SEASONAL INCIDENCE AND MANAGEMENT OF SUCKING PESTS OF POMEGRANATE

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1. INTRODUCTION

India, with its diverse soil and climate, offers ideal conditions for growing several kinds of fruit. Fruit crops are being grown in an area of about 3.94 million hectares with a total production of 50 million tonnes. In India, the per cent availability of fruits per head per day is only 55 g, which is far lower than the recommended level of 85 g per head per day by Indian Council of Medical Research (ICMR).

Pomegranate is one of the most adaptable subtropical minor fruit crops, commonly known as anar, dalim or dalimbe. It belongs to one of the smallest families of plant kingdom *i.e.* Punicaceae. Pomegranate is native to Iran, where it was first cultivated around 2000 BC and spread to the Mediterranean countries (Evereinoff, 1949). It is extensively cultivated in Spain, Morocco, Egypt, Iran, Afghanistan, Arabia and Baluchistan. Its cultivation spread further to other countries like China, Japan, USA, USSR, Pakistan and India. In India, during 1986, the area under pomegranate cultivation increased owing to the introduction of high yielding soft seeded variety “Ganesh” in the states of Maharashtra, Karnataka and Gujarat (Bose, 1986). The fruit is very much liked for its cool and refreshing juice. The bark and rind are recognized as astringents employed in therapeutics in the treatment of dysentery and diarrhea. The rind is used as dyeing material for cloth.

Pomegranate cultivation is unique in its own way. Because of its drought tolerant hardy nature, low maintenance cost, steady and good yields, fine table and therapeutic values, better keeping quality and possibilities of throwing the plant into rest during period when irrigation potential is low, especially in the hot semi-arid and desert regions of India, like states of Maharashtra, Uttar Pradesh, Andhra Pradesh, Gujarat, Karnataka and Tamil Nadu its cultivation has spread extensively. In Karnataka, it is grown in Bijapur, Bagalkot, Koppal, Bellary, Raichur and Gulbarga districts.

Pomegranate is a favourite table fruit of tropical and subtropical regions of the world. The fruits are good source of sugars (14-16%), minerals (0.7-1.0%) and fair source of iron (0.3-0.7 mg/100 g) and vitamin B-complex. Pomegranate juice is cooling, refreshing and has many good medicinal properties, especially for those suffering from leprosy. The roots, rind and seeds are medicinally important especially against diarrhoea. The rind is also used as dyeing material for cloth. A wild type of pomegranate grown in Himachal Pradesh has got great economic importance since its sun dried seeds are used to make condiment called anar-dana (Patyal and Nath, 1993).

Cultivation of high yielding varieties of pomegranate with intensive care and management in the recent past under irrigated condition with early stage exploitation of plant has lead to certain severe pest problems. Among them, infestation by sucking pests like aphids, thrips, whiteflies, mealy bugs, scale insects and mites results in reduction of pomegranate fruit yield and put the growers into hardship. The growers loose in terms of quantity and quality of fruits also. The major constraint in increasing export potential is the quality of fruit in terms of size, colour, freedom from blemishes and pesticide residue levels. To overcome the latter constraint it is necessary to develop eco-friendly management practices for sucking pests. Particularly, the management using the biological control agents will go a long way in stabilizing the quality production without disturbing the pomegranate ecosystem. Hence, investigations were made with following objectives.

1. To record various sucking insect pests on pomegranate and their natural enemies
2. To know seasonal incidence of major sucking pests of pomegranate and their relation with weather factors
3. To device effective and eco-friendly management practices for major sucking pests of pomegranate

2. REVIEW OF LITERATURE

The literature pertaining to various aspects of the sucking pests of pomegranate is presented below.

2.1 Sucking insect pests of pomegranate

The sucking pests recorded on pomegranate in India are presented in Table 1.

Butani (1976) reported over 45 species of insects on pomegranate. Karuppuchamy (1994) recorded insect pests attacking pomegranate along with plant part infested, peak activity and their natural enemies in Tamil Nadu. Balikai (2000) enlisted 32 insect pests of which nine were sucking pests and found feeding on pomegranate in the districts of Bijapur and Bagalkot of Karnataka.

2.1.1 Aphids

The pomegranate aphid, *Aphis punicae* Passerini was found feeding on upper surface of the leaves of pomegranate and Duranta, *Duranta plumeri* (El-Nagar *et al.*, 1982; Ismail *et al.*, 1985). *A. punicae* was found infesting twigs and leaves of pomegranate in central Maharashtra (Mote *et al.*, 1992).

According to Karuppuchamy *et al.* (1998) the aphid, *A. punicae* caused severe damage to flowers, fruits, twigs and leaves by desapping, which resulted in loss of quality of fruits and reduction in yield. Biradar and Shaila (2004) considered pomegranate aphid, *A. punicae* as minor pest of pomegranate. However, in recent years, this pest has assumed a serious form and it is occurring regularly through out the year with peak incidence in winter.

2.1.2 Thrips

Two species of grapevine thrips *viz*. *Retithrips syriacus* (Munae) and *Rhipiphorothrips cruentatus* Hood have been reported on pomegranate by Ananthakrishnan (1971). Besides pomegranate, these two species of thrips have been also recorded on jamun, castor, rose (Butani, 1976) and mango (Lee and Wen, 1982).

Another species of thrips, *Scirtothrips dorsalis* Hood, though recorded as minor pest on pomegranate, is assuming a status of key pest on pomegranate under the semi arid conditions in Gujarat (Bagle, 1993).

2.1.3 Whiteflies

Sporadic occurrence of *Dialeurodes citri* Ashm. on pomegranate was reported by Fletcher (1919). *Siphonimus finitimus* Silvestri was considered as a minor pest on pomegranate (Butani, 1976).

Mani and Krishnamoorthy (1999) noticed the severe out break of *Siphoninus phillyreae* (Haliday) on several pomegranate cultivars in Bangalore, India during October 1997. Balikai *et al.* (1999) observed *S. phillyreae* previously recorded as a minor pest of pomegranate in Karnataka, becoming a major pest in some areas of Bijapur district during February-April and 60-70 per cent foliage was infested on each plant. Karuppuchamy (1994) recorded *Bemisia tabaci* Genn. as a minor pest on pomegranate in Tamil Nadu

2.1.4 Mealy bug

Fletcher (1919) reported the occurrence of mealy bugs on pomegranate fruit stalks, *Planococcus lilacinus* (Cockrell) and *Ferrisia virgata* (Cockrell) were recorded on pomegranate by Ayyar (1924). Butani (1976) recorded two species of mealy bugs namely *Drosicha mangiferae* (Green) and *P. lilacinus* damaging pomegranate foliage.

Mealy bug *Dorsicha dalbergiae* Green was recorded for the first time on pomegranate by Rawat *et al.*,(1980). Severe infestation of *Planococuus citri* (Risso) on pomegranate was reported for the first time in India by Mani *et al.* (1990a). Three mealy bug species namely *P. citri*, *P. lilacinus* and *Nipaecoccus viridis* (Newsted) were recorded around Bangalore by Mani and Krishnamoorthy (1990).

Table 1: Sucking pests recorded on pomegranate

Sl. No.	Order	Family	Species of insect pests	References
1.	Hemiptera	Coreidae	*Leptoglossus memroanaceus* Fab.	Jadhav *et al.* (1976)
		Pentatomidae	*Jurtina indcia* Dall	Ayyar (1924), Raghunatha(1999)
			Halyomorpha picus Fab.	Ayyar (1924), Raghunatha(1999)
			Nezara virudula L.	Balikai (2000)
			Dolicoris indicus L.	Karuppachamy (1994)
2.	Homoptera	Aphididae	*Aphis punicae* (Passerini)	Butani (1974), Balikai (2000),
		Aleyrodidae	*Siphonimus phillyreae finitimus* Goux.	Niar (1976)
			Dialeurodus citri Ashm.	Fletcher (1919)
			Siphonimus finitimus Silvestri	Butani (1976)
			Bemisia tabaci Genn.	Karuppachamy (1994)
			Siphoninus phillyreae (Haliday)	Balikai (2000), Mani and Krishnamoorthy (1999)
			Aleurodicus disperses Russell	Balikai (2000), Raghunatha (1999)
		Psuedococcidae	*Dorsicha mangiferae* (Green)	Butani (1976)
			Planococcus lilacinus (Cockrell)	Butani (1976)
			Planococcus citri (Risso)	Mani and Krishnamoorthy (1990)
			Maconellicoccus tirsntas (Green)	Mani and Krishnamoorthy (1990)
			Psudococcus filamentus (Ckill)	Butani (1976)
			Nipaecoccus viridis (Newstead)	Mani and Krishnamoorthy (1990)
		Coccidae	*Arnidiella orientalis* (Newstead)	Butani (1976)

Contd…

Sl. No.	Order	Family	Species of insect pests	References
			Lepidosaphes hawaiensis (Maskell)	Butani (1976)
			Lepidosaphes punicae Green	Butani (1976)
			Pinnaspis theae (Maskell)	Butani (1976)
			Parlotoria oleae (Coluee)	Butani (1976)
			Parasissetia nigera (Nietner)	Jadhav and Ajri (1985)
				Karuppuchamy (1994)
3	Thysanoptera	Thripidae	*Retithrips syriacus* (Munae)	Ananthakrishnan (1971)
			Rhipiphorothrips cruentatus Hood	Ananthakrishnan (1971)
			Scirtothrips dorsalis Hood	Bagle (1993)
			Anaphothrips oligochaetus Kerny	Balikai (2000)
4.	Acarina	Eriophyidae	*Aceria granati* Can. and Massal	Butani (1976), Karuppuchamy (1994) and Balikai (2000)
		Tetranychidae	*Oligonychus punicae* (Hirst)	Butani (1976), Karuppuchamy (1994) and Balikai (2000)
			Eutetranychus orientalis (Klien)	Kumavat and Singh (2002), Banerjee (1988)
		Tenuipalpidae	*Tenuipalpus granati* Sayed	Karuppuchamy (1994)

The grapevine mealy bug, *Maconellicoccus hirsutus* (Green) was observed infesting stem, flower and fruits of three year old pomegranate trees at Bangalore (Mani and Krishnamoorthy, 1991).

2.1.5 Scale insects

Pinnaspis theae Maskell has been reported to damage pomegranate (Butani, 1976). Among scale insects, pomegranate scale, *Lindingaspis rossi* (Maskell) and olive scale, *Parlotoria oleae* (Coluee) were more common than *Aonidiella orientalis* (Newstead). *Lepidosaphes hawaiensis* Maskell, *Lepidosaphes punicae* Green and *Lepidosaphes rossi* (Maskell) (Hill, 1983). In Maharashtra, the scale insect, *Parasissetia nigera* (Nietner) assumed the status of a serious pest on pomegranate (Jadhav and Ajri, 1985).

2.1.6 Other sucking pests

Ayyar (1924) and Butani (1976) reported two pentatomid bugs namely *Jutina indica* Dall and *Halyomorpha picus* Fab. The bugs damaged the tender and ripe pomegranate fruits. An unusually heavy incidence of the leaf footed plant bug, *Leptoglossus memroanaceus* Fab. was recorded on pomegranate and sweet orange for the first time in Maharashtra (Jadhav *et al*., 1976). Karuppuchamy (1994) reported the incidence of pentatomid bug, *Dolicoris indicus* L. on pomegranate during last week of February 1994 at Naravalur, Tamil Nadu.

2.1.7 Mites

Karuppuchamy (1994) reported two mites, false spider mites, *Tenuipalpus granati* Sayed and Eriophyid mite *Aceria granati* Can. and Massal on pomegranate in Tamil Nadu.

The oriental mite, *Eutetranychus orientalis* (Klein) infested the pomegranate heavily. The active larva, protonymph, deutonymph and adults of both sexes sucked the cell sap from the leaves and subsequently spread to fruits. (Kumawat and Singh, 2002).

Putatunda *et al.* (2002) recorded the prostigmatic mites, *Tenuipalpus punjabensis* and *Tenuipalpus* sp. (Tenuipalpidae) on pomegranate in low frequency (less than 3 per sq. inch).

2.2 Natural enemies of sucking pests of pomegranate

The natural enemies of sucking pests of pomegranate are presented in Table 2.

2.2.1 On Aphids

Karuppuchamy (1994) recorded *Chrysoperla carnea* (Stephens) and *Scymnus coccivora* Ayyar on pomegranate aphid, *A. punicae*. Mani and Krishnamoorthy (1995) reported that, *A. punicae* was prayed by three coccinelids namely *Scymnus castaneus* Sci, *S. latemaculata* Motsch and *Menochilus sexmaculata* F. and syrphid, *Paragus serratus* (F.). However no parasitoids have been recorded on aphids.

Amin (2002) collected twelve species of natural enemies from the colonies of pomegranate aphid *A. punicae* in the El-Beida region, Libyra, including eleven species of predators, seven species belonged to the family Coccinellidae and one species each to the families Anthocoridae, Syrphidae, Cecidomyiidae and Chrysopidae, in addition to a parasitoid wasp of the family Braconidae.

2.2.2 On whitefly

According to Mani and Krishnamoorthy (1995), collection of whiteflies for two years yielded two species of Aphelinid parasitoid viz., *Encarsia inaron* Walker and *Encarsia* sp. Mani and Krishnamoorthy (1999) recorded totally six natural enemies, Aphelinid parasitoid, *Encarsia azmi* Hayat and predator *Scymnus* sp., *Cryptolaemus montrouzieri* Muls, *Chrysopa* sp., *Chielomenus sexmaculata* Fab. and *Acletoxineus indicus* for the first time on ash whitefly *S. phillyreae* in India.

Masbah (2003) noticed two parasitoid species, *E. inaron* and *E. lutae* emerging from *S. phillyreae* larvae and pupae.

