# MANAGEMENT OF ERIOPHYID MITE, *Aceria granati*, ON POMEGRANATE AND MORPHO-PHYSIO-HISTOPATHOLOGICAL EFFECTS OF THE PEST ON THE HOST

# अनार की एरियोफिड बरुथी, *ऐसेरिया ग्रेनेटी*, द्वारा परपोषी पौधे की अकारिकी-कार्यिकी-उत्तकीय संरचना पर प्रभाव एवं इसका प्रबन्ध

**VIJAY KUMAR AGRAWAL**

**THESIS**

Doctor of Philosophy in Agriculture

( ENTOMOLOGY )

2001

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY AND ZOOLOGY

S. K. N. COLLEGE OF AGRICULTURE

CAMPUS : JOBNER–303329

# "MANAGEMENT OF ERIOPHYID MITE, *ACERIA GRANATI*, ON POMEGRANATE AND MORPHO-PHYSIO-HISTOPATHOLOGICAL EFFECTS OF THE PEST ON THE HOST

अनार की एरिफोयिड बरूथी, *ऐसेरिया ग्रनेटी* द्वारा परपोषी पौधे की अकारिकी–कार्यिकी–ऊत्तकीय संरचना पर प्रभाव एवं इसका प्रबन्ध

***THESIS***

**SUBMITTED TO THE**
**RAJASTHAN AGRICULTURAL UNIVERSITY, BIKANER**
**IN COMPLETE FULFILMENT OF THE REQUIREMENT**
**FOR THE DEGREE OF**

# DOCTOR OF PHILOSOPHY

**IN**

**AGRICULTURE**

( ENTOMOLOGY )

**BY**

**V.K. AGRAWAL**

2000

# ACKNOWLEDGEMENT

The author wishes to express his deep sense of gratitude to Dr. C. K. Sharma, Professor, Dept. of Entomology, A. R. S. Durgapura (Jaipur) for his valuable guidance helpful suggestions and constructive criticism through out the course of study.

The author in gratified to record his sincere thanks to the members of Advisory Committee, Dr. H. L. Meena, Professor and Assoc. Director (Res), A. R. S. Durgapura, Dr. R. S. Dhaka, Associate Professor and Head, Dept of Horticulture, S K N College of Agriculture, Jobner, Dr. Ashok Sharma, Associate Professor and Deputy Director, Directorate of Research, Rajasthan Agricultural University, Bikaner and Dr. B. K. Sharma, Associate Professor and Head , Dept. of Statistics, S K N College of Agriculture, Jobner for their generous help and valuable suggestions during the course of study.

The author gratefully acknowledge Dr. P. Joshi, Dean and Dr. V. S. Kavadia, Former Dean, S K N College of Agriculture, Jobner for providing necessary facilities during the period of investigations.

It is pertinent to record sincere gratitude to Dr. N. L. Sen, Professor (Hort.), Dr. S. C. Bhardwaj, Professor (Entomolgy), Dr. P. M. Kanwat, Head, Dept. of Entomology, Dr. R. C. Jat, Dr. S.Mukherjee, Dr. N. K. Gupta for their valuable suggestions and commendable help rendered during the completion of this manuscript. Also help rendered by colleagues namely, Dr. Cheema, Sh. S. K. Goyal, Sh. S. L. Sharma and other staff members during study period is duly acknowledged.

I am highly indebted to my parents and brothers whose blessings and encouragement always remained a source of inspiration to me for higher studies.

Last but not last the most cordial appreciation goes to my wife Smt. Prem Lata, daughters, Ms. Bhawana and Subhra and sons, Luv and Kush, whose patience, sacrifice and moral support led me to complete my academic session.

(V.K.Agrawal)

CONTENTS


| Chapter No. | Particulars |
|---|---|
| 1. | INTRODUCTION |
| 2. | REVIEW OF LITERATURE |
| 3. | MATERIAL AND METHODS |
| 4. | EXPERIMENTAL RESULTS |
| 5. | DISCUSSION |
| 6. | SUMMARY |
| 7. | REFERENCES |
| | ABSTRACT (English) |
| | ABSTRACT (Hindi) |
| | APPENDICES |

LIST OF TABLES


| S.N. | Table | Title |
|---|---|---|
| 1. | 3.1 | Physical and chemical properties of the soil of experimental area |
| 2. | 4.1 | Mean fortnightly meteorological data and incidence of leaf curl suite, A. granati. |
| | 4.2.a | Correlation coefficients between mite incidence (mite population and leaf damage intensity) and weather parameters. |
| 4. | 4.2.b | Prediction equations and R2 for predicting mite of A ranati infesting pomegranate |
| 4 | | |
| 5. | 4.3 | Preference of A. granati to differnet faces of pomegranate tree, cv. Ganesh, at different peaks of mite infestation |
| 6. | 4.4.1 | Incidence of A. granati on different cultivars of pomegranate |
| 7. | 4.4.2 | Categorization of pomegranate cultivars on the basis of lcaidanuige infestation (%) |
| 8. | 4.4.3 | Mite incidence and morphological variations in leaves of different cultivars of pomegranate !s . |
| 9. | 4.5.1 a | Effect of mite feeding on growth of pomegranate plants , cv. Ganesh during 1995-96 |
| 10. | 4.5.1b | Effect of mite feeding on growth of pomegranate plants , Ganesh during 1996-97 |


Contd....

| S.N. | Table | Title |
|---|---|---|
| 11. | 4.5.2a | Effect of mite feeding on fruit formation in pomegranate plants, cv. Ganesh during 1995-96 |
| 12. | 4.5.2b | Effect of mite feeding on fruit formation in pomegranate plants, cv. Ganesh during 1996-97 |
| 13. | 4.5.3 | Effect of mite feeding on chlorophyll content of pomegranate leaves (mg/g fresh leaf wt.). |
| 14. | 4.5.4 | Effect of mite feeding on transpiration rate of pomegranate plants (µg cm sec-1) |
| 15. | 4.5.5 | Effect of mite feeding on relative leaf water content (RLWC) of pomegranate leaves |
| 16. | 4.7 | Bio-efficacy of some pesticides against A. granati on ome Tranate |

LIST OF FIGURES


| S. N. | Figure No. | Title |
|---|---|---|
| 1. | 4.1 a | Meteorological parameters and mite incidence 7 (1995-96) |
| 2. | 4.1 b | Meteorological parameters and mite incidence (1996-97) |

LIST OF PLATES


| Plates No. | Title |
|---|---|
| Plate 1 | A pomegranate twig infested by leaf curling mite, A. granati |
| Plate 4.1 | Healthy pomegranate leaf twig (one twig on left) and mite infested leaves (five wigs on right side) |
| Plate 4.5.2.a | Examples of distortion rating used to score flowers for distortion caused by A. granati. Top row, normal flowers (distortion rating 0); second row, distortion rating 1; third row, distortion rating 2; fourth row, distortion rating 3 |
| Plate 4.5 2b | Examples of distortion rating used to score fruits for distortion caused by A. granati. Top row, normal fruits (distortion rating 0); second row, distortion rating 1; third row, distortion rating 2; fourth row, distortion rating 3 |

k

r

# LIST OF APPENDICES


Appendix No. Title

Appendix 1 : Mite fauna damaging pomegranate in India

Appendix 2 : Crop protection levels

Appendix 3: Type of plant abnormalities/ injury caused by eriophyoids

Appendix 4 : ANOVA for preference of face by A. granati

Appendix 5 : AN OVA for varietal susceptibility of different cultivars (1995-96)

Appendix 6 : ANOVA for varietal susceptibility of different cultivars (1996-97)

Appendix 7 : ANOVA for varietal susceptibility of different cultivars (pooled analysis)

Appendix S :Vegetative variations due to feeding of A. granati in pomegranate plants

Appendix 9: ANOVA for bio-efficacy of pesticides against Agranali on pomegranat before spray

Appendix 10: ANOVA for bio-efficacy of pesticides against A granali on pomegranate at different intervals

e pomegranate (Punica granatum L.) is an ancient and favourite table fruit. It is commercially grown for its sweet
acidic fruits which provides a cool refreshing juice and is valued for its medicinal properties.

The fruit can successfully be grown even under conditions of severe draught and frost and as such, it is widely grown in the plains of Andhra Pradesh, Gujarat, Karnataka, Maharastra, Rajasthan, Tamil Nadu and Uttar Pradesh. Every year around 4000 tonnes of pomegranate valued between 7 - 8.5 crores are exported from India (Sudhakar, 2000). In Rajasthan, area under pomegranate is 389 ha, with the production of 2800 M. T. in the year 1995-96 (Anonymous, 1996a).

Pomegranate trees are attacked by about 45 species of insects in India (Butani, 1979). With the recent introduction of highyielding varieties and the subsequent improvement in agriculture practices, mites are also acquiring pest status,. Nevertheless, about one dozen mites have been reported in India damaging pomegranate (Appendix I). Among these, Eriophyid mites have been identified as potential pests of plants, which also act as vectors of plant pathogenic viruses (Ramani and Haq, 1989; Chakrabarti, 1999a). Association between eriophyids and injury to plants have received considerable attention (Keifer, 1952; Jeppson et al., 1975; Westphal, 1976; Ghos~et al., 1989). Eriophyids are exclusively phytophagous and highly host specific ve~Imiform mites inducing various types of malformations on their host plants (Das and Chakrabarti, 1988; Ramani and Haq, 1989). Majority of these eriophyids have been reported from a single host only except

rhyncaphytoptids which attu k more than one host plant (Chakrabarti, 1999 b). pomegranate leaf-curl mite, Aceria granati (Can. & Mass.) has got the status of important eriophid mite of pomegranate in India ( Sohi et al., 1997). The occurrence of A. granati has been observed in epidemic form in Rajasthan (Agrawal, 1990). As a result of colonization by mites, leaf edges roll, curl and shrink thus chlorophyll content is reduced, upsetting the photosynthetic process, resulting in reduction in plant growth and yield. A. granati has also been reported as a serious pest of pomegranate in the state of Uttar Pradesh ( Agrawal et al., 1990). Looking to the economic importance of the mite, the control package for A. granati has been incorporated in the "State package of practices of horticultural practices" (Anonymous, 1996b).

The introduction of the EIL concept for control of economic entomology in the early 1960s was an important step forward in the development of field crop and pest specific thresholds (Stern et al., 1959). It was felt necessary to distinguish between different factors that affect the yield loss (Stern, 1973). Though, crop production levels (Appendix- 2) can influence the damage effects, it is therefore, helpful to distinguish four production levels (de Wit, in Penning de Vries and Van Larr, 1982). Many horticultural crops and some of the cash crops fall into production level 1 and 2 (Rabbinge, 1985). At all production levels pests and diseases may play an important role as yield-reducing factors. Mites are only of importance in crops achieving production level 1 and 2.

Many authors have correlated the increase in mite population with the application pesticides. Some of them have stimulated the physiology of~directly and have effect on the natural enemies of mites indirectly (Huffaker and Spitzer, 1950, Van de Vrie et al., 1972). As a result in many cases it affects the host plant-mite relationship.

Considering the nature of pest status of A.granati on pomegranate which is an important arid zone fruit crop (Mohan Kumar et al.,1991), and the lack of information, an attempt has been made to evolve and design pest management practices based on a sound economically feasible and ecological footing.

The following objectives were set forth for the present studies:

1. Intensity of infestation and seasonal incidence of A.granati on pomegranate.

2. Influence of abiotic factors on the population build-up of the pest.

3. Varietal susceptibility of different cultivars of pomegranate against A.granati.

4. Effect of infestation of A.granati on morpho-physiological processes in pomegranate.

5. Histopathology and biochemical characterization of damaged leaves by A.granati.

6. Bio-efficacy of some pesticides against A.granati on pomegranate to develop chemical control schedule of the pest.

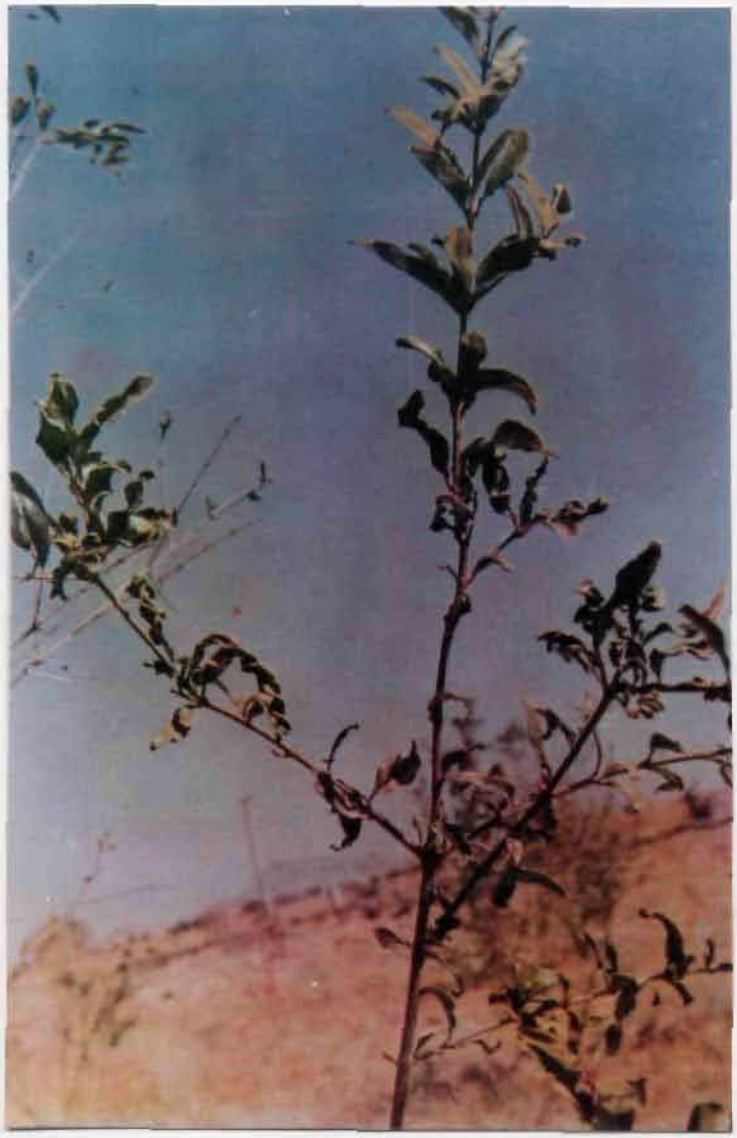


Plate 1 A pomegranate twig infested by leaf curling mite, *A. granati*

## 2. REVIEW OF LITERATURE

The available literature on pomegranate leaf curl mite, Aceria granati (Can. and Mass,) indicates that some aspects of its nature of damage and studies on ecological parameters have been briefly touched upon. However, information on varietal susceptibility of host plant, morpho-physio-histopathological constituents of host plant, and control is not available. An attempt has been made to review some of the

available pertinent and related literature (Vide infra).

### 2.1 SYSTEMIC POSITION AND NOMENCLATURE

| | | |
|---|---|---|
| Phylum | : | Arthropoda |
| Subphylum | : | Chelicerata |
| Class | : | Arachnida |
| Sub class | | Acari |
| Super order | | Actinotrichida |
| Order | : | Prostigmata |
| Sub order | : | Raphignathina |
| Super family | : | Eriophyoidea |
| Family | : | Eriophyid ae |
| Sub family | : | Eriophyinae |
| Genus | : | Aceria |
| Species | : | V ranati |

Siebold (1850) was the first to name the mite on linden as Eriophyes. A year late, Dujardin ( 1851) studied the same species on linden and described the species under the name Phytoptus. The proposed name of the type specimen of pomegranate leaf-curl mite, identified by Canestrini and Massalongo (1894) was Phytoptus granati Can. and Mass. Jeppson and Co-workers had recognised the pomegranate leaf-curl mite as Eriophyes granati (Can. and Mass.)
(Jeppson et al., 1975). Keifer (1944), in dividing the genus Eriophyes (Phytoptus-old name) into three genera, proposed the generic name Aceria, to receive those species having dorsal setiferous tubercles
located on the rear shield margin, directing the setae caudal. On the basis of these characters, Keifer (1944) proposed the name of pomegranate leaf-curl mite as Aceria granati (Cann. and Mass).

## 2.2. DISTRIBUTION

The occurrence of the mite A. granati as a pest was reported for the first time from Southern Europe and California infesting pomegranate (Keifer, 1938). The species was also reported infesting pomegranate in North America (Keife.r, 1946); Italy (Keifer, 1952); Pakistan (Kazimi and Ghani, 1969) and Iran (Arababi et al., 1999).

In India,damage due to A. granati was first reported in Mysore by Puttarudriah and ChannaBasavanna (1959). Subsequently it was reporteL from Karnataka and Delhi ( ChannaBasavanna, 1966); Varanasi (Mohansundram, 1985); Utter Pradesh (Agrawal et al., 1990), Rajasthan (Agrawal, 1990) and Tamil Nadu (Umapathy and Mohansundar~n, 1998).

## 2.3. NATURE OF DAMAGE

Eriophyoid mites feed only on the tissue of the plant hosts (Jeppson et al., 1975). Eriophyoid mites, on the whole, cause little no mechanical damage to plant tissue by their feeding. In fact, it is to their advantage to keep the host plant alive and so preserve the viability of the succulent tissue on which they feed.

Leaf-curl mite, A. granati has been found to damage pomegranate leaves. The mite injury causes rolling and stunting of the leaves (Keifer, 1946). Initially the leaves showed slender and thread-like processes and finally reduce the leaf lamina completely barren (Puttarudriah and ChannaBasavanna, 1959). Further, ChannaBasavanna (1966) reported that mite lived inside tight rolled edges of the leaves. The infested leaves became linear and highly deformed. According to MohanaSundaram (1985), mites were found inside the rolled edges of tender leaves, resulting into various deformities. Agrawal (1990) reported that the pest feeds in congregation on leaves, resulting in their curling and shrinkage. Similar nature of damage of the pest has been reported by Agarwal et al., (1990). Verma and Kapur (1990) also reported that the mite rolls the

leaves from the sides down on to under surface.

Different types of plant injuries on host plants by different species of eriophyids have been detailed by GhosLet al., (1989) (Appendix-3).

## 2.4. ROLE OF KEY ABIOTIC FACTORS ON MITE INCIDENCE

Studies undertaken to see the influence of abiotic factors on the population built up of leaf curl mite, A. granati', on pomegranate showed significant correlation of different weather factors with the population. Two population peaks were observed, first in April-May and another in the month of December (Agrawal et al., 1990).

Population studies carried out on false spider mite, Tenuipalpus granati Sayed, on pomegranate in Egypt, revealed that mite populations increased during the spring, reaching the peak in July, followed by gradual decrease until December (Zaher and Elbadry, 1964).

b

Al-Gboory and El-Haidari (1989) also carried out work on another false spider mite, Tenuipalpus punicae Pritchard and Baker infesting pomegranate in Iraq. They reported that the mite population touched a peak during summer (May to July) and caused economic damage to the plants, especially during July and August.

## 2.5. VARIETAL SUSCEPTIBILITY

The available literature revealed that no attempts have been made to study the relative susceptibility of host varieties to A. granati. Moreover, the damage due to A. granati was least in pomegranate cultivars Dhalka and GKVK-1 and it was maximum in Ganesh (Anonymous, 1996c).

Nevertheless, studies conducted on relative susceptibility of some field/fruit crops to the infestation of other species of genus Aceria indicated the variability in the level of mite injury in different cultivars.

YQ

Sundaraj et al. (1967) reported that medium-cum-pointed budded varieties of jasmine were highly resistant. While long-cum-pointed budded varieties were highly susceptible to Jasmin erineum mite, Aceria jasmini. Rajgopal et al. (1970) studied the physiological mechanism of resistance in Jasmine to Aceria jesmini and reported that there was a positive role of tissue moisture in favouring mite build-up.

Sithanantham and Velayutham (1979) studied the incidence of Aceria sacchari in six sugarcane varieties and reported that susceptibility of different sugarcane varieties to the pest could be related

to characters, such as leaf carriage, sheath tightness and bloom, fresh weight and moisture content, leaf sheath thickness and clearance of inner epidermis to vascular bundles in the leaf sheath.

Nat"rajan and Beevi (1990) screened twenty two pigeon pea entries for resistance to eriophyid mite, Aceria cajani and found that most of the entries had succumbed to high disease pressure and only four entries viz., Prabhat, SAI 35 Kr-1, SAIEMSO and Entry-86163 showed varying degree of resistance. Reddy et al. (1995) also tried to find out the mechanism of resistance to Aceria cajani in pigeonpea and reported

that the leaf cuticle and epidermal cell wall were 50-100 per cent ticker F
in resistant lines as compared to susceptible lines. They further observed that in resistant lines, the cuticle thickness was more than the stylet length and the mite was unable to penetrate the living epidermal cells to complete the life cycle.

Al-Gboory et al. (1991) studies the susceptibility of fig varieties Soltani and Adsi to Aceria flcus infestation and found that soltani variety was more susceptible to the mite infestation than fig variety Adsi. This difference may be attributed due to the fact that soltani leaves had many long and abundant hairs on the lower side.

Suresh and Mohansundaram (1995) screened 59 mango varieties for resistance to Aceria mangiferae in April and May, 1992. In general, infestation was higher in May than in April, and there were interactions between varieties and sampling periods, possibly due to heavy latex production following previous mite injuries.

