aphid Naved *et al.* (1995) also observed the importance of hairs on population density of aphid. They reported that low hair density and a shorter hair length had a larger population of aphid indicating the importance of trichomes in imparting resistance against aphid.

The least population of thrips on upper leaves was observed in S-22 and NS 101 whereas middle leaves of variety NS 101 and Manimaker had least thrips population in lower leaves. However the highest population of thrips was recorded on upper leaves in variation Kubergeeta and Ganpati whereas Kubergeeta and Ganpati variety had maximum population on middle leaves as well as in lower leaves. This indicated that there was no clear cut distribution and preference of thrips in plants.

The leaf area of upper leaves had positive correlation (r = 0.712) with thrips population indication that the population of thrips increased with increase in leaf area of upper leaf portion. This clearly indicated that the thrips preferred to concentrate on bigger size leaf and also prefer to feed on upper leaves and did not prefer the middle as well as the lower leaves. Similar observations on higher orientation and oviposition of thrips due to greater leaf area in different host plants were reported by Shaw *et al.* (1982). The leaf area of middle and lower leaves did not have any relation with the thrips populations, This indicated that other factors are responsible for the variation in thrips populations on the middle and lower leaves. The length width ratio of all three leaves and number of trichomes on upper and middle leaves had no correlation with the thrips populations, this indicated that other factors like histological and biochemical are responsible for the variation in the thrips populations on different leaves. The number of trichomes in lower leaves had negative correlation (r = -0.655) with the population of thrips this indicated that the presence of trichomes on lower leaves of tomato variations had adverse affected on the population of thrips.

The minimum population of jassid was recorded on upper leaves of variety NS 101 where as it was least in variety Akash on both middle and lower leaves, however the maximum population of jassid was observed in Pusa Ruby in all three leaves.

The leaf area of all three leaves, length-width ratio of upper and middle leaves and number of trichomes in middle leaves had no correlation with jassid population found on different leaves thus the bio-physical characters had no influence on the population of the jassid on upper as well as on middle leaves. This indicated that the other factors like crop canopy histological characters might be responsible for variation of jassid in different leaves, the length-width ration of lower leaves had a positive correlation with the mean population of jassid (r = 0.608), this indicated that with every one unit increase in length width ratio there was increase in jassid population by 1.62. This clearly showed that with increase in broadness of leaf there was increase in the population of jassid. The number of trichomes in upper and lower leaves was negatively correlated with the jassid population found on upper and lower leaves (r = -0.563, r = 0.605) and the inverse linear relationship among these variables showed that with every number increase in trichome on upper and lower leaves there was reduction in jassid population. This indicated that the antixemesis factor like presence of more trichomes on leaf surface impart resistance against jassid in tomato similar observation was also recorded by Butler *et al.* (1991) who reported that the population of *Emposca devastans* on cotton was adversely affected decreased when number of trichomes increased.

There was great variation in the yield level in different varieties and in hybrids. The marketable yield varied from 50.91 q/ha to 204.56 q/ha. This variation in yield parameter was mainly due to potential of varieties/ hybrids and the resistance/ susceptibility characters. The variety S-22, Manimaker and NS 101 were found to be good yielder and fairly resistant to all the pest. Among the varieties NS 101 was found to be resistant to all the pest with fairly good yielder. The resistant characters in NS 101 might be due to some biophysical characters which needs detail study.

5.3 Dynamics of major pests of tomato in relation to abiotic parameters

Studies on the influence of weather parameters on population dynamics of *H. armigera*, revealed that no weather parameter had significant effect on population dynamics of *H. armigera.* However the three peaks in population of *H. armigera* were observed from 22^{nd} April to 6^{th} May. During these periods maximum temperatures ranged between 42.27^{0}C to 42.64^{0}C and minimum temperature fluctuate between 24.97 C to 26.84 C. This indicated that these temperature were conducive for rapid multiplication of *H. armigera.* Morning relative humidity varied from 41 to 47 per cent whereas evening relative humidity varied from 14 to 23 per cent and these were observed to be more favourable for the optimum development of the pest. Parihar and Singh (1996) reported that the larval population of *H. armigera* on tomato was found to be low up to the 1st week of February and thereafter increased rapidly reaching a peak in last week of March. Deka *et al.* (1989) recorded the maximum density of *H. armigera* from mid February to first week of March. Yadav *et al.* (1991) found significant and positive correlation *of H. armigera* with maximum and minimum temperature and negatively correlation with relative humidity. In present study no clearcut influence of weather parameters was noticed.

