PESTS OF TULSI (*Ocimum tenuiflorum* L.) AND THEIR MANAGEMENT

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DECLARATION

I hereby declare that this thesis entitled "**Pests of Tulsi (*Ocimum tenuiflorum* L.) and their management**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellayani,
16-08-2007

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CERTIFICATE

Certified that this thesis entitled **"Pests of Tulsi (*Ocimum tenuiflorum* L.) and their management"** is a record of research work done independently by Ms. Malini Nilamudeen (2004-11-16) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Introduction

1. INTRODUCTION

Since the dawn of civilization, man has depended on plants for medicines, essential oils and a host of other uses. Over 80 per cent of the world's population relies on traditional medicines largely plant based for their healthcare (Fransworth and Soejarto, 1991). Several of the crude drugs for medicinal preparations come from the wild. It can indubitably be stated that the natural resources will diminish in due course. It is worthwhile to note that the demand for medicinal plants is growing at a frenetic pace. The international market for herbal products is estimated to be 62 billion US dollars which is poised to leap to five trillions by 2050. The supply of the raw materials of medicinal plants of good quality is thus being stepped up. Of late, the cultivation of medicinal and aromatic plants or mediculture has gained a lot of ground and is a key area in the international agribusiness trade.

India is one of the richest repositories of medicinal and aromatic plants in the world. Although thousands of plant species have been used for the last 5000 years in the traditional systems of medicine, at present only about 1500 species are in use. Out of this, only 40 or 50 species including tulsi (*Ocimum tenuiflorum* L.) syn. (*Ocimum sanctum* L.) are being exploited by the pharmaceutical industry (Sharma, 1999).

Kerala is one of the most advanced states with respect to the use of medicinal plants, especially in Ayurveda. In Kerala, where the land resources for agriculture are limited, agriculture and mediculture can be made complimentary to one another.

Tulsi, meaning 'the incomparable one' is an important medicinal plant which is in demand. The medicinal properties of tulsi were known since antiquity. This herb is mentioned in Charaka Samhita and Rig Veda. It is used for the treatment of problems related to heart, blood, intestine and snake bite. The whole plant is

recommended for treating sunstroke, headache and influenza (Puspangadan and Bradu, 1995). Eugenol, the important chemical constituent of tulsi is useful for the synthesis of vanillin. In Kerala, tulsi has been an ubiquitous member of the homestead farming system. Tulsi being shade tolerant can be raised as an intercrop in the coconut and rubber plantations spread out in about 14 lakh hectares.

Commercial cultivation of tulsi demands the development of improved crop husbandry practices. In agro ecosystems, when the area under a crop increases, the potential for pest problems also increases. Hence it goes without saying that the pest problems have to be identified and contained to obtain good quality produce. Hitherto, in tulsi, only the lacewing bugs and scale insects have been reported as major pests (Ayyar, 1963 and Nair, 1999). More information on the status of the pests is required for evolving strategies to tackle them. Perusal of the literature on pest control in medicinal plants reveals the recommendations for use of chemical pesticides. The problems of unwarranted chemical use calls for a sea change in pest control strategies. Ecofriendly pest management tactics has to be evolved for the production of uncontaminated produce. To address the above issues, the present investigation was taken up with the following objectives.

- To identify the major and minor pests of tulsi and their natural enemies.
- To find out the seasonal occurrence and distribution of pests and natural enemies.
- To assess the nature and extent of damage caused by each pest.
- To correlate various weather parameters with the occurrence of the pests and the extent of damage caused.
- To identify suitable botanical pesticides for the management of pests of tulsi and to determine their safety to spiders.

Review of Literature

2. REVIEW OF LITERATURE

Tulsi (*Ocimum tenuiflorum* L.) is an important medicinal plant grown in India. The productivity and yield of tulsi are being hampered by a number of pests which infest different parts of the plant. However, studies on the pests of tulsi and their management are meagre. Available information about the pests of tulsi, their management and natural enemies of the pests are reviewed hereunder. For an in-depth study, literature pertaining to these aspects of other crops is also reviewed.

2.1 OCCURRENCE OF PESTS AND NATURAL ENEMIES OF TULSI

2.1.1 Pests

***Monanthia globulifera* W.**

Ayyar (1963) described *M. globulifera* syn. *Cochlochila bullita* Horv. a black lacewing bug with hyaline wings as the most important pest of tulsi. He found them in colonies with all stages on the foliage and shoots of the plant and due to its attack; the foliage of tulsi plants completely turned brown and dried up. Nair (1975) reported *M. globulifera* as a serious pest attacking tulsi in Kerala. He found out that the eggs were thrust within the veins or edges of leaves and the nymphs were flat, black and spinous. Nayar *et al.*, (1976) also identified *M. globulifera* as a pest affecting tulsi leaves in large numbers in South India. Bhattacharya and Chakravorthy (1984) reported the lace wing bug of tulsi from Kalyani, West Bengal and the highest population peak occurred during March to May. The lace wing bug was observed in the tulsi fields of South Andaman by Chandra (1992). According to her, the nymphs and adults congregated on leaf surface and desapped it and the affected leaves curled, withered, dried up and finally dropped.

In Thrissur district of Kerala, *M. globulifera* was found attacking tulsi plants in large numbers (Rajan, 2003).

Nair (1975) and Nayar *et al.*, (1976) reported the infestation of *M.globulifera* on *Coleus aromaticus* L. Palaniswami and Pillai (1983) recorded the lace wing bug on *Coleus parviflorus* L. Dennis (1994) reported *Mentha arvensis* L. as an alternate host of *M. globulifera*. David (2001) mentioned lacewing bug as a minor pest of *Carthamus tinctorius* L. Rani (2001) reported the damage of *M. globulifera* on *Coleus forskholii* L. and the infested leaves developed yellow patches which later become brown, shrivelled and dried up. Chadha (2002) reported the incidence of *M. globulifera* on *Ocimum basilicum* L.

***Ceroplastodes cajani* Maskell**

C. cajani was observed as a serious pest of tulsi in South India by Nayar *et al.*, (1976). The scale insect infested the main stem and branches covering the surface in large numbers. Nair (1999) reported that the wax scale was a major pest of tulsi in Kerala. He also reported that during the initial stages of attack, the shoots became weakened and finally the whole plant withered.

Nayar *et al.*, (1976) reported the wax scale as a serious pest of *Tephrosia purpurea* L. and *Coleus* sp. David (2001) reported *Moringa oleifera* Lamk. as an alternate host of *C. cajani*. Singh (2004) reported the coccid infestation on redgram, *Cajanus cajan* Millsp. and the infestation was characterized by sickly, wilted and dried up plants.

***Pycnarmon caberalis* Guen.**

Nair (1975) reported that the larvae of the leaf roller, *P. caberalis* folded together the margins of individual leaves of tulsi and fed from within. *P. caberalis* was also identified as a leaf roller of tulsi by Nayar *et al.*, (1976).

P. caberalis was reported as a leaf roller of *O. basilicum* by Chadha (2002).

***Lycnestis amphix* Cr.**

Nair (1975) and Nayar *et al.*, (1976) reported *L. amphix* as an important leaf roller of tulsi.

***Syngamia abruptalis* Wlk.**

S. abruptalis was reported as a pest of tulsi from South India by Nayar *et al.*, (1976). Anont (1990) observed that a single larva of *S. abruptalis*, a major leaf roller of tulsi caused damage to more than twenty leaves and pupation took place within the leaf rolls.

Pradhan (1969) reported the infestation of *S. abruptalis* on *M. arvensis*. Pruthi (1969) mentioned the incidence of *S. abruptalis* on grapevine. Nayar *et al.*, (1976) reported this leaf roller as a pest of *M. arvensis* in Burma and India. Anont (1990) observed that leaves of *O. basilicum* were folded by the larvae of *S. abruptalis* and they remained within the fold and fed on the green matter.

***Spilosoma obliqua* Wlk.**

O. tenuiflorum was found severely affected by the larvae of *S. obliqua* and they voraciously consumed the leaves of tulsi plant leaving only the midrib (Mathur, 1962).

Mathur (1962) found out that the leaves of *Withania somnifera* L. were severely affected by the larvae of *S. obliqua*. Nayar *et al.*, (1976) reported the damage by *S. obliqua* on *Cannabis sativa* L. and *M. arvensis*. Rani (2001) reported that early instar larvae caused damage to the leaves of *Solanum viarum* L. by scraping the green matter, which resulted in skeletonization and drying and the later instars fed voraciously on leaves which resulted in defoliation.

***Cyrtacanthacris tartarica* L.**

Rajan (2003) reported that the grasshopper *C. tartarica* was a minor pest of tulsi and it consumed the tender foliage and made irregular holes.

The infestation of *C. tartarica* on *Gossypium hirsutum* L. was recorded by Balakrishnan *et al.*, (2004).

***Myllocercus viridanus* Fab.**

M. viridanus was observed as a minor pest of tulsi in a survey conducted in the year 2003 in Thrissur district of Kerala. The ash weevil fed on leaves from the margins inwards (Rajan, 2003).

The ash weevil has been reported as a pest on several plant species. However, reports of its incidence on medicinal plants are limited. Rani (2001) reported that adult beetles of *M. viridanus* caused severe foliage loss of *W. somnifera* and the grubs fed on roots which resulted in the wilting and drying up of the plant.

Nezara spp.

Rajan (2003) reported *Nezara antennata* Scott., *Nezara* sp. and *Agonoscelis nubilla* Fab. as minor sucking pests of tulsi and the pests desapped the tender shoots and panicles of tulsi.

N. antennata desapped the tender foliage of *Indigofera tinctoria* L. and the infested leaves withered and dried up. (Rajan, 2003).

***Riptortus linearis* L.**

The pod bug, *R. linearis* desapped the panicle of tulsi and the nymphs and adults sucked sap from the developing tender plant parts of *I. tinctoria*, which withered later (Rajan, 2003).

Aleurodicus dispersus **Russell**

During summer season the spiralling white fly, *A. dispersus* infested tulsi leaves in small numbers (Rani, 2004).

The other medicinal plants which served as hosts of *A. dispersus* were *Ricinus communis* L. and *Datura metal* L. (Rani, 2004).

***Bemisia tabaci* Genn.**

Tulsi plants in New Delhi were found severely infested by the white fly, *B. tabaci* during the summer season (Ahlawat and Srivastava, 1998). Borges (1999) reported several crops like potato, tomato, cassava, beans, strawberry etc. as alternate hosts of *B. tabaci.*

2.1.2 Natural Enemies

Predators

The spider *Leptus* sp. (Araneae: Erythraeidae) was reported as a predator of *A. dispersus* from Tamil Nadu (Geetha, 2000). Bharpoda *et al.,* (2006) identified the spiders *Neoscona* sp. *Argiope* sp. and *Peucetia* sp. as natural enemies of pests of medicinal plant, *Emblica officinalis* Geartn. According to Nema (2006) *Baisticus flavus* (Distant) (Hemiptera: Reduvidae) is a potential predator of *Nezara* sp. A single predator killed on an average of 15.45 host individuals.

Paragus serratus Fabr.(Diptera: Syrphidae) was reported to feed on *A. gossypii* (Dahiya *et al.,* 1988; Mani and Krishnamoorthy, 1989). Further in 1999, they observed *Chilocorus nigrita* Fab. (Coleptera: Coccinellidae) as an efficient predator of *A. dispersus.*

Parasitoids

Livingstone and Yacoob (1983) identified *Lathromeromyia* sp. (Hymenoptera: Trichogrammatidae) as an egg parasitoid of *M. globulifera.* Icuma and Hirose (1996) reported *Telenomus triptus* Nixon (Hymenoptera: Scelionidae) as an egg parasitoid of *N. antennata.*

Metaphycus mercet M. (Hymenoptera: Encyrtidae) was a primary nymphal endoparasitoid of *C. cajani* (Guerrieri and Noyes, 2000). The nymphs of *A. dispersus* were parasitized by *Encarsia* (?) *haitiensis* Dozier (Hymenoptera: Aphelinidae) (Ramani, 2000). *Encarsia guadeloupae* Viggiani is an effective parasitoid of spiralling white fly, causing about 70 to 80 per cent parasitisation (Ramani *et al,* 2002). Gelman and Gerling (2005) reported *Eretmocerus mundus* Mercet (Hymenoptera: Aphelinidae) as a parasitoid of *B. tabaci.* The parasitoid laid its eggs on the leaf underneath the host nymph. First instars hatched and penetrated the host and it parasitized four nymphal instars of *B.tabaci.*

Sharma and Borah (2004) identidfied a tachinid parasitoid *Blepharella lateralis* Macquart as a potential larval parasitoid of *S. obliqua.* It preferred late third instars to fourth instar larvae of the host.

2.2 EFFECT OF BOTANICALS AND CHEMICAL INSECTICIDES ON PESTS OF TULSI

Studies on the management of pests of tulsi are limited. The management studies of pests of tulsi affecting other crops are also reviewed here.

2.2.1 Effect of Botanicals on Pests.

Neem oil two per cent acted as a feeding inhibitor and insect growth regulator against *M. globulifera* and most botanicals were not effective on the egg stage of them, so preventive sprays were not effective (Smith, 2001).

The first report of the insecticidal property of neem seed kernel was made by Cherian and Menon (1944) who found that cold extracts of neem seed kernel was toxic to *A.gossypii.* Dhadke *et al.*, (1988) reported the effectiveness of neem oil two per cent and neem seed kernel extract five per cent in reducing the population of *A.gossypii* infesting cotton. Neem oil one per cent or pongamia oil one per cent effectively reduced the population of *A. gossypii* infesting *Plantago ovata* L. (Premsagar, 1992). *A. gossypii* infesting *O. basilicum* could be effectively controlled by the botanicals *viz.*, neem oil two per cent or pongamia oil two per cent (Chadha, 2002).

Natarajan and Sundaramurthy (1990) observed that growth and development of *B. tabaci*, a polyphagous pest was suppressed considerably by neem oil 0.50 per cent and one per cent. Price and Schuster (1991) found that the neem seed extract five per cent effectively reduced the number of *B. tabaci.* The ovicidal action of neem oil, neem seed kernel extract and neem oil + pongamia oil registered a mortality percentage of 59.27, 52.08 and 50.99 respectively on *A. dispersus* infesting mulberry. (Mariam and Chandramohan, 2000).

Singh (2002) evaluated the ovicidal effect of NSKE five per cent on eggs of *S. obliqua* infesting castor. About one fourth of the treated eggs did not hatch.

2.2.2 Effect of Chemical Pesticides on Pests.

Nair (1999) recommended the application of a systemic or contact insecticide for the control of *M.globulifera*. Rani (2001) reported that tulsi lace wing bug could be effectively controlled by the application of carbaryl 0.05 per cent or phenthoate 0.05 per cent. According to her opinion, before the application of insecticides, heavily infested leaves had to be removed. Smith (2001) suggested that contact insecticides including permethrin and carbaryl 0.05 per cent could be recommended against lace wing bug and the spray must be directed towards the underside of leaves. She also reported that acephate 0.01 per cent gave excellent control of *M.globulifera*. Chadha (2002) recommended the application of carbaryl 0.10 per cent in reducing the population of *M. globulifera* affecting *O. basilicum*.