Kumar (1999) screened some important commercial cultivars of litchi and reported that cultivars Shai, Mandrajee, Early Bedana and late Bedana harbour more mites resulting in higher fruit drop ranging from 20.26 to 25.0% during the early development stage. The cultivar Kasaba

was rated as less susceptible as compared to other cultivars recording the least infestation and fruit drop (7.20%), whereas other commercial cultivar China recorded higher percentage of leaves affected and fruit drop.

## 2.6. EFFECT OF MITE FEEDING ON MORPHO-PHYSIOLOGICAL PROCESSES

From the review of literature, it is evident that Eriophid mite feeding can cause considerable damage to the crop. No information is available about A. granati affecting the morpho-physiological process in pomegranate. Moreover, studies conducted on pertinent species have been reviewed here for the purpose. Characteristic deformation, to leaves, twigs, flowers and fruit caused by citrus bud mite, Aceria she!doni (Ewing) were illustrated and described in detail by Boyce and Korsmeier (1941). Similarly, decrease in the number of leaves per plant due to mite attack was reported by Avery (1962). The total leaf area of damaged plants usually was strongly reduced because of a decreaselrate W t, growth in leaf area (Avery and Briggs, 1968 and; Summers and Stocking, 1972). A slower rate of increase in the diameter of the trunk
followed by a delayed effect in the rate of growth of the stem was observed in the year following injury (Van de Vrie et al., 1972-and Barnes and Andrews, 1978). The influence on flowering of fruit trees was reported to be conspicuous in the year following the attack, resulting into a loss of yield by 75% (Golik, 1975). Tomczyk and Kropcz (1985) observed a retardation of the growth of all organs of damaged plants. Tomczyk et al. (1989) studied the feeding effects of spider mites on the host plants and observed that mite attack not only affected the tolerance but also changed plant physiological parameters. Moreover, some studies have
been conducted on the feeding effects of Tenuplapus punicae infesting a pomegranate (Al Gbrooy and El-haidari, 1989).

Walker et al. (1992) studied the effect of high population densities of Aceria sheldoni and fetched poor price as a result of loss in the fruit weight and fruit yield. Similarly, the bud mite A. sheldoni also caused distortion of lemon flowers and increased abscission rate in flowers and fruits (Phillips and Walker, 1997).

Vaneckova-Skuhrava (1996) studied the harmfulness of eriophyid mites on trees and shrubs in the Czech Republic and reported that the eriophyid mites attack increase the leaf weight with increasing number of galls pro leaf but the surface of attacked leaves decrease with increasing attack.

## 2.7. HISTOPATHOLOGY AND BIOCHEMICAL CHARACTE

RIZATION OF MITE DAMAGED HOST LEAVES

Information on Histopathology and biochemical characterization of damaged leaves of pomegranate due to A. granati is lacking. However, the literature relevant to present study is reviewed and presented below:

### 2.7.1. Biochemical characterization

Feeding by several species of eriophid mites caused severe leaf

deformities (Prasad, 1974 -and Ananthakrishnan, 1984). The biochemical analysis of galls formed by eriophyid mites on Pongamia glabra (Balasubramanian and Purushothaman, 1972), Prosopis cinereria L. and Zyziphus mauritiana Lam. Purohit et al. (1979) showed that they had higher amount of phenols and proteins as compared to healthy ones.

Manjunatha et al. (1989) also studied histochemical and biochemical aspects of galls of Pongamia glabra Vent caused by the mite, Aceria pongamia and reported that galled leaves were poor in starch, polysaccharides and RNA and richer in protein contents. Flechtmann and Berti-Filho (1994) studied the effect of feeding by Acaria acnisti

Keifer on Acnistus "auliflorus and reported that there was considerable increase in the content of the six macronutrients in the infested leaves. Micronutrient increase mainly in the iron and copper content was noted, zinc remained unchanged.

Baghel et al. (1994) studied morphological and bio-chemical characteristics of healthy and malformed panicles of mango and found that total carbohydrate, nitrogen, crude protein, phosphorus, TSS content were significantly higher in healthy panicles as compared to malformed panicles. However, moisture percentage and potassium content were observed markedly higher in malformed than in healthy

panicles.

Chakrabarti et al. (1999) studied the effect of Acalitus hibisci infestation on photosynthetic pigments of Hibiscus vihfolicus and found that chlorophyll a and b content of the infested leaves decreased by 18.05% and 39.01%, respectively, while carotene content was increased by 59.8%

2.7.2. Histopathological characterization:

Agrawal and Kandawsami (1959) observed that epidermal cell of sugarcane in the outer layer were largely flattened and destroyed in mite infested leaves. Both the parenchymatous matrix and vascular bundles were more or less equally affected.

Das et al. (1987) observed anatomical changes in jute stein as a result of feeding of yellow mite, Polyphagotarsonemus latus Banks and reported that the diameter of the infested stem was reduced. However, epidermal cells, collenchyma and metaxylem were reduced in volume in comparison to healthy stern.

## 2.8. EFFICACY OF PESTICIDES AGAINST A. GRANATI

No literature is available on chemical control of A. granatz' except a brief studies made by Agrawal (1990), where in he had evaluated the relative efficacy of six pesticides against A. granati infesting pomegranate through a field trial and found that monocrotophos (0.05%) was most effective, followed by ethion (0.05%). The overall performance of six pesticides in descending order of efficacy was : ronocrotophos, ethion, dicofol, di:methoate, malathion and phosphamidon.

In order to elucidate the situation with clarity,pertinent work done so far, on the chemical control of other species of genus Aceria are being reviewed in the present chapter.

Different workers have recommended different pesticides for the control of mango mite Aceria mangiferae, recommendation of spraying of pesticides before bursting of buds (Prasad et al., 1965), diazinon (0.03%) and phorate at 25 kg/acre (Rai et al., 1966); dimethoate, methyl demeton or phosphamidon as 0.01% EC (Yadav and Verma, 1969); aldicarb 0.05 kg/plant (Varma and Yadav, 1970); diazinon, moncrotophos or phosphamidon as 0.1% EC (Srivastava, 1974) and diazinon 0.01% (Butani and Srivastava,1979). Mishra and Das (1995) recommended the spray of sulfex or dicofol or dinocap with plant hormones (miraculan 200 ppm or planofix 200 ppm) against A. mangifera.e.

Mathur (1972) recommended spraying of Akar 38, phosphamidon, thiometon, di"mefhoate or d icofol at 10 days intervals against the litchi mite, Aceria litchi. Mukherjee et al. (1990) evaluated relative efficacy of nine pesticides in three concentration viz., low (0.01/0.1% a. c.), medium (0.03/0.2% a. c.) and high (0.05/0.3% a. c.) against A. litchi in a field trial and found that all the nine pesticides proved significant reduction of the mite population over the control. The over all percent leaf infestation

was in the following descending order, Dimethoate (8.14), wettable sulfur (11.46), carbaryl (12.27), Endosulfan (12.41), Tetradijon (12.90), Ethion (13.28), Dicofol (13.67), Mancozeb (13.73) and Carbendazim (17.17). Kumar (1992) concluded through field trials that mite A. litchi could be managed by combing pruning of infested twig after harvest with spray of dicofol or monocrotophos at 0.05 per cent twice with a seven days interval at the onset of flushing during September-October. However, pruning alone and application of 0.5 per cent di-methoate were

ineffective.

Letchoumanane and Subramaniam (1979) evaluated the relative efficacy of four soil applied insecticides at four doses against eriophyid mite Aceria jasmini on Jasmine and found that aldicarb at the highest dose (2 kg toxicant/ha) provided the effective control of the mite. It was followed b_y ' Carbofuran and phorate. However, disulfoton was proved to be least effective. Mallikarjunappa et al., ( 1990) reported the effectivity of Ethion (0.05%), fenpropathrin (0.01%), Dicofol(0.02%) and combination of ethion + dimethoate (0.05 + 0.03%) against A. jasmini. Udayagiri and Jagan Mohan ( 1993) also conducted a field trial for the control of A. jasmini on jasmine at IIHR, Bangalore to evaluate the efficacy of six pesticides (foliar sprays) in comparison to aldicarb (1.0 kg a. i./ kg) applied to the soil. The results indicated that the spray of monocrotophos (0.05%), phosalone (0.07%) and wettable sulpher (0.14%) were significantly effective in reducing the mite damage.

Gupta et al. (1975) reported that carbophenothion, carbofuran, dicrotophos, fenitrothion, fenthion, monocrotophos, phosalone and vamidothion(all at 0.015%)could bring upto 90% mortality of Aceria lycoperici infesting brinjal.

Gupta (1985) has reported the spraying of methyl demeton against Aceria ficus (cotte) as it control the mite effectively.

Naidu and ChannaBasavanna (1989) reported that systemic pesticides, except di~methoate brought about a reduction of mite, Eriophyes cumbopogonis on citrus grass (84.71 to 90.70% population in 120h). However, dimethoate was at par (70.99%) with the two conventional acaricides ( 68.39% and 67.07% in dic!fol and sulphur, respectively).

c



# 3. MATERIAL AND METHODS

Investigations entitled "Management of eriophid mite, Aceria granati on pomegranate and morphophysio-histopathological effects of the pest on the host" were carried out during 1995-96 to 1997-98. The details of experimental techniques, materials used and criteria adopted for evaluation of treatments during the course of investigations are described in this chapter under the following heads.

## 3. 1. GENERAL DETAILS OF THE EXPERIMENTS

### 3. 1. 1. Experimental site

The present investigations were conducted in pomegranate orchards at Asalpur Farm, S K N College of Agriculture, Jobner (Rajasthan) during the year 1995-96 to 1997-98. Geographically, Asalpur farm is situated 37 km West of Jaipur at 75.28° East longitude and 26.05° North latitude at 427 metre above mean sea level (MSL). The region falls under Agroclimatic Zone III a (Semi-Arid-Eastern-Plain) of the state. In the experimental orchards, pomegranate -t'-e os were having row to row and plant to plant distance of 5 metre

### 3.1. 2. Climate and weather conditions

The climate of the region is typically semi-arid characterised by the aridity of the atmosphere, scarcity of water, with extremity of temperatures, both during summer and winter. Maximum temperature in summer ranges between 30 to 46°C, whereas, in winter temperature falls below 2°C. The average rainfall varies between 400 to 500 mm, most of which is received in rainy season from July to September. Sporadic

showers in winter are also not uncommon. Wells are the only source of irrigation and water table is quite deep (about 25-30 metres).

The periodic data for temperature, relative humidity, rainfall, evaporation and sunshine hours for the period of experimentation were obtained from the Meteorological observatory, S. K. N. College of Agriculture, Jobner.

3.1. 3. Soil of experimental field

The soil of the experimental field was loamy sand in texture and low in organic carbon. The general physico-chemical characteristics of the experimental soil is given in Table 3.1.

Table 3.1. Physical and chemical properties of the soil of experimental area

| S. No. | Characteristics | Value A Physical composition |
|---|---|---|
| 1 | Soil type | Loamy sand |
| 2 | Particle density | 2.50 mg m-3 |
| 3 | Bulk density | 1.47 mg m-3 |
| 4 | Field capacity | 10.4% |
| 5 | Wilting point | 2.6% |
| 6 | Available water | 7.8% B Chemical properties |
| 1 | Available N | 151.30 kg ha-' |

| | | |
|---|---|---|
| 2 | Available P205 | 21.80 kg ha-1 |
| 3 | Available K20 | 305.60 kg ha-' |
| 4 | Organic carbon | 0.19% |
| 5 | EC at 25°C | 0.75 dSm-1 |
| 6 | pH | 8.3 |

3.1.4. Cultural management of the orchard

Standard cultural practices as recommended in state package

(Anonymous, 1996b) were adopted during the experimental period and ambey bahar season crop was taken for the studies.

3.2. SPECIFIC DETAILS OF THE EXPERIMENTS 3. 2. 1. Seasonal incidence

The seasonal incidence of A. granati was studied for two seasons on the plants of susceptible cultivar of pomegranate, Ganesh (Anonymous, 1992). Observations on mite population along with per cent damage intensity were made on three pomegranate trees of approximately of the same height, size and vigour during the year 199596 and 1996-97.

3. 2. 1. 1. Mite population

Fortnightly observations were recorded on three randomly selected plants (each plant was treated as one replication). Thirty leaves were plucked randomly from terminal branches of each plant.,i. e. 10 leaves, each from top, middle and bottom region, from all directions. The leaves

plucked from each plant were collected in separate properly labelled polythene bags and were taken to the laboratory for counting the mite,

population. These leaves were placed individually, on the sticky side of a
t
strip of transparent tape (2 x 12 mm) and were allowed to dry at room temperature. As the leaf dried, the mites crawled from the leaf and stick to the tape (Harvay and Martin, 1988). Counting of the mites was done under stereoscopic binocular microscope and population per leaf was computed. The data on the population counts were analysed statistically using randomized block design after transformation.

3.2.1.2. Per cent damage

Ten shoots each from 3 trees of Ganesh variety were randomly selected and tagged. The fortnightly observations on intensity of leaf curl was recorded on the basis of visual grading as per method described by Riles (1980).

Criteria for grading the severity of leaf curl complex
k

Damage symptoms of leaf curling in a ategory/grade _____
twig/plant_____

0 : No symptoms of leaf curling in a plant/leaf (A= None)

1 1 : 1 to 25 per cent leaves per twig showing curling symptoms (B = light damage)

2 : 26 to 50 per cent leaves per twig showing curling symptoms (C = Medium damage)

3 51 to 75 per cent leaves per twig showing symptoms (D = Heavy damage)

4 > 75 per cent leaves per twig showing curling symptoms (severe malformation) (E = severe damage)

The intensity of infestation (leaf curling) was worked out as per the formula given by Townsend and Henberger (Wenzyl, 1948).

i P _ Sum(n x v) x 100

1- NxR

Where

P = Intensity of leaf curl (%)
n = Number of twigs in each infested category ,.v = Numerical value of infested category

N = Total number of observational unit (number of twigs/plant observed)
'12 Total number of ratings 3.2.2. Effect of key abiotic factors

The observations taken on the mite population as well as per cent umite incidence on pomegranate variety Ganesh were correlated with abiotic factors, such as minimum and maximum temperature, relative humidity and rainfall. Correlation coefficiento (r) were computed of both the years. With a view to study combined quantitative impact different 'abiotic. factors such as maximum temperature (Xi), minimum temperature (x2), relative humidity for morning (X3) and for evening (X4), and total rainfall (X5) on the mite population (Y1) as well as on leaf damage intensity (Y2), a multiple linear regression model was worked out W SNC, all abiotic factors as independent variables, whereas, the population of the mite and leaf damage intensity as dependent variables.

3.2.3. Preference of face of tree to the mite

Ten shoots each from three trees of Ganesh variety were randomly :.tagged from all directions of the tree,i.e. north, south, east and west and :'observations were made on leaf curl intensity on shoots taking into

Fthancteristic adeformities accompanying the mite infestation, during infestation of the mite.

it

3:24. Varietal screening

3.2.4.1. Experimental details

Commonly grown of pomegranate, viz., Dholka, Jodhpur red, Ganesh, GKVK-1, Bassein seedless, P-23, C-137, P-26 and Jalore seedless were screened for their relative susceptibility to leaf curl mite, A. granati. Observational trees were kept free from pesticidal application during the course of study.

3.2.4.2. Method of observation

The observations on mite incidence were recorded on different F cultivars during peak periods as per method described vide supra 3.2.1.2.

The cultivars were also grouped into different categories: as less susceptible (< x - SD), moderately susceptible ( x - SD to x), highly susceptible (( x to x + SD)and extremely susceptible (> x + SD) as per

s the method described by Panda, C1979) Grouping was done on the basis

G of range value calculated by considering the value of general mean (x )

aQ

and standard deviation (SD ±) of prevent damage intensity of leaf curl in different pomegranate cultivars.

3.2.4.3. Mite incidence and morphological characters of leaves

The morphological characters of healthy pomegranate leaves such as length and width were measured in the centimetre scale. To measure leaf area, thin sections of leaves were examined under a microscope with the help of a micrometer. Other morphological characters like density of

s and hairs as well as intervenal distance, standard methods described by Arnott (1959) and Solbrig (1960) were followed. Ten fully matured leaves from one tree of each cultivar were selected randomly and the averages were computed.

3.2.5. Effect of mite feeding on morpho-physiological process of pomegranate

The observations were recorded from the initiation of injury symptoms and were continued systematically during the entire vegetative period. The 'effect of mite infestation on different parameters, such as plant growth, fruit development and crop yield in infested as well as healthy trees, was examined as per the method described by Tomezyk et al. (1989).

3.2.5.1. Rate of growth

The growth of mite infested plants in terms of plant height, stem girth, leaf size, leaf numbers, etc., was compared to the healthy plant of the same age, height and vigourness. 10 plants, each from infested and healthy plants were taken for comparison. The statistical analysis was performed using pooled `t' test. Per cent increase (+) or decrease (-) in plant height, stem girth, leaf size and leaf number WZ& also calculated.

3.2.5.2. Fruit development

Observations on the rate of fruit formation, number of fruit formed and yield of the plants were recorded in healthy and lants. Observations were also taken on distortion/deformities of fruits as a result of mite damage.

X2.5.3. Chlorophyll content

Chlorophyll content of the infested and healthy leaves of pomegranate was estimated during peak infestation by the method described earlier by Hiscox and Israelston (1979).

°3.2.5.4. Transpiration rate

The rate of transpiration was measured at different intervals in infested and healthy plants using steady state porometer (Li-Cor 1600, USA) during the entire vegetative period. Observations on adaxial and
tbaxial side of leaf were combined for finding out the total transpiration ,rate ., expressed in term of µg/cm2/sec.

3.2.5.5. Relative leaf water content (RLWC)

The relative water content of the infested and healthy leaves was determined by Weatherley's ( 1950) method as described by Slavik (1974) with slight modification. In this method, leaves were cut into pieces, .excluding petiole from healthy as well infested leaves, selected at random; The leaf pieces were taken from the middle portion around the mid rib of the leaf blade. The pieces were immediately weighed on ah electronic balance. After weighing, the pieces were allowed to float for saturation on the surface of water in glass Petridishes for 6 hours. Pieces were removed from water and placed on filter paper for removing excess water adhering to epidermal layer. The weight of saturated leaf pieces were taken and finally the pieces were oven dried at 80°C for 4-5 hours and reweighed. Relative water content was calculated using the following

formula:

Relative leaf water content - Origial fresh weight of the leaves - oven dry weight x 100 Turgid weight of the leaves - oven dry weight

9.2.6 Histopathology and biochemical characterization of damaged leaves

2.2.6.1 Histopathology:

Histopathological changes of mite affected leaves were studied by

preparing permanent slide by following the method described by Jenson (1962). For this purpose, healthy as well as infested leaves, plucked from

~_ 4-5 year old pomegranate plant of Ganesh cultivar, were fixed in Carnoy's A solution (absolute ethyl alcohol: glacial acetic acid in the ratio of 3:1) for one hour, then material was transferred into separate Petridishes by means of a fine brush. The fixed leaves were washed out in running tap water and dehydrated using 70% alcohol (12 hrs), 96% (30 minutes), absolute alcohol (30 minutes) and transferred to xylol for 5

Minutes. The leaves were then infiltrated with molten paraffin (60°C) for 1 hour. 10-12 gm thick sections were cut with a standard microtome and

Stained with safranin and fast green stain. The sections so obtained were u subjected to histopathological studies.

3.2.2 Biochemical studies: 3.2.6.2.1

Estimation of total phenol

Total phenols were estimated by the method described earlier by Bray and Thorpe (1954). 500 mg of fresh leaf material was taken and homogenised in 5-6 ml of hot 80% alcohol at 5000 rpm for 10 minutes. Supernatant fraction thus separated was cooled and final volume was

made to 10 ml with 80% alcohol. Out of this)0.5 ml was taken in a test tube and the volume was made up to 1 ml with distilled water. Folin's i agent (0.5 ml) was added and it was kept at room temperature for three minutes. One ml of 20% sodium carbonate solution, freshly prepared, was added and the volume of the mixture was made upto 10 ml with distilled water. The test tube was placed in boiling water bath for 1 minute. The mixture was cooled and absorbance was measured at 650

tam with the help of SPECTRONIC-20. Standard curve was prepared by *king the known amounts of phenol:.:.

3;2.6.2.2. Estimation of total soluble sugar

To estimate the soluble sugars, 100 mg of leaf material was taken and homogenised in 80 per cent (v/v) ethanol. Homogenate was
centrifuged thrice. Supernatant fraction thus separated was made to 25 ml with 80 per cent ethanol.

Soluble sugar was estimated by anthrone reagent method (Dubois et al., 1951). After fraction of soluble sugar, 0.5 ml of supernatant was taken in separate test tube dried in oven at 60°C. One ml distilled water was added to the dried material followed by 5 ml of freshly prepared
anthrone reagent. The tubes were kept in boiling water bath for 10 minutes cooled and absorbance was measured at 620 nm. Standard curve was prepared by taking the known amounts of glucose.

3.2.6.2.3. Estimation of reducing sugars

The reducing sugars were estimated by the method described by Nelson (1944). For this 0.2 ml supernatant was taken in a test tube and volume was made up to 1 ml with distilled water. Alkaline copper tartrate reagent (1 ml) was added and the mixture was heated in bong water bath for 10 minutes and then cooled under tap water. 1 ml of arsenicmolybdate colour reagent was added. kept for 10 minutes and then volume was made upto 10 ml with distilled water. The O.D was taken at 500 nm. The amount of reducing sugars was calculated using standard curves of glucose.