The influence of weather parameters on population dynamics of *L. trifolii* (on the basis of percentage damaged leaves) revealed that no weathers parameter had significant role on population dynamics of *L. trifolii.* However, the three peaks in maximum percentage of damaged leaves (indicating the incidence of the pest) were observed in between 18th March to 17th April. During these periods maximum temperature ranged from 37.99 °C to 39.73 °C and minimum temperature ranged between 18.60 °C to 23.14^{0}C. This indicated that these temperatures were favourable for rapid multiplication of *L. trifolii*, Morning relative humidity around these period varied from 53 per cent to 63 per cent and evening relative humidity varied from 15 per cent to 17 per cent were observed to be more favourable for the optimum development of the pest. Thus, there was no clear-cut effect of any weather parameters on the population build up of the pest. However, Bagmare *el al.* (1995) reported some effect of weather parameters on the population of *L. trifolii*; they reported that the mean temperature had positive effect on the population of *L. trifolii* whereas rainfall and relative humidity had negative effect. Jongdae *et al.* (1996) reported that feeding activity of larvae of *L. trifolii* was greatest at 20°C. Ozawa *et al.* (1999) observed the population growth rate of Liriomyza trifolii was highest at 25°C and female fecundity was varied from 15°C to 25°C. Suenaga *et al.* (1999) investigated the survival rate of pupae *of L trifolii* which was reduced at 30°C indicating the ill effect at this temperature.

Studies on the effect of weather parameters on population dynamics of *L. trifolii* (on the basis of length of mines) revealed that only the evening relative humidity had significant effect on the population dynamics of L. *trifolii* However, the maximum length of mines recorded on 7th April and 17th April. During these periods maximum and minimum temperature ranged in between 37 °C to 40°C and 18 °C to 24°C, respectively. This indicated that these temperatures were conducive for rapid multiplication of *L. trifolii.* Morning and evening relative humidity varied from 45 per cent to 65 per cent and 16 per cent to 20 per cent respectively which were observed to be more favourable for the development of the pest. The evening relative humidity was negatively correlated with the length of mines (r - -0.930), regression equation being Y_1 = 7.279-0.129X_1. This indicates that with every one per cent increase in evening relative humidity there was decrease in mine length by 0.129cm. There was very close association with evening relative humidity on reduction in the mine length.

Study on the influence of weather parameters on population dynamics of *Bemisia tabaci* revealed that no weather parameter had significant effect on the population of *B. tabaci*. However, the maximum population of whitefly was observed in three dates viz. 8th March, 28th March and 18th March. During these periods maximum and minimum temperature ranged between 35^0C to 38^0C and 16°C to 19°C. This indicated that these temperatures were conducive for rapid multiplication of whitefly. Alicae *et al.* (1999) reported that whitefly population was found at peak during hot dry season while Men *et al.* (1997) reported that maximum and minimum temperatures prevailed during December-January had adverse affect on the abundance of whitefly population on sunflower. Similarly the significance of temperature in regulation whitefly population was reported by Abdul *et al.* (1998). Morning and evening relative humidity varied from 62 per cent to 83 per cent and 16 per cent to 45 per cent, respectively were observed to be more favourable for development of the pest. Contradictary to our findings, Men *et al.* (1997) reported the abundance of whitefly in sunflower was influenced by morning and evening relative humidity where as Abdul *et al.* (1998) were of the view that whitefly population on tomato was not influenced by relative humidity. Mohan *et al.* (1988) studied the incidence of *Trialeurodes vaporariorum* on tomato in Nilgiris region, of Tamil Nadu, during 1987 and reported that the maximum incidence of *T. vaporariorum* during January to

August. Brewster *et al.* (1997) observed the two peaks population of whitefly on tomato at late September to October with indication any influences of weather parameters on the population of whitefly.