Premsagar (1992) recommended the application of dimethoate 0.05 per cent or fenthion 0.05 per cent for controlling *A.gossypii* affecting *P. ovata*. The application of dimethoate 0.05 per cent was effective in controlling the aphids, *A.gossypii* infesting *Abelmoschus esculentus* L. (Masoodkhan *et al.*, 2001). A spray of monocrotophos 0.05 per cent or dimethoate 0.06 per cent controlled *A. gossypii* in O. *basilicum* (Chadha, 2002).

Rani (2001) reported that caterpillars of *S. obliqua*, a pest of *W.somnifera* could be controlled by methyl parathion 0.05 per cent or acephate 0.01 per cent.

The application of malathion dust 0.10 per cent or soil drenching with chlorpyriphos 0.10 per cent gave good control of the grubs of *M. viridanus* affecting roots of *W. somnifera* and the adults of ash weevil could be controlled by carbaryl 0.5 per cent or fenthion 0.05 per cent (Rani, 2001).

P. caberalis, a leaf roller of *O. basilicum* could be effectively controlled by the application of quinalphos 0.05 per cent (Chadha, 2002).

Kambrekar *et al.*, (2003) screened fifteen insecticides under laboratory conditions for their residual toxicity against *A. dispersus* on acalypha and they found out that among the insecticides, triazophos 0.06 per cent and dimethoate 0.05 per cent persisted for a longer time and recorded 75 per cent mortality.

2.2.3 Effect of Botanicals on Spider Predators.

Nandakumar and Saradamma (1996) reported that neem based pesticides were safe to spiders *viz.*, *Tetragnatha* sp. and *Oxyopes* sp. Mann and Dhaliwal (2001) evaluated the impact of a neem based pesticide, Neem Azal against the beneficial arthropods of cotton and they found that the number of spiders per plant was significantly higher upon treatment with Neem Azal compared to control. Neem formulations Neemark and Achook at 0.30 per cent were quite safe to spider *Oxyopes* spp. in tea ecosystem (Sharma and Kashyap, 2002). Studies by Thamilvel (2004) revealed that Neem Azal one per cent TS at 0.004 per cent concentration was benign to spiders *Oxyopes* sp. and *Tetragnatha* sp. in bhindi fields. The studies on the effect of neem oil two per cent and illipe oil two per cent on spiders indicated that they caused less than 50 per cent mortality when applied topically (Manu, 2005). In a study conducted by Vijayasree (2006), it was found that neem oil two per cent, illipe oil two per cent and azadirachtin 0.004 per cent sprays in a coccinia crop were safe to spiders.

2.3 DISEASES AFFECTING TULSI

2.3.1 Viral Diseases

There are only a few reports of diseases of *O.tenuiflorum*. Horvath (1981) reported the susceptibility of *Ocimum gratissimum* L. to potato virus and tobacco necrosis virus. Yellow net vein symptoms caused by a Gemini virus in tulsi was reported by Ahlawat and Srivastava (1998).

2.3.2 Fungal Diseases

Davis *et al.*, (1993) made the first report of Fusarial wilt of *O. basilicum* in California. The affected plants initially drooped down and completely wilted later. In India, leaf blight of *O. basilicum* caused by *Colletotrichum capsici* V. was observed at first by Alam and Janardhanan (1994). Gullino *et al.*, (1995) studied the black spot of *O. basilicum* incited by *Colletotrichum gloeosporiodes* Penz. in Italy. They reported that the lesions appeared on leaves as either circular or irregular shaped necrotic spots. Later these spots expanded and coalesced.

Materials and Methods

3. MATERIALS AND METHODS

Survey was conducted in five locations of Thiruvananthapuram district to identify the pests and their natural enemies associated with tulsi (*Ocimum tenuiflorum* L.) for a period of one year from July 2005 to June 2006. A field experiment was also conducted during the same period at the Instructional Farm, College of Agriculture, Vellayani to evolve an eco-friendly management strategy against the pests of tulsi.

3.1 SEASONAL OCCURRENCE OF PESTS AND THEIR NATURAL ENEMIES OF TULSI

The locations selected for conducting the survey were Perumpazhuthoor, Parasuvaikkal, Poojapura, Peroorkada and Vellayani of Thiruvananthapuram district. The observations were recorded at monthly intervals for one year. Population count of pests, their damage and the natural enemies of the pests were recorded during the period of study. The unidentified pests and natural enemies were collected and preserved in seventy per cent alcohol for identification.

The weather parameters *viz.*, maximum and minimum temperature, relative humidity, rainfall and number of rainy days recorded during June 2005 to June 2006 are given in Appendix I.

3.1.1 Pests, Their Nature of Damage and Symptoms

During the period of survey the pests associated with tulsi, their nature of damage and symptoms produced on infested parts were recorded.

3.1.2 Natural Enemies of Pests of Tulsi

Both the predators and parasitoids associated with the pests of tulsi were recorded during the course of study. The parasitized stages of pests were collected from field and kept in polyethene covers for emergence. The emerged adult parasitoid species were identified.

3.1.3 Assessment of the Population of the Pest and Their Extent of Damage

The population of the pests and their damage were recorded from twenty observational plants in each of the five locations. The methodology adopted for recording the population of pests and damage caused by them on tulsi is given below.

Pest	Methodology adopted for recording	
	Population	Extent of damage
Lace wing bug *Monanthia globulifera* W.	Number of nymphs and adults per plant	No: of leaves damaged out of 400 leaves per plant
Aphids *Aphis gossypii* Glover	Number of aphids per plant	Inflorescence damage: No: of inflorescences infested out of eight inflorescences per plant and No: of branches infested out of five branches per plant.

Pest	Methodology adopted for recording	
	Population	Extent of damage
Mealy bug *Icerya seychellarum* (Westw.) *Icerya aegyptiacum* (Dgl.)	Number of mealy bugs per plant	No: of branches infested out of five branches per plant.
Scale insect *Ceroplastodes cajani* Maskell	Number of scale insects per plant	No: of branches infested out of five branches per plant.
Spittle bug *Phymatostetha deschampes* L.	Number of spittle bugs per plant	No: of branches infested out of five branches per plant.

In addition to these pests, the pests present in very low population on tulsi plants were also observed and recorded.

3.1.4 Assessment of Population of Spiders

Count of spider predators was recorded from twenty plants selected at random from five different locations.

3.1.5 Correlation Between Weather Parameters and Population of Pests and Their Extent of Damage and Natural enemies in Tulsi

The pest population and percentage of infestation on tulsi plants during the months of observation were correlated with weather parameters of previous as well as corresponding months. The degree of association of abiotic factors on the population build up of pests and spiders and the infestation by the pests were evaluated.

3.2 FIELD EVALUATION OF BOTANICALS FOR THE MANAGEMENT OF PESTS OF TULSI AND THEIR IMPACT ON SPIDERS.

An experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani from August 2005 to March 2006 to evaluate the efficacy of botanical pesticides for the management of pests of tulsi and their safety to spiders. Tulsi seedlings were raised in polyethene covers and transplanted in the main field one month after sowing.

Experimental Design

Crop	:	Tulsi (*O. tenuiflorum*)
Design	:	RBD
Treatments	:	8
Replications	:	3
Plot size	:	3 x 2.25 m
Spacing	:	60 x 45 cm

Treatments

T1: Neem cake application (basal) @250 kg ha^{-1}+Neem seed oil two per cent

T2: Mahua (Illipe) seed oil two per cent

T3: Neem cake application (basal) @250 kg ha^{-1}+Neem Seed Kernel Extract (NSKE) five per cent

T4: Pongamia oil two per cent

T5: Tobacco decoction

T6: Azadirachtin 0.004 per cent

T7: Dimethoate 0.05 per cent (Chemical check)

T8: Control

The treatments were applied need based.

Preparation of botanicals

Neem oil- soap emulsion

Five grams of bar soap shavings were dissolved in 980 ml of water. To this solution, 20 ml of neem oil was added and agitated to obtain two per cent emulsion.

Illipe oil- soap emulsion

Five grams of bar soap shavings were dissolved in 980 ml of water. To this soap solution, 20 ml of illipe oil was added and agitated to obtain two per cent emulsion.

Neem Seed Kernel Extract (NSKE)

Neem seeds were dried and 50 g of kernel was weighed out after removing the seed coat. The kernels were crushed well, tied in a piece of cloth and immersed in one litre of water for 12 hours to get five per cent neem seed kernel extract.

Pongamia oil- soap emulsion.

Five grams of bar soap shavings were dissolved in 980 ml of water. To this soap solution, 20 ml of pongamia oil was added and stirred well to obtain two per cent emulsion.

Tobacco decoction.

100 g of tobacco waste was chopped and steeped in 900 ml of water for 24 hours and then filtered. Twenty grams of bar soap shavings were dissolved in 100 ml luke warm water separately. The soap solution was added to the tobacco filtrate under violent agitation. This stock solution was diluted six times before spraying.

Azadirachtin 0.004 per cent.

Four ml of Neem Azal 1 per cent TS was added to one litre of water to obtain a solution containing azadirachtin 0.004 percent.

Dimethoate 0.05 per cent

1.67 ml of Rogor 30 EC was mixed in one litre water to get a solution containing dimethoate 0.05 per cent.

Control

Water spray was applied to all the control plots.

Labelling

Ten plants were selected at random from each plot and labelled for recording observations.

3.2.1 Assessment of Pest Population and Intensity of Damage

The population of the pests and extent of damage were recorded from the labelled plants on the first, third, seventh and fifteenth day after each spraying.

M.globulifera

The total number of lacewing bugs present in observational plants was counted and recorded. The mean population per plant was worked out. The extent of damage caused by lacewing bug was recorded by counting the number of newly infested leaves after the application of botanicals and the mean number of infested leaves was worked out.

A.gossypii

The total number of aphids present in the labelled plants was recorded and the mean population per plant was worked out.

Icerya spp.

The mean population of mealy bugs per plant was worked out after counting the total number of mealy bugs present in the labelled plants.

C. cajani

The total number of scale insects in the labelled plants was counted and the mean population per plant was recorded.

P. deschampes

The mean population of spittle bugs per plant was worked out after counting the total number *P. deschampes* present in the labelled plants.

3.2.2 Assessment of Population of Spiders

The count of spiders was recorded one, three, seven and fifteen days after spraying from the labelled plants in each treatment plot. The mean population per plant was worked out.

3.3 ASSESSMENT OF PATHOGENICITY OF DISEASE CAUSING ORGANISMS OF TULSI

3.3.1 Pathogenicity of Virus

Tulsi plants showing chlorotic symptoms were collected from the field and the extract was taken from young leaves showing chlorotic symptoms. One part of the leaf tissue was homogenized with one part of 0.01 molar, phosphate buffer (pH7.2) using a chilled mortar and pestle. The homogenate was maintained in an icebox and immediately used for inoculation. Inoculation was done on primary leaves of tulsi. Prior to inoculation, leaves were uniformly dusted with celite powder. Using a moistened pestle, the inoculum was applied gently on the upper surface of the fully opened leaves of the test plants. The surface was rinsed off after five minutes with distilled water using a wash bottle. Inoculation was also done on local lesion host, *Chenopodium amaranticolor* L. The plants were kept for seven days for the development of symptoms.

3.3.2 Pathogenicity of Fungus

Leaves showing symptoms of leaf spot were collected from the field. The affected parts were cut into bits and surface sterilized with 0.10 per cent mercuric chloride. The surface sterilized parts were then washed twice with sterile water and were placed on Potato Dextrose Agar medium (PDA) for initiating fungal growth. Pathogenicity and confirmation of disease were tested by inoculating mycelia on fresh healthy leaves. These were observed for the development of symptoms.

3.4 YIELD

The yield in terms of weight of marketable leaves collected from each plot was recorded. The benefit: cost ratio was also calculated.

Statistical Analysis

Data obtained from the five locations and from the field experiment were tabulated and subjected to analysis of variance (Panse and Sukhatme, 1985).

Results

4. RESULTS

Identification and seasonal occurrence of various pests attacking tulsi, their nature and extent of damage, natural enemies of pests of tulsi, relationship between the weather parameters and incidence of the pests and the results obtained from the field experiment to find out the effect of botanicals on the population of the pests and their extent of damage and on spiders are presented in this chapter.

4.1 OCCURRENCE OF PESTS AND NATURAL ENEMIES OF TULSI

Survey was conducted from July 2005 to June 2006 at monthly intervals in five different locations *viz.*, Perumpazhuthoor, Parasuvaikkal, Poojapura, Peroorkada and Vellayani of Thiruvananthapuram district to assess the seasonal occurrence of the pests of tulsi and the extent of infestation caused by them. The natural enemies of the pests were also recorded.

The pests observed in tulsi are presented in Table 1.

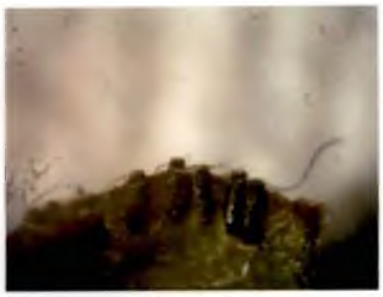
4.1.1 Description of Pests, Their Nature of Damage and Symptoms.

***Monanthia globulifera* W.**

The adult was a small black bug with hyaline wings. A pair of hollow trellised globular outgrowths was present dorsally on the thorax. It was curved inwards as hollow globules from the outer margins of the thorax. Both the nymphs and adults were very slow movers. They were always found in groups of six to eight. Eggs were black and barrel shaped (Plate 1). A batch of eight to ten eggs was thrust within the veins or edges of leaves, which appeared as small black spots. The operculum was clearly visible under magnification (10x). The incubation period

Table 1. Pests of tulsi recorded from various locations in Thiruvananthapuram district.

Order	Family	Common name	Scientific name
Hemiptera	Tingidae	Lace wing bug	*Monanthia globulifera* W.
	Aphididae	Aphids	*Aphis gossypii* Glover
	Margaroridae	Seychelles fluted scale Egyptian fluted scale	*Icerya seychellarum* (Westw.) *Icerya aegyptiacum* (Dgl.)
	Coccidae	Scale insect	*Ceroplastodes cajani* Maskell
	Cercopidae	Spittle bug	*Phymatostetha deschampes* L.
	Membracidae	Cow bug	*Anchon pilosum* L.
	Lygaeidae	Lygaeid bug	*Lygaeus* sp.
	Pentatomidae	Pentatomid bug	*Agonoscelis* sp.
	Alydidae	Rice bug	*Leptocorisa acuta* (Thunb.)
	Pseudococcidae	Root mealy bug	*Pseudococcus* sp.
Orthoptera	Acrididae	Short horned grasshopper	*Cyrtacanthacris* sp.
Lepidoptera	Pyralidae	Leaf roller	*Syngamia abruptalis* Wlk.
	Geometridae	Citraka looper	*Anisephyra ocularia* Fab.
Hymenoptera	Formicidae	Black ant	*Lasius* sp.
		Red ant	*Solenopsis* sp.