Table 2 : Natural enemies recorded on sucking pests of pomegranate

Sl. No.	Natural enemy	Family and order	Host insects/prey	References
1.	*Cryptolaemus montrouzieri* Muls.	Coccinellidae : Coleopteran	*Ferriesia virgata* (Cockrell)	Karuppuchamy (1994)
			Siphoninus philyreael (Haliday)	Mani and Krishnamoorthy (1999)
			Planococcus lillacinus (Cockrell)	Mani and Krishnamoorthy (1990)
2.	*Chrysoperla carnea* Stephens	Chrysopidae : Neuroptera	*Aphis punicae* (Passerini)	Karuppuchamy (1994)
3.	*Scymnus coccivora* Ayyar	Coccinellidae : Coleoptera	*Ferrisia virgarta* (Cockrell)	Karuppuchamy (1994)
4.	*Scymnus castaneus* Sic.,	Coccinellidae : Coleoptera	*Aphis punicae* (Passerini)	Mani and Krishnamoorthy (1995)
5.	*Scymnus latemaculata* Motsch	Coccinellidae : Coleoptera	*Aphis punicae* (Passerini)	Mani and Krishnamoorthy (1995)
6.	*Menochilus sexmaculata* F.	Coccinellidae : Coleoptera	*Aphis punicae* (Passerini)	Mani and Krishnamoorthy (1995)
7.	*Paragus serratus* (F.)	Syrphidae : Diptera	*Aphis punicae* (Passerini)	Mani and Krishnamoorthy (1995)
8.	*Encarsia inaron* Walker	Aphelinidae : Hymenoptera	*Siphoninus phillyreae* (Haliday)	Mani and Krishnamoorthy (1995)
9.	*Encarsia azmi* Hayat	Aptielinidae : Hymenoptera	*Siphoninus phillyreae* (Haliday)	Mani and Krishnamoorthy (1999)
10.	*Cheilomenus sexmaculata* (Fab.)	Coccinellidae : Coleoptera	*Siphoninus phillyerae* (Haliday)	Mani and Krishnamoorthy (1999)
11.	*Triommata coccidivora* (Felt)	Cecidomyiidae : Diptera	*Planococcus lilacinus* (Cockrell)	Mani and Krishnamoorthy (1990)
12.	*Spalgis epius* Westwood	Lycaenidae : Lepidoptera	*Planococcus lilacinus* (Cockrell)	Mani and Krishnamoorthy (1990)
13.	*Cacoxenus perspicaux* (Knab)	Drosophilidae : Diptera	*Planococcus lilacinus* (Cockrell)	Mani and Krishnamoorthy (1990)
14.	*Leptomastirx dacylopii* How.	Encyrtidae : Hymenoptera	*Planococcus citri* (Risso)	Mani and Krishnamoorthy (1990)

2.2.3 On mealy bug

Mani and Krishnamoorthy (1990) recorded two Dipteran parasitoids *viz*., *Triommata coccidivora* (Felt.), *Cacoxenus perspicaux* (Knab), two coleopteran predators *viz*., *C. montrouzieri, S. coccivora* and one lepidopteran predators belonging to Lycaenidae *viz*., *Spalgis eupius* Westwood on *P. lilacinus* and one encyrtid parasitoid, *Leptomastix dacylopii* How on *P. citri* in Bangalore.

2.3 Seasonal incidence of major sucking pests of pomegranate and their relation with weather parameters

2.3.1 Aphid

The maximum incidence of aphid, *A. puncae* was observed on pomegranate during the third week of February and March respectively in hilly areas of Yeriand and plains of Namakkal in Tamil Nadu (Karuppuchamy *et al*., 1998).

The mealy bugs (*Ferrisia* spp.), scale insect (*P. nigra*) and whitefly (*S. phillyseae*) were more abundant during March-June, showing a significant positive correlation with temperature and negative correlation with relative humidity. Thrips and aphids were most predominant during July-October and November – February, respectively in Maharashtra (Anonymous, 1989).

Biradar and Shaila (2004) reported that, in recent years that pomegranate aphid, *A. punicae* has assumed a serious form and noticed occurring regularly through out the year with more abundance in winter.

The pomegranate aphid, *A. punicae* was considered as a serious pest that invaded pomegranate orchards in the spring season in most years and sometimes at the beginning of the summer in Eastern Turkey (Bayhan *et al*., 2005).

2.3.2 Thrips

According to Everly (1960), heavy rains reduced the population of thrips while, hot and dry conditions with temperature above 37.8°C favoured the multiplication of thrips. The peak infestation of grape vine thrips was noticed during May-June in South India and March-April and August to October in Haryana and Punjab (Butani, 1974).

Bagle (1993) studied the seasonal incidence of thrips, *S. dorsalis* on pomegranate var. Ganesh under semi arid regions of Panchamahals in Gujarat. Population was abundant during June to August. Prolonged dry spell after rains was favourable for increase in population of thrips. The relationship of thrips population with weekly minimum, maximum temperature and relative humidity was positive and the correlation coefficient values of 0.65, 0.52 and 0.41, respectively.

2.3.3 Whitefly

Pomegranate whitefly, *S. phillyreae*, which was considered as a minor pest has become a major pest and appeared in severe form on pomegranate in Bijapur and Bagalkot districts, during February to April 1999 (Balikai *et al*., 1999).

Ash whitefly population was very high (40.4 to 70.3 per leaf) during February to May and very low (0.00 to 18.7 per leaf) from June to December when field studies were conducted in peninsular India from April 1997 to 1999 (Mani and Krishnamoorthy, 2002).

2.3.4 Mealy bug

Mealy bug infestation was more pronounced in summer months and less in winter months (Mani and Krishnamoorthy, 1990).

Mani and Krishnamoorthy (2000) reported that there was no significant relationship between temperature, humidity, rainfall and the mealy bug incidence. But the population of *P. lilacinus* had positive and significant correlation with the population of parasitoid *T. indica* ($r = 0.87$).

2.3.5 Mites

Karuppuchamy (1994) reported that, initial incidence of false spider mite, *T. granati* was noticed during second fortnight of July and reached its peak during the second fortnight of August (762 mites/10 leaves) and then gradually declined during September. Maximum edge rolling symptom caused by eriophyid mites was observed during second fortnight of April (18.18%) to the first fortnight of August (26.14%) in hill areas and from first fortnight of February (41.53%) to the first fortnight of June (31.02%) in plains.

2.4 Management practices for major sucking pests of pomegranate

2.4.1 Aphids

Ismail *et al.* (1985) reported pirimicarb (0.3 g/l), dimethoate (0.5 ml/l) and malathion (1.25 ml/l) as effective insecticides against aphids and opined that a second application at 20 days after the first fortnight be necessary.

Mote *et al.* (1993) reported that dimethoate (0.03%) and methyl demeton (0.03%) caused over 90 per cent mortality of pomegranate aphids.

Karuppuchamy *et al.* (1998) found the sprays of phosalone, endosulfan at 0.07%, neem oil 3%, fish oil rosin soap 2.5% to be highly effective by causing cent per cent mortality of aphids at three days after insecticide treatment on pomegranate.

According to Verghese (2000), various neem extracts and *Pongamia pinnata* oil did not have sufficient potential to achieve rapid knockdown effect on *A. punicae* on pomegranate and were significantly inferior to phosphamidon.

Imidacloprid and thiomethoxam both belonging to nitro guanidine group of insecticides used @ 25 g a.i./ha proved significantly superior in controlling aphids and jassids on okra. Dimethoate @ 300 g a.i./ha and cypermethrin @ 100 g a.i./ha followed the above two treatments in their efficacy. (Misra, 2002).

Imidacloprid (0.5 ml/l) and dimethoate (1.7 ml/l) were found to be highly effective and consistent in reducing aphid population over 50 per cent at 15 days after treatment. Maximum yield of 44.63 and 38.25 t/ha of pomegranate fruits was obtained in imidacloprid and dimethoate treatments, respectively (Birdar and Shaila, 2004).

2.4.2 Thrips

Spraying dimethoate (0.025%), methyl demeton (0.025%), phosphamidon (0.025%) or carbaryl (0.1%) twice at an interval of 10 days was found to be effective (Butani, 1974). Spraying of carbaryl (0.15%) at full bloom stage gave effective control of *R. cruentatus* on grapevine (Batra *et al*., 1980).

Bagle (1993) noticed that monocrotophos (0.5%), dimethoate (0.05%), phosphamidon (0.05%) to be effective and consistent in their efficacy against thrips for a period of 15 days. Rathod *et al.* (2003) reported that, imidacloprid 70 WS @ 5 g/kg seed treatment recorded significantly least number of thrips population on cotton.

Rameshbabu and Santharam (2000) reported that, imidacloprid 200 SL at 100 ml per ha, effective in checking the population of both thrips and aphids on groundnut.

2.4.3 Whitefly

The whiteflies could be controlled by spraying phosphamidon at 0.03 per cent (Muralikrishna, 1999). Two sprays of hostathion 40 EC (Triazophos 40 EC) @ 1.5 ml/l of water at 10 days interval gave good control of pomegranate whitefly *S. phillyreae* (Balikai *et al*., 1999).

Kambrekar (2000) reported that dimethoate + fish oil rosin soap (FORS) gave 80 per cent pupal and 65 per cent nymphal mortality at 15 days after treatment on guava spiraling whiteflies.

Mangoud (2002) reported that, the spray of oil (Masrona) showed 91.0 per cent average mortality of eggs, 51.3 per cent against nymphs and 18.4 per cent against adult white flies in pomegranate fields of Upper Egypt.

Thimmaiah (2002) reported that, combination of dimethoate (0.05%) and fish oil insecticidal soap (1%) was highly effective against all the stages of whiteflies recording 90 per cent nymphal, 80 per cent pupal and 95 per cent adult mortality of whiteflies in guava field.

2.4.4 Mealy bug

Phosphamidon (0.03%), monocrotophos (0.1%), malathion (0.04%) and dimethoate (0.03%) gave effective control of *F. virgata* (Butani, 1976).

The beetles, *C. montrouzieri* Muls. when released at the rate of 10 to 15 adults per guava plant afforded an excellent control of *F. virgata* within 50 days of release (Mani *et al*., 1990).

Studies by Ghule and Dhumal (1992) showed that spraying of acephate, methyl demeton, monocrotophos, quinalphos, dimethoate and phosphamidon at 0.08 per cent were able to keep the population of mealy bug *D. manigiferae* under check.

The mealy bugs, *Planococcus* sp., *Pseudococcus* sp, *F. virgata, M. hirsutus* and *N. viridis* on coffee, citrus, guava, grapes and other horticultural and plantation crops could be suppressed by release of 10 to 50 coccinellid beetles of *C. montrouzieri* per infested tree or per plant or 600 to 3000 beetle per hectare depending upon the degree of infestation and crop canopy (Singh, 1993).

Kulkarni *et al.* (2003) noticed that all the concentrations of 2, 3, 4, 5 and 6 g *Verticillium lecanii* per litre of water tested against mealy bugs (*P. citri, F. virgata* and *N. viridis*) on pomegranate. On the basis of effectiveness, economics and persistency, *Verticillium lecani* at 4 g/l of water was found to be the optimum for the management of mealy bugs on pomegranate in Rahuri, Maharashtra. In another study spraying of dimethoate 0.03, methyl demeton 0.025, and phosphamidon 0.1 per cent proved superior over all other treatments in controlling the aphids, thrips, mealy bugs and scale insects (Karuppuchamy, 1994).

Regupathy *et al.* (1997) reported that marking the mealy bug infested trees early in the season and release of *C. montrouzieri* @ 10 per tree and thrice per annum on citrus was effective to achieve the control citrus mealy bugs.

3. MATERIAL AND METHODS

Though pomegranate is gaining importance as one of the highly remunerative fruit crops in South India, it lacks the attention of researchers, particularly with respect to detailed work from entomological point of view. Present experiments were conducted to know the different sucking insect pests on pomegranate and their natural enemies. Studies were also made to collect the data on the seasonal incidence of major sucking pests of pomegranate and to device the eco-friendly management practices for major sucking insect pests of pomegranate.

Studies were conducted during 2006-07 at Kaladagi, 15 km away from Bagalkot in Karnataka located at longitude of 76°E and latitude of 16°N at an altitude of 526.9 meters from mean sea level. The details are described under following headings.

3.1 Sucking insect pests of pomegranate

Roving survey was made at fortnightly intervals to collect, identify and keep record of the different sucking insect pests and their natural enemies of pomegranate from July '06 to June '07 in and around Bagalkot. In each village five pomegranate gardens of above five years old were selected and visited at fortnightly interval. Fifty plants were selected randomly in each pomegranate orchard for recording observations throughout the study period. The insects so noticed were properly collected and brought to the laboratory to confirm their feeding and to know their correct identity. The insects were got identified by comparing the specimens maintained in the Department of Entomology, UAS, Dharwad.

3.2 Natural enemies of pomegranate sucking pests

During the survey, emphasis was also given to explore the natural enemies' complex in the pomegranate ecosystem. The particular study was carried out during the period from July '06 to June '07. The Natural enemies so noticed were properly collected and brought to the laboratory to confirm their preys or hosts and to know their correct identify. The natural enemies were got identified by PDBC, Bangalore.

3.3 Seasonal incidence of sucking pests of pomegranate and their relation with weather parameters

To know the seasonal incidence of the sucking pests, *viz*., aphids, thrips, whiteflies, mealy bugs and mites, a fixed plot survey was conducted on pomegranate variety Arakta and Sindhnur. The area of pomegranate cultivation considered for fixed plot survey composed of five villages namely Kaladagi, Ankalgi, Chikkasamsi, Govinakoppa and Udagatti. The incidence of sucking pests was recorded at fortnightly intervals on ten randomly selected pomegranate plants from each field. A proforma (Appendix 2) was developed and used to record the incidence of sucking pests encountered during the survey.

Weather parameters like maximum and minimum temperature, morning and evening relative humidity, total rainfall and number of rainy days were recorded from Agricultural Research Station, Bagalkot. The correlations between weather parameters and mean population of sucking pests *viz.,* aphids, thrips, whiteflies, mealy bugs and mites were worked out to know the nature and extent of associations that existed between them.

The sampling methodologies followed for different sucking pests are detailed below.

3.3.1 Aphids

Number of nymphs and adult aphids was counted from three terminals (each of 2.5 cm shoot length) in ten randomly selected plants in a garden. The average number of aphids per shoot was worked out.

3.3.2 Thrips

Observations on the population counts of thrips was recorded by counting number of nymphs and adults from five new shoots per plant, by shaking the shoots on hard card board pasted with black paper to facilitate easy visibility. The average number of thrips per new shoots was worked out.