Studies on the influence of weather parameters on population dynamics of *Aphis gossypii*, revealed that no any weather parameters had significant effect on population of *A. gossypii.* However, the maximum population of aphid was observed on 26th February and 8th March. During these periods maximum and minimum temperature ranged between 33°C to 40°C and 15°C to 17°C. This indicated that these temperatures were conductive for rapid multiplication of aphid. The population of aphid was found to be maximum when the maximum temperature reached to 30°C (Rougai *et al.*, 1999). Morning and evening relative humidity varied from 70 per cent to 76 per cent and 21 per cent to 27 per cent respectively which were observed to be more favourable. The importance of relative humidity was also shown by Kashyap and Bishnoi (1988) who reported that aphid population decreased sharply with increase of relative humidity and also with linear increase with mean temperature.

The studies on the influence of weather parameters on population dynamics of *Caliothrips indicus*, revealed that no any weather parameters had significant effect on population dynamics of C. *indicus.* However the peak population of thrips was observed on 8th March and 26 ' February. During these periods maximum and minimum temperature ranged between 33°C to 34°C and

15°C to 17°C respectively. This indicated that these temperatures were conducive for rapid multiplication of thrips. Similarly the importance of temperature was indicated by Lewis (1973) who reported that warm sunny dry summers in temperate regions encouraged reproduction and survival of most species of thrips. Where as Shaw *et al.* (1991) reported that temperature had no significant effect on thrips. Bughio *et al.* (1986) reported that population of *Thrips tabaci* reached to economics threshold level during the third week of June. Shaw *et al.* (1991) reported that the thrips was active from November to June and most active during December-January on pea. They were also observed the rainfall was found to be negative relationship with thrips population where as the rain had no effect on the population of thrips.

The studies on the influence of weather parameters on population dynamics of *Empoasca devastans* revealed that no any weather parameters had significant role on regulating the population of *E. devastans.* However, the peak population of jassid was observed from 28^{1} March to 7th April. During these periods maximum and minimum temperature ranged between 37^{0}C to 40 °C and 18°C to 22°C, respectively. This indicated that these temperature were found to be favourable for jassid. The importance of higher temperature of *E. devastons* was reported by Bughio *et al.* 1986 who reported that the population of *E. devastans* remained above the economic threshold level from the fourth week of May to end of June. Morning and evening relative humidity varied from 62 per cent to 66 per cent and 16 per cent to 21 per cent, respectively which seem to have no effect on pest population.

Thus the morning and evening relative humidity had no effect on the population ofjassid.

Summary, Conclusions & Suggestions for Future work

CHAPTER-VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE WORK

The present investigations entitled "Relative preference of different tomato varieties/ hybrids by major pest in relation to antixenosis and dynamics of pests population with regards to abiotic parameters" were carried out at Department of Entomology, I.G.A.U. Research farm during the Rabi season, 2002 with following objectives :

1. Relative resistance/ susceptibility of tomato varieties against pest complex of tomato.
2. Biophysical basis of resistance/ susceptibility to major pest.
3. Dynamics of major pest of tomato in relation to abiotic parameters.

Thirteen tomato varieties/hybrids *viz.* Pusa Ruby S-22, Punjab Keshri, Sanjeewani, BWT 101, Sun 5715, Navodaya, Manimaker, NS 101 (open pollinated), Kubergeeta, Ganpati, Sadabahar, Paras Dadi and Akash (hybrids) were tested against major pest of tomato like fruit borer, *H. armigera*, leaf miner, *Liriomyza trifolii*, whitefly *Bemisia tabaci*, aphid *Aphis gossypii*, thrips, *Caliothrips indicus* and jassid *Empoasca devastans*.

Relative preference of different tomato varieties/ hybrids to different pests and biophysical basis of resistance/susceptibility

On the basis of number, the minimum per cent of damaged fruit by *H. armigera* was observed in Manimaker followed by S-22, NS 101 and Paras Dadi whereas on the basis of weight the varieties Manimaker, Navodaya and NS 101 received least infestation. Significantly maximum fruit damage on number basis was recorded on Sanjeewani, BWT 101 followed by Sun5715 and Akash whereas on weight basis the maximum damage was recorded in Sanjeewani, BWT10 followed by Punjab Keshri on the weight basis. No relationship was observed between leaf area, length-width ratio of leaf, and number of trichomes with per cent damaged fruit.