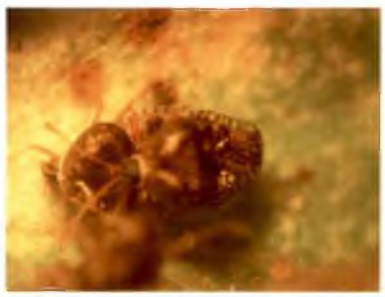


Egg

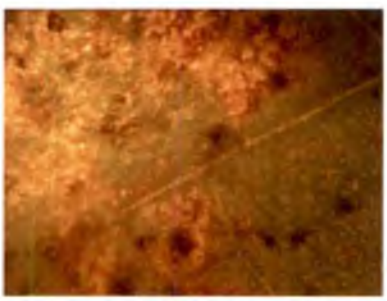
Nymph

Adult (dorsal view)

Adult (lateral view)



Mating adults



Damaged leaf

Leaf with excreta

Damaged plant

Plate 1. Different stages of *M.globulifera* and its symptoms on tulsi.

ranged from three to four days. The nymphs were flat, black and spinous. They congregated on the leaf surface in a circular pattern. The nymphs underwent five instars to reach adulthood.

The nymphs and adults sucked sap from leaves of all ages. The excreta of insects appeared as black oily spots and contaminated the leaves. Feeding punctures on leaf surface appeared as light pink and white spots due to the removal of chlorophyll. As a result of feeding, leaves curled, withered and finally dried up (Plate 1).

***Aphis gossypii* Glover**

The nymphs and adults were green coloured, with a pair of cornicles on the dorsal side of abdomen. Copious amount of honeydew was also secreted by the aphids.

During the flowering stage of the crop, aphids congregated and desapped the inflorescences. The infested inflorescences lost their turgidity and drooped down. Aphids also attacked tender branches. Due to desapping, the whole plant dried up. Ants were always associated with aphids, which made harvesting difficult (Plate 2).

***Icerya aegyptiacum* (Dgl.)**

The adult was a white coloured giant mealy bug with tubular outgrowths all over the body (Plate 2). In the initial stages of attack, only three to four adults were seen on a branch. Later they completely covered the affected portion. Due to desapping, the branches dried up.

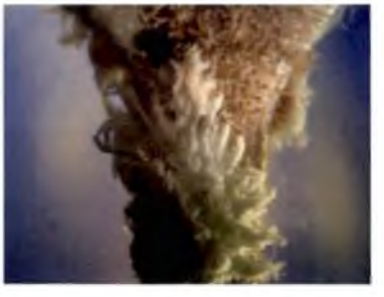
***Icerya seychellarum* (Westw.)**

The adult was a white coloured giant mealy bug with a prominent yellow ring on the dorsal side (Plate 2). The attack resulted in drying up of branches.

A.gossypii on inflorescence

A.gossypii on stem

Aphid damaged plant



I.aegyptiacum

I.seychellarum

Plate 2. Major pests of tulsi and their symptoms

***Ceroplastodes cajani* Maskell**

The adults were white in colour and they appeared as small round beads on the branches. The light pink coloured crawlers were seen on the tender branches. Due to the pink colour of the tender stem, the insects were not easily recognizable. Both nymphs and adults were vigorous sap feeders. Severely infested plants dried up quickly (Plate 3).

***Phymatostetha deschampes* L.**

The adult was an orange and black coloured spittle bug. They were found in large numbers on tulsi plants. The nymphs were enclosed in spittle like froth on the branches of the plant. This imparted an obnoxious appearance to the crop. The early nymphal instars were light cream in colour and the quantity of secretion was less. Later instars were black and white in colour and were hidden in copious amounts of froth (Plate 3). The froth like secretion was sticky in consistency and it protected the nymphs from predators. Desapping by nymphs and adults resulted in drying up of branches.

***Anchon pilosum* L.**

The black and grey coloured adults were occasionally found feeding on tender branches of tulsi. The adult had a hood like pronotum extending backwards (Plate 4). Eight to ten insects were found in a line feeding on plant juice. Honey dew secretion was noticed. Ants were associated with cow bugs which made harvesting difficult.

***Lygaeus* sp.**

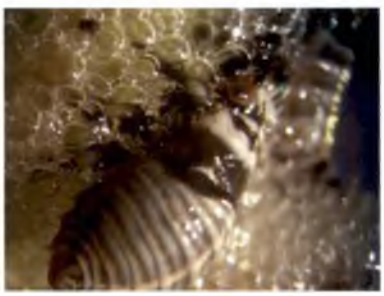
A lygaeid bug was observed in tulsi during evening hours. The bugs had two cream coloured round spots, one on the middle of each hemelytron (Plate 4). During evening hours, the bugs were not easily recognizable due to the similarity in colour

C.cajani (crawlers)

C.cajani (adult)

Tulsi plant damaged by scale insects

P.deschampes (nymph)



P.deschampes (nymph)

P.deschampes (adult)

Tulsi plant with spittle mass

Plate 3. Major pests of tulsi and their symptoms

A.pilosum

Lygaeus sp.

Agonoscelis sp.

L.acuta

Pseudococcus sp.

Cyrtacanthacris sp.

Plate 4. Minor pests of tulsi

between the bugs and dried up inflorescence. It was found infesting matured seeds of tulsi. The insect inserted its stylets into the matured seeds and sucked the sap.

***Agonoscelis* sp.**

A medium sized, cream coloured pentatomid bug infested the tender inflorescences of tulsi (Plate 4). These were short fliers and when disturbed they flew to nearby inflorescences. At later stages of the crop, the pest was not observed.

***Leptocorisa acuta* (Thunb.)**

The olive brown coloured adults of rice bug were found in large numbers on tulsi plants at the milky stage of the seeds (Plate 4). Since the seeds of tulsi were enclosed in small bracts, the damage was not clearly visible. A close perusal revealed the feeding by the insertion of the stylets into the seeds.

***Pseudococcus* sp.**

A white coloured medium sized mealy bug was found infesting the tap root as well as root hairs of tulsi (Plate 4). Due to desapping, the infested plants dried up eventually.

***Cyrtacanthacris* sp.**

A medium sized grey coloured short horned grasshopper was found feeding voraciously on tulsi leaves. (Plate 4).

S.abruptalis (larva)

S.abruptalis (pupa)

S.abruptalis (adult)

A.ocularia (larva)

A.ocularia (pupa)

Lasius sp.

Solenopsis sp.

Plate 5. Minor pests of tulsi.

***Syngamia abruptalis* Wlk.**

Adults were yellow coloured with black wavy markings on the wings. Pink coloured larvae remain inside the rolls and fed from within. Pupation took place inside the leaf rolls (Plate 5). Pupal period lasted for about three to four days. Individual leaves of tulsi were rolled inwards by the larvae of leaf roller.

***Anisephyra ocularia* Fab.**

The looper caterpillar was dark brown in colour and was rarely observed in tulsi. Pupation took place in leaf rolls (Plate 5). The caterpillar was found feeding on tulsi leaves.

***Lasius* sp.**

Small black coloured ants fed on the pollen grains and seeds of tulsi (Plate 5). They carried aphids from one plant to another.

***Solenopsis* sp.**

Small red coloured ants were also found feeding on pollen grains and seeds of tulsi (Plate 5). They also served as carriers of aphids.

4.1.2 Natural Enemies of Pests of Tulsi.

The list of natural enemies of the pests observed during the course of study is given in Table 2. Both predators and parasites were found associated with the pests of tulsi.

Table 2. Natural Enemies of pests of tulsi recorded from various locations in Thiruvananthapuram district.

Order	Common name	Scientific name.	Family
PREDATORS			
Araneae	Orb web spider	*Argiope* sp.	Araneidae
	Foliage hunter	*Cheiracanthium* sp.	Miturgidae
	Jumping spiders	*Hyllus semicupreus* (Simon) *Hyllus* sp.	Salticidae
	Orb web weaver	*Neoscona mukherjee* Tikader	Araneidae
	Lynx spiders	*Oxyopes birmanicus* Thorell *Oxopes shweta* Tikader	Oxyopidae
	Green orb spider	*Peucetia viridana* (Stoliczka)	Oxyopidae
	Long jawed spider	*Tetragnatha* sp.	Tetragnathidae
Diptera	Hover fly	*Paragus serratus* Fabr.	Syrphidae
PARASITOIDS			
Hymenoptera	Larval parasitoid	*Cotesia* sp.	Braconidae
	Adult parasitoid	*Coccophagus tschirchii* (Madhihassan)	Aphelinidae

***Argiope* sp.**

Orb web spider was commonly seen in tulsi fields. The abdomen was oval shaped with black and yellow coloured lines (Plate 6). It spun a circular web in between two plants.

***Cheiracanthium* sp.**

The adults were cream coloured with long front legs (Plate 6). The spiders curled up green leaves and waited inside the curl to catch prey. They mainly consumed aphids.

***Hyllus semicupreus* (Simon)**

The jumping spiders had robust cephalothorax and an abdomen both of which are about the same size (Plate 6). The eyes were arranged in two rows. They were found on leaves and were able to jump a long distance to seize soft bodied insects.

***Neoscona mukherjee* (Tikader)**

Neoscona sp. was a web building spider, which spun a small circular web among tulsi plants and rested outside the web (Plate 6). Insects trapped in the web were quickly killed by the spider.

***Oxyopes birmanicus* Thorell**

Brightly coloured lynx spiders with pointed abdomen were very common in tulsi plants. *O .birmanicus* had an orange coloured abdomen with black lines on the sides of the abdomen (Plate 6).

Argiope sp.

Cheiracanthium sp.

Hyllus sp.

N.mukherjee

O.birmanicus

O.shwetha

P.viridana

Tetragnatha sp.

Plate 6. Various species of spiders observed on tulsi plant

***Oxyopes shweta* Tikader**

O. shweta had an either green or black coloured abdomen with white diagonal stripes. The lynx spiders had long legs armed with prominent spines (Plate 6). They were extremely agile and efficient predators.

***Peucetia viridana* (Stoliczka)**

This species was a bright green orb spider with white markings on the abdomen and pinkish tinge on spiny legs (Plate 6). Large females carrying egg masses on the underside of the abdomen were observed at the centre of silken webs. They were efficient predators of aphids and other soft bodied insects.

***Tetragnatha* sp.**

The long jawed spiders were very common in tulsi plants. The adults had straw coloured body with prominent jaws and long legs (Plate 6). They were efficient predators of soft bodied insects *viz*., aphids and mealy bugs.

***Paragus serratus* Fabr.**

The syrphid was a black coloured medium sized fly. Light cream or green coloured apodous larvae were commonly found in aphid colonies (Plate 7). They consumed nymphs and adults of aphids. When removed from the plant, they became very sluggish. The puparium was also cream in colour. It was pointed at one end and bulged at the other and glued to the branches of tulsi plants (Plate 7).

P. serratus was attacked by a pupal parasitoid belonging to the family Encyrtidae (Plate 7). Due to its infestation, yellow coloured puparium turned black in colour. Within two days after discoloration, parasitoids emerged. The parasitoids were very small wasps with transparent wings (Plate 7).

P.serratus (maggot)

P.serratus (pupa)

P.serratus (adult)

Parasitoid of *P.serratus*

Plate 7. Different stages of *P.serratus* and its parasitoid

Parasitised larva of leaf folder

Bracon sp.

Parasitised adults of *C.cajani*

C.tschirchii

Plate 8. Parasitised pests of tulsi and their parasitoids

***Cotesia* sp.**

Cotesia sp. was an important larval parasitoid of leaf roller (Plate 8). The tiny black wasp laid eggs inside the host larva. When the development of the parasitoid was complete, the grubs came out of the host larvae and spun white cocoons outside the host body. The parasitized larvae became lethargic, ceased feeding and finally died (Plate 8).

***Coccophagus tschirchii* (Madhihassan)**

The aphelinid wasp was a parasitoid of tulsi wax scale, *C. cajani* (Plate 8). The unparasitised scale insect was white in colour, but due to parasitisation it turned black. Black wasps emerged from the parasitized scale insects through small holes made on the host body (Plate 8).

4.1.3 Population and Extent of Damage of Pests of Tulsi

The population and extent of damage caused by major pests of tulsi recorded during the survey are presented in Tables 3 to 13.

M.globulifera

The results of the survey on the seasonal incidence of *M.globulifera* on tulsi in five different locations of Thiruvananthapuram district are presented in Table 3.

Table 3. Seasonal occurrence of *M.globulifera* in tulsi at five locations of Thiruvananthapuram district.

Month	Mean number of lace wing bugs per plant at different locations					Mean
	Locations					
	Perumpazhuthoor	Parasuvaikkal	Poojapura	Peroorkada	Vellayani	
July 2005	125.35	123.50	136.10	129.70	132.20	129.37
August 2005	116.70	124.60	135.80	132.50	133.90	128.70
September 2005	108.65	126.40	132.20	132.45	131.20	126.18
October 2005	94.05	102.50	74.40	89.75	103.35	92.81
November 2005	86.35	92.40	74.20	87.60	91.15	86.34
December 2005	73.85	81.50	71.35	76.70	82.95	77.27
January 2006	92.20	95.90	104.75	102.05	112.45	101.47
February 2006	102.10	108.20	116.60	113.45	123.15	112.70
March 2006	137.75	129.55	127.10	123.25	128.95	129.32
April 2006	141.85	129.70	134.95	135.75	136.60	135.77
May 2006	118.30	109.60	121.45	117.35	124.35	118.21
June 2006	101.50	103.25	90.45	106.80	115.90	114.38
Mean	108.22	110.50	109.95	116.78	118.01	

CD (0.05)
Location : 6.883
Month : 10.662
M x L : 23.841

Perumpazhuthoor

The lowest population of *M.globulifera* was recorded during December 2005 (73.85) per plant and the highest during April 2006 (141.85). The population during December 2005 was on par with the population recorded during October 2005 (94.05), November 2005 (86.35) and January 2006 (92.20) and that of April 2006 was statistically similar with the population of July 2005 (125.35), March 2006 (137.75) and May 2006 (118.30). After September 2005, the population declined and reached the lowest by December 2005. From January 2006 onwards, the population increased and attained the highest level of 141.85 during April 2006. Compared to April 2006, the population of lacewing bug was lesser during May 2006 (118.30) and June 2006 (101.50).

Parasuvaikkal

A similar trend in population fluctuation was observed at Parasuvaikkal also. The population of *M.globulifera* ranged from 81.50 to 129.70 during the different months from July 2005 to June 2006. During September 2005, a higher population of 126.40 was recorded which was on par with the population during March 2006 (129.55) and April 2006 (129.70). From November 2005 onwards the population started declining and recorded the lowest count during December 2005 (81.50) which was statistically similar to the population recorded during October 2005 (102.50), November 2005 (92.40) and January 2006 (95.90). The population started increasing from January 2006 onwards and it was comparatively high during the summer months of March and April 2006.

Poojapura.

The population of *M.globulifera* ranged from 71.35 to 136.10 during the different months from July 2005 to June 2006. The population was the highest in July 2005 (136.10) which was statistically on par with the population recorded during August 2005 (135.80), September 2005 (132.20) and April 2006 (134.95). Afterwards, the population declined and by December 2005, the population was 71.35. The population began to rise

from January 2006 and was high during April 2006. Lower population of lacewing bug was recorded during May 2006 (121.45) and June 2006 (90.45).