3.2.6.2.4. Estimation of Free Amino Acids

The amount of free amino acids was estimated by ninhydrin reagent method (Moorey and Stein, 1958). Amino acids were measured in ethanol soluble fraction which was obtained earlier for measurement of ethanol soluble sugars. Suitable aliquot (0.5 ml) was taken in test tube, dried in oven at 60°C and cooled. One ml distilled water was added
followed by one ml ninhydrin reagent. Samples were kept in boiling water bath for 20 minutes. After cooling, 5 ml of toloune solution was added. The absorbance was measured with the help of SPECTRONIC -20 at 570 nm. Standard curve was prepared by taking known amount of

glycine.

The solutions used in determining the free amino acids were prepared as follows

Citrate buffer (0.2 m, PH S. 0)

Citfate buffer was prepared by dissolving 21 mg of citric acid in 200 ml of 1 N NaOH and total volume was made up to 500 ml by adding distilled water. pH of buffer was adjusted by using either dilute HC1 or NaOH. .

Mnhydrin reagent

Ninhydrin reagent was prepared by dissolving 400 mg of ninhydrin and 16 mg stannous chloride in a mixture of 10 ml citrate buffer + 10 ml methyl cellusolve.

3.2.6.2.5. Estimation of Protein

For the estimation of protein, the method described by Lowry et al., (1951) was used.

REAGENTS

Solution A : 2% $Na_2CO_3$ in 0.1 N NaOH

Solution B : 1% Copper sulphate

Solution C 2% Sodium potassium tartarate

Solution D : 100 ml solution A + 1.0 ml solution B 1.0 ml solution C

Solution E : Phenol reagent was diluted with glass distilled water in the ratio of 1:2.

PREPARATION OF STANDARD CURVE

Standard curve was prepared using Bovine Serum Albumin (BSA). 10 mg of BSA was dissolved in 100 ml of distilled water. In a series of test tubes 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 10.0 ml of protein solution was pipetted out in duplicates and a blank without protein was also prepared. The volume was made upto 1.0 ml in each test tube with distilled water. 5.0 ml of reagent D was added in each tube and mixed thoroughly. The mixture was allowed to stand at room temperature for 10 minutes followed by addition of 0.5 ml of reagent E and stirred immediately. The mixture was again allowed to stand at room temperature for 30 minutes. The absorbance was measured by SPECTRONIC-20 at 750 nm.

PROCEDURE

To estimate the protein content of leaves, 100 mg leaves were homoginised in 0.1 M NaCl to obtain supernatant containing all soluble proteins. A suitable volume of extract was taken and protein concentration was measured as described above.

.7. Bio-efficacy of pesticides against A.granati on pomegranate:

A preliminary field trial was conducted by taking two different doses of some pesticides viz., Monocrotophos (0.036 and 0.5%), Malathion (0.05 and 0.07°/a), Endosulforn (0.03 and 0.05%), Dicofol (0.04 and. 0.07%), Ethion (0.03 and 0.05%), Phoshamidon (0.03 and 0.05%), Acephate (0.03 and 0.05%) and Wettable sulpher (0.1 and 0.25%). The foliar sprays of these pesticides were done at 15 days interval. Observations on mite incidence was taken in the month of September 1996 as per the procedure detailed in item 3.2.1.2.

On the basis of preliminary trial, the following pesticidal treatments were found most effective resulting more than 40% reduction in mite population.

1. Monocrotophos 0.05%

2. Malathion 0.05% (higher dose also effective)

3. Di, methoate 0.05%

4. Dicofol 0.07%

5. Ethion 0.05% was

6. Phosphamidon 0.05%

7. Acephate 0.05%

Based on these findings, bio-efficacy of these chemicals including checks was evaluated at II peak in 1996 and I peak in 1997.

3.2.7.1 Experimental details 1)

Design : R.B.D.

4 Replications : 3

3) Unit: 2 plants

4) Variety: Ganesh

5) Plant age: 4-5 years

6) Treatments:

a) Monocrotophos at 0.05%

a
b) Malhthion at 0.05%
c) Di.;methoate at 0.05%

d) Dicofol at 0.07%

e) Ehtion at 0.05%

fl Phosphamidon at 0.05%

g) Acephate at 0.05%

h) Untreated check

8. Methodology: three fortnightly foliar pesticidal sprays, commencing from first week of October 1996 and March 1997, respectively were done.
9. Observations: observations on mite incidence were taken one day before and ten, thirty, sixty and ninety days after the spray-.. For this purpose ten shoots were randomly tagged/selected from each unit and data on leaf damage were recorded as per the methodology described under item 3.2.1.2.
10. Statistical analysis:

For finding out the efficacy of pesticides, the per cent reduction in mite incidence, based on leaf curling, were subjected to analysis of variance after transforming them to angular values.

The per cent reduction in different treatments was calculated as described by Henderson and Tilton (1955).

Percent reduction= I - T' X C" X100

Tb X C,

Where, Ta= mite damage intensity (%) observed after treatment

P

Tb = Mite damage intensity (%) observed before treatment
Ca = Mite damage intensity (%) observed from the untreated check after treatment.

Cb = mite damage intensity (%) observed from untreated check before treatment.

# 4. EXPERIMENTAL RESULTS

Result of the present investigation on "Management of criophid mite, _Aceria granati, on pomegranate and morpho- physiohistopathological effects of the pest on the host" are presented in this chapter under the following heads

4.1. Seasonal incidence of A. granati on pomegranate.
4.2. Effect of key abiotic factors on the population build-up of the pest. 4.3. Preference of face of tree to the mite
4.4. Varietal susceptibility of different cultivars of pomegranate against A. granati

4.5. Effect of mite feeding on morpho-physiological processes of pomegranate.

4.6. Histopathology and biochemical characterization of damaged leaves.

4.7. Bioefficacy of pesticides against A. granati on pomegranate to develop chemical control schedule of the pest.

## 4.1. SEASONAL INCIDENCE OF A. GRANATI ON POMEGRANATE

The present investigations on seasonal incidence of A. granati, were carried out on the pomegranate plants of susceptible cultivar, Ganesh, for two seasons under field conditions during 1995-1996 and 1996-1997.

During field observations, the mite has been found to damage pomegranate leaves. The infested leaves were deformed and became

*Table 4.1 Mean fortnightly meterological data and incidence of leaf curl mite* **A.granati**

| Meterological week | Temp. Max (°C) | Temp. Min (°C) | RH Morning (%) | RH Evening (%) | Rainfall (mm) | Mite population | % leaf damage |
|---|---|---|---|---|---|---|---|
| | | | 1995-96 | | | | |
| 14-15 | 30.9 | 15.8 | 62.5 | 20.5 | 2 | 45.89 | 87.33 |
| 16-17 | 34.5 | 19.7 | 50.5 | 20.5 | 0 | 40 | 98.67 |
| 18-19 | 40.7 | 24.45 | 50 | 32.5 | 0 | 36 | 74 |
| 20-21 | 41.5 | 25.15 | 53.5 | 36 | 0 | 34 | 63.33 |
| 22-23 | 42.95 | 26.3 | 42.6 | 23.5 | 0 | 29.78 | 58 |
| 24-25 | 41.9 | 25.25 | 44.5 | 34 | 0 | 24.56 | 46.67 |
| 26-27 | 39.95 | 21.7 | 54.5 | 41 | 11.6 | 22.32 | 39.33 |
| 28-29 | 36.2 | 22.6 | 77 | 65.5 | 124.8 | 18.69 | 35.33 |
| 30-31 | 30.5 | 23.9 | 96 | 85.5 | 158.6 | 16.45 | 28.67 |
| 32-33 | 30.1 | 23.95 | 91 | 76 | 70.3 | 19 | 28.67 |
| 34-35 | 30.1 | 23.6 | 85 | 68.5 | 169.8 | 21.45 | 46.67 |
| 36-37 | 31.2 | 20.7 | 69 | 66 | 7.4 | 22 | 63.33 |
| 38-39 | 31.55 | 20.2 | 75.5 | 64 | 12.3 | 22 | 76 |
| 40-41 | 32.4 | 17.85 | 65.5 | 61 | 0 | 44.55 | 93.33 |
| 42-43 | 31.5 | 16.2 | 65 | 61 | 0 | 23 | 100 |
| 44-45 | 30.25 | 14.1 | 63 | 50.5 | 0 | 23.67 | 99.33 |
| 46-47 | 29.75 | 12.35 | 59 | 38.5 | 0 | 24.89 | 80 |
| 48-49 | 23.95 | 4.95 | 71.5 | 47.5 | 0 | 27 | 68.67 |
| 50-51 | 22.7 | 6.2 | 68 | 40 | 0 | 39.11 | 69.33 |
| 52-1 | 21.45 | 4.15 | 72.5 | 39.5 | 0 | 40.89 | 66.67 |
| 2 3 | 21.5 | 4.15 | 67.5 | 38.5 | 0 | 42.56 | 66 |
| 4 5 | 21.2 | 3.75 | 68.5 | 43.5 | 0 | 43.44 | 60 |
| 6 7 | 22.05 | 6.65 | 64 | 42 | 0 | 44.89 | 65.33 |
| 8 9 | 24.8 | 10.35 | 69.5 | 39.5 | 0 | 50.33 | 72 |
| 10 11 | 31.9 | 15.1 | 56.5 | 44.5 | 0 | 46.55 | 79.33 |
| 12 13 | 33.1 | 13.95 | 52.5 | 30.5 | 0 | 43.56 | 88.67 |
| | | | 1996-97 | | | | |
| 14-15 | 32.8 | 13.6 | 52 | 33.5 | 0 | 42 | 90 |

| Meterological week | Temp. Max (°C) | Temp. Min (°C ) | RH Morning (%) | RH Evening ( %) | Rainfall (mm) | Mite population | % leaf damage |
|---|---|---|---|---|---|---|---|
| 16-17 | 34.05 | 15.4 | 48 | 29 | 0 | 39.89 | 80 |
| 18-19 | 37.03 | 17.4 | 44.5 | 24 | 0 | 33.44 | 80 |
| 20-21 | 38.4 | 20.5 | 61.5 | 35.5 | 10.4 | 29.22 | 66 |
| 22-23 | 41.2 | 23.05 | 48 | 27 | 9.8 | 23.78 | 61.33 |
| 24-25 | 35.2 | 23.65 | 78 | 50.5 | 136.3 | 22.11 | 53.33 |
| 26-27 | 35 | 24.55 | 69.5 | 46 | 9.2 | 19.22 | 44.67 |
| 28-29 | 36.25 | 26.4 | 77 | 51 | 52 | 17.78 | 40.67 |
| 30-31 | 31.05 | 23.6 | 91.5 | 73.5 | 139.2 | 16.78 | 34.67 |
| 32-33 | 29.95 | 23.6 | 91.5 | 75.5 | 136.6 | 18.78 | 42 |
| 34-35 | 31.4 | 24 | 84 | 72 | 107.9 | 19.22 | 52.67 |
| 36-37 | 29.8 | 23.2 | 87.5 | 77 | 67.9 | 21.11 | 58 |
| 38-39 | 34.05 | 21.95 | 75 | 66.5 | 8.3 | 22.56 | 65.33 |
| 40-41 | 32.5 | 17.5 | 78 | 52.5 | 22.5 | 25.56 | 76.67 |
| 42-43 | 30.7 | 15.35 | 79 | 54.5 | 0.5 | 35.29 | 86 |
| 44-45 | 31.15 | 8.6 | 84 | 28.5 | 0 | 30.33 | 94 |
| 46-47 | 28.25 | 6.8 | 75 | 44.5 | 0 | 39.78 | 99.33 |
| 48-49 | 25.25 | 5 | 73 | 21.5 | 0 | 43.67 | 86.67 |
| 50-51 | 24.25 | 2.55 | 78 | 22.5 | 0 | 44.44 | 78 |
| 52-1 | 23.95 | 2.6 | 85 | 25 | 0 | 41.44 | 72 |
| 2 3 | 20.85 | 2.2 | 82 | 42 | 0 | 32.33 | 68.67 |
| 4 5 | 19.25 | 3.4 | 80 | 35.5 | 0 | 39.22 | 66 |
| 6 7 | 22.85 | 3.8 | 77 | 38 | 0 | 36.78 | 73.33 |
| 8 9 | 24.95 | 6.95 | 71.5 | 29.5 | 0 | 35.55 | 80 |
| 10 11 | 28.9 | 8.25 | 69 | 38 | 0 | 33.44 | 88.67 |
| 12 13 | 28.95 | 11.65 | 68 | 38.5 | 0 | 32.55 | 90 |

**Fig 4.1.a Meterological parameters and mite incidence (1995-96)**

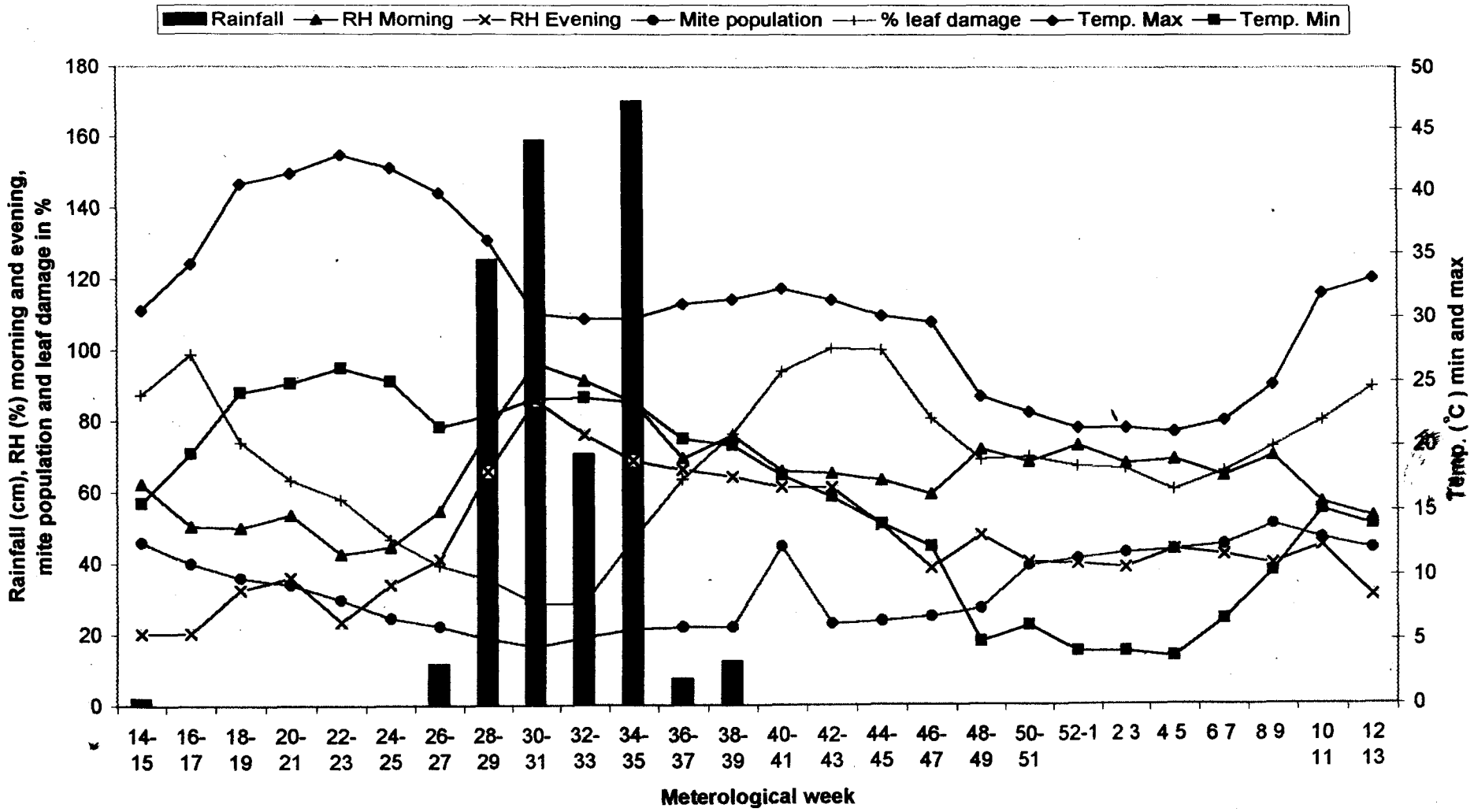
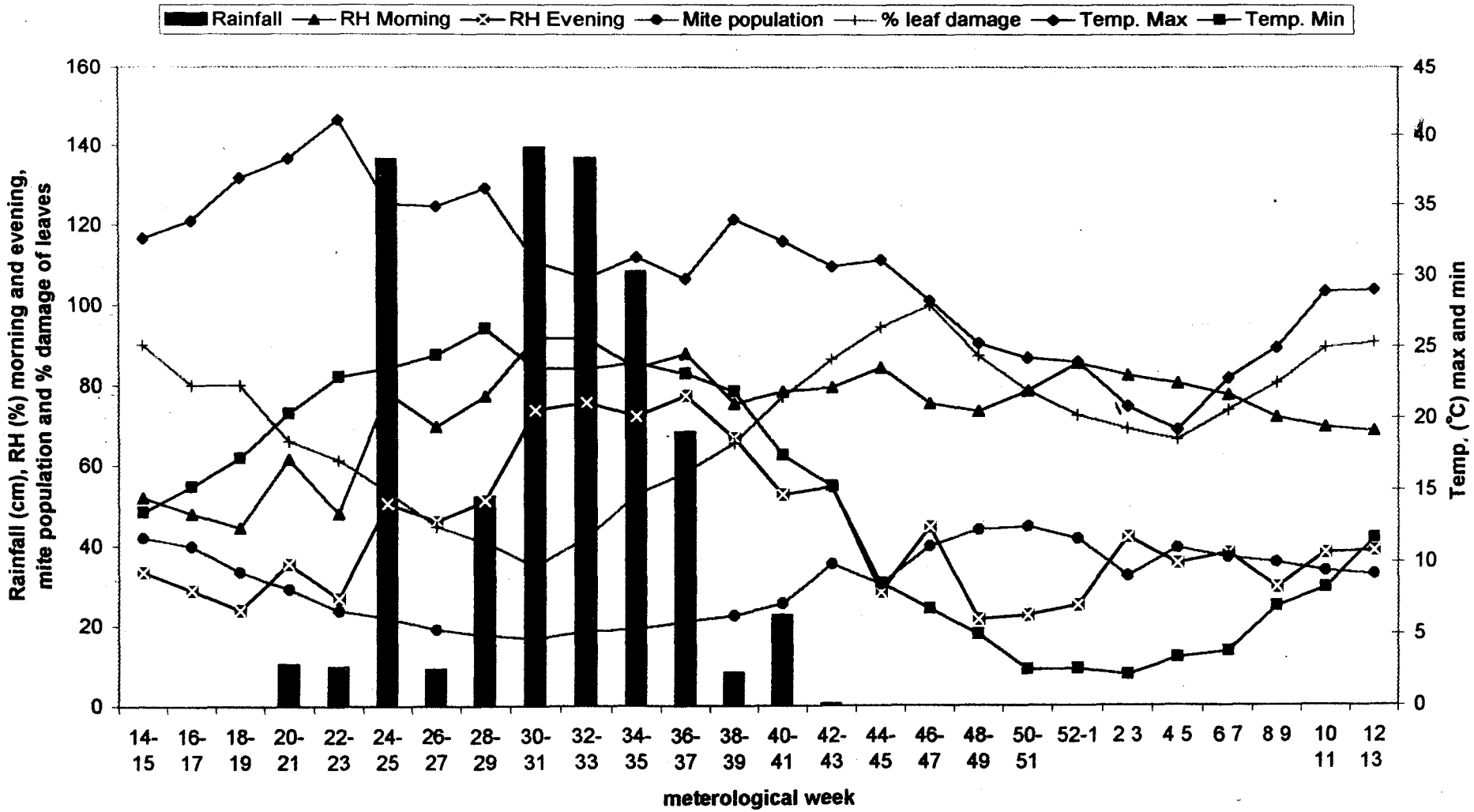


**Fig 4.1.b. Meterological parameters and mite incidence (1996-97)**



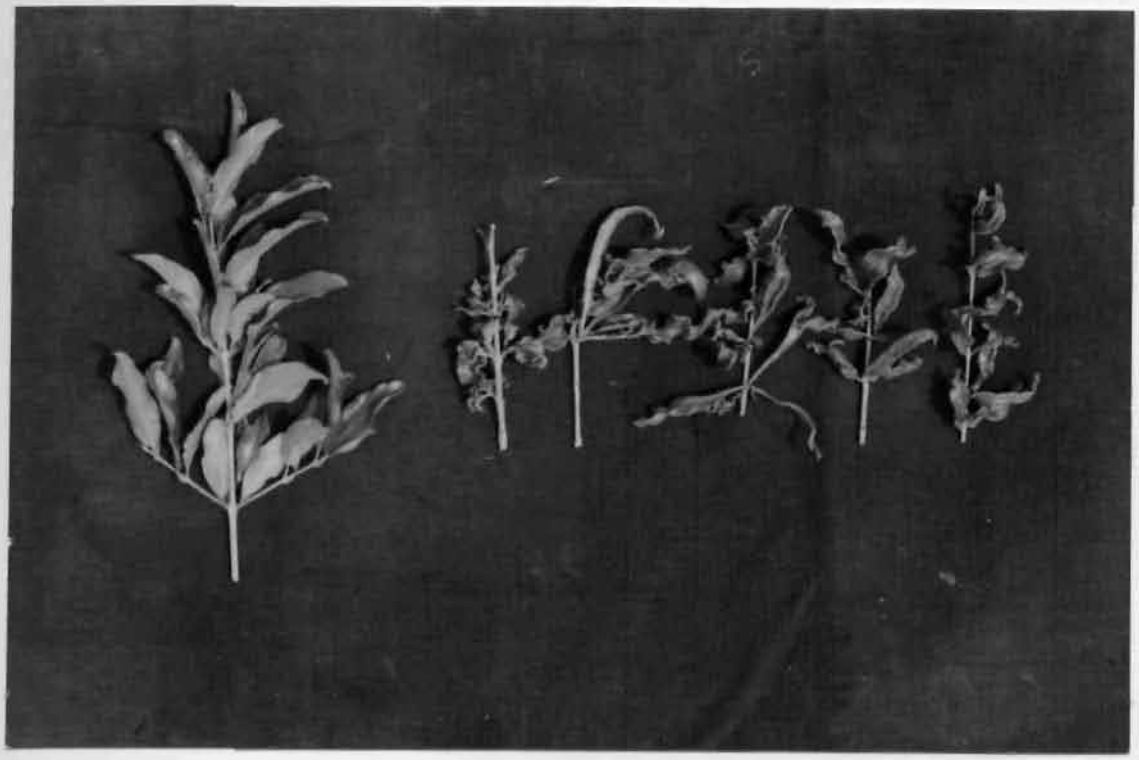


Plate 4.1 Healthy pomegranate leaf twig (one twig on left) and mite infested leaves (five twigs on right side)

rolled at edges on to undersurface and finally caused curling and shrinkage (Plate 4.1). The infestation was more severe at the arial parts of the plants.