The minimum percentage of affected leaves by leaf miner at upper leaves was observed in NS 101 and in Punjab Keshri where as Manimaker variety received minimum affected middle leaves. Variety S-22 received least infestation in lower leaves with non significant differences among them. No relationship was observed between leaf area of upper as well as middle leaves, length-width ratio of all three leaves and number of trichomes in upper as well as lower leaves with percentage affected leaves. The leaf area of lower leaves was positively correlated with percentage affected leaves (r = 0.627) and number of trichomes was negatively correlated with percentage affected leaves (r = -0.684), the regression equation being $Y_2 = 34.287 + 1.579X_3$ and $Y_2 = 29.63-0.0018\ X_7$ respectively. This indicates that with every one sq.cm increase in leaf area and number of trichomes there was an increase of 1.579 affected leaf and decrease in 0.001 per cent leaf miner infestation.

The least length of mines formed by leaf miner was observed in NS 101 followed by Sun 5715 and S-22 in upper leaves where as the varieties NS 101 and S-22 received least length of mine in middle leaves. Variety NS 101, Sun 5715 and Akash had least length of mine in lower leaves indicating that variety NS 101 had fairly resistant to leaf miner as compared to remaining varieties/ hybrids. The leaf area of upper leaves had no correlation with length of mines. The leaf area of middle leaves was positively correlated with length of mines (r = 0.614), similarly the leaf area of lower leaves was also positively correlated with length of mines (r = 0.581), the regression equation being Y_3 = -2.809 + 5.518 X_2 and Y_4 = 2.435 + 0.076 X_3 respectively. This indicates that with every one sq.cm. increase in leaf area there was increase of 5.518 cm length of mines in middle leaves and 0.076 cm in lower leaves. The relationship between length-width ratio as well as number of trichomes of all three leaves with length of mines was found to be non significant.

The minimum population of whitefly in upper leaves was observed in variety NS 101 followed by Paras Dadi, Sanjeewani, BWT 101 and Sun 5715 where as population was least in middle leaves in varieties like, Sanjeewani BWT 101, NS 101 followed by Sun 5715 and Navodaya and again NS 101 variety had least population of whitefly in lower leaves. However significantly maximum population of whitefly was recorded in Manimaker and S-22 in upper leaves, Akash and Pusa Ruby in middle leaves and Kubergeeta in lower leaves. The relationship between leaf area, length-width ratio of leaves and number of trichomes of all three leaves with whitefly population was found to be non significant.

The lowest population of aphid on upper leaves was observed in Sun 5715 followed Manimaker, Ganpati and NS 101. Manimaker, Sun 5715 and NS 101 had lowest aphid population in middle leaves whereas lowest aphid population was recorded in variety Ganpati in lower leaves. The leaf area of upper, middle and length-width ratio of middle as well as lower leaves had no correlation with aphid population. The length width ratio of upper leaves was positively correlated with aphid population (r = 0.660), the regression equation being $Y_5 = 14.868 + 9.058\ X_4$. This indicates that with every one unit increase in the length-width ratio there was increase in aphid population by 9.0581 per plant. Similarly the number of trichomes of all three leaves was negatively correlated with the aphid population (r = -0.754, r = -0.821, r = 0.619), the regression equation being $Y_5 = 7.043 - 0.0024\ X_6$, $Y_6 - 6.652 - 0.0022\ X_7$ and $Y_7 = 2.459 - 0.007\ X_8$; respectively for upper middle and lower leaves. This indicates that with every one increase in number of trichome there was decrease in aphid population by 0.0024, 0.0022 and 0.0007, respectively.

The minimum population of thrips on upper leaf was observed in S-22 and NS 101 and Manimaker had least thrips population in middle leaves where as variety NS 101 had least thrips population in lower leaves. The leaf area of middle and lower leaves had no correlation with thrips population. Where as the leaf area of upper leaves had linear and significantly correlation with thrips population (r = 0.712), the regression equation being Y8 = 1.423 + 0.0151 X_1. This indicates that with every one sq.cm increase in leaf area there was increase in population of thrips by 0.151. The number of trichomes of upper and middle leaves had negative correlation with the thrips population but it was found to be non significant. The number of trichomes of lower leaves was negatively correlated with the mean population of thrips (r =-0.655), the regression equation being Y9 = 2.43 - 0.0005 X_8. This indicates that with an increase in number of trichome on lower leaves there was decrease of 0.0005 thrip per plant.