Peroorkada

The lowest population of *M.globulifera* was recorded in December 2006 (76.70) and the highest in April 2006 (135.75). The population was high during September 2005 (132.45) and was statistically similar to that recorded in August 2005 (132.50) and April 2006 (135.75), March 2006 (123.25) and then decreased during the successive months. From January 2006 onwards, the population increased and reached the highest (135.75) during April 2006. Compared to April 2006, there was a fall in the population in May 2006 (117.35) and June 2006 (106.80).

Vellayani

The population of *M.globulifera* ranged from 82.95 to 136.60 among the various months from July 2005 to June 2006. A mean population of 131.20 was recorded in September 2005. From October 2005 onwards, the population began to decrease and reached the lowest (82.95) by December 2005 which was on par with that recorded in October 2005 (103.35) and November 2005 (91.15). The population increased after January 2006 and the highest count was recorded in April 2006 (136.60) which was statistically on par with July 2005 (132.20), August 2005 (133.90), September 2005 (131.20), February 2006 (123.15) and March 2006 (128.95). The population of lacewing bug slightly decreased in May 2006 and June 2006.

The average number of *M.globulifera* per plant in the five locations was compared. Among the five locations, the highest mean population of lacewing bug was recorded in Vellayani (118.01), which was statistically same as that obtained in Peroorkada (116.78). The lowest mean population per plant was recorded at Perumpazhuthoor (108.22) which was on par with the population at Poojapura (109.95) and Parasuvaikkal (110.59).

A comparison of the population of *M.globulifera* during the different months revealed the following. The highest population was recorded in April 2006 (135.77) and lowest in December 2005 (77.27). The mean population during April 2006 was statistically on par with the population during July 2005 (129.37), March 2006 (129.32), August 2005 (128.70) and September 2005 (126.18). Compared to December 2005 the population was higher during July 2005, August 2005 and September 2005. From October 2005 onwards, the population started decreasing and reached the lowest level in December 2005 which was statistically similar to the population recorded during November 2005 (86.34). From January 2006 onwards, the population of lacewing bug started increasing and reached the highest level in April 2006. During May 2006 and June 2006, compared to the other months, the population was lesser (118.21 and 114.38 respectively).

The results of the survey on the percentage of tulsi leaves damaged by *M.globulifera* are presented in Table 4.

Perumpazhuthoor

The percentage of tulsi leaves damaged by *M.globulifera* ranged from 34.62 to 75.84 during the different months from July 2005 to June 2006. During April 2006 the highest damage of 75.84 per cent was recorded, which was on par with September 2005 (70.78 per cent) August 2005 (66.56 per cent), March 2006 (69.05 per cent), and May 2006 (74.79 per cent). The damage recorded during July 2005 (55.40 per cent), October 2005 (55.54 per cent), February 2006 (54.42 per cent) and June 2006 (61.20 per cent) were statistically similar.

Peroorkada

The percentage of tulsi leaves damaged by *M.globulifera* ranged from 42.50 (November 2005) to 74.78 (April 2006) during the different months from July 2005 to

Table 4. Extent of leaves damaged by *M.globulifera* in tulsi at five locations of Thiruvananthapuram district (%).

Month	Mean number of leaves damaged per plant at different locations					Mean
	Locations					
	Perumpazhuthoor	Parasuvaikkal	Poojapura	Peroorkada	Vellayani	
July 2005	55.40 (7.51)	40.68 (6.46)	28.84 (5.46)	50.05 (7.15)	35.34 (6.03)	41.51 (6.52)
August 2005	66.56 (8.22)	43.86 (6.69)	40.53 (6.44)	58.95 (7.74)	47.80 (6.98)	51.13 (7.22)
September 2005	70.78 (8.47)	56.37 (7.57)	42.93 (6.63)	63.14 (8.01)	50.19 (7.15)	56.61 (7.59)
October 2005	55.54 (7.52)	37.06 (6.17)	33.24 (5.85)	44.69 (6.76)	43.34 (6.68)	42.43 (6.59)
November 2005	44.48 (6.74)	31.06 (5.66)	29.68 (5.54)	42.50 (6.59)	33.09 (5.84)	35.97 (6.08)
December 2005	34.62 (5.97)	29.38 (5.51)	28.73 (5.45)	46.90 (6.92)	28.39 (5.42)	33.34 (5.86)
January 2006	47.97 (6.99)	38.12 (6.25)	39.24 (6.34)	58.97 (7.74)	55.11 (7.36)	47.16 (6.94)
February 2006	54.42 (7.44)	46.29 (6.87)	43.18 (6.65)	59.59 (7.78)	60.61 (7.85)	52.58 (7.32)
March 2006	69.05 (8.37)	64.75 (8.11)	54.95 (7.48)	68.80 (8.35)	68.65 (8.35)	65.09 (8.13)
April 2006	75.84 (8.77)	67.48 (8.27)	53.58 (7.38)	74.78 (8.70)	93.43 (9.72)	72.44 (8.57)
May 2006	74.79 (8.71)	66.96 (8.24)	57.54 (7.65)	72.62 (8.58)	73.76 (8.65)	69.05 (8.37)
June 2006	61.20 (7.88)	53.57 (7.39)	50.10 (7.15)	50.10 (7.15)	59.01 (7.75)	54.65 (7.46)
Mean	58.44 (7.71)	47.16 (6.94)	41.25 (6.50)	57.06 (7.62)	52.44 (7.31)	

CD (0.05)
Location : 0.126
Month : 0.195
M x L : 0.436
Figures in parentheses are $\sqrt{x+1}$ transformed values.

June 2006. The damage during October 2005 (44.69 per cent) and December 2005 (46.90 per cent) were on par with that in November 2005 and damage in May 2006 (72.62) was on par with that in April 2006. The infestation during August 2005 (58.95 per cent), January 2006 (58.97 per cent) and February 2006 (59.59 per cent) were on par.

Vellayani

Significantly lower percentage damage was recorded during December 2005 (28.39 per cent) and November 2005 (33.09 per cent) and the higher in April 2006 (93.43). During August 2005 and September 2005 higher percentage damage of 47.80 and 50.19 were recorded and were on par. The damage in October 2005 (43.34 per cent) was statistically similar to that in August 2005 (47.80 per cent). The tulsi leaves damaged during January 2006 (53.11 per cent), February 2006 (60.61 per cent) and June 2006 (59.01 per cent) were statistically similar. The damage during March 2006 (68.65 per cent) and May 2006 (73.76 per cent) were also statistically similar.

A comparison of the extent of damage of tulsi leaves in five different locations was made. The highest damage was recorded at Perumpazhuthoor (58.44) which was statistically on par with the percentage damage at Peroorkada (57.06). At Vellayani, the percentage damage was 52.44. The mean percentage damage at Parasuvaikkal and Poojapura were 47.16 and 41.25 respectively.

Perusal of the data on the percentage of tulsi leaves damaged by *M.globulifera* during the different months from July 2005 to June 2006 revealed the following. Statistically lowest damage was recorded in December 2005 (33.34 per cent) followed by November 2005 (35.97 per cent). The highest damage was noted in April 2006 (72.44 per cent). During September 2005, damage recorded was 56.61 per cent which was statistically on par with the damage in June 2006 (54.65 per cent). From October 2005 onwards the extent of damage started decreasing and reached the lowest in December 2005. The damage recorded during October 2005 (42.43 per cent) and July 2005 (41.51 per cent) were on par. The infestation during August 2005 (51.13 per cent) and February 2006 (52.58 per

cent) were statistically similar. The extent of damage during January 2006, March 2006 and May 2006 were 47.16 per cent, 65.09 per cent and 69.05 per cent respectively.

A.gossypii

The results of the survey on the seasonal incidence of *A.gossypii* in five different locations of Thiruvananthapuram district are given in Table 5.

Perumpazhuthoor

The mean population of *A.gossypii* ranged from 12.35 to 32.80 per plant during the different months from August 2005 to June 2006. During August 2005 and September 2005, the mean population was comparatively higher than the succeeding months (25.20 and 29.85 respectively). From October 2005 onwards the population started declining and reached 12.65 per plant in December 2005 which was on par with the population recorded during June 2006 (12.35). From February 2006 onwards, the population increased and reached a peak in May 2006 (32.80). This was statistically similar to the population in September 2005 (29.85), March 2006 (31.90) and April 2006 (32.70). A drastic reduction in the population of aphids was recorded during June 2006 (12.35) and no aphid was observed during July 2005.

Parasuvaikkal

The mean population of *A.gossypii* ranged from 17.05 to 35.55 per plant during the different months from August 2005 to June 2006. During September 2005, mean population of aphids recorded was 25.05 per plant and this was on par with the population recorded in January 2006 (25.00) and February 2006 (28.95). From October 2005 onwards, population decreased and recorded only 17.25 aphids per plant during December 2005. From January 2006 onwards, population increased and reached a peak during March 2006 (35.55 per plant). Compared to the other months, a higher mean

Table 5. Seasonal occurrence of *A.gossypii* in tulsi at five locations of Thiruvananthapuram district.

Month	Mean number of aphids per plant at different locations					Mean
	Locations					
	Perumpazhuthoor	Parasuvaikkal	Poojapura	Peroorkada	Vellayani	
July 2005	0.00	0.00	0.00	0.00	0.00	0.00
August 2005	25.20	19.95	18.00	31.50	22.30	23.39
September 2005	29.85	25.05	22.60	32.00	25.80	27.06
October 2005	19.05	20.60	18.55	19.30	20.65	19.63
November 2005	15.50	17.60	17.25	15.25	18.35	16.79
December 2005	12.65	17.25	21.70	16.25	19.25	17.32
January 2006	18.55	25.00	25.60	23.85	24.40	23.48
February 2006	25.70	28.95	26.85	30.50	32.45	28.89
March 2006	31.90	35.55	36.65	36.15	37.30	35.51
April 2006	32.70	33.60	30.65	29.60	29.85	31.28
May 2006	32.80	29.85	22.65	24.55	24.80	26.93
June 2006	12.35	17.05	15.70	17.65	10.25	14.60
Mean	21.35	22.54	21.31	23.05	22.12	

CD (0.05)
Location : 1.213
Month : 1.879
M x L : 4.202

population of 33.60 and 29.85 per plant was recorded during April and May 2006 respectively and were on par. The lowest incidence was recorded during June 2006 (17.05).

Poojapura.

The population of *A.gossypii* on tulsi ranged from 15.70 to 36.65 per plant during the different months from August 2005 to June 2006. The lowest mean population was recorded during June 2006 (15.70) which was statistically similar with August 2005 (18.00), October 2005 (18.55) and November 2005 (17.25) and the highest during March 2006. Compared to July 2005, the mean population of aphids during August and September 2005 was high (18.00 and 22.60 respectively).

Peroorkada.

The population of *A.gossypii* ranged from 15.25 to 36.15 per plant during the different months from August 2005 to June 2006. The lowest population of aphids was recorded during November 2005 (15.25) which was on par with October 2005 (19.30) and December 2005 (16.25). The highest population was recorded during March 2006 (36.15). During August 2005 and September 2005, statistically similar population of 31.50 and 32.00 per plant was recorded respectively. From October 2005 onwards, population started decreasing till December 2005. During January 2006, the mean population of 23.85 per plant was observed. The population was comparatively higher during the months of February 2006, March 2006 and April 2006, among which March 2006 recorded the highest value (36.15). The mean population of aphids during the months of May 2006 and June 2006 were 24.55 and 17.65 respectively.

Vellayani

The population of *A.gossypii* on tulsi ranged from 10.25 to 37.30 per plant during the different months from August 2005 to June 2006. The population recorded during the

months of August 2005 (22.30), September 2005 (25.80), and January 2006 (24.40) and that during October 2005 (20.65), November 2005 (18.35) and December 2005 (19.25) were statistically similar. Thereafter, population gained momentum and recorded the highest in March 2006 (37.30). Afterwards, population gradually decreased and reached the lowest during June 2006 (10.25).

Among the five different locations, the mean population of *A.gossypii* per tulsi plant was the highest at Peroorkada (23.05). This was statistically on par with the mean population at Parasuvaikkal (22.54) and Vellayani (22.12). The lowest mean population was recorded at Poojapura (21.31), which was statistically similar with the value recorded at Perumpazhathoor (21.35).

The month wise comparison of the population of *A.gossypii* during different months indicated that the lowest population was recorded during June 2006 (14.60), which was statistically on par with the mean population of December 2005 (17.32) and November 2005 (16.79). During the month of August 2005 mean population of aphids was 23.39, which was statistically on par with the population of January 2006 (23.48). The population during the months of September 2005 and February 2006 were 27.06 and 28.89, and showed statistical similarity. The highest mean population of *A.gossypii* was observed in March 2006 (35.51). Compared to the other months, April 2006 also recorded a higher population of aphids (31.28).

The results of the survey on the extent of infestation of inflorescences of tulsi by *A.gossypii* are presented in Table 6.

The tulsi plants were in the inflorescence stage from August 2005 to November 2005.

Table 6.Extent of inflorescences damaged by *A.gossypii* in tulsi at five locations of Thiruvananthapuram district(%).

Month	Locations					Mean
	Perumpazhuthoor	Parasuvaikkal	Poojapura	Peroorkada	Vellayani	
July 2005	0 .00 (1.00)	0 .00 (1.00)	0 .00 (1.00)	0 .00 (1.00)	0 .00 (1.00)	0 .00 (1.00)
August 2005	65.99 (8.19)	55.53 (7.52)	71.02 (8.49)	44.65 (6.76)	52.94 (7.34)	57.68 (7.66)
September 2005	76.65 (8.81)	76.83 (8.82)	60.30 (7.83)	63.74 (8.05)	56.65 (7.59)	66.57 (8.22)
October 2005	37.97 (6.24)	41.89 (6.55)	46.32 (6.87)	38.22 (6.26)	37.89 (6.24)	40.34 (6.43)
November 2005	33.21 (5.85)	34.99 (5.99)	36.62 (6.13)	39.74 (6.38)	25.07 (5.11)	38.69 (5.89)
Mean	35.24 (6.02)	34.64 (5.97)	35.84 (6.07)	31.38 (5.69)	28.81 (5.46)	

CD (0.05)
Location : 0.348
Month : 0.348
M x L : 0.779
Figures in parentheses are $\sqrt{x+1}$ transformed values

Perumpazhuthoor.

The percentage damage recorded during the month of August 2005 was (65.99). The highest damage was observed during September 2005 (76.65 per cent). During October 2005 and November 2005, the damage gradually decreased and recorded only 37.97 per cent and 33.21 per cent respectively and was statistically similar.

Parasuvaikkal.

The trend in the intensity of damage was similar to that of Perumpazhuthoor. The statistically lowest percentage damage was recorded during November 2005 (34.99) and highest in September 2005 (76.83).

Poojapura

During the month of August 2005, 71.02 per cent of the inflorescences were infested by *A.gossypii*. Afterwards, the intensity of damage started declining and reached the lowest in November 2005 (36.62 per cent) which was statistically similar to October 2005 (46.32 per cent).

Peroorkada.

When compared to other locations, the damage of inflorescence by *A.gossypii* differed during the various months. The lowest was recorded during October 2005 (38.22 per cent) and the damage intensity slightly increased during November 2005 (39.74 per cent) and both were on par. The maximum intensity of damage was during September 2005 (63.74 per cent).