The sampling for (i) mite damage intensity and (ii) Intensity of mite population on leaves was carried out regularly at fortnightly interval vide supra 3.2.1.1 and 3.2.1.2.

The observations on leaf damage intensity (%) and average number of mites per 10 leaves were graphically represented in Figure 4.1.a and 4.1.b.

The data thus obtained (Table 4.1.1 and 4.1.2) revealed that the pest incidence observed throughout the year. However, leaf damage intensity ranged from 28.67-100 per cent in 1995-96 and 34.67-99.33 per cent in 1996-97. In both the years, the mite incidence was minimum in the July and it was maximum in October.

Similarly, the range of mite population was 16.45-45.89 mites/ 10 leaves in the year 1995-96, whereas, in 1996-97, it was 16.78-44.44 mites/ 10 leaves.

Correspondingly, the peak of mite population as well as leaf damage intensity built up was during April and October in 1995-96 whereas, in 1996-97, it was observed in April and November..

The optimum levels of temperature and relative humidity, as depicted by peak population were as follows

| -Year Peak | | Temperature (°C) | | | Humidity (%) | | Humidity |
|---|---|---|---|---|---|---|---|
| | | Max. I Mia. | | Av. Morning I Evening I Av. | | | |
| 1995-96 1 | | 30.9 | 15.8 | 23.35 62.5 | | 20.5 | 41.5 |
| | II | . 32.4 | 17.85 25.13 | | 65.5 | 61.0 | 63.25 |
| 1996-95 1 | | 32.8 | 13.6 | 23.20 52.0 | | 33.50 | 42.75 |
| | II | 28.25 | 6.8 | | | 17.53 75.0 | 44.5 59.75 |

t

The population after attaining peak in April and October-November gradually decreased during rainy and winter seasons, respectively. The same trend was noticed for leaf damage intensity.

4.2. EFFECT OF KEYABIOTIC FACTORS ON THE POPULATION BUILDUP OF THE PEST

In order to study the effect of different abiotic factors such as temperature (maximum and minimum), relative humidity (morning and evening) and rainfall on the population build up of pomegranate mite during 1995-96 and 1996-97, a correlation matrix was worked out between different abiotic factors and mite population as well as mite incidence.

Correlation matrix studies (Table 4.2.a) indicated significant relationship between mite population v/ s maximum temperature (r=0.4173), minimum temperature (r = -0.6711), morning relative humidity (r=-0.3450), evening relative humidity (r = -0.6616) and rainfall (r = -0.6181). Like ' wise significant correlation was observed between leaf damage intensity v/s minimum temperature (r= -.4977), morning relative humidity (r = -0.3593), evening humidity (r = -0.5175), rainfall (r = - 0.6718) . But the maximum temperature did not play any significant role on the incidence of mite.

Correlation studies further indicated a positive significant correlation between mite population and leaf damage intensity.

Results on determination of coefficient (R2) and the multiple linear equation developed for A. granati population (Y 1) as well as leaf damage intensity (Y2) (Table 4.2.b) indicated that the coefficient of determination (R2= 0.6726) for abiotic factors taken was able to explain the variation in the mite population to the extent of 67.26%. likewise, variation in leaf

Table 4.2.a Correlation coefficients between mite incidence (mite population and leaf damage intensity) and weather parameters.

| | Temperature (°Cj | | | Relative humidity (%) | | Rain fall (mm) | | Average mite population | | Leaf damage intensity |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mazimuws | Minimum | Morning | Evening | xa | (Yl j | (Y2) xl | x2 | x3 | x} |
| X 1 | 1.0000 | | | | | | | | | |
| X2 | 0.8351** | 1.0000 | | | | | | | | |
| X3 | -0.5055** | -0.1085 | 1.0000 | | | | | | | |
| X4 | -0.0132 | 0.4497** | 0.6393** | 1.0000 | | | | | | |
| X5 | 0.1182 | 0.5105** | 0.5859** | 0.6998** | 1.0000 | | | | | |
| Y1 | -0.4173** | -0.6711** | -0.3450* | -0.6616** | -0.6181** | 1.0000 | | | | |
| Y2 | -0.1824 | 0.4977** | -0.3593** | -0.5175** | -0.6718** | 0.6019** | 1.0000 * | | | |

Significant at p=0.05 and **Significant at p=0.01

w

Table 4.2.b Predictidn equations and R2 for predicting mite of A. granati infesting pomegranate.

| Dependent variability | Multiple Regression Equation | R2 value | Variation (%) |
|---|---|---|---|
| (A) For mite population YO | Y, = 89.04 - 0.931*X1 - 0.036X2 - 0.258*X3 - 0.226*X4 - 0.011X5 (0.448) (0.382) (0.120) (0.099) (0.031) ( | 0.6726 | 67.26 |
| (B) For per cent leaf damage intensity (Y2) | y2= 53.65 + 1.460X1 - 1.785X2 -0.088X3 + 0.176X4 - 0.166*X5 (1.068) (0.911) (0.287) (0.236) (0.073) | 0.8097 | 80.97 |

*significant at p = 0.05 ~* significantl= 0.01

(i) Values given in parentheses are standard errors of partial regression coefficient (ii) No. of observations= 52

Here

X, = Maximum temperature (°C)

X2 = Minimum temperature (°C)

X3 = Relative humidity (%) (Morning) X4 = Relative humidity (%) (Evening) X5 = Total rain fall (mm) Y1 = Mite population/ 10 leaves Y2 = % leaf damage intensity

.
to
m
0

damage intensity due to abiotic factors was recorded at 80.97% (R2 = 0.8097).

## 4.3. PREFERENCE OF FACE OF TREE TO THE MITE

Observations taken on preference of tree face (direction) to the mite (Table 4.3) showed that A. granati preferred the western side of the tree as compared to other sides. The incidence was significantly higher on the western face (95.00%) followed by northern face (94.67%). It was 85.67% on southern face. A significant difference in mite infestation on different faces at both peaks 1 i.e. April peak and November peak was also observed. Data on mite incidence depicted in Table 4.3 also revealed variation in the tree face irrespective of mite infestation peaks as interaction between tree face and infestation peak was found nonsignificant.

## 4.4. VARIETAL SUSCEPTIBILITY

The relative mite incidence of A. granati on the nine popular

cultivars of pomegranate viz., Dholka, Jodhpur red, Ganesh, GKVK-1, Bassein seedless, P-23, G-137, P-26 and Jalore seedless was studied during 1995-96 and 1996-97 under field conditions.

The sampling for leaf damage was carried out at both the peaks infestation in both the years ( vide supra 3.2.1.2).

Pooled data presented in Table 4.4.1 indicated that the per cent mite infestation intensity was significantly higher in cultivar Bassein seedless (80.17%) followed by Ganesh (75.33%). The lowest damage was noticed in Dholka (12.70%) followed by GKVK-1 (7.59%). The order of susceptibility in descending order was- Bassein seedless (80.17%) > Ganesh (75.33%) > G-137 (55.83%) > Jalore seedless (53.84%) > P-23

i

Table 4.3. Preference of A. granatt to different faces of pomegranate tree, cv. Ganesh, at different peaks of mite infestation

| Peak of | Mean leaf damage (%) on different faces infestation | | | | |
|---|---|---|---|---|---|
| | North | West | East | South | Mean |
| I | 90.00 | 90.00 | 76.67 | 77.33 | 83.50 |
| | (71.57) | (71.62) | (58.49) | (63.58) | (66.32) |
| II | 99.33 | 100.00 | 96.67 | 94.00 | 97.50 |
| | (87.25) | (90.00) | (83.86) | (76.42) | (84.38) |
| Mean | 94.67 | 95.00 | 86.67 | 85.67 | |
| | (79.43) | (80.81) | (71.17) | (69.99) | |

| | SEm± | C. D. at 5% |
|---|---|---|
| F | | |
| Peak (P) | (1.32) | (4.01) |
| Face (F) | (1.87) | (5.77) |
| F P x F | (2.65) | (NS) |

FYgures in parenthesis are angular transformed values.
(

Table 4.4.1. Incidence of Acerta granati on different cultivar4 of pomegranate.

| Cullivars | Mean mite Infestation intensity (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1995-96 | | | 1996-97 | | | Pooled mean | | |
| | I peak | II peak | Mean | I peak | II peak | Mean | I peak | II peak | Average |
| Dholka | 3.33 | 8.67 | 6.00 | 4.67 | 6.00 | 5.33 | 4.00 | 7.34 | 5.67 |
| | (8.57) | (17.01) | (12.79) | (12.42) | (12.78) | (12.60) | (10.50) | (14.70) | (12.70) |
| Jodhpur red | 29.33 | 40.00 | 34.67 | 23.33 | 32.67 | 28.00 | 26.33 | 36.33 | 31.33 |
| | (32.79) | (39.23) | (36.01) | (28.78) | (34.74) | (31.76) | (39.79) | (36.99) | (33.89) |
| Ganesh | 64.67 | 96.67 | 80.67 | 46.67 | 93.33 | 70.00 | 55.67 | 95.00 | 75.33 |
| | (49.66) | (83.86) | (66.76) | (43.08) | (81.14) | (62.11) | (46.37) | (82.50) | (64.44) |
| GKVK-1 | 3.33 | 10.67 | 7.00 | 7.67 | 8.67 | 8.17 | 5.50 | 9.67 | 7.59 |
| | (8.57) | (18.94) | (13.75) | (15.81) | (17.01) | (16.41) | (12.19) | (17.98) | (15.08) |
| Bassein | 66.67 | 93.33 | 80.00 | 63.33 | 97.33 | 80.33 | 65.00 | 95.33 | 80.17 |
| seedess | (54.75) | (77.71) | (66.23) | (52.78) | (84.52) | (68.65) | ((53.77) | (81.11) | (67.44) |
| P.23 | 40.00 | 63.33 | 51.67 | 38.00 | 63.33 | 50.67 | 39.00 | 63.33 | 51.17 |
| | (39.16) | (52.77) | (45.97) | (37.96) | (52.78) | (45.37) | (38.56) | (52.77) | (45.67) |
| G.137 | 18.00 | 86.67 | 52.33 | 18.67 | 100.00 | 59.33 | 18.33 | 93.33 | 55.83 |
| | (25.04) | (73.29) | (49.17) | (25.57) | (90.00) | (57.79) | (25.30) | (81.65) | (53.48) |
| P-26 | 35.33 | 50.00 | 42.67 | 27.33 | 43.33 | 35.33 | 31.33 | 46.67 | 39.00 |
| | (36.46) | (45.00) | (40.73) | (31.32) | (41.16) | (36.24) | (33.89) | (43.18) | (38.49) |
| Jalore seedless | 35.33 | 66.67 | 51.00 | 36.67 | 76.67 | 56.67 | 36.00 | 71.67 | 53.84 |
| | (36.47) | (54.99) | (45.73) | (37.22) | (61.92) | (49.57) | (36.85) | (58.46) | (47.65) |
| Mean | 32.89 | 57.33 | | 29.59 | 57.93 | | 31.24 | 57.63 | |
| | (32.39) | (51.42) | | (31.66) | (52.90) | | (32.03) | (52.16) | |
| | SEm | t CD at 5% | 5% | 5% | SEm | t CD at 5% | 5% | 5% | SEm | t CD at 5% | 5% |
| Cultivar (C) | (2.74) | (7.89) | (2.55) | (7.37) | (1.80) | (5.09) | Peak (P) | (1.29) | (3.72) | (1.20) | (3.47) | (0.85) | (2.40) |
| CxP | (3.87) | (11.16) | (3.61) | (10.42) | (2.54) | (7.10) | | | | | | | |
| YXCXP | | | | | | | | | | | | (3.60) | (10.17) |

Figures in parentheses are angular transformed values.

-x z

(51.17%) > P-26(39.00%) > Jodhpur red (31.33%) > GKVK-1(7.59%) > Dholka(5.67%).

J

None of the cultivars was found to be completely immune to leaf cull mite attack.

The categorization of nine pomegranate cultivars into different groups (less susceptible, moderately susceptible, highly susceptible and extremely susceptible) (Panda, 1979) were made considering pooled average of mite incidence taken for each cultivar. Grouping of the cultivars was done on the basis of range value considering the general mean ( x) and standard deviation (S. D. ±) ( Table 4.4.2).

Table 4.4.2. Categorization of pomegranate cultivars on the basis of leaf damage infestation (%).

| S.No | Group | Range value calculated as | Cultivars |
|---|---|---|---|
| 1 | Less susceptible | x - S. D. | Dholka and GKVK- 1 |
| 2 | Moderately susceptible | x - S. D to x | Jodhpur red and P-26 |
| 3 | Highly susceptible | x to x + S. D. | P-2,Jalore seedless and G 137 |
| 4 | Extremely susceptible | > x + S. D. | Ganesh and Bassein seedless |

Results of the analysis based on mite incidence taken at both the peaks in different cultivars were also found significant (Table 4.4.1) . The

**Table 4.4.3 Mite incidence and Morphological variations in leaves of different cultivars of pomegranate.**

| S. No. | cultivar | Mean mite infestation intensity (%) | Leaf length (cm) | Leaf width (cm) | Leaf size ($cm^2$) | Leaf thickness (μ m) | No. of veins/sq cm | No. of hairs/ sq cm | Intervenal distance (mm) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Dholka | 5.67 | 5.64 | 1.28 | 8.30 | 0.50 | 48 | 9 | 1.2 |
| 2 | Jodhpur red | 31.33 | 4.83 | 1.08 | 7.40 | 0.60 | 42 | 20 | 1.5 |
| 3 | Ganesh | 75.33 | 4.83 | 1.45 | 8.10 | 0.70 | 42 | 26 | 1.1 |
| 4 | GKVK-1 | 7.59 | 4.52 | 1.30 | 6.90 | 0.50 | 48 | 27 | 1.3 |
| 5 | Bassein seedless | 80.17 | 4.47 | 1.39 | 7.33 | 0.75 | 43 | 29 | 1.4 |
| 6 | P-23 | 51.17 | 5.09 | 1.28 | 7.60 | 0.65 | 53 | 23 | 1.3 |
| 7 | G-137 | 55.83 | 4.91 | 1.41 | 8.02 | 0.70 | 48 | 21 | 1.1 |
| 8 | P-26 | 39.00 | 5.13 | 1.21 | 7.30 | 0.50 | 50 | 18 | 1.4 |
| 9 | Jalore seedless | 53.84 | 5.10 | 1.39 | 8.10 | 0.65 | 49 | 26 | 1.4 |
| Correlation coefficient (r) value | | - | -0.39 | 0.58 | 0.18 | 0.91** | -0.31 | 0.75* | -0.11 |

* Significant at p=0.05 and **Significant at p=0.01

pooled average data revealed that mite incidence was significantly higher at II peak as compare to I peak.

Table 4.4.1 also indicated different incidence patterns on nine cultivars at both peaks. The results further showed that cultivars which were least susceptible to the mite at I peak became highly susceptible at second peak. During critical analysis it was found that cultivars Dholka and GKVK- 1 were having environmental effects as mite incidence was at par at both the peaks of mite infestation. Whereas, cultivar G- 137 was
. found to having maximum environmental effect on mite incidence as mite incidence 93.33% at II peak in comparison to 18.33% at I peak. Same trend was noticed in cultivar Ganesh, Bassein seedless, P-23 and Jalore seedless.

Observations were also recorded to correlate the mite incidence with morphological characters of leaves. It was observed that all the leaf characters examined varied among nine cultivars of pomegranate (Table 4.4.3). The values of r (0.11-0.58) were non-significant except in the case of leaf thickness (0.91) and hair density (0.75). However, it indicated a positive significant correlation between mite incidence and leaf thickness and hair density. The maximum leaf thickness and hair density was recorded on Bassein seedless (O.75µ m and 29/sq cm,respectively), while the corresponding minimum value was recorded on Dholka (0.50 µ m and 9/sq cm).

## 4.5. EFFECT OF MITE FEEDING ON MORPHO-PHYSIOLOGICAL PROCESSES OF POMEGRANATE

Studies were conducted for observing the interaction between host plant and mite species with particular reference to morpho-physiological variations in infested and healthy plants of Ganesh for two successive years~i.e., 1995-96 and 1996-1997. To keep the plants free of mite attack

F foliar sprays of monocrotophos at 1 ml/liter water were given at ,
. fortnightly intervals during infestation peaks.

4.5,1. Rate of growth

The observations were made for different parameters of plant growth; Liz., plant height, stem girth, plant spread, leaf size and number of leaves/twig on mite infested as well as healthy plants. The data depicted (Table 4.5.1.a & b) revealed that A. granati affected the plant growth, significant reduction in plant spread (3.40%) and leaf size (35.80%) was observed in mite infested plants during 1995-96. The trend was similar during 1996-96 depicting values as 5.39% and 37.04%, respectively, with addition to significant reduction in number of leaves per twig (8.69%). Moreover, plant height and stem girth were also decreased in both the years but the difference was found to be non

significant.

4.5.2. Fruit development

Observations were also made on different reproductive parameters like, number of flowers/ plant, number of fruits/plant, fruit weight, economic fruit yield and TSS content of the fruits in healthy as well as in mite infested pomegranate plants. The results presented in Table 4.5.2.a & b revealed that the mite significantly affected the fruit development characters. It also affected flowering, fruiting rate, fruit weight, economic fruit yield and TSS content of the fruits. The reduction was found significant in both the years. The data revealed a reduction of 26.79 per

cent in number of fruits, 32.00 per cent in fruit weight, 64.86 per cent in economic fruit yield and 8.82 per cent in fruit TSS during 1995-96. Whereas, the values for these parameters for 1996-97 were 41. 27, 46.30, 33.59, 75.32 and 11.76 percent, respectively.

4.5. la Effect of mite feeding on growth of pomegranate plants, cv. Ganesh during 1995-96.