3.3.3 White flies

The number of whiteflies was counted on three new shoots selecting one shoot each from top, middle and bottom portion of plant of five cm length per tree .Then the average number of whiteflies per 5 cm length shoot was calculated.

3.3.4 Mealy bugs

The sampling for mealy bugs was done on ten randomly selected infested pomegranate plants. From each plant, four shoots of 30 cm length were considered and counts were taken on the number of active and healthy looking nymphs and adults.

3.3.5 Mites

Observations on population counts of mites was recorded by seeing under microscope and counting number of healthy, moving nymphs and adults present in 2.5 cm^2 leaf.

3.4 Management practices for major sucking pests of pomegranate

The experiments to device eco-friendly management practices for major sucking pests were carried out during 2006-07 in pomegranate gardens of Fruit Growers Association Kaladagi, Bagalkot (16° North, 76° East, and 526.9 m above mean sea level) laid out in randomized block design with three replications and 13 treatments on six year old pomegranate trees of Arakta cultivar. Twelve treatments were imposed during new vegetative growth period (January-February 2007) of the crop. The details of different treatments tried for the management of major sucking pests of pomegranate and their dosages are presented in Table 3.

All the treatments, except release of *C. montrouzieri* were applied using knap sack high volume sprayer during morning hours. The grubs of *C. montrouzieri* were released by hand at the site of infestation of sucking pests on pomegranate trees.

Table: 3. Different treatments involving the eco-friendly management practices tested against major sucking pests of pomegranate

Sl. No.	Treatments	Dosage
1.	Thiamethoxam 25 WG	0.20 g/l
2.	Imidacloprid 200 SL	0.25 ml/l
3.	Dimethoate 30 EC	1.7 ml/l
4.	Dichlorvos 76 WSC	2 ml/l
5.	NSKE 5%	50 ml/l
6.	Fish oil rosin soap (FORS)	20 g/l
7.	Honge oil 2%	20 ml/l
8.	Nimbecidine 300 ppm	5 ml/l
9.	*Verticillium lecanii* 1 x 10^8 conidia/g	2 g/l
10.	Dichlorvas 76 WSC + Fish oil rosin soap	2 ml + 20 g/l
11.	Dimethoate 30 EC + Fish oil rosin soap	1.7 ml + 20 g/l
12.	Release of *Cryptolaemus montrouzieri* in the site of infestation of sucking pest	10 grubs/tree
13.	Untreated control	-

4. EXPERIMENTAL RESULTS

The results obtained from the experiments conducted to record the sucking insect pests of pomegranate, their natural enemies, seasonal incidence of major sucking pests *viz.,* aphids, thrips, whiteflies, mealy bugs, mites and their correlations to weather factors and to device the ecofriendly management practices for major sucking pests of pomegranate, are presented here under.

4.1 Sucking insect pests of pomegranate

An extensive roving survey was undertaken at fortnightly interval during *Ambe bahar* cropping season of pomegranate from July 06 to June 07 at Bagalkot, Karnataka. The study revealed 11 sucking pests feeding on pomegranate, out of which seven belonged to Homoptera, one to Hemiptera, three to Thysanoptera and two were mites (Table 4).Two sucking pest are placed on record for first time on pomegranate from India and three from the point of karnataka.

4.1.1 Pomegranate aphid, *Aphis punicae* Passerini (Homoptera : Aphididae)

A. punicae was noticed on pomegranate. Both nymphs and adults of which sucked sap from the tender shoots, leaves, flower and fruits of pomegranate plant (Plate 2).The infestation resulted in yellowing of leaves and sticky to touch.

4.1.2 Ash Whitefly, *Siphoninus phillyreae* (Haliday), Spiraling whitefly, *Aleurodicus disperses* Russell (Homoptera : Aleyrodidae)

The ash whitefly is smaller in size compared to spiraling whitefly. The female of spiraling whitefly laid eggs in a spiral manner on lower surface of leaves. The adults and nymphs of both species sucked the sap from the leaves and caused yellowing. Sooty mould development was also seen on the honeydew secreted by both the species of whiteflies the upper surface of on leaves (Plate 3).

4.1.3 Mealybug *Planococcus lillacinus* (Cockrell) (Homoptera : Pseudococcidae)

Both nymphs and adults of the mealy bugs caused considerable damage to the pomegranate by sucking the sap from the leaves, flowers and fruits, which resulted in yellowing of leaves and shedding of flowers and tender fruits (Plate 3). The market value of such fruits reduced considerably.

4.1.4 *Eurybrachys* sp. (Homoptera : Eurybrachidae)

The Eurybrachids were noticed on pomegranate both nymphs and adult sucked the sap on the tender pomegranate flowers and fruits (plate 4).

4.1.5 Pentatomid bug, *Nezara virudula* L. (Hemiptera : Pentatomidae)

During the present study, a pentatomid green bug *N. virudula* was observed to feed on leaves and pomegranate fruits (Plate 4). Both nymphs and adults sucked the sap from all the stages of fruits and caused discoloured spots on the rind.

4.1.6 Scale insects, *Parasaissetia nigra* (Neitn) (Coccidae : Homoptera) *Icerya purchasi* Maskell (Margorodidae : Homoptera)

Scale insects were observed on stem, flowers and fruits. In the case of heavy infestation, black sooty mould formation was noticed. The infestation attracted large number of ants (Plate 4).

4.1.7 Thrips, *Scirtothrips dorsalis* Hood, *Rhipiphorothrips cruentatus* Hood *Anaptothrips oligochaetus* Kerny (Thysanoptera : Thripidae)

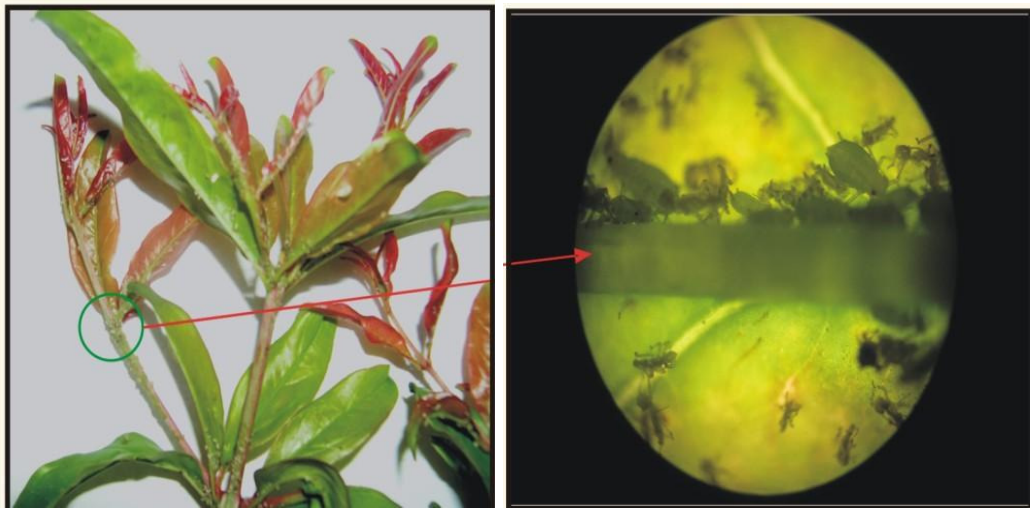
Nymphs and adults (Plate 4) of all the species were seen on the under surface of the leaves, on fruits and flowers. The lacerating and sucking by thrips resulted in shrivelling of leaves and fruits. Scarring of rind was also observed on fruits due to desapping (Plate 3), resulting in decreased marketability of fruits.

Table 4: Sucking pests noticed on pomegranate in Bagalkot district, Karnataka, during 2006-07

Sl. No.	Common name and scientific name	Family and order	Plant part affected	Peak activity	Remarks
1.	Pomegranate aphid, *Aphis punicae* Passerini	Aphididae : Homoptera	Terminal shoots	Dec to Jan.	AR
2.	Thrips, *Rhipiphorothrips cruentatus* Hood	Thripidae : Thysanoptera	Leaves	March to April	AR
3.	Thrips,*Scirtothrips dorsalis* Hood	Thripidae : Thysanoptera	Fruits and flowers	March to April	AR
4.	Thrips, *Anaphothrips oligochaetus* Kerny	Thripidae : Thysanoptera	Shoots	March to April	AR
5.	Mealybug, *Planococcus lilacinus* (Cockrell)	Psudococcidiae : Homoptera	Fruit and fruit stalk	March to April	AR
6.	Pomegranate whitefly, *Siphoninus phillyreae* Haliday	Aleyrodidae : Homoptera	Leaves	Feb to March	AR
7.	Spiralling whitefly, *Aleurodicus disperses* Russell	Aleyrodidae : Homoptera	Leaves	Feb to March	AR
8.	Pentatomid bug, *Nezara virudula* L.	Pentatomidae : Hemiptera	Leaves and fruits	Oct to Nov.	AR
9.	Eurybrachid bug, *Eurybrachys* sp.	Eurybrachidae : Homoptera	Fruits and flowers	Nov to Dec.	NR**
10.	Scale insect, *Parasiassetia nigra* (Neitn.)	Coccidae : Homoptera	Shoots	March to April	NR*
11.	Scale insect, *Icerya purchasi* Maskell	Margorodidae : Homoptera	Shoots	March to April	NR**
	Non insect pests				
1	Eriopid mite, *Aceria granati* Canestrini	Eriophyidae : Acari	Leaves	March to April	AR
2	False spider mite, *Tenuipalpus granati* Sayed	Tenuipalpidae : Acari	leaves, flower, fruits	March to April	NR*

AR = Already reported on POMEGRANATE
NR* = New report from Karnataka on pomegranate
NR** = New report from India on pomegranate

Plate 1: View of experimental plot



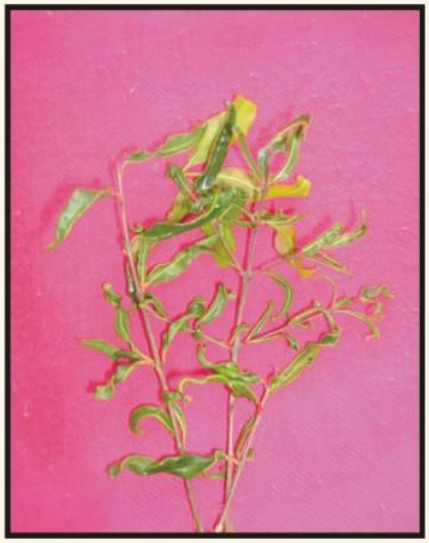
Aphids on new shoots

Plate : 2 Aphids on shoots and fruits

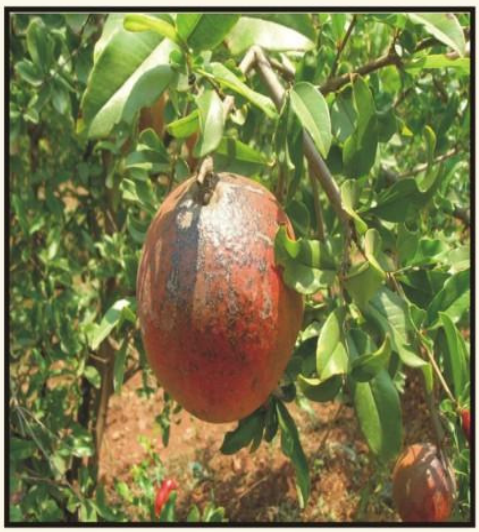
Whiteflies on leaves

Sooty mould developed on leaves

Mealy bug infestation on pomegranate



Edge rolling of leaves caused by Eryophid mites



Damage caused by Thrips on fruits

Plate :3 Damage symptoms caused by sucking pests

4.1.8 Mites, False spider mite, *Tenuipalpus granti* Sayed, (Tenuipalpidae : Acarina), Eriophyid mite, *Aceria granati* Can.and Massal (Tetranychidae : Acarina)

The edge rolling of leaves (Plate 3) was caused by eriophyid mites and recorded in all five locations and false spider mites were seen on leaves, flowers and fruits.

4.2 Natural enemies of sucking pests

The natural enemies encountered in the pomegranate ecosystem during roving survey along with their preys are presented in Table 5.

4.2.1 Natural enemies of aphids

Grubs of *Chrysoperla carnea* Stephens were noticed to feed on both nymphs and adults of *A. punicae* from December 06 to March 07 in all the five locations. The population of grubs of *C. carnea* ranged from two to ten and that of adults from one to seven per three terminal shoots. Maximum of nine grubs were recorded during February 07, the other natural enemies of *A. punicae* were *S. coccivora, C. Sexmaculata* and *C. septumpunctata*. (plate 5).

4.2.2 Natural enemies of whiteflies

Grubs of *C. carnea* predated over eggs and nymph of whiteflies. An Aphelinid parasitoid, *Encarsia* sp. was recorded on whitefly during February 07.

4.2.3 Natural enemies of mealy bugs

Grubs and adults of *C. montrouzieri* and *S. coccivora* were found predating on eggs, larva and adults of pomegranate mealy bugs. Activity of predators gradually increased from April to June and then declined from July onwards.

Apart from above listed natural enemies three species of praying mantids were also observed and founding the pomegranate ecosystem,the specific feeding habits were not ascertained. (Table 6)

4.3 Seasonal incidence of major sucking pests of pomegranate and their relation to weather parameters

4.3.1 Seasonal incidence of Pomegranate Aphid,

The population of aphid recorded at five location over the season is given table 6. The heavy incidence of aphids was observed in all the five locations during second fortnight of December 07 and reached the maximum of 19.82 per 2.5 cm terminal shoot length during first fortnight of January and then declined during April (2.60 aphids/2.5 cm length shoot).

The correlation studies made between incidence of aphids and weather parameters (Table 7) revealed that, morning relative humidity (r= 0.41615) showed positive and significant relationship, where as evening relative humidity (r=-0.5998), rain fall (r=-0.4294), number of rainy days (r=-0.5488) showed negative and significant relationship with incidence of aphids.

Though all the regression factors listed in table 7 were found to exert significant influence (except mean maximum temperature) collectively on the incidence of aphid, their influence differed significantly when considered individually. Among the various abiotic factors, mean minimum temperature, evening relative humidity and number of rainy days influenced aphid population to the extent of 67, 32 and 30 per cent, respectively.