Vellayani

During August 2005, 52.94 per cent of the inflorescences were infested by *A.gossypii*. It increased slightly during September 2005 (56.65 per cent) and both were on par. From October 2005 onwards, the intensity decreased and recorded the lowest during November 2005 (25.07 per cent).

The percentage of tulsi inflorescences infested by aphids at five locations was compared. The highest percentage damage was recorded at Poojapura (35.84). The mean percentage infestation recorded at Perumpazhuthoor and Parasuvaikkal were 35.24 and 34.64 respectively. The values recorded at these three locations were statistically similar. The lowest percentage of infestation was recorded at Vellayani (28.81). At Peroorkada 31.38 per cent of inflorescences were infested.

Among the four months from August 2005 to November 2005 of inflorescence damage, the highest percentage damage was recorded in September 2005 (66.57 per cent) and the lowest in November 2005 (38.69 per cent). The mean infestation during the months of August 2005 and October 2005 were 57.68 per cent and 40.34 per cent respectively.

The results of the survey on the infestation of tulsi branches by *A.gossypii* from December 2005 to June 2006 are given in Table 7.

Perumpazhuthoor

During December 2005, 52.12 per cent branches were infested by *A.gossypii*. Comparatively more damage occurred during January 2006 and February 2006 (72.84 and 62.67 respectively) and was on par. The damage was the maximum in March 2006 (79.55 per cent) which was statistically similar to the damage occurred in January 2006 (72.84 per cent). The level of infestation was lesser from April 2006 onwards and reached the lowest in June 2006 (20.05 per cent).

Table 7. Extent of branches damaged by *A.gossypii* in tulsi at five locations of Thiruvananthapuram district (%).

Month	Locations					Mean
	Perumpazhuthoor	Parasuvaikkal	Poojapura	Peroorkada	Vellayani	
December 2005	52.12 (7.28)	76.31 (8.79)	55.66 (7.53)	70.72 (8.47)	67.29 (8.26)	63.96 98.06)
January 2006	72.84 (8.59)	57.58 (7.65)	56.09 (7.57)	71.52 (8.52)	64.46 (8.09)	64.29 (8.08)
February 2006	62.67 (7.97)	60.89 (7.87)	47.82 (6.98)	68.79 (8.35)	69.79 (8.41)	61.73 (7.92)
March 2006	79.55 (8.97)	85.38 (9.29)	73.44 (8.63)	82.98 (9.16)	68.50 (8.34)	77.85 (8.88)
April 2006	61.33 (7.89)	57.47 (7.65)	75.82 (8.76)	55.18 (7.49)	70.80 (8.47)	63.80 (8.05)
May 2006	50.46 (7.17)	47.76 (6.98)	36.33 (6.11)	44.45 (6.74)	40.20 (6.42)	43.62 (6.68)
June 2006	20.05 (4.58)	31.57 (5.71)	29.17 (5.49)	26.25 (5.22)	24.20 (5.02)	26.04 (5.2)
Mean	55.10 (7.49)	58.44 (7.71)	52.14 7.29)	58.44 (7.71)	56.30 (7.57)	

CD (0.05)
Location : 0.359
Month : 0.426
M x L : 0.952
Figures in parentheses are $\sqrt{x+1}$ transformed values

Parasuvaikkal

The lowest percentage damage of tulsi branches was recorded during June 2006 (31.57). During March 2006 the damage was the highest (85.38 per cent) which was on par with the damage in December 2005 (76.31 per cent). From April 2006, onwards the intensity of damage started declining.

Poojapura.

During February 2006, the percentage of tulsi branches infested was 47.82. The infestation was very high during March 2006 and April 2006 and was statistically similar (73.44 and 75.82 respectively). During May 2006, a lower percentage damage of 36.33 was recorded. The lowest percentage of infested branches was recorded during June 2006 (29.17) and this was on par with the damage recorded in May 2006 (36.33).

Peroorkada.

During December 2005 and January 2006 the percentage of tulsi branches infested by aphids were 70.72 and 71.52 respectively which were statistically similar to that in February 2006 (68.79). The highest infestation occurred in March 2006 (82.98 per cent). Afterwards, the intensity declined and the lowest damage was observed in June 2006 (26.25 per cent).

Vellayani.

The lowest percentage of branches infested by *A.gossypii* was recorded during June 2006 (24.20) and the highest during April 2006 (70.80). The damage recorded during December 2005, January 2006, February 2006 and March 2006 were 67.29, 64.46, 69.79 and 68.50 per cent respectively and were on par with that in April 2006. From December 2005 to March 2006, the percentage of branches damaged was greater than sixty .

The infestation of tulsi branches by aphids at five different locations was compared. The highest percentage damage (58.44) was recorded at Parasuvaikkal and Peroorkada. This was statistically similar with the damage recorded at Vellayani (56.30) and Perumpazhuthoor (55.10). Among the five locations, the lowest intensity of damage was recorded at Poojapura (52.14).

The extent of infestation of tulsi branches during December 2005 to June 2006 was also compared. The highest percentage of infestation was recorded during March 2006 (77.85) and the lowest during June 2006 (26.04). The level of infestation during the months of December 2005 (63.96), January 2006 (64.29), February 2006 (61.73) and April 2006 (63.80) were statistically on par.

Icerya spp.

The results of the survey on the seasonal incidence of *Icerya* spp. on tulsi are given in Table 8.

Perumpazhuthoor

The lowest population of *Icerya* spp. was recorded in September 2005 (2.13) which was statistically similar to the population recorded during the months of July 2005 (3.10), August 2005 (3.02), October 2005 (2.25), January 2006 (3.49) and February 2006 (4.11). During November 2005 and December 2005 the *Icerya* spp. was completely absent in the surveyed plants. From March 2006 onwards population increased and recorded the peak value in May 2006 (9.24) which was on par with the population in June 2006 (8.89).

Table 8. Seasonal occurrence of *Icerya* spp. in tulsi at five locations of Thiruvananthapuram district.

Month	Mean number of mealy bugs per plant at different locations					Mean
	Locations					
	Perumpazhuthoor	Parasuvaikkal	Poojapura	Peroorkada	Vellayani	
July 2005	3.10 (2.02)	0 .00 (1.00)	0 .00 (1.00)	0 .00 (1.00)	2.47(1.86)	0.88 (1.37)
August 2005	3.02 (2.00)	0 .00 (1.00)	0 .00 (1.00)	0 .00 (1.00)	2.68(1.92)	0.90 (1.38)
September 2005	2.13 (1.77)	0.60 (1.23)	0 .00 (1.00)	3.83 (2.19)	2.67(1.92)	1.72 (1.65)
October 2005	2.25 (1.80)	0 .00 (1.00)	0 .00 (1.00)	2.77 (1.94)	1.06(1.44)	1.07 (1.44)
November 2005	0 .00 (1.00)	0 .00 (1.00)	0 .00 (1.00)	0 .00 (1.00)	0.95(1.39)	0.17 (1.08)
December 2005	0 .00 (1.00)	0 .00 (1.00)	0 .00 (1.00)	0 .00 (1.00)	1.73(1.65)	0.28 (1.13)
January 2006	3.49 (2.12)	0 .00 (1.00)	0 .00 (1.00)	3.93 (2.22)	4.86(2.42)	2.06 (1.75)
February 2006	4.11 (2.26)	3.94 (2.22)	3.01 (2.00)	3.24 (2.06)	6.53(2.74)	4.11 (2.26)
March 2006	5.85 (2.62)	5.42 (2.53)	4.31 (2.30)	3.17 (2.04)	5.79(2.61)	4.86 (2.42)
April 2006	6.82 (2.79)	2.35 (1.83)	3.61 (2.15)	2.41 (1.85)	4.77(2.40)	3.88 (2.21)
May 2006	9.24 (3.20)	6.98 (2.83)	4.95 (2.44)	2.81 (1.95)	6.96(2.81)	6.02 (2.65)
June 2006	8.89 (3.15)	5.26 (2.50)	5.06 (2.46)	3.28 (2.07)	5.78(2.60)	5.55 (2.56)
Mean	3.57(2.14)	1.53(1.59)	1.37 (1.54)	1.86 (1.69)	3.62(2.15)	

CD (0.05
Location : 0.007
Month : 0.116
M x L : 0.260
Figures in parentheses are $\sqrt{x+1}$ transformed values

Parasuvaikkal

During the first seven months of survey, *Icerya* spp. was recorded only in September 2005 (0.60). However, from February 2006 onwards, comparatively higher population was recorded. The population recorded during February 2006, March 2006, April 2006, May 2006 and June 2006 were 3.94, 5.42, 2.35, 6.98 and 5.26 respectively.

Poojapura.

The trend in the distribution of *Icerya* spp. was same as that of Parasuvaikkal as they were completely absent in the field from July 2005 to January 2006. During February 2006, March 2006 and April 2006, the population of *Icerya* spp. recorded was 3.01, 4.31 and 3.61 respectively. The highest population was recorded in June 2006 (5.06) which was on par with the population in May 2006 (4.95).

Peroorkada.

During April 2006, the population of *Icerya* spp. was the lowest (2.41). This was followed by October 2005 (2.77) and May 2006 (2.81) and were statistically on par. The population in January 2006 (3.93) was the highest which was on par with the population in September 2005 (3.83). During February 2006 (3.24), March 2006 (3.17) and June (3.28), the population was statistically similar.

Vellayani.

The population of *Icerya* spp. recorded during the months of July 2005, August 2005 and September 2005 were 2.47, 2.68 and 2.67 respectively and were on par. The lowest population was recorded in November 2005 (0.95) which was statistically similar with that recorded in October 2005 (1.06) and December 2005 (1.73). The population was the highest in May 2006 (6.96) and was statistically on par with February 2006 (6.53), March 2006 (5.79) and June 2006 (5.78).

On comparing the different locations it was found that the significantly higher population of *Icerya* spp. was recorded in Vellayani (3.62) and the lower in Poojapura (1.37). The population recorded in Parasuvaikkal, Peroorkada and Perumpazhuthoor were 1.53, 1.86 and 3.57.

Collation of the occurrence of *Icerya* spp. during the different months from July 2005 to June 2006 revealed that the population was comparatively low during the first seven months of survey. The lowest population was recorded in November 2005 (0.17) which was on par with that in December 2005 (0.28). This was followed by July 2005 and August 2005 (0.88 and 0.90 respectively) and was on par. The highest population was observed in May 2006 (6.02). The population during October 2005, September 2005, January 2006, February 2006, March 2006, April 2006 and June 2006 were 1.07, 1.72, 2.06, 4.11, 4.86, 3.88 and 5.55 respectively.

The results of the observation of damage caused by *Icerya* spp. on tulsi plants from July 2005 to June 2006 are presented in Table 9.

Perumpazhuthoor

During July 2005, 32.09 per cent of tulsi branches were infested by *Icerya* spp. This was statistically on par with the infestation occurred in August 2005 (29.56) and September 2005 (25.91). The plants were free from infestation during November 2005 and December 2005. The damage recorded during January 2006 (43.78), February 2006 (41.66) and March 2006 (47.63) were statistically similar. The highest damage was recorded in May 2006 (57.84) which was on par with April 2006 (56.42) and June 2006 (49.91).

Table 9. Extent of branches damaged by *Icerya* spp. in tulsi at five locations of Thiruvananthapuram district (%).

Month	Locations					Mean
	Perumpazhuthoor	Parasuvaikkal	Poojapura	Peroorkada	Vellayani	
July 2005	32.09 (5.75)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	28.13 (5.39)	7.01 (2.83)
August 2005	29.56 (5.53)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	26.19 (5.21)	6.56 (2.75)
September 2005	25.91 (5.19)	3.69 (2.17)	0.00 (1.00)	39.94 (6.39)	26.64 (5.26)	15.00 (4.00)
October 2005	27.05 (5.29)	0.00 (1.00)	0.00 (1.00)	33.64 (5.88)	10.12 (3.33)	9.89 (3.30)
November 2005	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	8.39 (3.06)	0.99 (1.41)
December 2005	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	21.25 (4.71)	2.03 (1.74)
January 2006	43.78 (6.69)	0.00 (1.00)	0.00 (1.00)	32.58 (5.79)	60.33 (7.83)	18.89 (4.46)
February 2006	41.66 (6.53)	32.14 (5.76)	39.31 (6.35)	33.64 (5.88)	71.04 (8.49)	42.56 (6.60)
March 2006	47.63 (6.97)	49.90 (7.13)	51.36 (7.24)	27.96 (5.38)	62.11 (7.94)	47.02 (6.93)
April 2006	56.42 (7.58)	28.94 (5.47)	45.11 (6.79)	27.96 (5.38)	55.93 (7.54)	41.90 (6.55)
May 2006	57.84 (7.67)	49.90 (7.13)	68.27 (8.32)	37.04 (6.17)	72.37 (8.56)	56.30 (7.57)
June 2006	49.91 (7.13)	49.29 (7.09)	52.95 (7.34)	31.77 (5.72)	52.99 (7.35)	47.02 (6.93)
Mean	29.58 (5.53)	10.49 (3.39)	11.82 (3.58)	16.81 (4.22)	37.81 (6.23)	

CD (0.05)
Location : 0.259
Month : 0.401
M x L : 0.896
Figures in parentheses are $\sqrt{x+1}$ transformed values

Parasuvaikkal

The infestation by *Icerya* spp. was absent during the months from July 2005 to June 2006 except during September 2005 (3.69 per cent). During February 2006. 32.14 per cent branches were infested which was on par with the damage in April 2006 (28.94 per cent). The highest damage was noticed during March 2006 and May 2006 (49.90 per cent) which was statistically on par with June 2006 (49.29 per cent).

Poojapura

The tulsi plants observed were free from the infestation of *Icerya* spp. from July 2005 to January 2006. During February 2006 and April 2006, 39.31 per cent and 45.11 per cent branches were infested by *Icerya* spp. respectively and were on par. More than fifty percentage branches were damaged during March 2006 (51.36) and June 2006 (52.95) and were statistically similar.

Peroorkada

The infestation of *Icerya* spp. noticed during September 2005 (39.94 per cent) and October 2005 (33.64 per cent) were statistically similar. During the next two months, no infestation was noticed. 32.58 per cent and 33.64 per cent branches were damaged during January 2006 and February 2006 respectively which was on par with the damage in March 2006 (27.96 per cent), April 2006 (27.96 per cent) and June 2006(31.77 per cent).

Vellayani.

During July 2005, August 2005 and September 2005 28.13 per cent, 26.19 per cent and 26.64 per cent branches were infested by *Icerya* spp. and were on par. The lowest infestation was recorded in November 2005 (8.39 per cent) which was statistically

similar to the infestation in October 2005 (10.12 per cent). It increased from December 2005 (21.25 per cent) onwards and recorded 60.33 per cent infestation during January 2006 which was statistically similar to that in March 2006 (62.11), April 2006 (55.93) and June 2006 (52.99). The highest infestation was recorded during May 2006 (72.37) which was on par with the infestation in February 2006 (71.04).

Perusal of the data on the percentage of branches infested by *Icerya* spp. in different locations revealed the following. The lowest infestation was recorded at Parasuvaikkal (10.49) which was on par with the infestation recorded at Poojapura (11.82). The infestation at Peroorkada was 16.81 per cent and Perumpazhuthoor, 29.58 per cent. The highest infestation was recorded at Vellayani (37.81).