Vegative variations in healthy and infested plants

| Types of plant | Av. Height of plant (m) | Av. Stem girth (cm) | Av. Plant spread (in2) | Av. Leaf size (cm) | Av. Number of leaves/twig (terminal) |
|---|---|---|---|---|---|
| Healthy plants | 1.93 | 13.56 | 2.67 | 8.10 | 22.00 |
| Mite infested plant | 1.88 | 13.39 | 2.58 | 5.20 | 21.50 |
| T value | 1.705 | 1.567 | 3.098** | 10.928** | 0.681 |
| increase (+) or decrease (-) in infested over healthy plants | (-) 2.59 | (-) 1.25 | (-) 3.40 | (-) 35.80 | (-) 2.27 |

* Significant at p=0.05 and **Significant at p=0.01

**Table 4.5.1b Effect of mite feeding on growth of pomegranate plants, cv. Ganesh during 1996-97.**

| Types of plant | Vegetative variations in healthy and infested plants | | | | |
|---|---|---|---|---|---|
| | Av. Height of plant (m) | Av. Stem girth (cm) | Av. Plant spread ($m^2$) | Av. Leaf size (cm) | Av. Number of leaves/twig (terminal) |
| Healthy plants | 2.10 | 14.30 | 2.93 | 8.10 | 23.00 |
| Mite infested plant | 2.00 | 14.00 | 2.78 | 5.10 | 21.00 |
| T value | 1.664 | 1.5390 | 4.2618** | 12.158** | 2.928 |
| % increase (+) or decrease (-) in infested over healthy plants | (-) 4.76 | (-) 2.09 | (-) 5.39 | (-) 37.04 | (-) 8.69 |

* Significant at p=0.05 and **Significant at p=0.01

**Table 4.5.2a Effect of mite feeding on fruit formation in pomegranate plants, cv. Ganesh during 1995-96**

| Types of plant | Reproduction variations in healthy and infested plants | | | | |
|---|---|---|---|---|---|
| | *Av. Number of flowers/plant | *Av. Number of fruits/plant | *Av. Weight of fruits (g) | *Av. Economic fruit yield (kg/plant) | *TSS (%) |
| Healthy plants | 56.00 | 50.00 | 125.00 | 18.500 | 17.00 |
| Mite infested plant | 40.00 | 32.00 | 85.000 | 6.500 | 15.50 |
| T value | 11.044** | 11.840** | 6.558** | 9.762** | 4.399** |
| % increase (+) or decrease (-) in infested over healthy plants | (-) 26.79 | (-) 36.00 | (-) 32.00 | (-) 64.86 | (-) 8.82 |

Significant at p=0.05 and **Significant at p=0.01

*Average of 10

**Table 4.5.2b Effect of mite feeding on fruit formation in pomegranate plants, cv. Ganesh during 1996-97.**

| Types of plant | Reproduction variations in healthy and infested plants | | | | |
|---|---|---|---|---|---|
| | *Av. Number of flowers/plant | *Av. Number of fruits/plant | *Av. Weight of fruits (g) | *Av. Economic fruit yield (kg/plant) | *TSS (%) |
| Healthy plants | 63.00 | 54.00 | 128.00 | 23.500 | 17.00 |
| Mite infested plant | 37.00 | 29.00 | 85.00 | 5.800 | 15.00 |
| T value | 17.750** | 17.390** | 9.459** | 17.545** | 6.708 |
| % increase (+) or decrease (-) in infested over healthy plants | (-) 41.27 | (-) 46.30 | (-) 33.59 | (-) 75.32 | (-) 11.76 |

*significant at p = 0.05 ** significant at p = 0.01

*Average of 10.

To estimate the severity of distortion in flowers as well as in fruits, pomegranate flowers and fruits were rated by scoring on a scale of 0 to 3 and the observations for flowers and fruit distortion have been depicted in plate 4.5.2a and 4.5.2.b, respectively.

Observations taken on distortion of flowers (Plate 4.5.2a) based on different rating (0-3) revealed that flowers, which gave a distortion rating 0, were elongated and produced symmetrical and cylindrical flowers of 2.8 to 3.4 cm in length. Distortion rating 1 was assigned to flowers which were slightly truncated (2.5-2.9 cm. long), and exhibited slight puckering of the petals at the styler end. Flowers scored as distortion rating 2 were truncated more severely (2.3-2.7 cm) and generally, although hot always, showed some asymmetry. Flowers with distortion rating 3 were completely distorted (< 2.3 cm in length), with completely distorted style, dwarfed and often exposed. With regards to distortion of fruits by rating the scale illustrated in plate (Plate 4.5.2b), distortion rating `0' was a

E normally shaped pomegranate. Distortion rating 1 was assigned to a pomegranate having slight pukering or squatness at the styler end of the fruit and with a less developed nipple (apical end), or was more asymmetrical than a normal pomegranate. Distortion rating 2 fruit were similar to those rated 1, except the asymmetry was more severe and comparatively small in size. Distortion rating 3 fruit exhibited severe distortion with compact growth.

4.5.3. Chlorophyll content

Chlorophyll content of the leaves of mite infested and healthy plants of pomegranate was estimated at both the peaks of mite infestation '"during 1995-96 and 1996-97. The observations (Table 4.6.3) showed that chlorophyll content was reduced in pomegranate leaves due to mite feeding. It was observed that reduction in chlorophyll content at II peak was higher as

compare to I peak. The per cent reduction at II peak was 15.34% as

Plate 4.5.2.a Examples of distortion rating used to score flowers for distortion caused by *A. granati*. Top row, normal flowers (distortion rating 0); second row, distortion rating 1; third row, distortion rating 2; fourth row, distortion rating 3

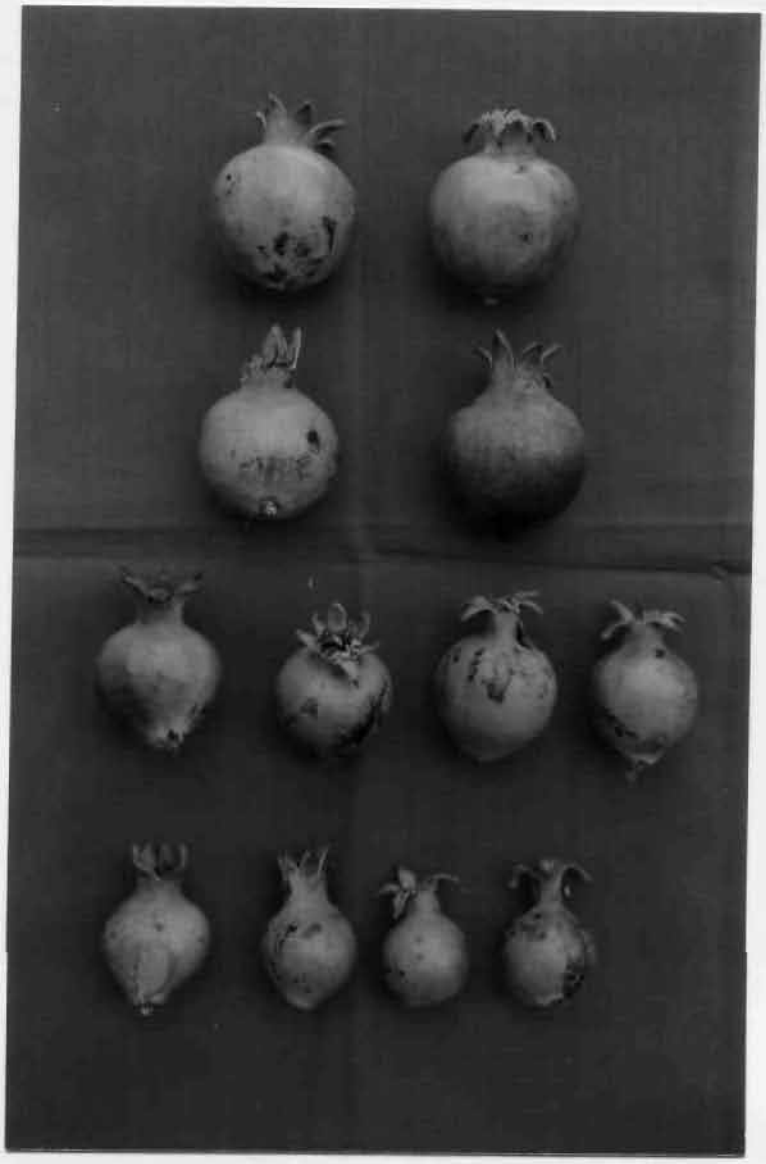


Plate 4.5.2b Examples of distortion rating used to score fruits for distortion caused by *A. granati*. Top row, normal fruits (distortion rating 0); second row, distortion rating 1; third row, distortion rating 2; fourth row, distortion rating 3

compared to 6.98% at I peak in 1995-96. Whereas, in 1996-97, it was 29.71 and 19.10 per cent, respectively.

Table 4.5.3 Effect of mite feeding on chlorophyll content of pomegranate leaves (Mg/g fresh leaf weight).

| Type of plant | Chlorophyll type | Mean chlorophyll content at different intervals | | | |
|---|---|---|---|---|---|
| | | 1995-96 | | 1996-97 | |
| | | I peak | II peak | I peak | II peak |
| Healthy plants | `a' | 0.92 | 0.98 | 0.98 | 0.98 |
| | `b' | 0.80 | 0.78 | 0.80 | 0.80 |
| | Total | 1.72 | 1.76 | 1.78 | 1.78 |
| Mite infested plants | `a' | 0.89 | 0.79 | 0.75 | 0.66 |
| | `b' | 0.71 | 0.70 | 0.69 | 0.66 |
| | Total | 1.60 | 1.49 | 1.44 | 1.25 |
| increase (+) or decrease (-) in infested over healthy plants | | (-) 6.98 | (-) 15.34 | (-) 19.10 | (-) 29.77 |

4.5.4. Transpiration rate

It was observed that mite feeding stimulated transpiration rate in infested plants. The rate of transpiration was 19.42 to 22.37% higher in infested plant during 1995-96, whereas, it was 15.91 to 19.58% higher in the 1996-97 (Table 4.5.4). It was also noticed that the _rate was higher at II peak of infestation as compared to I peak.

"GUItu~ ,S
PLLBRAR" O-.'

Table 4.5.4 Effect of mite feeding on transpiration rate of pomegranate plants (ug cm-2 Sec-' ).

| Type of plant | Mean transpiration rate at different intervals | | | |
|---|---|---|---|---|
| | 1995-96 | | 1996-97 | |
| | I peak | II peak | I peak | II peak |
| Healthy plants | 7.88 | 8.09 | 7.98 | 8.12 |
| Mite infested plants | 9.41 | 9.89 | 9.25 | 9.71 |
| increase (+) or decrease (-) in infested over healthy plants | (+) 19.42% | (+) 22.37% | (+) 15.91% | (+) 19.58% |

4.5.5 Relative leaf water content (RLWC):

The effect of mite feeding on relative leaf water content (RLWC) of pomegranate leaves was studied under field conditions and it was observed that mite feeding caused decline in RLWC at both the peaks of mites infestation. However, reduction in RLWC was higher at II peak as compared to I peak in both the years (Table 4.5.5). The per cent
E reduction in RLWC was 11.36-14.48 at I peak, whereas, it was 22.1623.36 per cent at II peak of mite infestation.

Table 4.5.5 Effect of mite feeding on relative leaf water content (RLWC) of pomegranate leaves.

| Type of plant | Mean transpiration rate at different intervals | | | |
|---|---|---|---|---|
| | 1995-96 | | 1996-97 | |
| | I peak | II peak | I peak | II peak |
| Healthy plants | 67.05 | 73.73 | 67.81 | 73.68 |
| Mite infested plants | 59.43 | 57.39 | 57.99 | 56.47 |
| %increase (+) or decrease (-) in infested over healthy plants | (+) 11.6 | (+) 22.16 | (+) 14.48 _ | (+) 23.36 _' |

## 4.6 EFFECT OF MITE INFESTATION ON HISTOPATHOLOGY AND BIOCHEMICAL CHARACTERIZATION OF POMEGRANATE LEAVES

Studies were also conducted to understand the mechanism of alternation in histopathology and biochemical characterization of mite damaged leaves of pomegranate.

### .4.6.1 Histopathology

The damage caused by A. granati was of peculiar characteristic and could be identified readily by the deformed leaves which rolled at edges on to under-surface and finally caused curling and shrinking. The

Table 4.6.2 Biochemical constituents of healthy and mite infested leaves of pomegranate, cv. Ganesh.

| Type of plant | Mean value on fresh leaf weight basis | | | | |
|---|---|---|---|---|---|
| | Total phenols (mg/gm) | Total soluble (sugar mg/g) | Reducing sugar (mg/g) | Free amino acid (mg/g) | Proteins (mg/g) |
| Healthy leaves | 15.442 | 39.14 | 21.30 | 32.16 | 24.32 |
| .Mite infested leaves | 19.256 | 44.19 | 25.68 | 21.82 | 19.95 i |
| increase (+) or decrease (-) infested over healthy leaves | (+) 24.698 | (+) 12.90 | (+) 20.56 | (+) 32.15 | (+) 17.97 |

size of the affected leaves became smaller and discoloration of the leaves also took place.

During the course of histopathological investigations of damaged leaves, it was observed that epidermal cells in the outer layer were flattened and destroyed. A very important change which occured in the epidermal cell layer was the disturbing effect on the function of the stomatal aperture. The vascular bundles in the damaged leaf. very distinct in comparison to healthy leaf.

4.6.2 Biochemical characterization

The investigations were also taken up to study the bio-chemical variation of healthy and mite damaged leaves and it was evident from the data presented in Table 4.6.2 that total phenols, total soluble sugar and reducing sugar content were relatively higher in mite infested leaves as compared to healthy ones. However, free aminoacids and protein content were observed markedly higher in healthy leaves.

4.7 810-EFFICACY OF SOME PESTICIDES AGAINST A. GRANATI ON POMEGRANA TE.

The efficacy of seven selected pesticides, (found most effective in preliminary chemical control trial) was evaluated in field against A. granati on pomegranate cv Ganesh. The trend of effectiveness of different treatments have been presented in the following text.

4.7.1 One day before spray:

Observations taken on mite incidence, in term of per cent leaf infestation due to the mite, revealed that mean mite incidence was nonsignificant in all the plants in both the year i.e. 1996-97 and 1997-98 (Table 4.7 and Appendix 9).

V.2 Ten days after first spray

Among different pesticidal treatments foliar spray of monocrotophos at 0.05 per cent was found significantly superior over all the tested pesticides in the both the years (Table 4.7), giving 61.48 and 64.72 per cent reduction in mite incidence in 1996-97 and 1997-98, respectively. However, foliar sprays of ethion at 0.05 per, cent and dicofol at 0.07 per cent were found statistically at par with the treatment of monocrotophos in 1997-98. Pooled data also showed the same trend. The spray of malathion (0.05%) was found least effective.

On the basis of pooled data the descending order of efficacy of different pesticides 10 days of spray was- monocrotophos > ethion > Dicofol > Acephate > DQmethoate >Phosphamidon > Malathion.

4.7.3 Thirty days after first spray

The treatment of monocrotophos at 0.05 per cent was found significantly superior, followed by ethion at 0.05 per cent, among all the pesticidal treatments in 1996-97 and as well as on the basis of pooled mean of both the years. The mean per cent reduction in mite incidence in monocrotophos and ethion treatments were 83.94 and 78.23,

' respectively. The foliar spray of phosphamidon was found to be least effective, however, it was at par with malathion, diamethoate and acephate. The descending order of efficacy of different pesticides wasmonocrotophos > ethion > Dicofol > acephate > diamethoate > malathion

> phosphamidon.

4.7.4 Sixty days first spray

It is evident from the data that foliar spray of monocrotophos at 0.05 was found most effective. However, the treatment was at par with ethion and dicofol in both the years. The least effective treatment was found to be of phosphamidon in both the year. Moreover, the pooled

**Table-4.7 Bio-efficacy of some pesticides against *A. granati* on pomegranate.**

| Treatments | Mean mite incidence before treatment (%) | | % reduction in damage incidence of leaves at different intervals | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1996-97 | | | | 1997-98 | | | | Pooled mean | | | |
| | 1996-97 | 1997-98 | 10 DAS | 30 DAS | 60 DAS | 90 DAS | 10 DAS | 30 DAS | 60 DAS | 90 DAS | 10 DAS | 30 DAS | 60 DAS | 90 DAS |
| Monocro-tophos at 0.05% | 70.67 | 74.00 | 61.48 [52.04]* | 82.56 [65.33] | 85.60 [67.68] | 86.53 [68.49] | 64.72 [53.57] | 85.31 [67.56] | 87.77 [69.57] | 88.19 [69.90] | 63.10 [52.81] | 83.94 [66.45] | 86.69 [68.63] | 87.36 [69.20] |
| Malathion at 0.05% | 74.00 | 69.33 | 42.89 [41.10] | 67.79 [55.46] | 77.35 [61.61] | 77.93 [62.11] | 36.50 [37.14] | 68.39 [55.78] | 79.83 [63.29] | 82.38 [65.18] | 39.70 [39.12] | 68.09 [55.62] | 78.59 [62.49] | 80.16 [63.65] |
| Diamethoate at 0.05% | 69.33 | 71.33 | 47.45 [42.54] | 70.24 [56.95] | 73.56 [59.06] | 81.19 [65.37] | 53.10 [46.79] | 74.08 [59.41] | 82.50 [65.27] | 83.62 [66.18] | 50.28 [44.67] | 72.18 [58.18] | 78.03 [62.17] | 82.41 [65.78] |
| Dicofol at 0.07% | 74.00 | 70.00 | 51.96 [46.13] | 77.55 [61.78] | 85.40 [66.87] | 84.26 [66.66] | 59.73 [50.62] | 73.01 [58.76] | 86.46 [68.42] | 86.68 [68.61] | 55.85 [48.38] | 75.28 [60.27] | 64.32 [67.65] | 85.47 [67.64] |
| Ethion at 0.05% | 73.33 | 76.00 | 54.18 [47.39] | 75.60 [62.69] | 82.90 [65.60] | 84.28 [66.66] | 61.39 [51.61] | 80.85 [64.08] | 86.63 [68.68] | 85.36 [67.56] | 57.79 [49.50] | 78.23 [63.39] | 84.77 [67.14] | 84.82 [67.11] |
| Phosphamid-on at 0.05% | 72.67 | 74.00 | 38.67 [38.45] | 65.29 [53.91] | 73.37 [59.02] | 79.29 [63.02] | 42.05 [40.47] | 70.48 [57.09] | 78.91 [62.72] | 82.73 [65.43] | 40.36 [39.46] | 67.89 [55.50] | 76.14 [60.87] | 81.01 [64.23] |
| Acephate at 0.05% | 70.00 | 69.33 | 52.98 [46.73] | 68.97 [56.18] | 76.76 [61.20] | 82.13 [65.05] | 45.96 [42.69] | 76.46 [60.78] | 84.09 [66.50] | 82.49 [65.29] | 49.47 [44.71] | 72.72 [58.48] | 80.43 [63.85] | 82.31 [65.17] |
| Untreated check | 74.67 | 70.00 | - | - | - | - | - | - | - | - | - | - | - | - |
| S Em ± | 3.12 | 1.96 | [0.96] | [1.02] | [1.07] | [1.09] | [1.20] | [1.04] | [0.76] | [0.78] | [1.81] | [1.24] | [4.01] | [3.47] |
| C.D. at 5% | NS | NS | [2.95] | [3.14] | [3.29] | [3.34] | [3.71] | [3.21] | [2.35] | [2.42] | [5.38] | [3.69] | [NS] | [NS] |

DAS= days after treatment

* values in parenthesis are angular transformed values

mean data revealed that all the insecticidal treatments were at par with each other. The descending order or efficacy was: inonocrol.ophos > dicofol > ethion > acephate > malathion > dimethoate > phospharnidon.

4.7.5 Ninety days after first spray

Observation recorded on per cent reduction in mite incidence concluded that foliar spray of monocrotophos at 0.05 per cent was most effective: Moreover, all the treatments were found to be sequentially at par to each other. Pooled mean data revealed that all the pesticidall treatments were at par in reducing the rnite population. The descending order of efficacy was: monocrotophos > dicofol > ethion > dimethoate > acephate > phosphamidon >

` malathion.

4.7.1, Over alll efficacy of pesticides

Taking overall picture into consideration, it was concluded that out

of seven pesticides evaluated,' monocrotophos (0.05%) proved most effective followed by ethion (0.05%). The treatment of malathion (0.05%) was found least effective. The treatment of dicofol, acephate and diamethoate existed in the middle order of efficacy in reducing mite incidence caused by A. granati on pomegranate.

# 5. DISCUSSION

## 5.1 SEASONAL INCIDENCE OF A. GRANATI ON POMEGRANATE

The observations for this_ study were taken on pomegranate cultivar, Ganesh. Population fluctuation recorded during the period of observation showed that the mite incidence was observed throughout the year. The observations taken on mite incidence with respect to mite population as well as leaf damage intensity revealed two peaks, first in April and another in the months of Oct.- Nov. Similar results were also recorded by Agrawal et al., 1990. They observed two population peaks A. granati causing damage on pomegranate in Utter Pradesh, one in the month of April-May and another in the month of December. They also reported that the mites were present through out the year except July

August which is a period of complete defoliation.

In present studies, the mite incidence after attaining peaks in April and Oct.-Nov., gradually declined during rainy and winter seasons, respectively. This may probably be attributed to mortality consequent to exposure to high humidity in rainy season and decline in temperature during winters. The highest population of the mango bud mite, Aceria magifera in February and gradual decrease until May with a peak in June-July was also reported by Bindra and Bakhetia (1969). According to'- Abou-Awad (1981), the population of A. mangifera in Egypt increased in April reaching peak in late May (70 mites/leaf) when the mean temperature was more than 30°C with RH more than 50%. They also observed a second small peak in late October.

In the present study, the tested cultivar, Ganesh remained I evergreen and plant bears new growth just after completion of rainy season and winters and it has also been observed that mite infestation was more severe at the arial parts of the plants. The observations depicted incidence peaks with initiation of new growth. Present studies are in agreement with Sharma et al. (1986) who observed the population peak of litchi mite, Aceria litchi in April-May and reported a correlation of

peak period of infestation with the availability of tender plant tissues.

Zaher and Elbadry (1964) reported population peak of false spider mite, Tenuipalpus granati, damaging pomegranate in Egypt in July (after spring) followed by gradual decrease until December. Similarly, AlGboory and El-Haidari (1989b) studied about another false spider mite of pomegranate, T. punicae in Iraq and reported that the mite population reached a peak during summer; (May to June).

5.2 EFFECT OF KEYABIOTIC FACTORS ON THE POPULATION BUILD - UP OF THE PEST

The population build up of any pest very closely associate with weather conditions prevailing during the preceding and corresponding periods. In present studies, the incidence depicted a significant negative correlation with respect to temperature, humidity and rainfall. A significant negative correlation has also been reported by Sharma et al. (1986) for Aceria litchi infesting litchi also confirms the present findings. In the present studies all the key abiotic factors resulted into a negative effect on mite incidence which indicated the susceptibilityy of the mite towards the extremities of weather parameters.