The minimum population of jassid in upper leaf was observed in variety NS 101 where as variety Akash had minimum jassid population in middle as well as in lower leaves. Significantly maximum population of jassid was recorded in Pusa Ruby in all three leaves. The correlation between leaf area of all three leaves with jassid population was found to be non significant. The length-width ratio of upper and middle leaves had no correlation with jassid population. Where as the length-width ratio of lower leaves had a positive correlation with the mean population of jassid (r = 0.608). The regression equation being Y_{10} = 2.05 + 1.62 X_5. This indicates that with every one unit increase in the length-width ratio there was increase in jassid population by 1.62. The number of trichomes in upper and lower leaves had negative correlation with the mean population of jassid. The V value being r = -0.563 and r = 0.605, respectively, the regression equation being Y_{11} = 1.955 - 0.001 X_6 and Y_{11} = 1.315 - 0.0004 X_8, respectively. This indicates that with an increase in number of trichome there was decrease in jassid population by 0.0001 on upper leaves and 0.0004 on lower leaves. While comparising the yield, the variety S-22 had yield highest (204.58q marketable yield/ha) followed by Punjab Keshri (203 q/ha), Pusa Ruby (198.01 q/ha), Manimaker (197.42 a/ha), Navodaya (140.67 q/ha), and NS-101 (135.5 q/ha). The hybrids were found to be very low yielder, the yield varied from 50.91 q/ha to 119.83 q/ha with their susceptibility to all the pest whereas open pollinated varieties *were* fairly resistant to all the pests. Dynamics of major pest of tomato in relation *to* abiotic parameters.

The relationship between weather parameters and mean damaged fruit was found to be non significant. The three peaks in fruit damage were observed on 22nd April, 29th April and 3rd May. During these period maximum and minimum temperature ranged from 42.27°C to 42.64°C and 24.97°C to 26.84°C. The morning and evening relative humidity had some negative affect on the incidence of fruit borer.

The percentage damaged leaves by leaf miner had no correlation with the weather parameters. However, the maximum affected leaves was observed on dated 28th March, 07th April and 17th April indicating the incidence of the pest. During these periods the maximum and minimum temperatures ranged from 35°C to 40°C and 18°C to 24°C. At this period the morning and evening relative humidity ranged from 45 per cent to 63 per cent and 15 per cent to 21 per cent, respectively.

The length of mines had no correlation with weather parameters except evening relative humidity. The maximum length of mines was observed on 7 April and 17th April indicating the incidence of the pest. During these periods the maximum and minimum temperature ranged from 28°C to 40°C and 21°C to 24°C, respectively. At this period the morning and evening relative humidity ranged from 53 per cent to 66 per cent and 15 per cent to 21 per cent, respectively. Evening relative humidity was negatively correlated with length of mines ($r = -0.930$), the regression equation being $Y_1 = 7.279-0.129X_1$. This indicates that with every per cent increase in evening relative humidity there was decrease in length of mines by 0.129 cm.

The maximum population of whitefly was observed on 8th March to 28 March. During these periods the maximum and minimum temperature ranged from 33°C to 38°C and 16°C to 19°C and during this period the morning and evening relative humidity ranged from 62 per cent to 70 per cent and 16 per cent to 24 per cent respectively.

The weather parameters had no correlation with aphid population. The maximum population of aphid was observed on 26th February to 8th March. During these period the maximum and minimum temperature ranged from 35°C to 34°C and 15°C to 17°C, respectively. During these period the morning and evening relative humidity ranged from 69 per cent to 77 per cent and 23 per cent to 27 per cent, respectively. The maximum population of thrips was observed in two dates i.e. on 8th March and 26 ^{t} February. During these periods maximum and minimum temperature and morning and evening relative humidity ranged from 33°C to 40°C and 15°C to 17°C and 69 per cent to 77 per cent and 23 per cent to 27 per cent, respectively. The highest population of jassid was observed on 7th April and again on 28^{t} March. During these periods maximum and minimum temperature ranged from 37°C to 39°C and 18°C to 22°C and relative morning and evening humidity varied from 62 per cent to 69 per cent and 16 per cent to 22 per cent, respectively.

Suggestions for further work:

The following suggestions are given for further work:

1. The resistance characters in variety NS 101 should be studied in detail to find out the behaviour of resistance.
2. Involvement of specific biophysical and bio-chemical characters on preference/non-preference and antibiosis.
3. The presence/ absence of different attractant, repellents and deterrents and their role in preference/non preference.
4. Influence of different abiotic and biotic factors on the seasonal abundance and population dynamic of individual pest.
5. Screening of germplasm against the pests to find out the donar parent responsible for resistance against specific pest.