Among the different months from July 2005 to June 2006, the highest percentage infestation of tulsi branches infested by *Icerya* spp. was recorded during May 2006 (56.30) and the lowest during November 2005 (0.99) which was on par with the damage in December 2005 (2.03). The damage during August 2005 (6.56 per cent) and July 2005 (7.01 per cent) were on par. This was followed by the infestation during the months of October 2005 (9.89), September 2005 (15.00) and January 2006 (18.89). The infestation during February 2006, March 2006, April 2006, and June 2006 were 42.56 per cent, 47.02 per cent and 41.90 per cent respectively.

C.cajani

The results of the survey on the seasonal occurrence of *C.cajani* on tulsi are presented in Table10.

Out of the five locations, infestation by *C.cajani* was completely absent in Perumpazhuthoor and Poojapura during the entire period of survey.

Table 10. Seasonal occurrence of *C.cajani* in tulsi at five locations of Thiruvananthapuram district.

Month	Mean number of scale insects per plant at different locations					Mean
	Locations					
	Perumpazhuthoor	Parasuvaikkal	Poojapura	Peroorkada	Vellayani	
July 2005	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
August 2005	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	14.81 (3.98)	2.61 (1.90)
September 2005	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	22.59 (4.86)	4.19 (2.28)
October 2005	0.00 (1.00)	21.66 (4.76)	0.00 (1.00)	0.00 (1.00)	27.13 (5.30)	12.54 (3.68)
November 2005	0.00 (1.00)	25.63 (5.16)	0.00 (1.00)	0.00 (1.00)	27.15 (5.31)	13.59 (3.82)
December 2005	0.00 (1.00)	28.08 (5.39)	0.00 (1.00)	18.79 (4.45)	19.47 (4.52)	21.85 (4.78)
January 2006	0.00 (1.00)	31.06 (5.66)	0.00 (1.00)	23.18 (4.91)	25.48 (5.14)	26.46 (5.24)
February 2006	0.00 (1.00)	28.20 (5.40)	0.00 (1.00)	21.93 (4.78)	28.13 (5.39)	25.94 (5.19)
March 2006	0.00 (1.00)	28.93 (5.77)	0.00 (1.00)	27.12 (5.30)	28.83 (5.46)	28.27 (5.41)
April 2006	0.00 (1.00)	31.62 (5.71)	0.00 (1.00)	32.88 (5.82)	47.68 (6.97)	37.07 (6.17)
May 2006	0.00 (1.00)	29.89 (5.55)	0.00 (1.00)	26.48 (5.24)	29.62 (5.53)	28.70 (5.45)
June 2006	0.00 (1.00)	28.31 (5.41)	0.00 (1.00)	22.82 (4.88)	24.64 (5.06)	25.21 (5.12)
Mean	0.00 (1.00)	17.40 (4.29)	0.00 (1.00)	10.36 (3.37)	22.72 (4.87)	

CD (0.05)
Location : 0.129
Month : 0.258
M x L : 0.448
Figures in parentheses are $\sqrt{x+1}$ transformed values

Parasuvaikkal.

The scale insects were present on tulsi plants from October 2005 onwards. During October 2005, mean population of *C.cajani* per plant was 21.66 which were on par with the population in November 2005 (25.63). Afterwards, the population gradually increased and a greater population of 31.06 was observed during January 2006. During February 2006 and March 2006, the values were 28.20 and 28.93 respectively and they were on par with the highest population noted during April 2006 (31.62).

Peroorkada

Scale insects were completely absent in this location from July 2005 to November 2005. The lowest population of 18.79 scale insects per plant was recorded during December 2005 which had statistical similarity with the population during February 2006 (21.93). From December 2005 onwards, population showed an increasing trend. The highest population was recorded during April 2006 (32.88).

Vellayani.

The lowest population of *C.cajani* was observed in August 2005 (14.81). After that, the population showed an increasing trend till November 2005. During December 2005 and June 2006 significantly lower population of 19.47 and 24.64 were recorded and were on par. Again the population increased and recorded the highest count during April 2006 (47.68).

Comparison of the population of scale insects in the three locations revealed the following facts. Significantly higher population was noted at Vellayani (22.72) and lower at Peroorkada (10.36). At Parasuvaikkal, the mean population recorded was 17.40.

The distribution of scale insects among the different months from July 2005 to June 2006 was compared. During July 2005, they were completely absent in all the locations. From August 2005 onwards, the population showed an increasing trend. The population recorded during January 2006, February 2006 and June 2006 were 26.46, 25.94 and 25.21 were statistically on par. The population per plant was the highest (37.07) during April 2006.

The results of the survey on the extent of infestation caused by *C.cajani* on tulsi plants are given in Table 11.

Parasuvaikkal

The infestation by scale insects was not observed from July 2005 to September 2005. During October 2005, 69.28 per cent of the branches were infested. The infestation decreased during November 2005 (44.69 per cent) and December 2005 (39.18 per cent) and was statistically similar. From January 2006 onwards, the extent of damage was higher till April 2006. The highest infestation occurred during March 2006 (76.62 per cent) which had statistical similarity with the damage recorded in February 2006 (73.25 per cent) and April 2006 (71.87 per cent). During May 2006 and June 2006, the percentage of branches infested was 45.93 and 35.83 respectively and were on par.

Peroorkada

Pest infestation was not observed from July 2005 to November 2005. Only 36.43 per cent of tulsi branches were infested in December 2005 which was on par with the damage in May 2006 (44.45) and June 2006 (42.95). From January 2006 to April 2006, more than fifty per cent of the branches were damaged, and the highest damage occurred during February 2006 (75.82). The percentage of branches damaged during April 2006 (72.73) was statistically on par with that of February 2006. The infestation showed diminishing trend in May 2006 (44.45) and June 2006 (42.95) compared to the other months.

Table 11. Extent of branches damaged by *C.cajani* in tulsi at five locations of Thiruvananthapuram district (%).

Month	Locations					Mean
	Perumpazhuthoor	Parasuvaikkal	Poojapura	Peroorkada	Vellayani	
July 2005	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
August 2005	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	28.97 (5.47)	5.20 (2.49)
September 2005	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	55.23 (7.49)	9.05 (3.17)
October 2005	0.00 (1.00)	69.28 (8.38)	0.00 (1.00)	0.00 (1.00)	39.44 (6.35)	26.56 (5.25)
November 2005	0.00 (1.00)	44.69 (6.75)	0.00 (1.00)	0.00 (1.00)	43.23 (6.65)	22.04 (4.80)
December 2005	0.00 (1.00)	39.18 (6.34)	0.00 (1.00)	36.43 (6.12)	39.18 (6.34)	38.31 (6.27)
January 2006	0.00 (1.00)	64.31 (8.08)	0.00 (1.00)	61.89 (7.93)	63.01 (8.00)	63.00 (8.00)
February 2006	0.00 (1.00)	73.25 (8.62)	0.00 (1.00)	75.82 (8.76)	73.94 (8.65)	74.34 (8.68)
March 2006	0.00 (1.00)	76.62 (8.8)	0.00 (1.00)	69.63 (8.40)	55.82 (7.54)	67.06 (8.25)
April 2006	0.00 (1.00)	71.87 (8.53)	0.00 (1.00)	72.73 (8.58)	60.45 (7.83)	68.22 (8.32)
May 2006	0.00 (1.00)	45.93 (6.85)	0.00 (1.00)	44.45 (6.74)	52.34 (7.30)	47.58 (6.97)
June 2006	0.00 (1.00)	35.83 (6.07)	0.00 (1.00)	42.95 (6.62)	57.47 (7.65)	44.97 (6.78)
Mean	0.00 (1.00)	34.40 (5.95)	0.00 (1.00)	22.52 (4.85)	43.76 (6.69)	

CD (0.05)
Location : 0.239
Month : 0.478
M x L : 0.828
Figures in parentheses are $\sqrt{x+1}$ transformed values

Vellayani

The scale insect infestation was not observed during July 2005. From August 2005 onwards, infestation by *C.cajani* increased and during September 2005, 55.23 per cent infestation was recorded. The infestation during March 2006 (55.82 per cent), April 2006 (60.45 per cent), May 2006 (52.34 per cent) and June 2006 (57.47 per cent) were on par with September 2005. Less than fifty per cent branches were infested by scale insects from October 2005 to December 2005. During January 2006, 63.01 per cent of the branches were infested. The highest infestation occurred during February 2006 (73.94 per cent).

The percentage of branches of tulsi infested by scale insects at the three different locations *viz.*, Parasuvaikkal, Peroorkada and Vellayani were collated. The highest infestation was recorded at Vellayani (43.76) and lowest at Peroorkada (22.52). At Parasuvaikkal, percentage of branches infested was 34.40.

The percentage of branches infested by scale insects during the different months was compared. The percentage of branches infested during the months of February 2006 (74.34), March 2006 (67.06) and April 2006 (68.22) was statistically on par. Only 5.20 per cent of the branches were infested during August 2005. After that, infestation increased and higher levels were observed during the summer months. Compared to the previous months, damage during May and June 2006 was lesser (47.58 and 44.97 per cent respectively) and were on par.

P.deschampes

The results of the survey on the seasonal incidence of *P.deschampes* on tulsi are presented in Table 12.

During the period of survey, the tulsi plants in the locations, Perumpazhuthoor and Parasuvaikkal were free from the infestation of spittle bug.

Table 12. Seasonal occurrence of *P.deschampes* in tulsi at five locations of Thiruvananthapuram district

Month	Mean number of spittle bugs per plant at different locations					Mean
	Locations					
	Perumpazhuthoor	Parasuvaikkal	Poojapura	Peroorkada	Vellayani	
July 2005	0.00 (1.00)	0.00 (1.00)	3.21(2.05)	2.86 (1.96)	6.43 (2.73)	2.25 (2.25)
August 2005	0.00 (1.00)	0.00 (1.00)	3.24 (2.06)	3.41 (2.09)	5.23 (2.49)	3.93 (2.22)
September 2005	0.00 (1.00)	0.00 (1.00)	4.38 (2.32)	3.16 (2.04)	4.62 (2.37)	4.02 (2.24)
October 2005	0.00 (1.00)	0.00 (1.00)	3.13 (2.03)	3.85 (2.20)	4.36 (2.32)	3.75 (2.18)
November 2005	0.00 (1.00)	0.00 (1.00)	3.67 (2.16)	5.28 (2.51)	3.52 (2.13)	4.11 (2.26)
December 2005	0.00 (1.00)	0.00 (1.00)	3.71 (2.17)	4.23 (2.28)	3.65 (2.15)	3.88 (2.21)
January 2006	0.00 (1.00)	0.00 (1.00)	4.49 (2.35)	3.93 (2.22)	3.64 (2.16)	4.02 (2.24)
February 2006	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
March 2006	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
April 2006	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
May 2006	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
June 2006	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
Mean	0.00 (1.00)	0.00 (1.00)	1.82 (1.68)	1.86 (1.69)	2.17 (1.78)	

CD (0.05)
Location : 0.061
Month : 0.122
M x L : 0.211
Figures in parentheses are $\sqrt{x+1}$ transformed values

Poojapura

During the period of survey from July 2005 to June 2006 *P.deschampes* were observed in the field only for a period of seven months from July 2005 to January 2006. The population ranged from 3.13 to 4.49 per plant during the different months. The population showed an increasing trend from July 2005 onwards and during September 2005, a higher mean population of 4.38 insects per plant was recorded. During October 2005, population showed a slight decrease (3.13) and then increased in the succeeding months. The highest population was observed in January 2006 (4.49). The population recorded during the different months except January 2006 was statistically similar.

Peroorkada

During July 2005, a mean population of 2.86 was observed which was on par with the population in August 2005 (3.41) and September 2005 (3.16). The population increased during the succeeding months and the highest population was recorded in November 2005 (5.28). From December 2005 onwards, it again decreased and during January 2006, a population of 3.93 per plant was observed. From February 2006 onwards, spittle bug was completely absent.

Vellayani

The highest population was recorded during July 2005 (6.43). After that, the population showed a diminishing trend and reached the lowest level during November 2005 (3.52). During December 2005 and January 2006, the mean population per plant was 3.65 and 3.64 respectively and was on par with the population recorded during November 2005.

The population of spittle bug at the three different locations *viz.*, Poojapura, Peroorkada and Vellayani were compared. The highest population was noted at Vellayani

(2.17). The population at Peroorkada and Poojapura were 1.86 and 1.82 respectively and they were statistically on par.

Collation of the mean population of spittle bug per tulsi plants during the different months from July 2005 to January 2006 revealed the following. The population was the highest during November 2005 (4.11) which was on par with August 2005 (3.93), September 2005 (4.02), December 2005 (3.88) and January 2006 (4.02). During September 2005 and January 2006, similar population (4.02) was recorded. From February 2006 onwards, *P.deschampes* were not observed on tulsi plants surveyed.

The results of the survey on the extent of infestation of tulsi plants by *P.deschampes* are presented in Table 13.

The incidence of spittle bug on tulsi plants was not observed in Perumpazhuthoor and Parasuvaikkal.

Poojapura

The percentage of branches infested ranged from 41.11 to 51.26. During July 2005, 41.11 per cent of the branches were infested which were statistically similar to the infestation recorded during October 2005 (42.85 per cent), November 2005 (42.81 per cent), December 2005 (42.44 per cent) and January 2006 (44.97 per cent). The damage increased in August 2005 (50.05 per cent) and reached a peak in September 2005 (51.26 per cent) and both were on par. From October 2005 onwards, the infestation decreased and 42.44 per cent of the branches were infested. A slight increase in infestation occurred during January 2006 (44.97).

Peroorkada

During July 2005 and August 2005, 31.77 per cent and 29.17 per cent of the branches were infested respectively and was statistically similar with the damage

Table 13. Extent of branches damaged by *P.deschampes* in tulsi at five locations of Thiruvananthapuram district (%).

Month	Locations					Mean
	Perumpazhuthoor	Parasuvaikkal	Poojapura	Peroorkada	Vellayani	
July 2005	0.00 (1.00)	0.00 (1.00)	41.11 (6.48)	31.77 (5.72)	52.12 (7.29)	41.25 (6.50)
August 2005	0.00 (1.00)	0.00 (1.00)	50.05 (7.15)	29.17 (5.49)	45.97 (6.85)	41.12 (6.49)
September 2005	0.00 (1.00)	0.00 (1.00)	51.26 (7.23)	35.44 (6.03)	41.38 (6.51)	42.43 (6.59)
October 2005	0.00 (1.00)	0.00 (1.00)	42.85 (6.62)	40.70 (6.48)	40.20 (6.42)	41.12 (6.49)
November 2005	0.00 (1.00)	0.00 (1.00)	42.81 (6.61)	55.82 (7.54)	38.78 (6.31)	45.51 (6.82)
December 2005	0.00 (1.00)	0.00 (1.00)	42.44 (6.59)	44.83 (6.77)	37.42 (6.19)	41.51 (6.52)
January 2006	0.00 (1.00)	0.00 (1.00)	44.97 (6.78)	51.31 (7.23)	44.97 (6.78)	47.02 (6.93)
February 2006	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
March 2006	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
April 2006	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
May 2006	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
June 2006	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
Mean	0.00 (1.00)	0.00 (1.00)	18.09 (4.37)	16.56 (4.19)	17.32 (4.28)	

CD (0.05)
Location : N.S
Month : 0.435
M x L : 0.754
Figures in parentheses are $\sqrt{x+1}$ transformed values

recorded in September 2005 (35.44 per cent). From September 2005 onwards, the damage increased and peaked during November 2005 (55.82 per cent). During January 2006 also, a higher level of infestation (51.31) was recorded which was on par with the infestation in November 2005.