5.3 PREFERENCE OF FACE OF TREE TO THE MITE

Among the four faces of the tree the north, east, south and west,

the incidence was significantly higher on the west face and it was

minimum on south face. This difference might be attributed to the fact that western face of the tree was exposed minimum to sunlight than the other sides. A. granati prefers to live inside the rolled leaf, so as to conserve moisture and non-preference to sunlight. This observation is in agreement with those of Al-Gboory and El-Haidari (1989b) who also reported the preference of west face by false spider mite, Tenuipalpus punicae damaging pomegranate in Iraq. However, contrary to this, ElHalawany (1991) reported the preference of east side by citrus mite, Brevipalpus calfornicus.

## 5.4 VARIETAL SUSCEPTIBILITY OF DIFFERENT CULTIVARS OF POMEGRANATE AGAINST A. GRANA Ti.

Nine cultivars of pomegranate grown in orchard at Asalpur Farm of Rajasthan Agricultural University, campus-Jobner were screened for the incidence of A. granati. The results of two years data indicated that none of the cultivar was completely free from the attack of mite. However,
Dholka and GKVK-1 cultivars were observed to support minimum mite population. The infestation level was higher in case of Ganesh and Bassein seedless with an average of 75.33 and 80.17 per cent mite intensity, respectively, and minimum mite load was recorded at Dholka and GKVK-1 with an average of 5.67 and 7.59 per cent mite intensity, respectively. on the basis of prevalence of A. granati on different cultivars, they were grouped as
1. Extremely susceptible: Ganesh and Bassein seedless 2. Highly susceptible:
P-23, Jalore seedless and G-137 3. Moderately susceptible : Jodhpur red and
P-26 4. Less susceptible : Dholka and GKVK- 1.

A perusal of available literature revealed that no published information is currently available on the varietal screening of pomegranate cultivars against A. granati except a brief indication that damage due to A. granati was least in pomegranate cultivars Dholka and GKVK-1 and it was maximum in Ganesh (Anonymous, 1996c).

During the study, mite incidence was recorded at both the infestation peaks viz., I peak and II peak. A significantly higher mite

s

incidence was noticed at II peak. Significant effect of interaction between infestation peaks ( environmental inducement) and cultivars on the mite incidence was also noticed. Results showed that some cultivars which were least susceptible to the mite at first peak were found highly susceptible at second peak. It can be concluded from the above studies that the pattern of incidence of the mite was not similar on all the

Y cultivars of pomegranate during different infestation peaks. Present findings are in cognizance with the findings of Suresh and

" Mohansundaram (1995) who screened 59 mango varieties for resistance to ceria mangifera in April arid May, 1992. In general, infestation was higher in May than in April and there were interaction between varieties and sampling periods, possibly due to heavy latex production following previous mite injuries. Likewise, Mukherjee et al, (1989) also reported the significant effect of interaction between rice cultivars and months on the mite population. The pattern of incidence of the mite was not similar on nine cultivars of rice during different months of a year.

In the present studies modification of host response which is technically known as " predisposition" was observed as some pomegranate cultivars which were least susceptible to the mite at first peak were found highly susceptible to the mite at II peak. Yarwood (1976) reported that combinations of temperature, moisture, gaseous environment, light, air movement, pressure, genetic constitution,

nutrients, non-nutrient chemicals, contact surface, mechanical injury and time, etc., determined the growth of the plants and affected their susceptibility to biotic and abiotic injuries. Rajgopal et al., ( 1970) also studied the physiological mechanism of resistance in Jasmine to Aceria jasmini and reported that there was a possible role of tissue moisture in favouring mite build-up.

A perusal of data on the morphological characters of leaves of different pomegranate cultivars, revealed positive significant correlation between mite incidence and leaf thickness as well as leaf hair density as it favoured the mite attack due to restraining tissue moisture and hair density favours the mite development and fecundity. Present results are in agreement with the findings of Al Gboory et al., (1991) reported that fig variety Soltani was more susceptible to the mite Aceria ficus than Adsi and this difference may be attributed due to the fact that Soltani leaves had many long and abundant hairs on the lower side.

5.5 EFFECT OF MITE FEEDING ON MORPHO-PHYSIOLOGICAL PROCESSES OF POMEGRANATE

A knowledge of the often complex relationship between insect populations and their effect on the yield-forming processes of crops is useful for assessing pest status and devising methods of minimising the effect of infestation on yield (Bardner and Fletcher, 1974). Injury to plants caused by mites and the specific reactions of the plants have attracted the attention of acarologist and plant physiologist during last few years. The studies conducted on the aspect included reaction of the entire plant organism, changes in the individual plant organs, tissues and cell and change in chemical and biochemical processes. The mechanism 'of the mutual interaction between A. granati and pomegranate plant is not known. In present studies the rate of plant growth, fruit development, chlorophyll content, transpiration rate and

relative leaf water content in mite infested and healthy plants were studied.

5.5.1 Rate of growth:

It is evident that pomegranate leaf curling mite feeding changes the growth intensity of the host plant. The most common change observed was retardation of the growth of all organs of damaged plants. Tomczyk and Kropczynska (1985) also reported similar observations as a consequence of mite damage to the host plant. In the present study significant reduction in plant spread, leaf size and number of leaves per twig was observed. Avery (1962) also reported the reduction in the number of leaves per plant and total leaf area of mite damaged citurs plants. Similar results were also reported by Avery and Briggs (1968) and Summers and Stocking (1972). Baghel et al., (1994) too reported that the number of leaves/shoot:;, leaf area/shoot were significantly higher in

healthy as compared to malformed pinnacles of mango plants.

5.5.2 Fruit development

It has been reported that the influence of mite damage on cropping in fruit trees may occur in early stage of fruit development, in many cases early dropping of immature fruits and later on the ripening of the fruits (Van de Vire et al., 1972 ; Golik 1975 and Hoyt and Tanigoshi 1983). In the present investigation, the influence of A. granati on flowering and fruit development in pomegranate plants was also observed and results showed that A. granati affected the flowering as well as fruit rate, fruit weight, economic fruit yield and TSS content of the fruits significantly.

Al-Gboory and El-Haidari (1989a) have studied the role of feeding of Tenupalpus punicae on pomegranate fruit characters and found that TT punicae affected the colour, skin texture and size of the fruits. They

further reported that the mites sucked the cell sap of the fruit epidermis, resulting into dry fruit skin. Likewise, Baghel et al.,(1994) also reported that percentage of hermaphrodite flowers were significantly higher in healthy as compared to malformed mango plants.

In the present study significant reduction in fruit yield was also recorded. A. granati significantly affected the plant growth rate and the explanation of loss of fruit yield may be obvious. The above facts also lend support from finding given_ by Hoyt and Tonigoshi (198.3) who observed that feeding of P. ulrni mite may cause serious yield losses in pear plants.

During the studies significant reduction in TSS content was observed in the fruits of healthy plants. The TSS content of pomegranate fruits was affected as a attack of T.punicae (Al-Gboory and El-Haidari, 1989). However, Laing et al., (1972) did not find any difference in sugar content in grapes from plants infested by Tetranychies pacificus and healthy one.

Observations made on distortion of pomegranate flowers as well as fruits indicated different ratings of distortion based on severity of distortion. Similar observations in citrus crop Aceria sheldoni recorded by Walker et al. (1992) and Phillips and Walker (1997) infested by citrus bud mite.

5.5.3 Chlorophyll content

The chlorophyll content in leaves of infested plants was comparatively loll' . This finding is in conformity with those of Chakrabarti et al. (1999) who also reported decreased chlorophyll content in the leaves of Hibiscus vitifolicus damaged by Acalitus hibisci, an eriphyid mite. Van de Vrie et al., ( 1972) suggested that the chlorophyll content was reduced in apple leaves after they were damaged by P. uhni.

The evidences suggested that decrease in chlorophyll content may be correlated with the duration of feeding period and mite density (Tomczyk and Van de Vrie, 1982; De Angelis et al., 1983). The main reason for reduction in chlrophyll content in present studies is probably mechanical damage to the chloroplasts during feeding.

5.5.4 Transpiration rate

In the present investigation, it was found that pomegranate plants damaged by A. granati feeding lost large amounts of water by transpiration. It has been noticed that the intensity of this process increased with increased mite damage. Similar observations has been reported by Golik, (1975) which support the present findings. Likewise, Sances et al., (1981), found an initial increase and a later decrease in the intensity of transpiration as a result of feeding of strawberry plants by T. urticae. The reasons for changes in the transpiration intensity can be attributed to damage to the protective surface of the leaves and disturbance to..the functioning of the Stomatal opening. This finding gets support from the observations made by Sances et al. (1979).

5.5.5 Relative leaf water content (RLWC)

During the present studies it was observed that mite feeding caused decrease in RLWC. These results are in agreement with the findings of Baghel et al., (1994) also reported significantly higher moisture percentage in malformed panicles, which may be due to reduced dry matter accumulation in malformed panicles than healthy panicles as observed in the investigations.

## 5.6 EFFECT OF MITE INFESTATION ON HISTOPATHOLOGY AND BIOCHEMICAL CHARACTERIZATION OF POMEGRANATE LEAVES

In case of eriyiophyid mites, the mites remain embedded in plant tissues for a long time. In doing so a plant may alter the Histopathology and biochemical characterization of the affected plant tissues.

### 5.6.1 Histopathology

In the present study it was observed that epidermal cells in the outer layer of damaged leaves were flattered and destroyed due to A. granati attack and disturbing effects on the function of the Stomatal apparatus were recorded. As the higher transpiration rate was also recorded in damaged leaves, the explanation of disturb function of the stomatal apparatus is obvious. During the study, vascular bundles in the damaged leaf were very distinct in comparison to healthy leaves. Agrawal and Kandasami (1959) also reported the similar observations in damaged sugarcane leaves as a result of feeding of Eriphyid sp. likewise Das et al., (1987) observed badly disrupted vacolar tissue in mite affected stem of jute damaged by yellow mite, Polyphagotarsonemus latus. Both these

observations confirm the present findings.

### 5.6.2 Biochemical characterization

The concentration of organic compounds in the leaf tissue, e.g. phenolic compounds, carbohydrates, aminoacids and proteins, can also be influenced by mite feeding. Some changes in the concentration of these constituents may exert an influence on the physiology of the plant. In the present study the phenols, total soluble sugar and reducing sugar contents were relatively higher in A. granati infested leaves as compare to healthy ones. However, free aminoacids and protein content were markedly higher in healthy leaves as compare to uninfested leaves.

The observations on the presence of higher phenols, total soluble sugar and reducing sugar content in the damaged leaves is in conformity with the report of Purohit et al., (1979) who observed increased phenols in Prosopis cineraria leaf gall. Manjunatha et al., (1989) reported higher amount of free phenols, soluble sugar and reducing sugar in young healthy leaf tissues in Pongczmia glabra. They further reported that phenols which was a secondary compound of the host plant implicated as defensive agents in plant-herbivore interaction
was presumably high in young leaves as to impart protection from herbivores (Rhodes, 1979). They also observed high amount of free sugars in mite damaged leaves and concluded that high amount of sugar may be attributed to nutritional superiority of damaged leaves over mature leaves. In the present study, free aminoacid content was markedly higher in healthy leaves as compared to infested leaves. These findings are also in conformity with those of Manjunatha et al. (1989) who observed poor aminoacid pool in mite damaged leaves. However, lower amount of protein in the damaged leaves was obtained during the present. study. Zukova (1963) observed a reduction of total protein in leaves of crysanthemum on which T. orticae has been feeding. Contrary to this Manjunatha et al (1989) observed that normal leaf tissues were poorer in protein deposits as compared to mite damaged tissues.

## 5.7. BIOEFFICACY OF SOME PESTICIDES AGAINST A.GRANATI ON POMEGRANATE.

Because of the paucity of data on chemicals effective against eriophids, chemicals tested were not limited to the usual acaricides. Therefore, a preliminary trial was conducted to evaluate the most effective pesticide against A. granati.

Out of seven pesticides, evaluated against A. granati infesting pomegranate, monocrotophos (0. 05%) was found to be the most effective.

The present findings are in agreement with those of Agrawal (1990), who found monocrotophos (0.05% ) as most effective against A.granati infesting pomegranate. In the present studies, ethion (0.05%) was found to be at par in effectiveness with monocrotophos which is in agreement with Agrawal (1990). The next best pesticide was dicofol (0.05%). Kumar (1932) found dicofol and monocrotophos as most effective (0.05%) against Aceria litchi damaging litchi plants in Bihar. Likewise, Udayigiri

j and Jagan Mohan (1993) also reported that spray of monocorotophos (0.05%), phosalone (0.07%) and wettable sulpher (0.14%) were significantly effective in reducing the jasmine mite Aceria jasmini. In the present study, diamethoate (0.05) ranked in the middle order of efficacy and also at par to dicofoland acephate. Naidu and ChannaBasavanna (1989) reported that systemic pesticides, except diamethoate brought about a reduction of eriophid mite (Eriphyes cymbopogonis) population upto 90 per cent in 120 hrs. whereas, diamethoate caused 70% reduction in mite population and found at par with the two conventional acaricides (68.39% and 67.07% reduction in dicofol and sulpher respectively). Nevertheless, Bindra and Bakhetia (1971) reported unsatisfactory control with diamethoate spray (0. 025%) against Aceria mangifera.

I

SUMMARY

The results of the present investigation "Management of Erlophyid mite, Acerla granati, on pomegranate and morphophysio-histopathological effects of the pest on the host" conducted during the year 1995-96 to 1997-98 presented and discussed in the preceding sections are being summarized as under.

The incidence of. A. granati was observed through out the year and attained two peaks, first in April and second in October-November.

The effects of key abiotic factors was studied on the population buildup of the mite as well as its damage intensity. Correlation studies indicated a positive correlation between mite population and leaf damage intensity. Further, correlation matrix studies indicated significant negative relationship between mite population v/s maximum and minimum temperature, morning and evening relative humidity and rainfall also. Multiple correlation study through regression analysis showed that these abiotic factors played significant role explaining 67.26 and 80.97 per cent variation in the population of A. granati and its damage intensity, respectively.

Among the four faces of the tree, the incidence of A. granati was significantly higher on the west face and it was minimum on south face.

Nine pomegranate cultivars were screened against the infestation of A. granati, under field conditions. Cultivars Dholka and GKVK- 1 were

I

observed to be least susceptible to the mite attack, followed by Jodhpur red and P-26 which were found to be moderately susceptible. While

L cultivars, P-23, . Jalore seedless and G-137 were proved highly susceptible, cultivars Ganesh and Bassein seedless were proved extremely susceptible. In the present studies modification of host response which is technically known as "predisposition" was observed as some pomegranate cultivars which were least susceptible to the mite at first peak were found highly susceptible at II peak. Significant; positive correlation was also noticed between mite incidence and leaf thickness as well as leaf hair density.

Observations taken on feeding effect of the mite on morphophysiological process revealed that mite attack significantly affected the plant growth rate, fruit development, chlorophyll content transpiration rate and relative leaf water content. significantly the plant spread, leaf size and number of leaves per twig, whereas, no significant affect was noticed in plant height and stem girth. It was also observed that the mite significantly affected flowering, fruiting, fruit weight, economic fruit yield and TSS content of the fruits. Distortion of the flowers as well as fruits were also observed due the attack of A. granati. The chlorophyll content in leaves of infested plants was comparatively low. Whereas, transpiration rate of infested plant was higher as compare to healthy plants. Mite feeding decreased the relative leaf water content (RLWC).

In histopathological investigations of damaged leaves, it was observed that epidermal cells in the outer layer were flattened and destroyed and resulted in disturbance of stomatal functioning. The vascular bundles in the damaged leaves were very disthxct in comparison to healthy leaves. Investigation taken on biochemical characterization of damaged as well healthy leaves revealed that total phenols, total soluble sugars and reducing sugars content was relatively higher in mite infested

leaves as compare to healthy ones. However, free aminoacids and protein content were observed markedly higher in healthy leaves.

Out of seven pesticides evaluated against A. granati infesting pomegranate, monocrotophos (0. 05%) was found to be most effective followed by ethion (0.05%). The next best pesticides were dicofol (0.05%), acephate (0.05%) and diamethoate (0.05%). The treatment of malathion (0.05%) was found least effective against A. granati.

REFERENCES

Abou-Awad, B.A. 1981. Studies on ecology of mango bud mite, Aceria mangifera Sayed in Egypt. Acarologia 22: 445-450

Agrawal, L.; Mukherhjee, I. N.; Singh , R. N., Singh, R. K.; and Singh, J. 1990. Studies on two species of Eriophyid mites infesting fruit plants in Uttar Pradesh, India. In "Progress in Acarology, Vol II " (Ed. ChannaBasavanna, G. P. and Viraktamath, C. A.) Oxford and IBH Publishing Co. pvt. Ltd., New Delhi, 1989,pp 20.

Agrawal, R. A. and Kandasami, P. A. 1959. Nature of damage caused by Eriophyid mite in sugarcane. Curr. Sci., 28 (7) : 297.

Agrawal, V. K. 1990. Efficacy of some pesticides against Eriophid mite on pomegranate. Abs in IV National Symposium on Acarologry held from Oct 12-14, 1990 at Calicut, pp 70.

Al- Gboory, I.; El-Halawany, M. E. and Abdel-Samed, M. A. 1991. Susceptibility of Soltani and Adsi fig varieties trees to the infestation with Eriophyes ficus colic and Tetranychus curticae Koch. In Modern Acarology Vol 1. Academia, Prague

and SPB Academic Publishing bv, The Hague, pp. 589-593.

Al-Gboory, I. and El-Haidari, H. 1989a. Studies on some factors affecting the pomegranate false spider mite, Tenupalpus punicae (Acari ternupalpidae) in Iraq. In "Progress in Acarology, Vol II " (Ed. ChannaBasavanna, G. P. and Viraktanath, C. A.). Oxford and IBH Publishing Co. pvt. Ltd., New Delhi, 1989,pp 67-72.

Al-Gboory, I. and El-Haidari, H. 1989b. Some ecological aspects of the pomegranate false spider mite, Tenuipalpus punicae (Acari: Tenuipalpidae) in Iraq. In "Progress in Acarology, Vol IIA (Ed. ChannaBasavanna, G. P. and Viraktanath, C. A.) Oxford and IBH Publishing Co. pvt. Ltd., New Delhi, 1989. Pp 73-79.

Ananthakrishnan, T. N. 1984.. Biology of gall insects. Oxford and IBH publishing Co., New Delhi, pp 362.

Anonymous, 1992. Annual Report of AICRP on Arid Zone Fruits, centre - Jobner, 1991-92. Pp 28.

Anonymous, 1996a. Vital horticultural statistics for 1995-96. Directorate of Horticulture, Government of Rajasthan. Pp 30.

Anonymous, 1996b. Anar. In. Rajasthan Me Udhayanki Phasley. Directrate of Horticulture, Government of Rajasthan, Jaipur, pp 31 -34.

Anonymous, 1996c. Pomegranate, In "Coordinated Fruit Research in Indian Arid zone. A Two Decades Profile (1976-1995). (Ed. Pareek, O. P. and Vishal Nath). NRC for Arid Horticulture, Bikaner, pp. 31 -44.

Arababi, M., Kamali, H., Mehsenien, A. B. and Baradaran, P. 1999. Status of Eriophid mite on fruit trees of Iran. Abs in Souvenir of Silver Jubilee Symposium of Acarological Society of India held at Bangalore from Oct. 27 - 30, 1999. Pp. 18.

Arnott, H. J., 1959. T urtox News, 37: 192 - 194.

Avery, D. J. 1962. The vegetative growth of young plants of Brompton plum infested with fruit tree red spider mite. Ann. Rep. East Mallin Res. Stn., 1961, pp. 77 - 80.

Avery, D. J. and Briggs, J. B., 1968. Damage to leaves caused by fruit tree red spider mite, Panonychus ulmi (Koch). J. Hort. Sci., 43 : 464 -473.

Baghel, B. S., Jaiswal, U. L., Nema, B. K. and Nema, M. K. 1994. Morphological and bio-chemical studies of healthy and malformed panicles in different cultivars of mango (Mangifera indica L.) . Recent Horticulture, 1 (1) : 4 -10.

Balasubramanian, M. and Purushothaman, D. 1972. Phenols in healthy and galled leaves of Pongamia glabra Vent caused by an eriophyid mite, Eriophytes chesianii Masee. (Eriophyidae : Acarina) Indian J. Expt. Bio., 10 : 394 - 395.

Bardner, R. and Fletcher, K.E. 1974. Insect infestations and their effects on the growth and yield of field crops: a review. Bull. Ent. Res., 64: 141-160.

Barnes, M. M. and Andrews, K. L. 1978. Effects of spider mites on almond tree growth and productivity. J. Econ. Entomol., 71 : 555 - 558.

Bincira, O.S. and Bakhetia, D.R.C. 1969. Studies on the population dynamics of the mango bud mite, Aceria mangifera Sayed, in relation to the incidence of malformation. J. Res. Punjab Agric. Univ., 6: 200-206.

Bindra, O.S. and Bakhetia, D.R.C. 1971. Investigation on the etiology and control of mango malformation. Indian J. Hort., 28(1): 80-85.