4.3.2 Seasonal incidence of Pomegranate Thrips

The incidence of thrips was more during the February 07 and gradually reached the maximum of 9.14 thrips on five new shoots per plant during second fortnight of March 07. From May onwards there was decline in thrips population in all the five locations (Table 8).

Table 5: Natural enemies of sucking pests of pomegranate encountered during the study

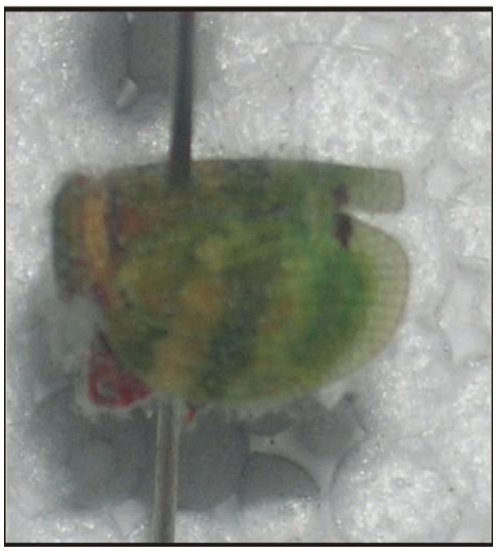
Sl. No.	Natural enemy	Family and order	Host/prey
1.	*Cryptolaemus montrouzieri* Mulsant	Coccinellidae : Coleoptera	Mealy bugs
2.	*Scymnus coccivora* Ayyar	Coccinellidae : Coleoptera	Aphids, mealy bugs
3.	*Cheilomenus sexmaculata* Fabricus	Coccinellidae : Coleoptera	Aphids
4.	*Hippodomia variegate* (Goeze)	Coccinellidae : Coleoptera	Soft bodied insects
5.	*Coccinella septumpunctata* (Linnaeus)	Coccinellidae : Coleoptera	Aphids
6.	*Chrysoperla carnea* Stephens	Chrysopidae : Neuroptera	Aphids, whiteflies, mealy bugs
7.	*Statilia* sp.	Mantidae : Mantodea	General predator
8.	*Amorphoscelis* sp.	Amorphoscelidae : Mantodea	General predator
9.	*Phyllothelys* sp.	Mantidae : Mantodea	General predator
10.	*Encarsia* sp.	Aphelenidae : Hymenoptera	Whitefly

Thrips, scirtothrips dorsalis

False spider mite Tenuiplapus granati

Icerya purchasi

Nezara virudula



Eurydrachis sp.

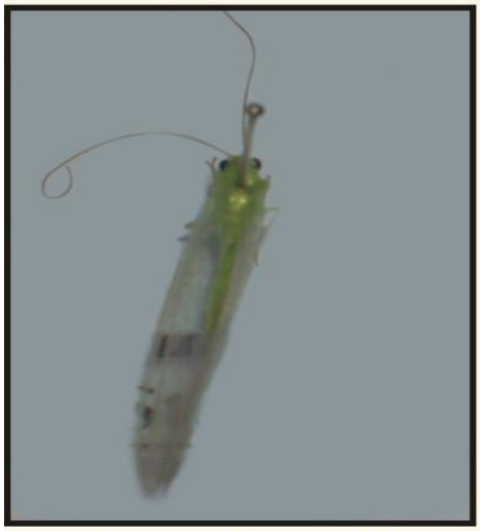
Plate 4. Sucking pests of pomegranate

Cryptolaemous montrouzieri

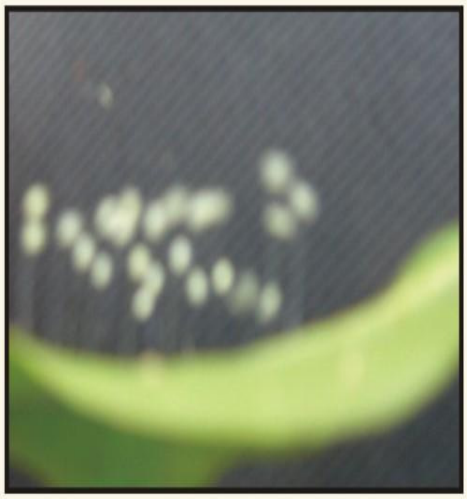
Cheilomenus sexmaculatus

Coccinella septumpunctata

Cheilomenus sexmaculatus



Chrysoperla carnea



Eggs of chrysoperla carnea

Plate : 5 Natural enemies of sucking pests

Table: 6 Seasonal incidence of pomegranate aphids in Bagalkot district during 2006-07

Months		*Average no of aphids/2.5 cm shoot					average
		Kaladagi	Ankalgi	Govinakoppa	Udagatti	Chikkasamsi	
July	I FN	2.5	1.4	2.6	1.3	1.9	1.94
	II FN	0.9	0.8	0.7	1.4	0.3	0.82
August	I FN	1.1	0.0	1.5	0.0	1.1	0.74
	II FN	0.3	0.7	0.7	0.7	0.3	0.54
September	I FN	0.2	3.8	2.7	0.7	0.9	1.66
	II FN	1.4	0.9	0.7	5.2	3.9	2.42
October	I FN	3.2	3.4	3.2	3.8	3.9	3.50
	II FN	4.1	4.1	2.6	4.7	3.5	3.80
November	I FN	4.4	3.2	1.6	4.2	6.2	3.92
	II FN	8.2	6.7	4.8	10	9.1	7.76
December	I FN	7.2	6.9	3.8	7.6	3.4	5.78
	II FN	25.0	12.0	4.4	9.0	3.0	16.68
January	I FN	23.0	16.0	17.0	12.1	3.0	19.82
	II FN	17.3	18.7	10.2	13.3	21.9	16.28
February	I FN	12.2	9.9	10.6	11.4	13.8	11.58
	II FN	14.7	10.7	14.7	7.9	4.6	10.52
March	I FN	8.9	12.0	14.1	5.8	7.2	9.60
	II FN	5.3	7.4	6.9	6.2	8.4	6.84
April	I FN	3.8	2.3	3.0	1.2	2.7	2.60
	II FN	2.6	2.3	2.1	3.0	2.0	2.40
May	I FN	4.0	2.8	1.4	1.8	1.9	2.38
	II FN	2.2	1.4	1.8	1.9	2.6	1.98
June	I FN	1.8	1.6	1.1	0.9	1.5	1.38
	II FN	0.9	1.0	0.6	1.1	0.6	0.84

* - Average number of aphids on ten plants

Table: 7 Relationship between the population of pomegranate aphids and weather parameters during 2006-07

Sl. No.	Weather parameters	r	Regression equation	R^2
1.	Maximum temperature (^{0}C)	-0.12436	y = -171.83 × + 2587.4	0.0155
2.	Minimum temperature (^{0}C)	-0.12436	y = -0.6078** × + 24.514	0.6773
3.	Morning relative humidity (%)	-0.41615*	y = 0.5994* × + 69.543	0.1732
4.	Evening relative humidity (%)	-0.56982**	y = -1.0602** × + 63.34	0.3247
5.	Rainfall (mm)	-0.42945*	y = -2.374* × + 32.937	0.1844
6.	Number of rainy days	-0.54884**	y = -0.1932** × + 2.635	0.3012

* - Significant at 5%
** - Significant at 1%

The simple correlation studies revealed that the morning relative humidity had positive and significant (r=0.5065) relationship with incidence of thrips while evening relative humidity (r=-0.4905) had significant and negative relationship, maximum temperature (r=-0.01578), rainfall (r=-0.3266), and number of rainy days (r=-0.3465) had negative and non-significant relationship with population of thrips. (Table 9)

Among all the regression factors listed in Table 9, only morning and evening relative humidity influenced significantly to the tune of 25 and 24 per cent, respectively on incidence of thrips but the influence of other factors was found to be non-significant.

4.3.3 Seasonal incidence of Pomegranate whiteflies

The incidence of both species of whiteflies on pomegranate was maximum during second fortnight of February 07, and first fortnight of March 07 with an average of 14.40 and 13.38 per three new shoots, respectively (Table 10).

The correlation studies made between incidence of whiteflies and weather parameters (Table 11) revealed significant and positive relationship of whiteflies population with morning relative humidity (r=0.5811), evening relative humidity, (r=0.72545), rainfall (r=0.4136) and number of rainy days (r=0.4699) but the relationship of whiteflies with maximum temperature (r=0.1257) and minimum temperature (r=0.0798) was non-significant.

Except maximum and minimum temperature, all the regression factors listed in the Table 11 were found to exert significant influence collectively over the incidence of whiteflies. Their influence differed significantly when considered individually. Among the various abiotic factors evening and morning relative humidities, influenced to the extent of 52 and 33 per cent, respectively.

4.3.4 Seasonal incidence of Pomegranate mealy bugs

The incidence of mealy bugs was more from March 07 onwards and gradually reached to a peak with 11.33 per 30 cm shoot per plant during second fortnight of April, 07. From June onwards there was gradual decline in mealy bugs population in all five locations (Table 12).

The results of simple correlation studies made between incidence of mealy bugs and weather parameters (Table 13) revealed that morning relative humidity recorded significant and positive (r=0.5956) relationship, while evening relative humidity recorded negative and significant relationship (r=-0.57499) with incidence of mealy bugs. Both maximum and minimum temperatures had positive and non-significant (r=0.3750, r=0.1872), relationship with mealy bugs, but rainfall and number of rainy days had negative and non-significant relationship.

Among all regression factors listed in Table 13, only morning and evening relative humidities were found to exert significant influence on incidence of mealy bug, their influence differed significantly when considered individually. Among the aboitc factors morning and evening relative humidities influenced to the tune of 35 and 33 per cent, respectively.

4.3.5 Seasonal incidence of Pomegranate mites

Incidence of mites gradually increased from January 07 onwards and reached to a maximum of 13.12 mites per cm^2 leaf area during first fortnight of March 07 and then decreased gradually from second fortnight onwards (Table 14).

The simple correlation studies made between incidence of mites and weather parameters (Table 15) revealed that, morning relative humidity had positive and significant relationship (r=0.60293), while evening relative humidity (r=-0.7339), rainfall (r=-0.4473), number of rainy days (r=-0.4589) showed negative and significant relationship with the population of mites.

Except maximum and minimum temperatures, all the regression factors listed in Table 15 was found to exert significant influence collectively over the incidence of mites. But their influence differed significantly when considered individually. Among the various abiotic factors, evening relative humidity, morning relative humidity and number of rainy days and rainfall influenced to the tune of 53, 36, 23 and 20 per cent, respectively.

Table: 8 Seasonal incidence of pomegranate thrips in Bagalkot district during 2006-07

Months		*Average no of thrips on 5 new shoots/plant					average
		Kaladagi	Ankalgi	Govinakoppa	Udagatti	Chikkasamsi	
July	I FN	1.4	2.8	2.0	1.4	1.9	1.90
	II FN	0.9	2.0	1.4	1.0	0.5	1.16
August	I FN	0.4	0.0	0.3	0.6	0.7	0.40
	II FN	0.3	0.7	0.6	0.4	0.5	0.50
September	I FN	0.9	1.5	2.1	0.3	0.7	1.10
	II FN	0.4	0.5	0.3	0.5	1.1	0.56
October	I FN	1.5	0.9	0.8	0.5	1.0	0.94
	II FN	1.0	0.5	0.4	1.2	0.5	0.72
November	I FN	1.3	1.4	1.3	1.0	2.9	1.58
	II FN	0.7	0.6	0.5	0.7	1.9	0.88
December	I FN	0.6	2.4	2.5	1.4	1.5	1.68
	II FN	1.7	2.7	2.2	0.9	1.5	1.80
January	I FN	3.1	3.7	2.3	2.4	2.0	2.70
	II FN	1.7	1.0	1.9	2.1	1.8	1.70
February	I FN	1.3	2.5	3.8	1.2	1.4	2.04
	II FN	3.0	1.8	2.7	3.2	3.0	2.74
March	I FN	4.1	5.9	5.2	3.4	4.2	4.56
	II FN	9.8	9.5	5.2	9.2	12	9.14
April	I FN	11	4.8	5.2	6.3	2.8	6.02
	II FN	5.0	1.2	11.0	9.0	1.9	5.62
May	I FN	3.1	1.9	1.8	2.0	1.6	2.08
	II FN	1.7	1.1	1.5	1.9	1.2	1.48
June	I FN	1.5	1.2	1.4	1.3	1.7	1.42
	II FN	1.0	1.5	0.3	1.3	0.9	1.00

* - Average number of thrips on ten plants

Table: 9 Relationship between the population of pomegranate thrips and weather parameters during 2000-07

Sl. No.	Weather parameters	r	Regression equation	R^2
1.	Maximum temperature (^{0}C)	-0.01578	Y = -58.478 × +1746	0.0002
2.	Minimum temperature (^{0}C)	0.12688	Y = 0.2513 × 20.512	0.0161
3.	Morning relative humidity (%)	0.50654*	Y = 1.9566* × +68.555	0.2566
4.	Evening relative humidity (%)	-0.49055*	Y = -2.4476* × + 62.821	0.2406
5.	Rainfall (mm)	-0.32661	Y = -4.8418 × +30.342	0.1067
6.	Number of rainy days	-0.34650	Y = -0.3272 × 2.274	0.1201

* - Significant at 5%
** - Significant at 1%

Table: 10 Seasonal incidence of pomegranate whiteflies in Bagalkot district during 2006-07