Vellayani

The infestation varied from 37.42 per cent to 52.12 per cent during the different months from July 2005 to January 2006. From August 2005 onwards, the infestation decreased and the lowest infestation was recorded during December2005 (37.42). During January 2006, 44.97 per cent of branches were infested. The infestation recorded in July 2005 (52.12) was statistically higher when compared with the other months.

Perusal of the data on the extent of infestation caused by spittle bug at different locations showed that the percentage infestation that occurred at Poojapura (18.09) Vellayani (17.32) and Peroorkada (16.56) were statistically similar.

Among the different months from July 2005 to January 2006, the highest percentage infestation occurred during January 2006 (47.02) which was on par with July 2005 (41.25), September 2005 (42.43) and November 2005 (45.51). The lowest infestation occurred during the months of August 2005 and October 2005 (41.12 per cent). This was statistically on par with the percentage infestation during December 2005 (41.51).

4.1.4 Population of Spiders

The population of spiders on tulsi was surveyed at monthly intervals from July 2005 to June 2006. The results of the survey are given in Table 14.

Table 14. Seasonal occurrence of spiders in tulsi at five locations of Thiruvananthapuram district.

Month	Mean number of spiders per plant at different locations					Mean
	Locations					
	Perumpazhuthoor	Parasuvaikkal	Poojapura	Peroorkada	Vellayani	
July 2005	2.70	3.10	2.35	2.80	2.85	2.76
August 2005	2.80	3.35	3.35	3.55	3.65	3.34
September 2005	3.70	4.15	3.20	2.40	3.45	3.38
October 2005	1.65	1.90	1.55	1.55	1.70	1.67
November 2005	2.15	1.40	2.10	2.20	1.75	1.92
December 2005	1.85	1.95	2.35	2.00	1.60	1.95
January 2006	3.55	3.65	3.40	3.00	2.90	3.30
February 2006	3.45	3.85	3.75	3.50	3.35	3.58
March 2006	2.10	2.15	2.10	2.20	1.60	2.03
April 2006	2.00	2.00	1.90	2.15	3.00	2.21
May 2006	2.60	2.60	2.50	2.15	2.05	2.38
June 2006	2.00	2.20	2.55	2.50	1.80	2.21
Mean	2.55	2.69	2.59	2.50	2.48	

CD (0.05)
Location : 0.196
Month : 0.304
M x L : 0.679

Perumpazhuthoor

The population of spiders on tulsi was the highest during September 2005 (3.70) which was statistically on par with the population recorded in January 2006 (3.55) and February 2006 (3.45) and the lowest in October 2005 (1.65) which was on par with that in December 2005 (1.85). From March 2006 onwards, the population decreased and recorded a lower count of 2.00 per plant during June 2006.

Parasuvaikkal

The population of spiders ranged from 1.40 to 4.15 per plant during the different months from July 2005 to June 2006. The lowest count was recorded during November 2005 which was on par with the population in October 2005 (1.90) and December 2005 (1.95) and the highest during September 2005 (4.15). The population of spiders during the months of August 2005 (3.35), January 2006 (3.65) and February 2006 (3.85) were statistically similar to that of September 2005. From October 2005 to December 2005, the population count of spiders was very low. It gained momentum during the months of January 2006 and February 2006.

Poojapura

The population of spiders was the lowest during October 2005 (1.55) and the highest in February 2006 (3.75). The population of spiders in August 2005 (3.35), September 2005 (3.20) and January 2006 (3.40) were on par with February 2006. The population sharply declined during October 2005. From November 2005 onwards, population again increased and attained a peak in February 2006. The population decreased slightly after February 2006.

Peroorkada.

The spiders per tulsi plant ranged from 1.55 to 3.55 during the different months from July 2005 to June 2006. From July to September 2005. significantly higher population count of spiders was observed. The lowest count of 1.55 spiders per plant was recorded during October 2005, which was statistically similar with the population in December 2005 (2.00). From January 2006 onwards. population gradually increased and peaked during February 2006 (3.50) and from March 2006 onwards, population showed a decreasing trend.

Vellayani

The lowest count of 1.60 spiders per plant was recorded during the months of December 2005 and March 2006. During August 2005, the population attained the highest level of 3.65 spiders per plant which was statistically similar to that in September 2005 (3.45) and February 2006 (3.35). After that, the population decreased and reached the lowest in December 2005. The population was comparatively high during April 2006 (3.00). The count of spiders decreased in May 2006 (2.05) and June 2006 (1.80).

Perusal of the count of spiders of tulsi in different locations revealed the following. The lowest population count of spiders was recorded at Vellayani (2.48), which was statistically on par with the population recorded at Poojapura (2.59), Perumpazhuthoor (2.55) and Peroorkada (2.50). A significantly higher population of spiders was recorded at Parasuvaikkal (2.69).

The mean population of spiders during the different months from July 2005 to June 2006 was compared. The highest mean population was recorded during February 2006 (3.58). This was statistically similar with the mean population observed during August 2005 (3.34), September 2005 (3.38) and January 2006 (3.30). The lowest population was recorded during October 2005 (1.67) which was statistically similar to the population observed in November 2005 (1.92) and December 2005 (1.95).

4.1.5 Correlation Studies Between Weather Parameters and Incidence of Pests, Their Damage and Population of Spiders in Tulsi.

The results of the correlation studies between weather parameters of current month and incidence of pests, their damage and population of spiders are presented in Table 15.

The population of *M.globulifera* did not show significant relationship with any of the weather parameters studied. However it was positively correlated with maximum and minimum temperature, evening relative humidity and rainfall. Morning relative humidity and number of rainy days had negative correlation with population.

The percentage of leaves damaged by *M.globulifera* had significant positive correlation with maximum temperature only (r value = 0.7983). Though the relationship was not significant, the leaf damage had positive correlation with minimum temperature. The percentage of leaves damaged was negatively correlated with relative humidity, rainfall and number of rainy days, but the relationship was not significant.

The population of *A.gossypii* had non significant positive relation with maximum temperature. It had significant negative correlation with evening relative humidity (r value= -0.7753) and rainfall (r value= -0.7530). The mean aphid population was negatively correlated with minimum temperature, morning relative humidity and number of rainy days.

The percentage of branches infested by *A.gossypii* was positively correlated with maximum temperature, though the relationship was not significant. It had significant negative correlation with evening relative humidity (r value= -0.7986) and rainfall (r value= -0.8398). The percentage infestation was negatively correlated with minimum temperature, morning relative humidity and number of rainy days.

Table 15. Correlation coefficients between weather parameters of current month and pests, their extent of damage and spiders in tulsi.

Parameters	Temperature (^{0}C)		Relative Humidity RH (%)		Rainfall (mm)	Number of rainy days
	Maximum temperature	Minimum temperature	RH- morning	RH-evening		
Y1	0.2689	0.3667	-0.5833	0.0098	0.0082	-0.2029
Y2	0.7983*	0.4317	-0.5703	-0.356	-0.4515	-0.4948
Y3	0.6329	-0.0288	-0.0069	-0.7753*	-0.7530*	-0.5330
Y4	0.5978	-0.1157	-0.0111	0.7986*	-0.8398*	-0.7055
Y5	0.6329	-0.0288	-0.0069	-0.7753*	-0.7530	-0.533
Y6	0.7740	0.1357	-0.3116	-0.3529	-0.5333	-0.7829*
Y7	0.6791	0.2804	-0.3518	-0.5237	-0.631	0.3905
Y8	0.6308	0.1767	-0.2385	-0.5506	-0.7822*	-0.6475
Y9	-0.8901*	-0.3232	0.2751	0.4510	0.5891	0.6257
Y10	-0.8770*	-0.3949	0.3384	0.3895	0.4832	0.2335
Y11	-0.0097	-0.0063	-0.4227	-0.0050	-0.0865	-0.1955

* Significant at 1 per cent: 0.7079

Y1 = Mean population of *M.globulifera*
Y2 = Percentage leaves damaged by *M.globulifera*
Y3 = Mean population of *A.gossypii*
Y4 = Percentage damage by *A.gossypii*
Y5 = Mean population of *Icerya* spp.
Y6 = Percentage branches damaged by *Icerya* spp.
Y7 = Mean population of *C. cajani*
Y8 = Percentage branches damaged by *C. cajani*
Y9 = Mean population of *P.deschampes*
Y10 = Percentage branches damaged by *P.deschampes*
Y11 = Mean population of spiders per plant

The mean population of *Icerya* spp. had non significant positive correlation with maximum temperature and significant negative correlation for evening relative humidity (r value= -0.7752) and rainfall (r value= -0.7530).

The percentage of branches infested by *Icerya* spp. had significant positive correlation with maximum temperature (r value=0.7740) and significant negative correlation with number of rainy days (r value = -0.7829).

The mean population of *C.cajani* had no significant relationship with any of the weather parameters. The population had positive correlation with maximum and minimum temperature and negative correlation with relative humidity, rainfall and number of rainy days.

The percentage of branches damaged by *C.cajani* had significant negative correlation with rainfall (r value= -0.7822). The relationship was not significant with other weather parameters.

The population of *P.deschampes* was negatively correlated with maximum temperature, and the relationship was significant (r value= -0.8901). It had negative correlation with minimum temperature and positive correlation with other weather parameters. The percentage of branches damaged by *P.deschampes* showed a significant negative correlation with maximum temperature (r value= -0.8770). It had positive correlation with other weather parameters, except minimum temperature.

The population of spiders per plant was negatively correlated with all the weather parameters, but the relationship was not significant.

The results of the correlation studies between weather parameters of previous month and incidence of pests, their damage and natural enemies are presented in Table 16.

Table 16. Correlation coefficients between weather parameters of previous month and pests, their extent of damage and spiders in tulsi

Parameters	Temperature (^{0}C)		Relative Humidity RH (%)		Rainfall (mm)	Number of rainy days
	Maximum temperature	Minimum temperature	RH- morning	RH-evening		
Y1	0.3303	-0.1612	-0.1964	-0.2272	-0.1981	-0.5580
Y2	0.8256*	0.1746	0.0761	-0.6617	-0.6365	-0.7395
Y3	0.5115	-0.1910	0.2458	-0.7006	-0.7075	-0.6367
Y4	0.2970	-0.2409	0.5346	-0.5176	-0.5657	-0.4843
Y5	0.5115	-0.1910	0.2458	-0.7006	-0.7075	-0.6367
Y6	0.7683*	-0.1347	0.0077	-0.5860	-0.6945	-0.8718*
Y7	0.6840	0.2839	0.1703	-0.6381	-0.6192	-0.4997
Y8	0.5723	0.0034	0.1071	-0.5493	-0.6876	-0.6547
Y9	-0.8852*	-0.1568	0.0071	0.6361	0.7370*	0.7218*
Y10	-0.8680*	-0.1614	0.1693	0.5955	0.7064	0.7336*
Y11	-0.2043	-0.3578	0.1754	0.0097	0.6673	-0.1669

* Significant at 1 per cent: 0.7079

Y1 = Mean population of *M.globulifera*
Y2 = Percentage leaves damaged by *M.globulifera*
Y3 = Mean population of *A.gossypii*
Y4 = Percentage damage by *A.gossypii*
Y5 = Mean population of *Icerya* spp.
Y6 = Percentage branches damaged by *Icerya* spp.
Y7 = Mean population of *C. cajani*
Y8 = Percentage branches damaged by *C. cajani*
Y9 = Mean population of *P.deschampes*
Y10 = Percentage branches damaged by *P.deschampes*
Y11 = Mean population of spiders per plant

The population of *M.globulifera* did not show significant relationship with any of the weather parameters. However, it was positively correlated with maximum temperature, and negatively correlated with the other weather parameters.

The percentage of leaves damaged by *M.globulifera* had significant positive correlation with maximum temperature of previous month (r value = 0.8256) and significant negative correlation with number of rainy days (r value= -0.7395). It was positively correlated with minimum temperature and morning relative humidity. Evening relative humidity and rainfall had negative correlation with percentage of leaves damaged by *M.globulifera*.

The population of *A.gossypii* had no significant relationship with any of the weather parameters. It was positively correlated with maximum temperature and morning relative humidity and had negative correlation with other weather parameters. The percentage of branches damaged by *A.gossypii* had no significant relationship with any of the weather parameters

The mean population of *Icerya* spp. had positive correlation with maximum temperature and morning relative humidity, though the relationships were not significant. The population had non significant negative correlation with minimum temperature, evening relative humidity, rainfall and number of rainy days.

The percentage of branches damaged by *Icerya* spp. had significant positive correlation with maximum temperature (r value= 0.7683) and significant negative correlation with number of rainy days of previous month (r value= -0.8718).

The mean population of *C.cajani* had positive correlation with maximum and minimum temperature and morning relative humidity. The population had negative correlation with evening relative humidity, rainfall and number of rainy days, but the relationships were not significant.

The percentage of branches infested by *C.cajani* had no significant relationship with any of the weather parameters. However, it was positively correlated with maximum and minimum temperature and negatively correlated with morning and evening relative humidity.

The mean population of *P.deschampes* had significant positive correlation with rainfall (r value= 0.7370) and number of rainy days (r value= 0.7218). The mean population had significant negative correlation with maximum temperature of previous month (r value= -0.8852). The population was negatively correlated with minimum temperature and positively correlated with morning and evening relative humidity.

The percentage of branches damaged by *P.deschampes* had significant positive correlation with number of rainy days (r value= 0.7336) and significant negative correlation with maximum temperature(r value= -0.8680). The relationship was not significant with the other weather parameters.

The mean population of spiders per plant had no significant correlation with any of the weather parameters of the previous month. However, it was negatively correlated with maximum and minimum temperature and positively correlated with morning and evening relative humidity.

4.2 FIELD EVALUATION OF BOTANICALS FOR THE MANAGEMENT OF PESTS OF TULSI AND THEIR IMPACT ON SPIDERS

4.2.1 Effect of Botanicals on Population and Extent of Damage of Pests

M.globulifera

The population of *M.globulifera* at different intervals after the application of treatments expressed as number per plant is presented in Table 17.

Table 17. Effect of botanicals on *M.globulifera* in tulsi after spraying

Treatments	Mean number of *M.globulifera* per plant							
	Days after first spray				Days after second spray			
	1	3	7	15	1	3	7	15
Neem cake soil application @ 250 kg ha^{-1} + Neem seed oil 2%	14.27	14.27	14.50	16.57	14.10	14.13	14.97	16.70
Illipe seed oil 2%	11.20	11.40	12.20	13.37	12.17	12.27	13.07	14.57
Neem cake soil application @ 250 kg ha^{-1} +NSKE 5%	11.77	9.59	9.10	11.10	11.93	14.33	12.37	13.67
Pongamia oil 2%	9.90	5.53	6.77	7.30	9.63	9.53	0.23	11.50
Tobacco decoction	10.80	10.63	10.37	10.80	7.97	11.43	10.17	14.93
Azadirachtin 0.004%	9.27	4.57	4.40	4.43	7.07	8.89	8.47	9.30
Dimethoate 0.05%	10.37	9.47	10.23	8.63	10.33	9.63	9.80	9.77
Control	37.23	39.13	42.17	45.67	38.03	39.33	37.57	40.47
CD (0.05)	5.54	4.25	4.32	3.93	2.38	3.89	6.50	5.83

After first spraying.