Boyce', A. M. and Korsmeier, R. B. 1941. The citrus bud mite, Eriophyes sheldoni Ewing J. Econ. Entomol., 34: 745 - 756.

Bray, H. G. and Thorpe, W. V. 1954. Meth Biochem. Anal. 1 : 27- 52.

Butani, D. K. 1979. Insects and fruits. Periodical expert book agency, Delhi, pp 219.

Butani, D. K. and Srivastava, R. P. 1979. Efficacy of insecticides for the control of mango bud mite Aceria mangiferae (Acari : Eriophyidae). First All India Sym. Acarology, Bangalore, pp 6 ( Abstr.).

Canestrini, G. and Massalongo, 1894. Atti. Soc. Veneto Trent, 2 (1) : 465.

Chakrabarti, S. 1999a. Plant mite interaction with reference to gall formation. Souvenir of Silver Jubilee Symposium. held at Bangalore from Oct 27 - 30 1999, pp. 11 - 12.

Chakrabarti, S. 1999b. A review of Eriophid mites (Eniophyoidea) studies in Eastern and North Eastern India. Souvenir of Silver Jubilee Symposium. held at Bangalore from Oct 27 - 30 1999, pp. 22 - 23.

Chakrabarti. S., Chakrabarti. S. and Chakrabarti. S. 1999. Effect of Acalitus hibisci (Eriophyidea) infestation on photosynthetic pigments of Hibiscus vitifolicus. Souvenir of Silver Jubilee Symposiumm held at Bangalore from Oct 27 - 30 1999, pp. 22.

ChannaBasavanna, G. P. 1966. A contribution to the knowledge of Indian Eriophyid mites (Eriophyoidea : Tlrombidiformes : Acarina). University of Agr. Sciences, Bangalore, pp 1530.

Chaudhri, W. M., Akbar, S. and Rasool A. 1974. Taxonomic studies of the mites belonging to families Tenuipalpidae, Tetranychidae, Tuckerellidae, caligonellidae, Stigmaeidae and Phytoseiidae. Univ. Agro. Lyallpur. 250 pp.

Das, B. and Chakrabarti, s. 1988. Eriophyid mites (Acari: Eriophyoidea) of North-East India- some aspects of their evolution and host associations. In Progress in Acarology-II (Ed. ChannaBasavanna,

G.P. and Virakataha, C.A.). Oxford & IBH, New Delhi. pp 391-394.

Das, L. K., Mitra, G. C. and Roychowdhury, D. N. 1987. Anatomical changes of juite stem by yellow mite. Science and culture, 53 (8) 252-253.

De Angelis, J.D., Berry, R.E. and Krantz, G.W. 1983. Photosyntheis, leaf

conductance and leaf chlorophyll content in spider mite (Acari:

Tetranychidae) injures peppermint leaves. Environ. Entomol.,

12:345-349.

Dhooria, M. S. and Sandhu, G. S. 1973. Curr. Sci., 42: 179 - 180.

Dubois, M., Gilles, K. A., Hamilton, J. K., Robbers, P. A. and Smith, F. 1951. Colourimetric method for determination of sugar and related substances. Analyt. Chem. 28: 350 - 356.

Dujardin, F. 1851. Sur des acariens a quarte Pied, parasites des vegeteaux, et. Qui, Dovient Former un genre particular (Phytoptus). Ann. Nat. Sci. Series 3., 15 : 166 - 169.

El-Halawany, M. E. 1991. Some factors affecting the distribution of Bervipapus califomicus (Banks) on citrus. In Modem Acarology vol I, Academia, Prague and SBP, Academic- Publishing BV, The Hague, pp 555-558.

Flechtmann, Carlos, H. W. and Berti-Filho, E. 1994. Effect of feeding by two species of Eriophyid mites (Acari, Eriophyidae) on the mineral content of their host plant. Internat. J. Acarol. 20 (1) : 61 - 65.

Ghosh, N. K., Das, B. and Chakrabarti, S. 1989. Injury by gall mites (Acari : Eriophyoidea) to plants in northeast India. In : Progress in Acarology vol.2 (Eds., C. P. ChannaBasavanna and C. A. Viraktamath). Oxford and IBH Co. Pvt. Ltd., New Delhi, pp 135 - 140.

Golik, Z. 1975. A study of the destructiveness of the fruit tree red spider mite, Panonychus ulmi (Koch) on apple. Zesz. Probi. Postepow Nauk Roln., 171: 15 - 34.

Gupta, S. K. 1977. Some un-described and little known species of Amblyseius (Acarina : Phytoseiidae) from western and northern India. Indian J. Acar., 1 : 28 - 37.

Gupta, S. K. 1979. A taxonomic review of oriental phytoseiidae (Acarina Mesostigmata). Adv. Insect Taxonomy, workshop, Manali, 9 - 12 Oct, 1979, pp 71 (Abst.).

Gupta, S. K. 1985. "plant mites of India" Ed. Director, Zoological Survey of India, Calcutta, pp. 89 - 90, 193-194.

Gupta, S. K., Sidhu, A. S. and Singh, G. 1975. Chemical control of brinjal eriophyid mite, Aceria lycopersici (wolf). Pesticides, 9 : 52 - 54.

Gupta, Y. N. and Gupta, S. K. 1979. On a collection of teranychii mites from Madhya Pradesh, India with description of a new Eotetranychus (Atari : Trombidiformes). Indian J. Acar., 3 (2) : 87 - 91.

Harvey, T. L. and Martin, T. T. 1988. Sticky tape method to measure cultivar effect on wheat curl mite ( Acari : Eriophyidae) ppulation in wheat spices. J. Eton. Entornol., 81 (2) : 731 - 732.

Henderson, C. F. and Tilton, E. W. 1955. Test acaricides against the brown wheat mite, J. Econ. Entomol., 48 : 157 -161.

HiscOx, J. D. and Israelston, G. F. 1979. A method for extraction of chlorophyll palm leaf tissue without masceration. Can. J Bot., 57 132 - 1334.

Hoyt, S.C. and Tanigoshi, L.K. 1983. Economic injury levels for apple mite pests. In B.A.Croft and S.C. Hoyt (Editors), Integrated management of insect pests of pome and stone fruits. John Wiley and Sons, New York, NY, pp 203-218.

Huffakar, C. B. and Spitzer, Jr. C., 1950. Some factors affecting red spider mite populations on pears in California. J Econ. Entomol., 43: 819 - 831.

Jenpson, W. A. 1962. Botanical Histochemistry principles and practice. W. H. Freeman and Co., Sanfrancisco.

Jepson, L. R., Keifer, H. H. and Baker, E. W. 1975. Mites injurious to economic plants. Univ. Calif. Press. 452 - 453.

Kazimi, S. K. and Ghani, M. A. 1969. Eriophydae (Acarina) and their predators in West Pakisthan. Technical Institute of Biological Control (1969). No. 12: 157 - 162.

Keifer , H. H. 1938. Eriophyid studies I, Bull Calif. DeptAgr., 27 : 181 - 206.

Keifer, H. H. 1944. Eriophyid studies I. Bull Calif. DeptAgr., 33: 18 - 38.

Keifer , H. H. 1946. A review of North American economic eriophyid mites. J. Econ. Entmol. 39 (5) : 563 - 590.

Keifer , H. H. 1952. The Eriophyid mites of California. Bull Calif. Dept-, Insect Surv., 2 (1) : 29.

Keifer , H. H., Baker, E. W., Kono, T., Delfinado, M. and Styer, W. E. 1982. An illustrated guide to plant abnormalities caused by eriophid mites in North America. USDA Agi ulture Hand book No. 573. pp. 1 - 178.

Kumar, K. K. 1992. Management of litchi mite, Aceria litchi Keifer. Indian J. P1. Prot., 20 (2) : 229 - 231.

Kumar, K. K. 1999. Relative susceptibility of litchi (Litchi chinensis), cultivars to curl mite Aceria litchi. Abst. In Souvenir of Silver Jubilee Symposium of Acarological Society of India held at Bangalore from Oct., 27 - 30. 1999. Pp. 20.

Laing, J.E., Calvert, D.L. and Huffaker, C.B. 1972. Preliminary studies of the effect of Tetranychus pacificus on yield and quality of grapes in the San Joaquin Valley, California. Environ. Entomol. , 1: 658-663.

Letchoumanane, S. and Subramaniam, T.R. 1979. Relative efficacy of soil applied insecticides in the control of the eriophyid mite (Aceria jasmin) on jasmine. First All India Symposium on Acarology, Bangalore, pp 215-221.

Lowry, O. H., Rosebrough, N. J., Farr, A. L. and Randell, R. J. 1951. Proline measurement with the folin phenol regent. J. Biol Cnem., 19: 265.

Mallikarjunappa, S., Mishra, R. K., Mithyantha, M. S. and Sivasankaram, K. 1990. Bioefficacy of pesticides against the eriophyid mite Aceria jasmini (Acari : Eriophyidae) infesting jasmine. Abst. In Fourth National Symposium on Acarology held at Calicut from Oct. 12 - 14, 1990, Pp. 73.

Manjunatha, M., Bhatt, N. S. and Puttaswamy, 1989. Morphology, histopathology, histochemistry and biochemical constituents of mite (Aceria pongamia) Induced leaf galls and healthy leaves of Pongamia glabra. In ! Progress in Acarology Vol II (Ed. ChannaBasavanna, G. P. and Viraktamath, C. A.), Oxford IBH Publishing Co. Pvt. Ltd., New Delhi, pp. 141 - 146.

Mathur, S. N. 1972. Efficacy of pesticides on the control of litchi mite, Aceria litchi. III Inter. Symp. Sub. Trop. & Trop. Hort., Bangalore, 11: 589.

Menon, M. G. R., Ghai, S. and Katiyar, K. N. 1971. Two new records of false spider mites from India ( Acarina : Tenuipalpidae). Indian J. Ent., 33 : 469 - 470.

Mishra, D. N. and Das, T. K. 1995. Efficacy of some pesticides and plant harmones in the control of mango bud mite and its impact on various growth characters. Environment and Ecology, 13 (2) : 354 - 360.

MohanKumar, S., Arumugam, T. and Rangarajan, A. V. 1991. Pomegranate a valuable arid zone fruit crop. Spice India, 4 (5) : 7 - 9.

Mohansundram, M. 1985. The eriophyid fauna of Varanasi with description of two species of Tetra ( Acari : Eriophyidae). In Progress in Acarology vol I (Ed. In Progress in Acarology Vol II (Ed. ChannaBasavanna, G. P. and Viraktamath, C. A.), Oxford IBH Publishing Co. Pvt. Ltd., New Delhi, pp. 385 - 389.

Moorey, S. and Stein, W.H. 1958. J. Biol. Chem., 211: 907-913.

Mukherjee, A. B., Singh, P. and Somchoudhury, A. K. 1990. Relative efficacy . of some pesticides against Aceria litchi (Keifer), an important pest of litchi. Abst. In Fourth National Symposium on Acarology held at Calicut from Oct. 12 - 14, 1990. Pp. 65.

Mukherjee, P.K., Sarkar, P.K., Somachoudhury, A.K. and Roy, M. 1989. Relative incidence of Oligonychus oryzae on nine varieties of paddy and its control. In Progress in Acarology Vol II ( Ed. ChannaBasavanna, G. P. and Viraktamath, C. A.), Oxford IBH Publishing Co. Pvt. Ltd., New Delhi, pp. 53-57.

Nageshachandra, B. K. and ChannaBasavanna, G. P. 1976. Mite host list of Indian false spider mites ( Acarina : Tenuipalpidae). Acar, Newsl.,3 :3-5.

Naidu, v.G. and ChannaBasavanna, G.P. 1989. Chemical control of Eriophyes cymbopogonis (Acari: Eriophyidae), a pest of citronella grass. In Progress in Acarology Vol II (Ed. ChannaBasavanna, G. P. and Viraktamath, C. A.), Oxford IBH Publishing Co. Pvt. Ltd., New Delhi, pp. 439-441.

Natrajan, K. and Beevi, N. D. 1990. Eriophid mite infesting piogenpea. South Indian Horticulture, 38 ( 3) : 29 - 32.

Nelson, N. 1944. A photometric adoption of somogy's method for the determination of glucose. J. Biol. Chem., 153 : 375 - 380.

Niles, G. A. 1980. Breeding cotton for resistance to insect pests. In Breeding plant resistance to insects ( Eds. Maxwell, F. G. and Jennings, P. R.) pp. 36 - 370.

Panda, N. 1979. Principles of host plant resistance to insect pests. Hindustan Publishing Co., (India), Delhi, pp. 251 - 253.

Penning de Vries, F. W. R. and Van Laar, H. H. (Eds.,), 1982. Simulation of plant growth and crop production. Simulation Monograph, Pudoc, Wageningen, pp. 308.

Phillips, P. A. and Walker, G. P. 1997. Increase in flower and young fruit abscission caused by citrus bud mite (Acari : Eriophyidae) feeding in the axillary buds of lemon. J. Econ. Entomol. 90 (5) 1273 - 1282.

Prasad, A., Singh, H. and Sukia, T. N. 1965. Present malformation disease. Indian J. Hort., 22 (3) : 254 - 265.

Prasad, V. 1974. A catalogue of mites of India. Indira Publishing House, Ludhiana (Punjab), India, pp. 320.

Purohit, S. D., Ramawat, K. G. and Arya, H. C. 1979. Phenolics, peroxidase and phenolase as related to gall formation in some and zone plants. Chem. Sci. 48 : 714 - 716.

Puttarudriah, M. and ChannaBasavanna, G. P. 1959. A preliminary account of phytophagous mites of Mysore. Proc. First All India Cong. Zool. Pt.2 : 530 - 539.

Rabbinge, R. 1985. Aspects of damage assessment. In world crop pests spider mites, their biology, natural enemies and control vol I A & B. (Ed : Helle, W. and Sabelis, M. W.). El Sevier, Oxford, pp. 261 - 272.

Rai, B. K., Verma, S. and Kumar, K. 1966. Evaluation of some pesticdes for the control of mango bud mite Aceria mangiferae sayed (Acerina Eriophyidae). Indian J, Ent. 28: 176 - 180.

Rajgopal, K., Jayaraj, S. and Subramaniam, T. R. 1970. Physiological mechanism of resistance in Jasmine to blister mite, Aceria jasmini C (Arachinida, Acari, Eriophyidae). Indian J. Expt. Biol. , 8 : 44 - 47.

Ramani, N. and Haq, M. A. 1989. Incidence and relative abundance of the mango mite, Cisabertoptus kenyae (Acari : Eriophyidae) In "Progress in Acamlogy" (Ed. ChannaBasavanna, G. P. and Viraktamath, C. A.). Oxford & IBH, New Delhi, pp. 115 - 119.

Reddy, M. V., Sheila, V. K., Murthy, A. K. and Padma, N. 1995. Mechanism of resistance to Aceria cajani in pigeonpea. International J. Tropical Plant Diseases, 13 (1) : 51 - 57.

Rhoades, D.F. 1979. In: Rosenthal, G.A. and janzen;. ,D.H. (Eds.) Herbivores, their interaction with secondary plant metabolites. Academic Press Inc., London. pp 3-54.

Sadana, G. L. and Chhabra, S. C. 1974. New records of the host and predators of the phytophagous mite, Oligonychus mangiferus (Rahman and Sapra). Sci. & Cult., 40 (8) : 362 - 363.

Sadana, G. L. and Chhabra, S. C. 1980. An addition to the tetranychoid mite fanna of the Punjab, India. Sci. & Cult., 46 (10) : 369 - 376. Sadana, G. L. and Gupta, B. K. 1984. New species of the genus Tenuipalpus Donnadieu (Tenuipalpidae : Acarina) from India. Entomon. 9 (2) : 141 - 147.

Sadana, G. L. and Joshi, R. 1976. Host range of the mite Bervipalpus califormicus (Banks) infesting citrus. Sci. & Cult., 42 (2) : 106 - 109.

Sances, F.V., Wyman, J.A. and Ting, J.P. 1979. Morphological responses of strawberry leaves to infestation of the two spotted spider mite. J. Eco. Entomol., 72: 710-713.

Sances, F.V., Wyman, J.A., Ting, J.P., Steenwizk, R.Van and Oatman, E.R. 1981. Spider mite interactions with photosynthesis, transpiration and productivity of strawberry. Environ Entomol. , 10: 442-448.

P~,;Cu ltiv~,e/
e 41RRARY .

Sharma, D.D., Singh, S.F. and Akhauri, R.K. 1986. Relationship between the population of Aceria litchii Keifer on litchi and weather factors. Indian J. Agric. Scien., 56(1): 59-63.

Siebold, G. R. Von. 1850. Bemerkungen uber psychiden. Jahresber. Schfes. Ges. Kult. 28: 84 - 89.

Sitanantham, S. and Velayutham, N. 1979. Varietal differences in sugarcane in relation to susceptibility for the mite Aceria sacchari (Acari : Eriophyidae). first All India Symp. Acarology, Bangalore, pp. 23 (Abst.).

Slavik, B. 1974. Methods of studying plant water relations. Academia publishing House of the Czechosovak Academy of Sciences. Prague, pp 137.

Sohi, A. S., Dhooria, M. S., Mahal, M. S. and Mann, J. S. 1997. Nomenclature status of important insects and mites with particular reference to India. J. Insect. Sci. 10 (1) : 91 - 114.

Solbrig, 0. 1960. J. Am. Arb. 41:259 - 269.

Srivastava, R. P. 1974. Comparative efficacy of various insecticides against mango bud mite Aceria mangiferae sayed. Indian J. Ent. 36 (1) : 74 - 75.

Stern, V. M. 1973. Economic thesholds. Annu. Rev. Entomol. 18 : 259 - 280.

Stem, V. M., Smith, R. F., Van de Bosch, R. and Hagen, K. 1959. The integration of chemical and biological control of the spotted alfalfa

aphid-Part I. The integrated control concept. Hilgardia, 29 : 81 - 101.

Sudhakar, T. 2000. Export of pomegranate. In Awareness programme on pomegranate. Govt. of A. P. and APEDA/ Pp. 31.

Summers, F. M. and Stocking, C. R. 1972. Some immediate effects on almond leaves of feeding by Bryobia rubrioculus (Scheuten). Acarologia 14: 170 - 178.

Sundararaj, J. S., Seemanathaini, B. and Varadan, K. M. 1967. "A mullai (Jasminum auriculatum) selection highly resistant to gall mite. Madras Agri J. 54 : 599 - 601.

Suresh, S. and Moha sundaram, M. 1995. Susceptibility of mango varieties to the bud mite Aceria mangifera. Madras Agric. J. 82 (12) 686 - 669.

Tomc zyk, A. and Kropezynska, D. 1985. Effect on the host plants. In World crop pests : spider mites their biology, natural enemies and control. Vol II. (Ed.: Hello, W. and Sabelis, M. W.). El sevier, Oxford,

pp. 317 - 329.

Tomc-zyk, A., Kropezynsha, D. Van der Vrie, M, and Kielkiewicz, M. 1989. Stimulating effects of spider mite (Tetranychus urticae) feeding on their host plants. In progress in Acarology (Ed --ChannaBasavanna, G. P. _and Viraktamath, C. A.) Oxford & Ibn Pvt. Ltd., India, pp. 15 - 21.

Tomezyk, A. and Van de Vrie, M. 1982. Physiological and biochemical changes in three cultivars of chrysanthemum after feeding by fetranychus urticae. In J.H. Visser and A.K. Minks (editors), Proc.

5th Int. symp. Insect Plant Relationship, Wageningen, 1982. PUDOC, Wageningen, The Netherlands, pp 391-RS-392.

Udayagiri, S. and Mohan, J. 1993. Chemical control of the eriophyid mite, Aceria jsmini (Acari: Eriophydidae) on Jasmine. Abst. In III All India Symposium in Acarology, Bangalore pp 64.

Umapathy, G. and Mohansundaram, M. 1998. New host and Distribution record of some gall mites ( Eriophyidae : Acarina) from South India. Madras Agrc. J. 85 (1) : 69 - 70.

Van 6 Vrie, M. Mc. Murtry, J. A. and Huffakar, C. B. 1972. Ecology of mites and their natural enemies. A review. III Biology, ecology and pest status and host plant relations of tetrancychids. Hilgardia 41: 345-432.

Vaneckova-Skuhrava, 1. 1996. Harmfulness of eriophyid mites (Eriophyoidea, Acari,) causing galls on trees and shrubs in the Czech republic. Anz. Schadlingskde, Pflanzenschtz, Um weltschutz 69: 81 - 83 (1996).

Varma, A. and Yadav, T. D. 1970. Efficacy of systemic insecticidal granules against mango bud mite Aceria mangiferae sayed (Eriophyidae : Acarina). Indian J. Ent., 32 (3) : 211 - 214.

Verma, B. R. and Kapur, M. 1990. Eriophyoid mites (Acari .-Eriophyoidea) of arid zone fruit crops and quarantine. Indian J, Ent., 52 (2) : 249 - 252.

Walker, G. P., Voulgaropoulos, A. L. and Phillips, P. A. 1992. Effect of citrus bud mite (Acari : Eriophyidae) on lemon yield. J.Econ. Entomol. 85 (4) : 1318 -1329.

Weatherly, P. E., 1950. Studies in the water relations of the cotton plants. I. The measurement of water deficits in leaves. New phyto., 49 : 81 - 97.