Months		*Average no of whiteflies 3 new shoots/plant					average
		Kaladagi	Ankalgi	Govinakoppa	Udagatti	Chikkasamsi	
July	I FN	0.5	0.8	1.3	0.3	0.3	0.64
	II FN	0.5	0.3	0.9	0.0	0.0	0.34
August	I FN	0.4	0.0	0.4	0.4	0.2	0.28
	II FN	1.2	0.3	0.7	0.7	0.3	0.64
September	I FN	1.1	0	0.0	0.3	0.4	0.36
	II FN	0.7	0.8	0.5	0.2	0.0	0.44
October	I FN	0.3	0.9	0.8	0.4	0.7	0.62
	II FN	1.0	1.0	1.7	0.5	1.8	1.20
November	I FN	1.6	2.6	1.3	0.7	2.7	1.78
	II FN	2.0	3.4	3.0	1.8	2.0	2.44
December	I FN	4.6	3.1	2.6	2.2	2.2	2.94
	II FN	2.9	3.7	2.2	3.5	4.1	3.28
January	I FN	3.2	4.0	3.3	3.8	4.2	3.7
	II FN	4.3	3.4	4.6	5.1	5.3	4.54
February	I FN	4.8	7.8	6.0	6.3	5.0	5.98
	II FN	18.0	10.0	11.2	19.0	13.8	14.40
March	I FN	16.0	6.0	17.0	20.0	7.9	13.38
	II FN	13.3	9.5	13.0	12.0	13.0	12.16
April	I FN	9.6	8.0	12.0	13.0	11.3	10.78
	II FN	11.0	4.7	5.9	9.3	12.0	8.58
May	I FN	12.1	7.1	5.0	5.4	4.8	6.88
	II FN	5.4	3.4	3.2	4.6	4.3	4.18
June	I FN	2.1	2.1	1.3	2.4	1.0	1.78
	II FN	0.0	0.4	0.5	0.5	0.8	0.44

* - Average number of whiteflies on ten plants

Table: 11 Relationship between the population of pomegranate whiteflies and weather parameters during 2000-07

Sl. No.	Weather parameters	r	Regression equation	R^2
1.	Maximum temperature (^{0}C)	0.12571	Y = 17.58 × +692.57	0.0158
2.	Minimum temperature (^{0}C)	-0.07988	Y = -0.739 × +21.388	0.0064
3.	Morning relative humidity (%)	0.58118**	Y = 1.0486** × + 68.488	0.3378
4.	Evening relative humidity (%)	-0.72545**	Y = -1.6908** × + 64.511**	0.5263
5.	Rainfall (mm)	-0.41369*	Y = -2.8646* × +31.35	0.1711
6.	Number of rainy days	-0.46994*	Y = -0.2073* × + 24.20	0.2208

* - Significant at 5%
** - Significant at 1%

Table: 12 Seasonal incidence of pomegranate mealy bugs at Bagalkot district during 2006-07

Months		*Average no mealy bugs of 3 new shoots/plant					Average
		Kaladagi	Ankalgi	Govinakoppa	Udagatti	Chikkasamsi	
July	I FN	1.3	1.4	1.8	1.1	1.0	1.32
	II FN	0.7	0.9	1.6	0.5	0.4	0.82
August	I FN	0.2	0.6	0.3	1.3	1.6	0.8
	II FN	1.2	2.8	2.5	1.8	0.6	1.78
September	I FN	0.9	0.6	0.9	0.9	2.2	1.10
	II FN	1.7	0.6	0.7	1.6	1.4	1.20
October	I FN	2.5	2.3	2.6	1.6	2.2	2.24
	II FN	4.4	4.2	2.9	2.4	2.8	3.34
November	I FN	2.3	1.5	3.0	1.7	0.8	1.86
	II FN	2.6	2.1	2.6	4.1	4.1	3.10
December	I FN	3.6	3.6	4.2	4.2	5.4	4.20
	II FN	3.9	3.2	1.7	1.6	3.1	2.70
January	I FN	2.7	2.9	4.8	2.2	5.3	3.58
	II FN	4.8	3.9	3.2	4.4	2.3	3.72
February	I FN	3.2	3.1	6.3	2.7	3.2	3.70
	II FN	8.0	5.2	2.7	3.8	5.8	5.10
March	I FN	8.1	8.9	8.6	10.5	9.7	9.20
	II FN	11.2	10.5	8.6	12.6	9.6	10.54
April	I FN	10.2	8.6	10.2	11.3	10.6	10.20
	II FN	9.5	14.8	12.2	11.1	9.0	11.33
May	I FN	5.4	4.7	4.8	5.2	2.7	4.56
	II FN	5.0	2.7	8.6	6.5	5.3	5.62
June	I FN	2.5	2.9	2.0	3.8	0.8	2.40
	II FN	1.1	2.5	1.6	1.5	2.0	1.74

* - Average number of mealybugs on ten plants

Table: 13 Relationship between the population of pomegranate mealybugs and weather parameters during 2000-07

Sl. No.	Weather parameters	r	Regression equation	R^2
1.	Maximum temperature (^{0}C)	0.03750	Y = 91.317 × +1249.4	0.0014
2.	Minimum temperature (^{0}C)	0.18727	Y = 0.2437 × + 20.099**	0.0351
3.	Morning relative humidity (%)	0.59565**	Y = 1.512** × +66.88	0.3548
4.	Evening relative humidity (%)	-0.57499**	Y = -1.8854** × +64.892	0.3306
5.	Rainfall (mm)	-0.35133	Y = -3.4226 × 33.21	0.1234
6.	Number of rainy days	-0.36877	Y = -0.2288 × +2.4579	0.0136

* - Significant at 5%
** - Significant at 1%

Table: 14 Seasonal incidence of pomegranate mites at Bagalkot district during 2006-07

Months		*Average no of mites per 2.5 cm^2 leaf area					Average
		Kaladagi	Ankalgi	Govinakoppa	Udagatti	Chikkasamsi	
July	I FN	1.82	1.20	0.91	0.82	1.33	1.22
	II FN	0.60	0.98	0.68	1.23	0.73	0.84
August	I FN	2.50	2.60	3.10	3.50	2.60	2.86
	II FN	0.35	1.20	1.30	0.20	1.30	0.87
September	I FN	0.30	0.50	0.30	0.25	0.52	0.37
	II FN	1.60	2.60	3.50	4.30	3.70	3.14
October	I FN	0.90	0.60	0.70	0.60	0.47	0.65
	II FN	3.50	2.60	3.70	5.70	2.80	3.66
November	I FN	5.40	4.30	5.10	3.20	1.60	3.92
	II FN	5.40	5.30	3.60	2.40	6.80	4.70
December	I FN	4.80	5.20	4.30	4.60	5.20	4.82
	II FN	3.50	2.60	3.80	4.50	3.80	3.64
January	I FN	5.40	6.50	6.51	5.80	7.10	6.26
	II FN	7.20	9.70	10.51	13.75	7.60	9.75
February	I FN	11.20	12.50	13.21	15.00	11.00	12.58
	II FN	8.60	8.60	10.50	12.50	11.20	10.28
March	I FN	13.80	11.30	11.20	8.60	7.80	10.54
	II FN	15.40	12.30	11.20	13.20	13.50	13.12
April	I FN	14.20	11.30	12.30	10.30	9.50	11.52
	II FN	10.30	12.30	10.20	8.60	9.30	10.14
May	I FN	7.60	6.80	7.60	7.80	8.90	7.74
	II FN	6.80	3.80	6.50	6.80	5.82	5.94
June	I FN	3.50	4.50	3.50	4.80	3.50	3.96
	II FN	3.50	2.50	3.50	2.10	3.60	3.04

* - Average number of mites on ten plants

Table: 15 Relationship between the population of pomegranate mites and weather parameters during 2000-07

Sl. No.	Weather parameters	R	Regression equation	R^2
1.	Maximum temperature (^{0}C)	0.10986	Y = 209.74 × +430.34	0.0121
2.	Minimum temperature (^{0}C)	-0.10414	Y = -0.1063 × +21.67	0.0108
3.	Morning relative humidity (%)	0.60293**	Y = 1.1999**× +66.57	0.3635
4.	Evening relative humidity (%)	-0.73394**	Y = -1.8868** × +68.0	0.5387
5.	Rainfall (mm)	-0.44735*	Y = -3.4169* × + 38.80	0.2001
6.	Number of rainy days	-0.45895*	Y = -0.2364* × +2.877	0.2361

* - Significant at 5%
** - Significant at 1%

4.3.6 Relationship between incidence of sucking pests with weather parameters at two weeks lead time

Correlation studies between average population of sucking pests and weather parameter at two weeks lead time showed that (Table 16), evening relative humidity and number of rainy days recorded significant and negative relationship with incidence of all the sucking insect pests and mites. Remaining weather parameters *viz.,* temperature and rainfall had negative relationship with the incidence of sucking pests.

4.4 Management practices for major sucking pests of pomegranate

The bioefficacy of selected insecticides, natural oils and their effectiveness against major sucking pests' *viz.,* aphids, thrips, mealy bugs and whiteflies was carried out in the pomegranate orchards at fruit Growers Association, Kaladagi and Bagalkot.

4.4.1 Management of aphids

Efficacy of different treatments *A. punicae* was analysed in comparison with untreated control and the data obtained are presented in table 17. There was no significant difference among treatments with respect to mean population of aphids at one day before imposing treatments.The aphid population ranged from 39.00 to 41.00 per 2.5 cm shoot length.

All the treatments differed significantly over untreated control in reducing the aphid incidence after one, three, seven and 14 day after treatment (DAT). Thiamethoxam and imidacloprid excelled over all other treatments and registered significantly highest per cent reduction of aphids at one, three, seven and 14 DAT and recorded an average of 85.90 and 83.54 per cent reduction of aphid population over untreated control respectively.

Dimethoate + fish oil rosin soap (FORS) and dimethoate alone emerged as next best treatments recording a mean reduction of 82.71 and 81.07 per cent, respectively. Among plant and animal products NSKE and FORS, respectively recorded 48.58 and 47.66 per cent reduction in population of aphids over untreated control.

4.4.2. Management of thrips

The population of thrips before spraying ranged from 15.33 to 17.67. There was no significant difference in mean population of thrips at one day before treatment (Table 18). The significant difference were observed in the per cent reduction of thrips population over un treated control at one, three, seven and 14 DAT. One day after treatment, thiamethoxam (76.05%), dimethoate (77.16%), dichlorvos (68.98%) and diamethoate + FORS (78.94), dichlorvos + FORS (67.60%) were at par with each other but imidacloprid (87.50%) gave significantly higher per cent decline of thrips. At three days after treatment imidacloprid, thiamethoxam, dimethoate, dimethoate + FORS recorded significantly higher per cent protection of thrips population of 86.94, 88.03, 83.43 and 84.82 per cent, respectively. Diclorvos was next best treatment. At seven days after treatment imidalcoprid and thiomethoxam recorded significantly higher per cent decline 93.47 and 88.03, respectively. Among plant and animal products NSKE and FORS recorded reduction aphids at 7 DAT 50.98 and 47.69 per cent, respectively.

At 14 DAT, Thiamethoxam, imidacloprid, dimethoate, dimethoate + FORS were at par with each other and recorded significantly higher per cent decline of thrips population.

4.4.3 Management of whiteflies

It is inferred from the data presented in Table 19 that there was no significant difference in population of whiteflies at one day before treatment which ranged from 21.00 to 22.67 per new shoot of 5 cm length.

Table: 16 Correlation coefficient between incidence of sucking pests and weather parameters at two weeks lead time

Pests	Temperature (^{0}C)		Relative humidity (%)		Rainfall (mm)	Number of rainy days
	Minimum	Maximum	Morning	Evening		
Aphids	-0.1395	-0.8461**	0.4264*	-0.5155**	-0.3847	-0.5068**
Thrips	-0.0768	-0.1466	0.5256**	-0.6796**	-0.3390	-0.4279*
Whiteflies	-0.0026	-0.3344	0.5778**	0.7856**	-0.4608*	-0.5435**
Mealybugs	-0.1082**	-0.8436**	0.6311**	-0.6815**	-0.3670	-0.4872*
Mites	-0.0154	-0.3855	0.6582**	-0.7376**	-0.4583*	-0.5570*

* - Significant at 5%
** - Significant at 1%

Table: 17 Efficacy of different treatments on pomegranate aphids

Tr. No.	Treatments	Dose	PTC	Per cent reduction of aphid population				Per cent reduction over untreated control
				1 DAT	3 DAT	7 DAT	14 DAT	
T_1	Thiamethoxam 25 WG	0.20 g/l	39.33	89.90a (71.50)	94.09a (75.95)	92.45a (74.12)	80.52a (63.79)	85.90
T_2	Imidacloprid 200 SL	0.25 ml/l	39.33	86.46ab (68.39)	91.56a (73.36)	91.53a (73.23)	77.97a (61.99)	83.54
T_3	Dimethoate 30 EC	1.7 ml/l	41.00	81.27bc (64.34)	85.42b (67.55)	82.92b (65.71)	74.69a (59.79)	77.73
T_4	Dichlorvas 76 WSC	2 ml/l	41.00	75.54c (60.34)	82.12b (64.96)	68.44cd (55.91)	58.40b (49.83)	67.78
T_5	Neem Seed Kernel Extract (NSKE)	50 ml/l	39.00	38.45d (38.30)	54.75cd (47.71)	65.92cde (54.30)	48.58c (44.17)	48.58
T_6	Fish Oil Rosin Soap (FORS)	20 g/l	39.00	37.56d (37.77)	57.20c (49.13)	62.40def (52.16)	46.87c (43.16)	47.66
T_7	Honge oil	20 g/l	40.33	26.29e (30.81)	47.82de (43.73)	57.60ef (49.38)	39.38d (38.82)	39.43
T_8	Nimbecidin	5 ml/l	40.67	26.91e (31.21)	50.56cde (45.31)	58.48def (49.88)	38.34d (38.23)	40.21
T_9	*Verticillium. lecanii* 1×10^8 conid/g	2 ml/l	39.33	35.43d (36.35)	58.40c (49.82)	62.64def (52.31)	34.67d (36.03)	44.44
T_{10}	Dichlorvas + FORS	2 ml+ 20 g/l	40.33	81.00bc (64.31)	82.65b (65.47)	73.55c (59.12)	62.80b (52.40)	71.66
T_{11}	Dimethoate + FORS	1.7ml+ 20 g/l	40.00	83.33b (65.92)	86.64b (68.56)	84.20b (66.64)	76.68a (61.10)	79.37
T_{12}	Release of *C. montrouzeri*	10 grubs/ tree	39.67	17.00f (24.02)	43.37e (41.10)	53.75f (47.13)	59.70b (50.58)	40.11
T_{13}	Un treated control	-	40.33	3.34g (10.35)	2.48f (9.06)	4.26g (10.88)	3.28e (10.30)	-
SE m±		-	NS	1.685	1.593	1.895	1.436	-

Means followed by same letter do not differ significantly by DMRT (P = 0.05)
Figures in the parenthesis are angular transformed values
PTC – Pre treatment count per 2.5 cm shoot length DAT – Days after treatment