Abstract

"Relative preference of different tomato varieties/ hybrids by major pest in relation to antixenosis and dynamics of pests population with regards to abiotic parameters"

by

ISHWARI KUMAR

ABSTRACT

Thirteen tomato varieties were screened against different pests of tomato. The pest population was recorded in upper, middle and lower leaves. Various biophysical parameters of these varieties were also studied to find whether there is any relation between a specific parameters and infestation of different pests exist. The minimum per cent of damaged fruit by *Helicoverpa armigera* was observed in Manimaker followed by S-22, NS 101 and Paras Dadi varieties on the basis of number of damaged fruit. Manimaker, Navodaya and NS 101 varieties had low infestation on the weight basis. Significantly maximum damaged fruit on number basis was recorded on Sanjeewani BWT 101 followed by Sun 5715 and Akash, whereas on weight basis, maximum damage was recorded in Punjab Keshri. No any relationship was observed between leaf area, length- width ratio of leaf and number of trichomes with per cent damaged fruit. The minimum percentage affected leaves by leaf miner was recorded in NS 101 followed by Punjab Keshri and Manimaker in upper as well as in middle leaves but variety S-22 had least infestation on lower leaves. Significantly maximum percentage of affected upper leaves was observed in Ganpati followed by Pusa Ruby and Sanjeewani BWT 101, whereas, Ganpati and Sadabahar varieties had maximum damaged middle leaves. Maximum infestation in lower leaves was observed in varieties like Pusa Ruby, Sadabahar, Ganpati and Paras Dadi. The leaf area of lower leaves was positively and number of trichomes on middle leaves was negatively correlated with per cent affected leaves, correlation coefficient being r = 0.627 and r = -0.684 respectively. The least length of mines in upper leaves was observed in NS 101 followed by Sun 5715 and S-22 varieties. NS 101 and S-22 had minimum infestation in middle leaves also whereas varieties NS 101, Sun 5715 and Akash had least length of mines in lower leaves. Only the leaf area of middle and lower leaves was positively correlated with the length of mines.

The minimum population of whitefly on upper leaves was observed in NS 101 followed by Paras Dadi, Sanjeewani BWT 101 and Sun 5715. The incidence of whitefly in middle leaves was minimum in varieties like Sanjeewani BWT 101, Sun 5715 and Navodaya. Variety NS 101 had low whitefly population in lower leaves. No biophysical parameters had correlation with whitefly population in all three leaves. The lowest population of aphid in upper leaves was observed in Sun 5715 followed by Manimaker, Ganpati and NS 101 Varieties, Manimaker, Sun 5715 and NS 101 received least population

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of aphid in middle leaves whereas variety Ganpati had minimum population of aphid in lower leaves. The length width ratio of upper leaves as well as number of trichomes of upper, middle and lower leaves had negative correlation with the aphid population, the correlation coefficient being r = -0.660, r= -0.754, r = - 0.821 and r = - 0.619, respectively.

The minimum population of thrips in upper leaves was observed in S-22 followed by NS 101 whereas varieties NS 101 and Manimaker had minimum population of thrips in middle leaves, variety NS 101 had least thrips population on lower leaves. The leaf area of upper leaves and number of trichomes of lower leaves was negatively correlated with thrips population. The lowest population of jassid in upper leaves was observed in NS 101 whereas Akash had least population of jassid in middle and lower leaves. The length width ratio of lower leaves and number of trichomes of upper as well as lower leaves was negatively correlated with jassid population.