Wenzyl, H. (1948) Zur Erfassung des Schadansmabes in Pflanzenschutzversuten pfanzenchutz Berichte (wien) : 81 - 84 (Fide : Pflanzenchutz Nachrichten (Bayer) 16: 148 - 157 (1963). 41

Westpsl, E. 1976. Marcellia, 38 : 77 - 93.

Yadav, T. D. and Varma, A. 1969. Evalution of pesticides against mango bud mite, Aceria mangiferae sayed (Eriophyidae : Acarina). IndianJ. Ent., 31 : 244 - 246.

Yarwood, C.E. 1976. Modification of the host response-predispostion. In: Encyclopaedia of Plant Physiology, New Series Volume-4 (Eds. R.

< Heitefusus and P.H. williams), Spring-Verlag, New York, pp 703718. -

Zaher, M. A. and Elbadry, E. A. 1964. Survey and population studies of red and false spider mites. First International Cong. Acarology Proc. Fort Collins, Colo. Extrai d' Acarologia, 6 : 425 - 435.

Zukova, V.P. 1963. Feeding mechanisms f the spider mite Tetranychus telarius Tr. Nauchno-Issled, Inst. Azshch. Rast. Uzb. SSR, 6:13-18)

Management of Eriophyid mite, Aceriagranad, on pomegranate and

morpho-physio-histopathological effects of the pest on the host

V. K. Agrawal*

ABSTRACT#

Investigations were carried out during the year 1995-96 to 1997-98 on "Management of Eriophyid mite, Aceria granati, on pomegranate and morpho-physio-histopathological effects of the pest on the host" at Aslapur Farm and in the Department of Entomology, S K N College of Agriculture, Jobner.

The incidence of A. granati was observed throughout the year and attained the peaks, first in April and second in October-November.

With regards to influence of abiotic factors on the incidence of the mite, the mite population showed significant negative correlation with temperature (minimum and maximum), relative humidity and rainfall.

The mite preferred west face of the tree and minimum mite infestation was observed on South face.

Among nine cultivars of pomegranate, maximum damage of A. granati was noticed on Ganesh and Bassein seedless and it was minimum on Dholka and GKVK-1. Significant correlation was also noticed between mite incidence and leaf thickness as well as leaf hair density.

Observations taken on feeding effect of the mite on morpho-physiological process revealed that mite attack adversely affected the plant growth, fruit development, chlorophyll content of the leaves and relative leaf water content (RLWC), whereas, transpiration rate of damaged plant was higher.

Under histopathological studies of the damaged leaf, it was observed that cells in the outer layer were flattened and destroyed, resulting in disturbing in stomatal functioning, Studies on biochemical characterization of damaged and healthy leaves revealed higher content of total phenols, total soluble sugars and reducing sugars in mite damage leaves in comparison to healthy leaves, whereas, free aminoacids and protein content were higher in healthy leaves.

Out of the seven pesticides tried against A, granati, monocrotophos (0.05%) was found most effective followed by ethion (0.05%). The next best pesticides were dicofol (0.05%), acephate (0.05%) and diamethoate (0.05%). The treatment of malathion (0.05%) was found least effective.

Assistant Professor, AZCRP on Arid zone Fruits, S K N College of Agriculture, Jobner, Rajasthan Agricultural University, Bikaner.

# Thesis submitted in complete fulfillment of the requirement for the degree of DOCTOR OF PHILOSOPHY in faculty of Agriculture in the subject of Z, 4dftd,~Fyunder the supervision of Dr. G. K. Sharma, Professor, Department of Entomology, A. R. S. Uurgapura.

# अनार की एरिफोयिड बरूथी, *ऐसेरिया ग्रनेटी* द्वारा परपोषी पौधे की अकारिकी – कार्यिकी – ऊत्तकीय संरचना पर प्रभाव एवं इसका प्रबन्ध

वी. के. अग्रवाल*

## सारांश**

अनार की एरिफोयिड बरूथी, *ऐसेरिया ग्रेनेटी* द्वारा परपोषी पौधे की अकारिकी–कार्यिकी–उत्तकीय सरंचना पर प्रभाव एवं इसके प्रबन्ध हेतु अनुसन्धान कार्य सन् 1995–1996 से 1997–98 तक आसलपुर फार्म एवं कीट विभाग, श्री कर्ण नरेन्द्र कृषि महाविद्यालय, जोबनेर में पूर्ण किया गया ।

*ऐसेरिया ग्रेनेटी* का प्रकोप वर्ष भर देखा गया तथा शिखर प्रकोप अप्रेल तथा अक्टूम्बर – नवम्बर माह में आकां गया ।

बरूथी आपतन का अधिकतम व न्यूनतम तापमान, साक्षेप आर्द्रता तथा वर्षा की मात्रा के साथ उच्च ऋणात्मक सह–सम्बन्ध दिखाई दिया ।

बरूकी द्वारा पौधे की पश्चिम दिशा का सबसे अधिक व दक्षिण दिशा को सबसे कम अनुकूल पाया गया ।

अनार की नौ प्रजातियों में से *ऐसेरिया ग्रेनेटी* का सबसे अधिक प्रकोप गणेश एवं वेसिन सीडलेस प्रजाति पर व सबसे कम ढोलका एवं जी.के.वी.के.–1 पर आकाँ गया ।

बरूकी आपतन का अनार की पत्ती की मोटाई व रोमिल घनत्व के साथ उच्च सह–सम्बन्ध पाया गया ।

अनुसन्धान के दौरान बरूथी के खाद्य प्रभाव का परपोषी पौधे की अकारिकी–कार्यिकी संरचना पर विपरीत असर देखा गया ।

बरूथी ग्रासित पत्तियों की ऊत्तकीय सरंचना को देखने पर पता चला की ऐसी पत्तियों की त्वचा बाहरी सतह चपटी व त्रुटिपूर्ण पाई गई ! बरूथी ग्रसित पत्तियों में फिनोल, धुलनशील व ह्यसिय शर्करा की मात्रा स्वस्थ पत्तियों के अपेक्षा अधिक पाई गई । जबकि स्वतन्त्र एमाइन व प्रोटीन की मात्रा कम पाई गई !

*ऐसेरिया ग्रेनेटी* की रोकथाम हेतु सात कीटनाशियों/बरूथीनाशियों के अध्ययन के दौरान मोनोक्रोटोफॉस (0.05 प्रतिशत) सबसे अधिक प्रभावशाली पाया गया, इथियोन (0.05 प्रतिशत) प्रभाविकता में इसके काफी निकट रहा । जबकि मैलाथियान (0.05 प्रतिशत) सबसे कम प्रभावशाली पाया गया ।

---

* सहायक आचार्य कीट विभाग, श्री कर्ण नरेन्द्र कृषि महाविद्यालय,जोबनेर राजस्थान कृषि विश्वविद्यालय, बीकानेर ।

**कीट विज्ञान विषय में विद्या वाचस्पति की उपाधि की आवश्यकता में पूर्ण पूर्ति हेतु प्रस्तुत किया गया शोध ग्रथ जिसे डा. गिरीश कुमार शर्मा, आचार्य, कीट विभाग, कृषि अनुसंधान केन्द्र दुर्गापुरा के निर्देशन में पूरा किया गया ।

# APPENDIX I

## *MITE FAUNA DAMAGING POMEGRANATE IN INDIA.*

| S. No. | Name of mite | Taxonomic position | Linkage monitoring By | Distribution | Reference |
|---|---|---|---|---|---|
| 1 | *Amblyseius (Euseius) alstonia* Gupta | Phytoseiidae: Mesostigmata | Polyphagous | All parts of India | Gupta, 1977 |
| 2 | *A.(Amblyseius) largoensis* (Muma) | Phytoseiidae: Mesostigmata | Polyphagous | All parts of India | Gupta, 1977 |
| 3 | *A.(Euseins) ovalis*(Evans) | Phytoseiidae: Mesostigmata | Polyphagous | All parts of India | Gupta, 1977 |
| 4 | *A.(proprioseiopsis)peltatus* Van der merwe | Phytoseiidae: Mesostigmata | Monophagous | West Bengal | Gupta, 1979 |
| 5 | *Oligonychus punicae* (Hirst) | Tetranychidae: Prostigmata | Grapevine, pomegranate, litchi | Punjab, Tamilnadu | Gupta, 1985 |
| 6 | *O.mangiferus* (Rahman & Sapra) | Tetranychidae: Prostigmata | Polypohagous | All parts of India | Sadana and Chhabra, 1974 |
| 7 | *Brevipalpus obovatus* | Tenupapidae: prostigmata | Polyphagous | HP, West Bengal, Punjab, Delhi. | Chaudhari et al, 1974 |
| 8 | *B. phoenicis* (Geiskes) | Tenupapidae: prostigmata | Polyphagous | All parts of India | Nageschandra and ChannaBasavanna, 1976 |
| 9 | *B. Californicus* (Banks) | Tenupapidae: prostigmata | Polyphagous | All parts of India | Sadana and Joshi, 1976 |
| 10 | *Tenupaplus punicae* Prtichard & Baker | Tenupalpidae: Prostigmata | Pomegranate, Guava, Prunus, Tecoma | Punjab, Meghalaya | Dhooria and Sadndhu, 1973 |

| S. No. | Name of mite | Taxonomic position | Linkage monitoring By | Distribution | Reference |
|---|---|---|---|---|---|
| | | | | Delhi and MP | Gupta and Gupta, 1979 |
| 11. | *T. aboharensis* Sadana & Chhabra | Tenupalpidae: Prostigmata | Monophagous | Punjab | Sadana and Chhabra, 1980 |
| 12 | *T. granati* Sayed | Tenupalpidae: prostigmata | Pomegranate, Plumbago | Delhi | Menon et al, 1971 |
| 13 | *T. solanesis* | Tenupalpidae: prostigmata | Pomegranate | Solan (HP) | Sadana and Gupta, 1984 |
| 14 | *T.Guptai* | Tenupalpidae: prostigmata | Pomegranate | Solan (HP) | Sadana and Gupta, 1984 |
| 15 | *Aceria granati*(Can. & Mass.) | Eriophyidae: Prostigmata | Monophagous | Mysore | Puttarudriah and ChannaBasavanna, 1959 |
| | | | | Karnataka | ChannaBasavanna, 1966 |
| | | | | Varanasi (U.P) | Mohansundram, 1985 |
| | | | | Uttar Pradesh | Agrawal et al, 1990 |
| | | | | Rajasthan | Agrawal, 1990 |
| | | | | Tamil Nadu | Umapathy and Mohansundaram, 1998 |

APPENDEX -2

Crop production levels (Rabbinge, 1985):

Production level 1: growth occurs under conditions of ample plant nutrients and water. Growth and yield are determined by weather
n conditions and crop physiological characteristics. Growth rates of C3 plants under these conditions amount generally to 200 kg dry matter ha-' day-1 and for C4 plants depending on latitude they vary between 200 and 400 kg dry matter ha-' day-1. Potential yields are approached under
t
f these conditions. 9

t
Production level 2: growth is limited by shortage of water at least part of the time, so that growth rates are reduced by the ratio between the actual and potential transpiration. Growth rates under these conditions are in general much lower than their potential value and vary

' between 100 and 200 kg dry matter ha-1 day-1.

Production level 3: growth is limited at least of the time by shortage of water and nitrogen and this results in growth rates which are generally lower than 100 kg dry matter ha-1 day-'.

Production level 4: growth occurs under conditions where water or nutrients are limiting during the major part of the growing period so that growth rates vary usually between 12 and 50 kg dry matter ha-' day-'. Yields are generally not much higher than 1000 kg dry matter per hectare per growing season.

Types of plant abnormalities/injury caused by eriophyoids.

Generally eriophyoids mites infest aerial parts of the plants resulting in a simple discoloration to complex gall formation. Following plant abnormalities have been reported/observed on host plant by different species of eriophyoids (Jeppson et alai 975 and Gosh et al., 1989).

1.Big Buds :- Some times eriophoides are found within the buds of plants, where they receive the optimum environment for their growth and reproduction. Due to mainly the feeding activities of the mites, the developing buds swell and this inhibits the further growth of the apical
`, buds and the flowering stem. As infestation proceeds, normal plant growth is obstructed. The colour of the buds may change from dark brown to yellowish brown. Example : Aceria mangiferae Infesting mango, Mangifera indica.

2. Leaf curling and shrinkage These symptoms are usually related with the vagrant feeders. They attack almost all aerial parts causing vascular atrophy, wrinkling and the curling of the leaves. Loss of pigmentation may also occur. One example is edge rolling in pomegranate, caused by Aceria granati. Heavy infestation of this mite may stunt all leaves along a shoot.

3. Discoloration :- Some eriophyoide mites cause discoloration of the leaves. This loss of pigmentation is due to the penetration of the stylets of the mites into the soft epidermal tissue of the leaf. Examele :- Tegonotus jambolensis infesting Syzigium cu mini.

4. Erineum :- This is excessive growth of the surface hairs of the plants specially the hairs present on the under surface of the leaf. Erineum may be found as small localized patches or extensively affected areas on various plant parts. The erineum may be variously coloured from crimsom to chocolate brown. Example : Aceria litchi infesting litchi

chinenesis.

5. Russetting :- This symptom is eskind to discoloration and is also caused by vagrant mites. Both the leaf lamina and the veins are affected

by feeding of the mites. It is suspected that the salivary enzymes l liberated by the mite during feeding is responsible for this. Example:.,

Tegonotus mangiferae infesing Mangifara indica.

7. Galls :- Galls are pathologically developed cells, tissues or organs of plants that arise mostly by hypertrophy or hyperplasy under the influence of parasitic organisms such as bacteria, fungi, nematodes, mites and insects. Eriophyides induced galls are always of open type with soft and persistent ostiole and copious nutritive hairs inside. From the nature and the morphology of the galls formed, it is evident that gall eriophyides are highly host specific. Example : Aceria cordiae infesting Cordiae myxa.

APPENDIX - 4

ANOVA for preference of face by AA gratia

| Sources of variation | df | Mean sum of squares |
|---|---|---|
| Replication | 2 | 28.040 |
| Peak (P) | 1 | 19600.595** |
| Face (F) | 3 | 185.122** |
| P x F 3 43.088 Error | 14 | 21.005 * |

r

Significant at p=0.05 and **Significant at p=0.01

APPENDIX - 5

ANOVA for varietal susceptibility of different pomegranate cultivars (1995-96).

| Sources of variation | df | Mean sum of squares |
|---|---|---|
| Replication | 2 | 62.14 |
| Cultivar ( C) | 8 | 2226.87** |
| Peak (P) | 1 | 4892.52** |
| C x P | 8 | 269.46** |
| Error | 34 | 44.91 * |

significant at p = 0.05 ** significant p = 0.01

I

APPENDIX - 6

ANOVA for varietal susceptibility of different pomegranate cultivars (1996-97).

| Sources of variation | df | Mean sum of squares |
|---|---|---|
| Replication | 2 | 2.95. |
| Cultivar ( C) | 8 | 2316.64** |
| Peak (P) | 1 | 6087.81** |
| C x P | 8 | 658.62** |
| Error | 34 | 39.17 |

*significant at p = 0.05 ** significant p = 0.01

APPENDIX - 7

ANOVA for varietal susceptible different pomegranate cultivars (pooled analysis).

| Sources of variation | df | Mean sum of squares |
|---|---|---|
| Replication with in year | 4 | 32.55 |
| Year (Y) | 1 | 3.77 |
| Cultivar ( C) | 8 | 4483.17** |
| Peak (P) | 1 | 10947.70** |
| YxC | 8 | 60.35 |
| Y x P | 1 | 32.63 |
| C x P | 8 | 195.81** |
| Y x C x P | 8 | 759.83** |
| Pooled Error | 68 | 38.80 * |

Significant at p=0.05 and **Significant at p=0.01

## APPENDIX – 8

**Vegetative variations due to feeding of *A. granati* in pomegranate plants.**

| S.No. | Height of plant (m) | | Stem girth (cm) | | Plant spread ($m^2$) | | Leaf size ($cm^2$) | | Number of leaves/twig | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Healthy | Infested | Healthy | Infested | Healthy | Infested | Healthy | Infested | Healthy | Infested |
| | **1995-96** | | **1995-96** | | **1995-96** | | **1995-96** | | **1995-96** | |
| 1 | 1.90 | 1.80 | 13.6 | 13.4 | 2.59 | 2.61 | 8.9 | 5.3 | 23 | 22 |
| 2 | 2.00 | 1.95 | 13.5 | 13.2 | 2.71 | 2.53 | 8.0 | 5.0 | 22 | 23 |
| 3 | 2.00 | 1.95 | 13.5 | 13.2 | 2.73 | 2.49 | 8.3 | 6.1 | 19 | 20 |
| 4 | 1.95 | 1.95 | 13.8 | 13.3 | 2.62 | 2.54 | 7.4 | 5.9 | 21 | 20 |
| 5 | 1.85 | 1.80 | 13.4 | 13.5 | 2.66 | 2.64 | 7.8 | 4.8 | 22 | 22 |
| 6 | 1.95 | 1.90 | 13.2 | 13.2 | 2.74 | 2.58 | 8.3 | 4.9 | 24 | 21 |
| 7 | 2.00 | 1.95 | 13.2 | 13.1 | 2.79 | 2.64 | 8.9 | 5.3 | 20 | 23 |
| 8 | 1.85 | 1.80 | 13.8 | 13.7 | 2.56 | 2.53 | 7.1 | 4.6 | 24 | 20 |
| 9 | 1.90 | 1.85 | 13.7 | 13.6 | 2.68 | 2.59 | 7.4 | 4.7 | 20 | 21 |
| 10 | 1.85 | 1.85 | 13.9 | 13.7 | 2.62 | 2.65 | 8.9 | 5.4 | 24 | 24 |
| $\bar{x} \pm \sigma$ | 1.93± 0.06 | 1.88 ± 0.06 | 13.56 ± 0.25 | 13.39 ± 0.22 | 2.67 ± 0.07 | 2.58 ±0.06 | 8.10 ± 0.6 | 5.20 ± 0.50 | 22 ± 1.76 | 21.50 ± 1.51 |
| | **1996-97** | | **1996-97** | | **1996-97** | | **1996-97** | | **1996-97** | |
| 1 | 2.20 | 2.10 | 14.5 | 14.0 | 2.83 | 2.81 | 8.0 | 5.0 | 23 | 22 |
| 2 | 2.00 | 2.05 | 13.6 | 13.5 | 2.92 | 2.73 | 8.9 | 5.0 | 24 | 22 |
| 3 | 2.20 | 2.00 | 13.6 | 13.5 | 2.89 | 2.68 | 8.9 | 5.4 | 23 | 20 |
| 4 | 2.05 | 2.15 | 14.2 | 13.5 | 2.81 | 2.75 | 7.4 | 4.7 | 23 | 22 |
| 5 | 1.95 | 2.10 | 14.6 | 14.0 | 2.99 | 2.84 | 7.4 | 5.9 | 25 | 21 |
| 6 | 1.95 | 1.90 | 14.9 | 14.5 | 3.05 | 2.78 | 8.9 | 5.2 | 24 | 23 |
| 7 | 2.35 | 2.15 | 14.2 | 14.0 | 2.95 | 2.84 | 7.1 | 4.6 | 22 | 21 |
| 8 | 2.20 | 1.80 | 14.8 | 14.0 | 2.92 | 2.73 | 8.3 | 5.6 | 19 | 19 |
| 9 | 2.15 | 1.85 | 14.6 | 14.5 | 2.84 | 2.79 | 7.8 | 4.8 | 22 | 20 |
| 10 | 1.95 | 1.90 | 14.0 | 14.5 | 3.10 | 2.85 | 8.3 | 4.9 | 25 | 20 |
| $\bar{x} \pm \sigma$ | 2.10 ± 0.14 | 2.00 ± 0.13 | 14.30 ± 0.46 | 14.00 ± 0.41 | 2.93 ± 0.09 | 2.78 ± 0.06 | 8.10 ± 0.67 | 5.00 ± 0.41 | 23.00 ± 1.76 | 21.00 ± 1.25 |

# APPENDIX 9

***ANOVA for bio-efficacy of pesticides against A. granati on pomegranate before spray***

| Source of variation | Df | MSS | |
|---|---|---|---|
| | | **1996-97** | **1996-98** |
| Replications | 2 | 18.1665 NS | 15.500 NS |
| Treatments | 7 | 12.5714 NS | 19.785 NS |
| Error | 14 | 29.2142 | 11.500 |

# APPENDIX 10

ANOVA for bio-efficacy of pesticides against *A.granati* on pomegrante at different intervals

| Source of variation | Df | Mean sum of squares | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10 days | | 30 days | | 60 days | | 90 days | |
| | | 1996-97 | 1997-98 | 1996-97 | 1997-98 | 1996-97 | 1997-98 | 1996-97 | 1997-98 |
| Replications | 2 | 3.32486 | 1.8161 | 8.1434 | 0.3608 | 2.1119 | 9.7227 | 28.3040 | 2.8616 |
| Treatments | 6 | 59.8480** | 115.7584** | 56.0017** | 50.5692** | 42.8773** | 21.8889** | 15.0268** | 10.3599** |
| Error | 12 | 2.7445 | 4.3252 | 3.1201 | 3.2652 | 3.4170 | 1.7425 | 3.5338 | 1.8445 |

* Significant at p=0.05 and **Significant at p=0.01