Table: 18 Efficacy of different treatments on pomegranate thrips

Tr. No.	Treatments	Dose	PTC	Per cent reduction of thrips population				Per cent reduction over untreated control
				1 DAT	3 DAT	7 DAT	14 DAT	
T_1	Thiamethoxam 25 WG	0.20 g/l	15.33	76.05b (60.73)	88.03a (69.77)	88.03ab (69.77)	81.94a (65.10)	79.38
T_2	Imidacloprid 200 SL	0.25 ml/l	17.00	87.50a (69.69)	86.94ab (68.79)	93.47a (75.17)	89.03a (70.87)	84.97
T_3	Dimethoate 30 EC	1.7 ml/l	16.00	77.16b (61.45)	83.43abc (66.00)	85.51b (67.65)	79.50ab (63.34)	77.23
T_4	Dichlorvas 76 WSC	2 ml/l	17.33	68.98b (56.19)	74.54c (59.98)	67.13c (55.03)	59.49cd (50.48)	63.40
T_5	Neem Seed Kernel Extract (NSKE)	50 g/l	15.67	36.05c (36.85)	49.32d (44.59)	50.98d (45.54)	49.02de (44.42)	42.21
T_6	Fish Oil Rosin Soap (FORS)	20 g/l	17.33	28.47c (32.85)	36.11de (36.78)	47.69d (43.63)	44.21ef (41.65)	34.99
T_7	Honge oil	20 ml/l	16.67	34.03c (35.66)	39.81de (39.05)	46.06de (42.72)	35.88efg (36.65)	34.81
T_8	Nimbecidin	5 ml/l	15.33	37.00c (37.44)	39.23de (38.73)	45.37de (42.29)	32.82fg (34.92)	34.47
T_9	*Verticillium. lecanii* 1×10^8 conid/g	2 ml/l	15.33	37.08c (37.47)	43.47de (41.23)	50.00d (44.98)	36.94efg (37.40)	37.74
T_{10}	Dichlorvas + FORS	2 ml+ 20 g/l	16.67	67.60b (55.35)	75.49bc (60.52)	71.79c (57.95)	67.60bc (55.35)	66.49
T_{11}	Dimethoate + FORS	1.7ml+ 20 g/l	17.33	78.94b (62.67)	84.72abc (67.01)	86.51n (68.55)	82.64a (65.56)	79.08
T_{12}	Release of *C. montrouzeri*	10 grubs/ tree	17.67	15.07d (22.76)	33.44e (35.10)	35.60e (36.57)	29.72h (32.70)	24.15
T_{13}	Un treated control	-	16.33	4.07e (9.53)	4.31f (9.81)	4.07f (9.53)	4.07h (9.53)	-
SE m±		-	NS	2.304	2.624	2.026	2.772	-

Means followed by same letter do not differ significantly by DMRT (P = 0.05)
Figures in the parenthesis are angular transformed values
PTC – Pre treatment count per five new shoots DAT – Days after treatment

Table: 19 Efficacy of different treatments on pomegranate whiteflies

Tr. No.	Treatments	Dose	PTC	Per cent reduction of whiteflies population				Per cent reduction over untreated control
				1 DAT	3 DAT	7 DAT	14 DAT	
T_1	Thiamethoxam 25 WG	0.20 g/l	20.00	76.72a (61.13)	83.33a (65.91)	88.36a (70.09)	79.10a (62.83)	78.50
T_2	Imidacloprid 200 SL	0.25 ml/l	21.00	77.17a (61.81)	82.54a (65.28)	82.54b (65.78)	86.51a (68.55)	78.97
T_3	Dimethoate 30 EC	1.7 ml/l	21.67	73.73a (59.17)	81.51a (64.61)	81.63b (64.66)	80.04a (63.44)	75.87
T_4	Dichlorvas 76 WSC	2 ml/l	22.00	72.56a (58.44)	80.26a (63.60)	72.99c (58.71)	66.87b (54.84)	69.82
T_5	Neem Seed Kernel Extract (NSKE)	50 g/l	21.33	37.28b (37.60)	46.74b (43.11)	56.20d (48.55)	41.68cd (40.13)	42.12
T_6	Fish oil rosin soap (FORS)	20 g/l	22.33	34.12b (35.72)	43.08b (40.99)	45.98ef (42.67)	34.85d (36.12)	36.15
T_7	Honge oil	20 ml/l	23.00	34.60b (36.00)	44.35b (41.73)	45.63ef (42.46)	34.70d (36.05)	36.47
T_8	Nimbecidin	5 ml/l	22.67	38.29b (38.20)	46.43b (42.93)	42.35f (40.58)	33.73d (35.33)	36.84
T_9	*Verticillium. lecanii* 1×10^8 conid/g	2 ml/l	22.33	20.83c (27.14)	41.09b (39.84)	53.26de (46.85)	46.27c (42.84)	37.01
T_{10}	Dichlorvas + FORS	2 ml+ 20 g/l	22.00	73.02a (58.70)	78.91a (62.64)	74.97c (60.08)	66.18n (54.44)	69.92
T_{11}	Dimethoate + FORS	1.7ml+ 20 g/l	22.33	73.17a (58.79)	80.48d (63.79)	85.01ab (67.24)	79.09a (62.77)	76.08
T_{12}	Release of *C. montrouzeri*	10 grubs/ tree	22.00	19.94c (26.44)	38.03b (38.06)	56.05d (48.45)	63.63b (52.89)	41.06
T_{13}	Un treated control	-	22.00	3.52d (8.85)	3.37c (8.64)	3.35g (9.76)	3.18e (8.41)	-
SE m±		-	NS	1.631	1.818	1.505	2.127	-

Means followed by same letter do not differ significantly by DMRT (P = 0.05)
Figures in the parenthesis are angular transformed values
PTC – Pre treatment count per three new shoots 5 cm length DAT – Days after treatment

Table: 20 Efficacy of different treatments on pomegranate mealybugs

Tr. No.	Treatments	Dose	PTC	Per cent reduction of mealy bugs population				Per cent reduction over untreated control
				1 DAT	3 DAT	7 DAT	14 DAT	
T_1	Thiamethoxam 25 WG	0.20 g/l	33.33	72.78ab (56.58)	72.61ab (58.42)	71.51a (54.89)	70.00b (57.03)	69.24
T_2	Imidacloprid 200 SL	0.25 ml/l	32.67	74.46ab (59.63)	78.47ab (62.39)	79.59a (63.16)	70.42b (57.03)	71.97
T_3	Dimethoate 30 EC	1.7 ml/l	31.33	76.37ab (60.92)	77.31ab (61.54)	79.24a (63.04)	73.09b (58.73)	72.74
T_4	Dichlorvas 76 WSC	2 ml/l	31.67	67.33b (55.31)	50.52b (57.24)	77.55a (61.87)	70.52b (57.52)	67.72
T_5	Neem Seed Kernel Extract (NSKE)	50 g/l	32.67	34.67c (36.04)	47.85c (43.75)	54.96b (47.85)	45.82d (42.58)	42.06
T_6	Fish Oil Rosin Soap (FORS)	20 g/l	32.33	26.85cd (31.19)	46.30c (42.85)	56.68b (48.83)	53.58cd (47.03)	42.09
T_7	Honge oil	20 ml/l	32.33	28.21cd (31.82)	40.87c (39.64)	47.16b (43.35)	28.89[e] (32.50)	32.52
T_8	Nimbecidin	5 ml/l	34.00	30.30cd (33.33)	46.04c (42.71)	52.86b (46.63)	33.25[e] (35.09)	36.85
T_9	*Verticillium. lecanii* 1×10^8 conid/g	2 ml/l	31.33	24.57cd (29.68)	41.52c (40.03)	45.33b (42.26)	45.69d (42.51)	35.51
T_{10}	Dichlorvas + FORS	2 ml+ 20 g/l	32.67	74.39ab (59.62)	72.61ab (58.42)	79.59a (63.16)	71.51b (57.89)	70.76
T_{11}	Dimethoate + FORS	1.7ml+ 20 g/l	31.00	78.00a (62.01)	81.99a (64.86)a	78.54a (62.42)	70.00b (57.03)	73.37
T_{12}	Release of *C. montrouzeri*	10 grubs/ tree	32.67	23.54d (28.10)	53.03c (46.72)	81.00a (64.15)	94.09a (75.95)	59.18
T_{13}	Un treated control	-	31.00	3.23e (10.58)	5.25d (10.89)	3.23c (10.35)	3.36f (8.55)	-
SE m±		-	NS	2.000	2.293	2.260	1.834	-

Means followed by same letter do not differ significantly by DMRT (P = 0.05)
Figures in the parenthesis are angular transformed values
PTC – Pre treatment count per four shoots of 30 cm length DAT – Days after treatment

All the treatments differed significantly over untreated control in reducing the aphid incidence after one, three, seven and 14 days after treatments. At 1 and 3 DAT, all insecticides and insecticide + FORS, treatments were on par with each other. At 7 and 14 DAT, imidacloprid and dimethaote + FORS recorded significantly higher (88.36, 86.51 and 85.01, 79.09 respectively) per cent reduction of whiteflies population. Next best treatments were thiamethoxam and dimethoate which recorded 77.12 and 75.87 mean per cent reduction over untreated control, respectively. The pomegranate trees which received grubs of *C. montrouzieri* recorded maximum of 63.63 per cent reduction of whiteflies population at 14 DAT. Among oil formulation, FORS recorded 45.47 mean per cent reduction of whiteflies population over untreated control.

4.4.4 Management of mealy bugs

The population of mealy bugs before imposing treatments ranged from 31.00 to 34.00. It is inferred from the data presented in Table 20 that there was no significant difference in the mean population of mealy bugs at one day before treatment.

But after imposing treatment at one, three and seven days after treatment imidacloprid, thiamethoxam, dimethoate, dichlorvos+FORS, dimethoate + FORS recorded significantly higher per cent reduction of mealybug population and finally afforded 71.97, 69.24, 72.74, 70.76 and 73.37 per cent reduction over untreated control. But at the end of 14 DAT, all insecticides were inferior to the treatment which received 10 grubs of *C. montrauzieri* recorded significantly higher per cent reduction (94.09) of mealy bugs. Among all treatments, dimethoate + FORS recorded higher (73.37) per cent reduction of mealy bugs over untreated control. Dimethoate was next best treatment which recorded 72.48 per cent reduction of mealy bugs over untreated control.

5. DISCUSSION

Infestations by sucking pests on many fruit crops have become economically more important over the past decade. Often considered only as incidental or minor pests, today they are responsible for causing considerable damage especially in exporting fruit crops like pomegranate, grape, citrus, etc. All over the world, the sucking pests cause more damage to pomegranate than other pests. The export value of pomegranate is much dependent on the quality of fruit. Most of the sucking pests of pomegranate reduce the quality of fruits either directly or indirectly. In India, 50 per cent of fruits produced may fetch low price in international market as a result of attack by the sucking pests. It becomes imperative to have detailed understanding about their distribution through survey, seasonal incidence and devising economically and eco-friendly management practices. Hence, the present study was undertaken and salient findings related to above aspects of investigations are discussed in the present chapter in the light of earlier work done.

5.1 Sucking insect pests of pomegranate

The present study based on the extensive roving survey in and around Bagalkot district of Karnataka brought to the light 11 different sucking pests and two non-insect pests (mites) sucking the plant sap from different parts of the pomegranate plant. Out of these 11 were already reported, two were new to India and four were new to Karnataka on pomegranate.

Homoptera

The following Homopteran pests were observed during the survey work.

5.1.1 Pomegranate aphid, *Aphis punicae* Passerini

This is a specific pest of pomegranate. Infestation was noticed in all five locations, it was also recorded by Butani (1976) in India and Balikai (2000) from Northern Karnataka.

5.1.2 Spiraling white fly, *Aleurodicus disperses* Russel

This is polyphagous pest, also recorded on pomegranate during December to March 2007, but the incidence was less. It has been reported by Muralikrishna (1999) on pomegranate from Bangalore and Balikai (2000) from Northern Karnataka.

5.1.3 Pomegranate whitefly *Siphoninus phillyreae* Haliday

This is another whitefly observed on pomegranate throughout the study period. This is smaller in size than spiraling whitefly, which was reported for the first time on pomegranate by Nair (1978). Severe incidence of this pest was also recorded by Balikai *et al.* 1999 in northern Karnataka which supports the present findings.

5.1.4 Mealy bug, *Planococus lillacinus* (Cockrell)

This species of mealy bug was seen attacking fruits and their stalk on pomegranate plant. The same was reported also by Balikai (2000) from Northern Karnataka.

5.1.5 Scale insects, *Parasissetia nigra* (Nietner), *Icerya purchasi* Maskell.

These two species of scale insects were found to infest pomegranate stem and foliages. The Scale insect, *P. nigra*, was reported by Karuppuchamy (1994) in Tamil Nadu and Jadav and Ajri (1985) in Maharashtra on pomegranate. But *I. purchasi* a new record noticed on pomegranate.

5.1.6 Euribrachid bug, *Eurybrachis* sp.

This is a new sucking pest recorded in pomegranate and was observed to feed on leaves and fruits. However, the infestation was very negligible.

Hemiptera

5.1.7 Green bug, *Nezara virudulla* L.

A species of pentatomid bug, *Nezara virudula* was noticed on pomegranate during roving survey. The same was also recorded by Balikai (2000) on pomegranate in Northen Karnataka. The detailed studies relating to its bioecology need to be made.

Thysanoptera

5.1.8 Thrips, Rhipiphorothrips cruentatus Hood, *Scirtothrips dorsalis* Hood, *Anaphothrips oligochaetus* Karny

All the three species thrips were found to lacerate and suck the sap from pomegranate leaves, flowers and also fruits. The same was also reported by Balikai (2000) from Northern Karnataka which corroborate with the present findings.

5.19 Non insect pests, False spider mite, *Tenuipalpus granati* Sayed, Eriophyid mite, *Aceria granati* Canestrini and Massal

The edge rolling symptom of damage caused due to sucking by eriophid mites was observed in all five locations during first fortnight of January onwards. The pest and similar symptoms of damage are also reported by Karuppuchamy (1994) from Tamil Nadu and Balikai (2000) from Northern Karnataka.