The population of different pests was observed throughout the study period and it was correlated with abiotic parameters. The peak infestation of *Helicoverpa armigera* was observed on 22^{nd} April, 29^{th} April and 7^{th} May. No any weather parameter was correlated with population of *Helicoverpa armigera.* The peak population of leaf miner (on the basis of percentage damaged leaves) was observed during 6 January to 7^{th} May. The maximum length of mines formed by leaf miner was observed on 7th April and 17th April. Only the evening relative humidity was negatively (r = -0.930) correlated with length of mines. The maximum population of whitefly was observed from 8 March to 28^{th} March. Weather parameters had no relation with whitefly population. The maximum aphid population was observed on 26^{th} February and on 8^{th} March. There was no effect of weather parameter on aphid population. The highest population of thrips was observed on 8 ' March and 26 ' February. The weather parameters did not have any relation with thrips population. The maximum population of jassid was recorded on 7 ' April and 28 March. The weather parameters had no effect on jassid population, indicating that weather parameters did not have any role in regulating the population of jassid. Thus it is concluded that among open pollinated varieties S-22, Manimaker and NS 101 were found to be resistant to all the pests and they have also good yield potential. Hybrids were found to be susceptible to the all the pests with very low yielder.

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Appendices

Appendix I : Leaf area and length-width ratio of upper leaf

Variety	Length of **leaf** (cm)	Width of leaf (cm)	Constant factor	Leaf area (sq. cm.)	**L-W** Ratio
Pusa Ruby	4.45	2.14	0.9	8.57	2.08:1
S-22	2.90	1.42	0.9	3.71	2.04:1
Punjab Keshri	3.52	1.63	0.9	5.16	2.16:1
Sanjeewani BWT 101	2.50	1.13	0.9	2.54	2.21:1
Sun 5715	3.15	1.64	0.9	4.65	1.92:1
Navodaya	3.32	1.48	0.9	5.46	2.24:1
Manimaker	3.41	1.72	0.9	5.28	1.98:1
NS 101	2.84	1.38	0.9	3.53	2.06:1
Kubergeeta	3.93	1.91	0.9	6.75	2.06:1
Ganpati	4.22	2.20	0.9	8.35	1.92:1
Sadabahar	3.42	1.53	0.9	4.71	2.23:1
Paras Dadi	3.66	1.77	0.9	5.83	2.07:1
Akash	3.71	1.83	0.9	6.11	2.03:1

Note : L = Length of leaf; W = Width of leaf

Appendix II : Leaf area and length-width ratio of middle leaf

Variety	Length of leaf (cm)	Width of leaf (cm)	Constant factor	Leaf area (sq. cm.)	L-W Ratio
Pusa Ruby	5.53	2.75	0.9	13.68	2.01:1
S-22	3.81	2.06	0.9	7.06	1.85:1
Punjab Keshri	4.62	2.58	0.9	10.73	1.79:1
Sanjeewani BWT 101	4.23	2.06	0.9	7.84	2.05:1
Sun 5715	3.84	2.10	0.9	7.26	1.83:1
Navodaya	4.91	2.67	0.9	11.80	1.84:1
Manimaker	4.40	2.29	0.9	9.07	1.92:1
NS 101	3.64	1.95	0.9	6.39	1.87:1
Kubergeeta	4.55	2.31	0.9	9.25	1.97:1
Ganpati	4.73	2.53	0.9	10.77	1.87:1
Sadabahar	4.28	2.31	0.9	8.90	1.85:1
Paras Dadi	4.31	2.44	0.9	9.46	1.76:1
Akash	4.61	2.43	0.9	10.08	1.89:1

Note : L = Length of leaf; W = Width of leaf

Appendix III : Leaf area and length-width ratio of lower leaf

Variety	Length of leaf (cm)	Width of leaf (cm)	Constant factor	Leaf area (sq. cm.)	L-W Ratio
Pusa Ruby	4.54	2.37	0.9	9.68	1.92:1
S-22	3.27	1.78	0.9	5.24	1.84:1
Punjab Keshri	4.56	2.45	0.9	10.05	1.86:1
Sanjeewani BWT 101	4.22	2.38	0.9	9.04	1.77:1
Sun 5715	3.52	1.99	0.9	6.30	1.77:1
Navodaya	4.86	2.73	0.9	11.94	1.78:1
Manimaker	3.77	2.20	0.9	7.46	1.71:1
NS 101	3.74	2.20	0.9	7.40	1.70:1
Kubergeeta	3.75	2.03	0.9	6.85	1.85:1
Ganpati	4.47	2.89	0.9	11.63	1.55:1
Sadabahar	3.72	2.18	0.9	7.30	1.71:1
Paras Dadi	4.33	2.31	0.9	9.00	1.87:1
Akash	4.62	2.54	0.9	10.56	1.82:1

Note : L = Length of leaf; W = Width of leaf

VITA

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