5.2 Natural enemies of sucking pests

5.2.1 On aphids

Population of *C. carnea* was maximum during December 2006 to March 2007 in all five locations. Grubs of *C. carnea* ranged from two to ten and adult from one to seven per three terminals. Maximum of nine grubs were recorded during February 2007. Other natural enemies of *A. punicae* were *S. coccivora, C. sexmaculata*, *C. septumpunctata*. All these were placed on record by Karuppuchamy (1994) in Tamil Nadu.

5.2.2 On Whiteflies

Grubs of *C. carnea* were recorded to feed on whiteflies. An Aphelinid parasitoid *Encarsia* sp. was recorded on whiteflies during February 2007. The same species of natural enemies was recorded by Karuppuchamy *et al.* (1998) in Tamil Nadu and Mani and Krishnamoorthy (1995) at Bangalore.

5.2.3 On Mealy bugs

The grubs and adults of *C. montrouzieri* and *S. coccivora* were observed to predate on eggs, larva and adults of pomegranate mealy bugs. Activity of natural enemies was maximum during April and May 2007 and population of natural enemies declined from June onwards. The activity of predators coincided with the activity of pests. Both above mentioned species of natural enemies were also encountered by Mani and Krishnamoorthy (1990) and Karuppuchamy (1994) in Tamil Nadu on mealy bugs.

5.3 Seasonal incidence of major sucking pests of pomegranate and their relation with weather parameters

5.3.1 Aphids

The peak activity of pomegranate aphids was observed during second fortnight of December 2006 onwards, which reached maximum of 19.82 aphids per 2.5 cm terminal shoot during first fortnight of January 2007. The present findings are in confirmation with Karuppuchamy (1994) who noticed peak activity of pomegranate aphids during month of February and March in Tamil Nadu and Biradar and Shaila (2004) recorded peak activity of aphids during winter months.

The simple correlation studies made between incidence of aphids and weather parameters revealed that only morning relative humidity (r = 0.4161) showed positive and significant relationship, which may lead to increase in per cent hatching of eggs, where as all other weather parameters showed negative and non-significant relationship with incidence of aphids. Except maximum temperature all the regression factors exerted significant influence over incidence of aphid. Among the various abiotic factors minimum temperature, evening relative humidity influenced to the extent of 67 and 32 per cent, respectively. On the contrary, Karuppuchamy *et al.* (1998) reported that the correlation between the incidence of aphid and weather parameters was non-significant. This may be due to variation in the pruning pattern.

5.3.2 Thrips

The highest infestation of thrips was noticed in the second fortnight of March 2007 with an average number of 9.14 thrips per five new shoots. This was due to the fact that tender leaves and fruits were available during the respective periods which favoured the multiplication of the pest. This is in conformation with the findings of Karuppuchamy (1994) who observed the maximum damage during middle of April and first week of July on leaves and fruits, respectively, in Tamilnadu. The deviation in the incidence reported by others may be due to the changes in weather factors and pruning pattern. Simple correlation studies between incidence of thrips and weather parameters revealed that only morning relative humidity (r = 0.5065) influenced positively and significantly, while evening relative humidity (r = -0.4905) recorded significant and negative relationship with thrips incidence, but remaining weather parameters recorded non-significant relationship with population of thrips.

Among all regression factors only morning and evening relative humidity influenced significantly to the tune of 25 and 24 per cent respectively on incidence of thrips. According to Bagle (1993) also, weekly average minimum and maximum temperature had a highly significant positive correlation with population of thrips. Besides, relative humidity also showed positive correlation with the population of thrips with 'r' value being 0.409. However, rainfall pattern did not influence the population of thrips on pomegranate. Contrary to the present findings may be attributed to the different in pruning pattern.

5.3.3 Whitefly

Population density of both the whiteflies was maximum during second fortnight of February and first fortnight of March 2007 with an average of 14.40 and 13.38 per three new shoots respectively. It declined from March onwards. The results of present findings corroborate with the reports of Balikai *et al.* (1999) who observed maximum incidence during February to April months. Shevale and Kulgud (1998) recorded whiteflies population more abundant during March to June on pomegranate in Maharashtra,

The results of correlation studies between incidence of whiteflies and weather parameters revealed that only morning relative humidity (r = 0.5811) recorded positive and significant relationship. While evening relative humidity (r = -0.7254), rainfall (r = 0.4136), number of rainy days (r = 0.4679) also recorded significant and negative relationship, but maximum temperature (r = 0.1257) and minimum temperature (r = -0.0798) had non-significant relationship with incidence of whiteflies. The results are in close conformity with Shevale and Kaulgud (1998) who reported incidence of whiteflies to show significant positive correlation with temperature and a negative correlation with relative humidity. The variation in correlations reported by earlier workers may be due to change in weather factors and pruning pattern. But Mani and Krishnamoorthy (2002) noticed non-significant relationship with temperature, humidity, rainfall and positive and significant relation with natural enemies, but the regression coefficient of the natural enemies was significant.

5.3.4 Mealy bugs

Nymphs and adults of mealy bug *P. lillacinus* made early appearance during February and caused maximum damage during March and April month recorded average maximum population of 10.54 and 11.33 mealy bugs per 30 cm shoots. The mealy bug incidence was normally seen during the fruiting stage, which is in agreement with the findings of Mani and Krishnamoorthy (1990) and Karuppuchamy (1994), Shevale and Kaulgud (1998) who reported incidence of mealy bug *Ferrisia* spp more abundant during March to June in Maharashtra, which is also a fruiting period, supports the present findings.

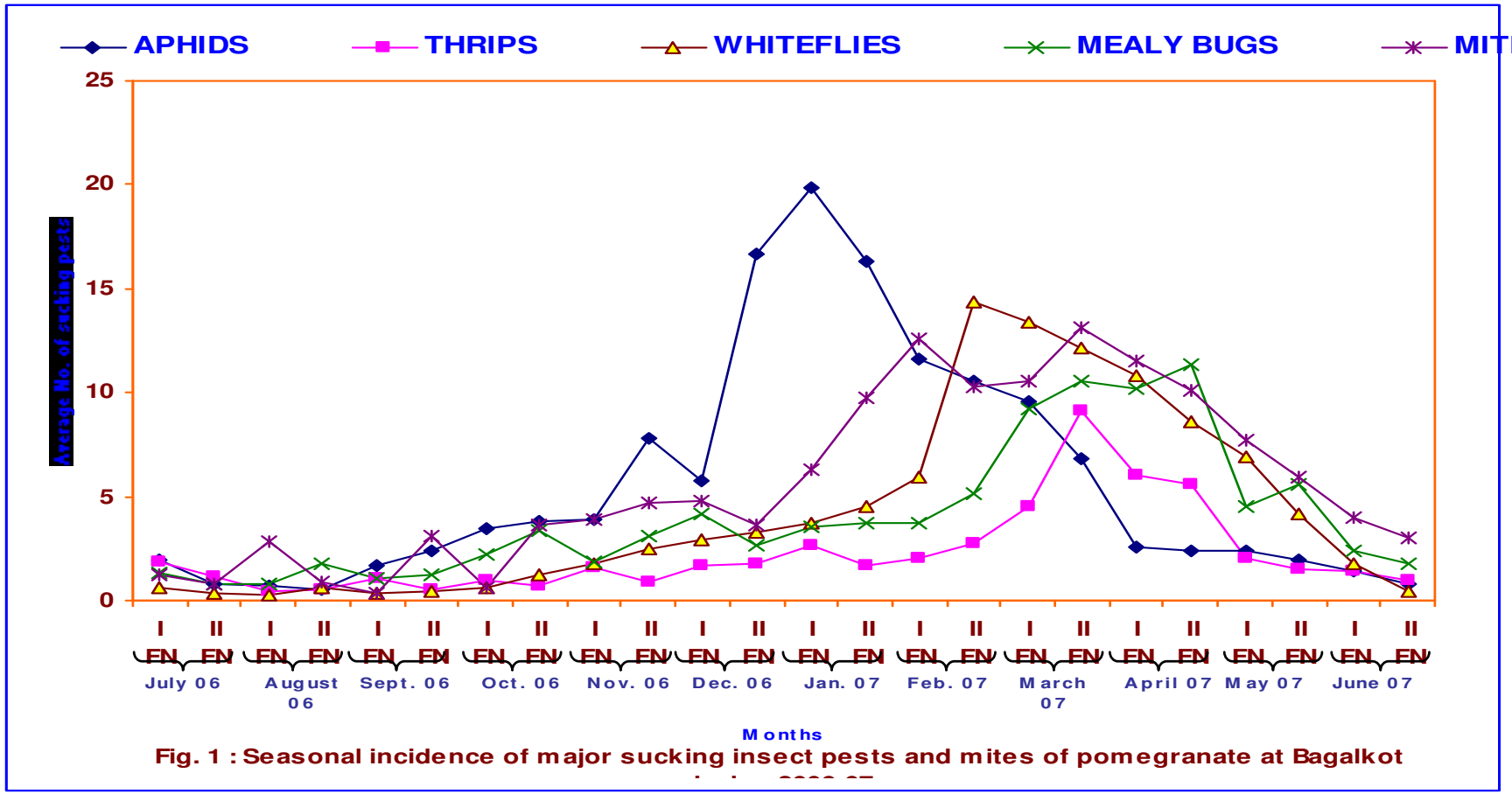


Fig. 1: Seasonal incidence of major sucking insect pests and mites of pomegranate at Bagalkot during 2006-07

The correlation studies made between incidence of mealy bugs and weather parameters revealed that morning relative humidity (r = 70.5956) had significant and positive relationship, evening relative humidity had significant negative relationship, whereas maximum and minimum temperatures had positive and non-significant relation (r = 0.3750, r = 0.1872). The number of rainy days had negative and non-significant relationship with incidence of mealy bugs. Among the abiotic factors only morning and evening relative humidity influenced to the tune of 35 and 33 per cent respectively. Shevale and Kaulgud (1998) noticed population of mealy bug to have significant positive correlation with temperature and negative correlation with relative humidity. But according to Mani and Krishnamoorthy (2000), there was no significant relationship between temperature, humidity, rainfall and mealy bug population.

5.3.5 Mites

Incidence of mites started from January 07 and reached to peak during first fortnight of March 07 (13.12 mites per cm^2 leaf area). There was decrease in population of mites from second fortnight of May which might be due to the influence of rainfall.

Simple correlation studies results showed that increase in morning relative humidity favoured the multiplication of mite pest. Evening relative humidity, rainfall and number of rainy days had negative and significant relationship with mite population and these factors reduced the incidence of mite. Among all abiotic factors, evening and morning relative humidity influenced to the extent of 53 and 36 per cent respectively. These are in confirmation with findings of Karuppuchamy (1994) who also observed maximum edge rolling symptoms by mites during second fortnight of June, though correlation between incidence and weather parameters was non-significant.

5.3.6 Relationship between incidence of sucking pests with weather parameters at two weeks lead time

To develop forecast models, the correlation studies were made between weather parameters at two weeks lead time and population of sucking pests. Morning relative humidity recorded positive and significant correlation while evening relative humidity, number of rainy days, recorded significant and negative relationship with all sucking pests and mites at two weeks lead time. Accordingly if the morning relative humidity increases then the population of sucking pests could be higher at next two weeks. The higher morning relative humidity during second fortnight of December higher is the expected population of aphids during first fort night of January.

5.4 Management practices for major sucking pests of pomegranate

5.4.1 Aphids

Aphid population per 2.5 cm length of shoot one day before treatment ranged from 39.00 to 41.00. Among all the treatments tested against pomegranate aphids at one, three, seven and 14 days after treatment (DAT) both Thiamethoxam and Imidacloprid recorded significantly higher 85.90 and 83.54 per cent reduction of aphid population over control respectively. Dimethoate + fish oil rosin soap (FORS), Dimethoate alone were next best treatment which recorded 79.37 and 77.73 per cent reduction of aphid population over control respectively, NSKE recorded 51.92 per cent mean reduction of aphid population. According to Mishra (2002), Thiamethoxam and Imidacloprid, both belonging to nitroguanidinie group, used @ 25 g a.i/ha, proved significantly superior in controlling aphids and jassids on okra. The similar results are obtained in the present study on pomegranate. The results with respect to dimethoate are in agreement with those reported by Mote *et al.* (1993) and Biradar and Shaila (2004). Further, Verghese (2000) observed that various neem extracts and pongamia oil did not have sufficient potential to achieve rapid knockdown of *A. punicae* on pomegranate.

5.4.2 Thrips

The population of thrips per five new shoots one day before treatment ranged from 15.33 to 17.33. Among all treatments imposed on pomegranate thrips, (except thiamethoxam at 1 DAT) both imidacloprid and thiamethoxam recorded significantly higher per cent

reduction of thrips population at 1, 3, 7 and 14 DAT, and also recorded 84.97 and 79.38 per cent protection against thrips over control, respectively. Next best treatments were Dimethoate + FORS, Dimethoate, which gave 79.08 and 77.23 per cent protection against of thrips over control. Treatment with dichlorvos was comparatively less effective than rest of the chemical treatments. The results with respect to Dimethoate are in agreement with the report of Bagle (1993) according to whom dimethoate and phosphamidon at 0.05 per cent were effective and consistent in their efficacy over a period of 15 days on pomegranate thrips. Rathod *et al.* (2003) reported Imidacloprid 70 WS @ 5 g/kg seed treatment resulted in significantly least number of thrips population on cotton.

According to Ramesh Babu and Santharam (2000), Imidacloprid 200SL at 100 ml per ha was effective in checking the population of both thrips and aphids on groundnut.

5.4.3 Whiteflies

One day before treatment, whitefly population per three new shoots of 5 cm length ranged from 20.00 to 23.00 without any significant difference. Though there was no significant difference among insecticides and insecticide + FORS treatments at 1 and 3 DAT but imidacloprid and Dimethoate + FORS recorded significantly highest per cent reduction of whiteflies population at 7 and 14 DAT. The next best treatments were thiamethoxam and dimethoate which recorded 82.54 and 81.63 per cent reduction of whiteflies population at 7 DAT. But at 14 DAT, both thiamethoxam and dimethoate also recorded significantly higher per cent reduction of whiteflies. Among FORS recorded higher mean per cent reduction of whiteflies (45.47%). Efficacy of oil formulations starts at 3 DAT, but reaches maximum during 7 DAT and then onwards there was decline in their efficacy. This is in confirmation with findings of Thimmaiah (2002), who noticed Dimethoate + FORS was highly effective against all stages of whiteflies which recorded 90 per cent nymphal, 80 per cent pupal, 95 per cent adult mortality on Guava. Kambrekar (2000) reported that Dimethoate + FORS gave 80 per cent pupal and 65 per cent nymphal mortality at 15 DAT of Guava spiraling whiteflies.

5.4.4 Mealy bugs

Population of mealy bugs per four shoots of 30 cm (1 day before treatment) ranged from 31.00 to 34.00. At 1, 3 and 7 DAT thiamethoxam, imidacloprid, dimethoate, and dimethoate + FORS recorded significantly higher per cent reduction of mealy bugs population, but at the end of 14 DAT only the treatment which received 10 grubs of *C. montrouzieri* recorded significantly highest (94.09%) reduction of mealy bug population. The next best treatments were thiamethoxam, imidacloprid, dimethoate, dimethoate + FORS recording 70.00, 70.42, 73.09 and 70.00per cent reduction of mealy bugs at 14 DAT. Combination of dimethoate + FORS recorded higher (73.37%) reduction of mealy bugs over control. This is in conformation with Singh (1993) who reported release of grubs of *C. montrouzieri* @ 10 to 50 per tree suppressed the mealy bugs on coffee. According to Mani *et al.* (1990), *C. montrouzieri* @ 15 adults per plant suppressed the guava mealy bug. Regupathy et al. (1997) also recommended the release of 10 grubs of *C. montrouzieri* per tree for control of mealy bugs on citrus. The results with respect to dimethoate are in agreement with report of Karuppuchamy (1994), Ghule and Dhumal (1992).

Future line of work

1. In depth studies need to be undertaken on bio-ecology of the sucking pests over a longer period of time so as to develop forecast models.
2. The study relating to residue analysis of different combinations of promising insecticides and oils need to be done as pomegranate is an export orient fruit crop.
3. Further exploitation of other natural enemies other than *C. montrouzieri*, mass production and release for managing the sucking pests may be worked out.

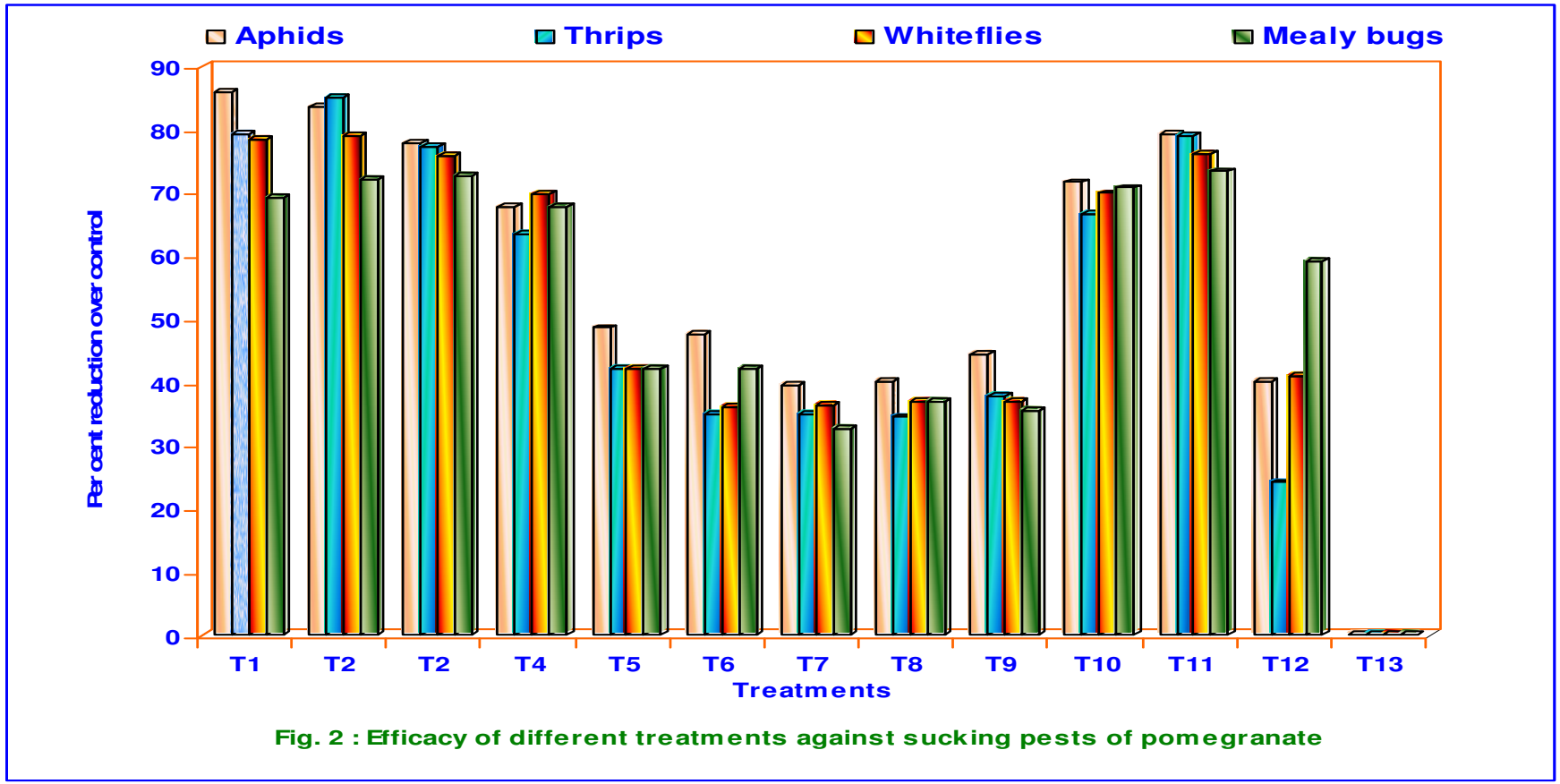


Fig. 2: Efficacy of different treatments against sucking pests of pomegranate

6. SUMMARY AND CONCLUSIONS

The investigations made on the various sucking insect pests of pomegranate and their natural enemies, seasonal incidence of major sucking pests and their relation to weather parameters and eco-friendly management aspects for major sucking pests of pomegranate were undertaken at the orchards of Fruit Growers Association, Kaladagi and farmers fields in Bagalkot district, Karnataka during 2006-07. The results of investigations are summarized in this chapter.

The roving survey taken up during 2006-07 at fortnightly interval in and around Bagalkot revealed the association of 11 sucking insect pests. Among these, 10 belonged to Homoptera, one to Hemiptera, three to Thysonaptera and two were non insect pests (mites). During roving survey, as many as 10 natural enemies (predators and parasitoids) were encountered on sucking pests of pomegranate ecosystem. Among these, 5 belonged to Coleoptera, one each to Neuroptera and Hymenoptera. Three species of praying mantids were noticed as general predators.

Fixed plot survey conducted at five locations *viz.,* Kaladagi, Ankalgi, Govinkoppa, Udagatti and Chikkasamsi to know the seasonal incidence of major sucking pests revealed that aphid infestation was maximum during second fortnight of January in all locations. This may be due to availability of new foliage and high morning relative humidity.

The infestation by thrips was maximum during second fortnight of March due to availability of new foliage, flowers and fruits coupled with the favourable weather parameters like high temperature and no rains during that period.

Whiteflies population increased from second fortnight of December and reached peak during second fortnight of February. Mealy bugs increased from second fortnight of February onwards and reached peak during second fortnight of April. This may be due to coincidence of plants producing new shoots and fruits. High temperature and humid condition favoured to build up mealy bug population.

Mite infestation increased from second fortnight of January and reached peak during first fortnight of April and declined from first fortnight of May onwards.

Most of the farmers used synthetic pyrethroids against fruit borers, which led to destruction of natural enemies and induced the buildup of sucking pests. The population of sucking pests was negligible during August and September which may be due to pruning and foliage shredding resulting in break up of the life cycle of sucking pests and further buildup. Among all weather factors, rainfall and number of rainy days act as key mortality factors for all sucking pests.

Thiamethoxam and imidacloprids were most effective in controlling aphids; these two chemicals were found to reduce the incidence by 85.90 and 83.54 per cent over control. Experiment conducted to manage the pomegranate thrips revealed that Imidacloprid and thiomethoxam were best treatments which recorded 84.37 and 79.38 per cent reduction over control. Dimethoate + FORS was next best treatment.

Imidacloprid and thiamethoxam were most effective in controlling whiteflies. These two chemicals were found to reduce the incidence by 78.97 and 78.50 per cent reduction over control. Dimethoate + FORS was next best treatment which recorded 76.08 per cent reduction over control. Dimethoate + FORS, dimethoate and imidacloprid were most effective chemical treatments against mealy bugs. Release of *Cryptolaemus montrouzieri* Mulsant grubs was effective against pomegranate mealy bug at the end of 14 DAT.

- Among the sucking pests recorded during roving survey, four were new to pomegranate ecosystem in Karnataka and two were first record from India on pomegranate ecosystem.
- Among all natural enemies recorded, five were entirely new records in pomegranate ecosystem in Northern Karnataka and four were new records from India in pomegranate ecosystem
- Incidence of sucking pests was maximum during summer months because it coincided with new foliage, flower and fruit formation.

- Thiamethoxam and imidacloprid were most effective in controlling aphids, thrips and white flies.
- Release of *Cryptolaemus montrouzieri* @ 10 grubs per tree was effective against pomegranate mealy bug at the end of 14 DAT.

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Appendix – I: Mean fortnightly meteorological data for the year 2006-07 of Agricultural Research Station, Bagalkot, Karnataka

Months		Temperature (^{0}C)		Cumulative rain fall(mm)	Relative humidity (%)		No. if rainy days
		Maximum	Minimum		Morning	Evening	
July 2006	I FN	26.70	22.50	2.40	62.53	68.78	1
	II FN	26.05	22.20	12.00	65.93	77.53	3
August 2006	I FN	26.70	21.80	2.00	66.64	73.50	1
	II FN	28.40	21.45	0.00	64.92	60.75	0
September 2006	I FN	30.70	21.91	73.80	58.86	63.46	5
	II FN	28.13	21.57	57.40	73.68	71.53	5
October 2006	I FN	27.61	21.32	80.60	82.06	67.80	3
	II FN	30.31	20.51	12.40	85.06	54.28	2
November 2006	I FN	28.72	19.40	0.00	74.73	63.40	0
	II FN	29.41	19.88	0.00	62.62	58.13	0
December 2006	I FN	29.31	16.95	0.00	73.14	49.86	0
	II FN	27.48	14.08	0.00	76.12	47.33	0
January 2007	I FN	28.08	13.94	0.00	78.13	51.14	0
	II FN	30.17	15.79	0.00	77.13	58.31	0
February 2007	I FN	28.84	16.40	0.00	76.70	39.80	0
	II FN	33.04	15.92	0.00	76.60	42.20	0
March 2007	I FN	34.67	18.32	0.00	82.40	42.35	0
	II FN	35.65	22.6	1.60	83.60	46.33	0
April 2007	I FN	37.92	26.80	1.20	81.78	49.07	2
	II FN	37.72	26.40	5.40	75.87	59.64	2
May 2007	I FN	38.54	26.52	27.20	76.40	54.42	2
	II FN	36.46	26.79	25.30	74.40	57.15	2
June 2007	I FN	35.43	26.79	68.60	63.13	51.53	5
	II FN	30.72	26.39	98.20	58.00	67.92	6

Appendix – II: Proforma used for the fixed plot survey of pomegranate sucking pests and their natural enemies

Palce : Soil type : Name of the farmer :
Variety : Plant protection measures taken: Date of survey :

Date of observation		Average population of sucking pests											
		1	2	3	4	5	6	7	8	9	10	Average.	NE
July 2006	I FN												
	II FN												
August 2006	I FN												
	II FN												
September 2006	I FN												
	II FN												
October 2006	I FN												
	II FN												
November 2006	I FN												
	II FN												
December 2006	I FN												
	II FN												
January 2007	I FN												
	II FN												
February 2007	I FN												
	II FN												
March 2007	I FN												
	II FN												
April 2007	I FN												
	II FN												
May 2007	I FN												
	II FN												
June 2007	I FN												
	II FN												

SEASONAL INCIDENCE AND MANAGEMENT OF SUCKING PESTS OF POMEGRANATE

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ABSTRACT

The investigations on various sucking insect pests of pomegranate and their natural enemies, seasonal incidence of major sucking pests and their relation to weather parameters and eco-friendly management aspects for major sucking pests of pomegranate were undertaken at the orchards of Fruit Growers Association, Kaladagi Bagalkot district, Karnataka during 2006-07.

The roving survey at fortnightly interval in and around Bagalkot revealed the association of 11 sucking insect pests. Among these, 10 belonged to Homoptera, one to Hemiptera, three to Thysonaptera and two were mites. Ten natural enemies were encountered during the survey. Among these, five belonged to Coleoptera, one each to Neuroptera and Hymenoptera. Three species of praying mantids were noticed as general predators in pomegranate ecosystem.

Fixed plot survey conducted at. Kaladagi, Ankalgi, Govinkoppa, Udagatti and Chikkasamsi to know the seasonal incidence of major sucking pests revealed that aphid infestation was maximum during second fortnight of January. The infestation by thrips was maximum during second fortnight of March due to availability of new foliage, flowers and fruits coupled with the favourable weather parameters like high temperature and no rains. The population of Whiteflies reached peak during second fortnight of February. Infestation by Mealy bugs was maximum during second fortnight of April as coinciding flowering and fruiting. Activity of mites was peak during first fortnight of April.

Experiment conducted to manage the pomegranate sucking pests revealed that Thiamethoxam and imidacloprid were found to reduce the incidence of aphids, thrips and white flies population by 85.90, 83.54 and 84.37, 79.38 and 78.97 and 78.50 per cent over control respectively. Dimethoate + fish oil rosin soap (FORS), dimethoate and imidacloprid were most effective treatments against pomegranate mealy bugs. Release of *Cryptolaemus montrouzieri* Mulsant @ 10 grubs per tree was effective against pomegranate mealy bug at the end of 14 DAT.