One day after spraying, neem cake soil application @ 250 kg ha^{-1} + neem seed oil 2 per cent (14.27), illipe seed oil 2 per cent (11.20), neem cake soil application @ 250 kg ha^{-1} +NSKE 5 per cent (11.77), pongamia oil 2 per cent (9.90), tobacco decoction (10.80), azadirachtin 0.004 per cent (9.27) and dimethoate 0.05 per cent (10.37) reduced the population of *M.globulifera* significantly when compared to control (37.23). Among the different treatments against the lace wing bugs, the most effective one was azadirachtin 0.004 per cent followed by pongamia oil 2 per cent and both were on par.

On the third day after spraying, the population of *M.globulifera* was significantly controlled by the treatments, neem cake soil application @ 250 kg ha^{-1} + neem seed oil 2 per cent (14.27), illipe seed oil 2 per cent (11.40), neem cake soil application @ 250 kg ha^{-1} +NSKE 5 per cent (9.59), pongamia oil 2 per cent (5.53), tobacco decoction (10.63), azadirachtin 0.004 per cent (4.57) and dimethoate 0.05 per cent (9.47), when compared to control (39.19). Azadirachtin 0.004 per cent and pongamia oil 2 per cent sprays were statistically the most effective treatments.

Seven days after the application, all the treatments were significantly superior in reducing the population of lace wing bugs when compared to control (42.17). Azadirachtin 0.004 per cent (4.40) and pongamia oil 2 per cent (6.77) were most effective and both these treatments were on par. The population of *M.globulifera* recorded in plants receiving the treatments, neem cake soil application @ 250 kg ha^{-1} +NSKE 5 per cent, dimethoate 0.05 per cent, tobacco decoction and illipe seed oil were 9.10, 10.23, 10.37 and 12.20 respectively and were on par.

The population reduction observed at fifteen days after spraying showed the same trend as that of third and seventh day. All the treatments were significantly superior to control in curtailing the population of lace wing bugs. Azadirachtin 0.004 per cent recorded the lowest population of *M.globulifera* (4.43) and the second best treatment was pongamia oil 2 per cent (7.30). Both these treatments were statistically similar. The

population recorded in treatments dimethoate 0.05 per cent (8.63) tobacco decoction (10.80) and neem cake soil application @ 250 kg ha^{-1} +NSKE 5 per cent (11.10) were on par. The effect of the treatments illipe seed oil 2 per cent (13.37) and neem cake soil application @ 250 kg ha^{-1} +neem seed oil 2 per cent (16.57) in limiting the population of *M.globulifera* were statistically similar.

After second spraying

One day after second spraying all the treatments were significantly superior in reducing the population of *M.globulifera*, when compared to control (38.03). The population of lace wing bugs in the treatments, azadirachtin 0.004 per cent (7.07) and tobacco decoction (7.97) were statistically on par. Pongamia oil 2 per cent (9.63), dimethoate 0.05 per cent (10.33) and neem cake soil application @ 250 kg ha^{-1} + NSKE 5 per cent (11.93) were on par. The treatments, illipe seed oil 2 per cent (12.17) and neem cake soil application @ 250 kg ha^{-1} + neem seed oil 2 per cent (14.10) produced similar effect on the population of *M.globulifera* .

Three days after application, all the treatments were effective in controlling *M.globulifera*, when compared to control (39.33). The treatments, azadirachtin 0.004 per cent (8.89), pongamia oil 2 per cent (9.53) dimethoate 0.05 per cent (9.63), tobacco decoction (11.43) and illipe seed oil 2 per cent (12.27) were on par in suppressing the population of lace wing bugs. Neem cake soil application @ 250 kg ha^{-1} + neem seed oil 2 per cent (14.13) and neem cake soil application @ 250 kg ha^{-1} + NSKE 5 per cent (14.33) were statistically similar in their effect against *M.globulifera*.

On the seventh day after application, all the treatments effectively reduced the population of lace wing bugs compared to control (37.57). Neem cake soil application @ 250 kg ha^{-1} + neem seed oil 2 per cent (14.97), illipe seed oil 2 per cent (13.07), neem cake soil application @ 250 kg ha^{-1} + NSKE 5 per cent (12.37) pongamia oil 2 per cent (10.23), tobacco decoction (10.17), azadirachtin 0.004 per cent (8.47), dimethoate 0.05 per cent (9.80) worked a statistically similar control of lace wing bug.

Considering the effect of treatments on the fifteenth day of treatment, all of them were significantly superior in suppressing the population of *M.globulifera* compared to control (40.47). The lowest population was recorded in azadirachtin 0.004 per cent treated plots (9.30), which was on par with pongamia oil 2 per cent (11.50), illipe seed oil 2 per cent (14.57), tobacco decoction (14.93), neem cake soil application @ 250 kg ha^{-1} + NSKE 5 per cent (13.67) and dimethoate 0.05 per cent (9.77).

The effect of botanicals on the damage caused by *M.globulifera* on leaves is presented in Table 18.

After first spraying.

One day after spraying, when compared to control (19.03) all the treatments were significantly superior in controlling the damage by *M.globulifera*. The maximum suppression in damage was obtained in plants treated with azadirachtin 0.004 per cent (3.40). The second best treatment was pongamia oil 2 per cent (4.93) which was statistically on par with the chemical check, dimethoate 0.05 per cent (5.20). The plots which received the treatments neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent, neem cake soil application @ 250 kg ha^{-1} +neem seed oil 2 per cent and tobacco decoction recorded 6.43, 7.47 and 7.70 number of damaged leaves respectively, and were on par. Illipe seed oil 2 per cent treated plots had a mean number of 8.46 damaged leaves per plant.

On the third day after spraying, all the treatments were superior in reducing the damage by lace wing bugs, except neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent compared to control (33.10). The treatments, azadirachtin 0.004 per cent (11.53), pongamia oil 2 per cent (12.70), dimethoate 0.05 per cent (14.96) neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent (17.13), tobacco decoction (22.03), and illipe seed oil 2 per cent (22.27) were statistically similar in containing the damage by *M.globulifera* . Seven days after application also, all the treatments were found effective

Table 18. Effect of botanicals on the extent of damage by *M.globulifera* in tulsi after spraying

Treatments	Mean number of leaves damaged by *M.globulifera* per plant							
	Days after first spray				Days after second spray			
	1	3	7	15	1	3	7	15
Neem cake soil application @ 250 kg ha^{-1} + Neem seed oil 2%	7.47	24.9	30.67	31.33	6.30	24.73	20.13	23.23
Illipe seed oil 2%	8.46	22.27	26.23	27.83	5.10	22.00	24.70	21.80
Neem cake soil application @ 250 kg ha^{-1} +NSKE 5%	6.43	17.13	20.63	26.90	5.80	25.37	20.57	19.76
Pongamia oil 2%	4.93	12.70	18.06	18.83	4.17	20.70	18.10	17.53
Tobacco decoction	7.70	22.03	25.03	24.40	5.73	21.03	20.37	23.13
Azadirachtin 0.004%	3.40	11.53	13.00	17.23	3.23	16.63	15.13	16.30
Dimethoate 0.05%	5.20	14.96	23.83	20.30	4.83	20.96	16.30	17.33
Control	19.03	33.10	44.93	40.27	8.43	39.50	31.70	35.20
CD (0.05)	1.46	10.75	10.46	9.29	1.46	1.86	9.64	7.36

in curtailing the damage to leaves compared to control (44.93). The best treatment was azadirachtin 0.004 per cent (13.00) which was statistically similar to pongamia oil 2 per cent (18.06) and neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent (20.63). The treatments, dimethoate 0.05 per cent (23.83) tobacco decoction (25.03), illipe seed oil 2 per cent (26.23) and neem cake soil application@ 250 kg ha^{-1}+ neem seed oil 2 per cent (30.67) were statistically on par.

On the fifteenth day after the application of treatments, the lowest number of damaged leaves per plant was recorded in azadirachtin 0.004 per cent treated plots (17.23). This indicated that azadirachtin 0.004 per cent was the most effective treatment. However, it was statistically on par with pongamia oil 2 per cent (18.83), dimethoate 0.05 per cent (20.30) and tobacco decoction (24.40). These treatments were followed by neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent (26.90) and illipe seed oil 2 per cent (27.83). All these treatments were statistically superior to control (40.27).

After second spraying

On the first day after spraying, all the treatments *viz.*, neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent (6.30), illipe seed oil 2 per cent (5.10), neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent (5.80), pongamia oil 2 per cent (4.17), tobacco decoction (5.73), azadirachtin 0.004 per cent (3.23) and dimethoate 0.05 per cent (4.83) significantly suppressed the damage caused by *M.globulifera* when compared to control (8.43). The lowest damage was observed in plots treated with azadirachtin 0.004 per cent which was statistically similar to pongamia oil 2 per cent.

Three days after second round application, all the treatments significantly reduced the damage to leaves when compared to control (39.05). The treatments, neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent (24.73), illipe seed oil 2 per cent (22.00), neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent (25.37), pongamia oil 2 per cent (20.70), tobacco decoction (21.03), azadirachtin 0.004 per cent (16.63),

dimethoate 0.05 per cent (20.96) were statistically on par in their effectiveness in controlling the leaf damage. The best treatment was azadirachtin 0.004 per cent which was followed by pongamia oil 2 per cent.

On the seventh day after spraying, the damage to leaves by *M.globulifera* was effectively controlled by all the treatments except illipe seed oil 2 per cent (24.70) when compared to control (31.70). Azadirachtin 0.004 per cent treated plants recorded the lowest damage (15.13), which was followed by dimethoate 0.05 per cent (16.30), pongamia oil 2 per cent (18.10), neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent (20.13), tobacco decoction (20.37), neem cake soil application@ 250 kg ha^{-1} +NSKE 5 per cent (20.57) and illipe seed oil 2 per cent (24.70).

Fifteen days after spraying, the effect of treatments in limiting the pest damage on leaves was evident when compared to control (35.20). The treatments, neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent (23.23), illipe seed oil 2 per cent (21.80), neem cake soil application@ 250 kg ha^{-1} +NSKE 5 per cent (19.76), pongamia oil 2 per cent (17.53), tobacco decoction (23.13), azadirachtin 0.004 per cent (16.30) and dimethoate 0.05 per cent (17.33), significantly reduced the leaf damage by *M.globulifera* compared to control.

A.gossypii

The population of *A.gossypii* estimated as number of aphids per plant at different intervals after application of treatments is given in Table 19.

On the first day, there was significant reduction in the population of aphids in plots which received various treatments compared to control (41.43). Among the botanicals, the best treatment was azadirachtin 0.004 per cent (10.90) which was statistically on par with the chemical check, dimethoate 0.05 per cent (8.77). The treatments, illipe seed oil 2 per cent (24.47) and pongamia oil 2 per cent (26.20) were statistically similar in curtailing aphids. Neem cake soil application@ 250 kg ha^{-1} + neem

Table 19. Effect of botanicals on *A.gossypii* on tulsi after spraying

Treatments	Mean number of *A.gossypii* per plant			
	1 DAS	3 DAS	7 DAS	15 DAS
Neem cake soil application @ 250 kg ha^{-1} + Neem seed oil 2%	34.37	33.7	37.77	40.03
Illipe seed oil 2%	24.47	24.73	26.7	26.03
Neem cake soil application @ 250 kg ha^{-1} +NSKE 5%	34.4	34.6	33.97	36.53
Pongamia oil 2%	26.2	29.17	31.3	28.13
Tobacco decoction	16.7	11.83	11.43	11.03
Azadirachtin 0.004%	10.9	8.83	8.47	8.59
Dimethoate 0.05%	8.77	7.23	5.97	5.47
Control	41.43	43.97	46.9	50.2
CD (0.05)	5.59	3.55	3.62	4.87

seed oil 2 per cent and neem cake soil application@ 250 kg ha^{-1} +NSKE 5 per cent recorded 34.37 and 34.40 respectively and were on par.

Three days after spraying. dimethoate 0.05 per cent, azadirachtin 0.004 per cent. tobacco decoction, illipe seed oil 2 per cent, pongamia oil 2 per cent, neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent and neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent reduced *A.gossypii* population significantly when compared to control (43.97), the population being 7.23, 8.83, 11.83, 24.73, 29.17, 33.70 and 34.60 respectively.

On the seventh day, after spraying, all the treatments were effective in containing *A.gossypii*, compared to control (46.90). Among the treatments, azadirachtin 0.004 per cent treated plants showed significantly lower population (8.47) which was on par with the chemical check, dimethoate 0.05 per cent (5.97). Tobacco decoction treatment also suppressed the population of aphids effectively (11.43). Treatments *viz.*, neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent, illipe seed oil 2 per cent, neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent and pongamia oil 2 per cent were comparatively less effective against aphid, the population being 37.77, 26.70, 33.97,and 31.30 respectively.

At fifteen days after spraying, azadirachtin 0.004 per cent, tobacco decoction, illipe seed oil 2 per cent, pongamia oil 2 per cent neem cake soil application @ 250 kg ha^{-1}+ neem seed oil 2 per cent and neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent significantly suppressed the population *A.gossypii* when compared to control (50.20). The population of aphids ranged from 8.59 to 40.03 in the treatments. Azadirachtin 0.004 per cent was the most effective botanical treatment and was on par with dimethoate 0.05 per cent (5.47). The treatments, illipe seed oil 2 per cent, pongamia oil 2 per cent and neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent and neem cake soil application @ 250 kg ha^{-1}+ neem seed oil 2 per cent showed significantly higher population compared to azadirachtin 0.004 per cent and dimethoate 0.05 per cent application.

Icerya spp.

The population of *Icerya* spp. recorded as total number of mealy bugs per plant at different intervals after spraying is given in Table 20.

One day after spraying, the treatments tobacco decoction (6.23), neem cake soil application @ 250 kg ha^{-1}+ neem seed oil 2 per cent (7.53), and pongamia oil 2 per cent (7.60) were statistically superior than control in containing the population of mealy bugs. The population recorded in plots treated with neem cake soil application@ 250 kg ha^{-1}+ NSKE 5 per cent (8.33), dimethoate 0.05 per cent (8.40), azadirachtin 0.004 per cent (8.93), illipe seed oil 2 per cent (11.03) were on par with that recorded in control plot (11.27).

Three days after spraying, all the treatments except illipe seed oil 2 per cent (11.00) were significantly superior to control (13.60) in reducing the population of *Icerya* spp. The population recorded in treatments, azadirachtin 0.004 per cent, dimethoate 0.05 per cent, neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent, pongamia oil 2 per cent, tobacco decoction and neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent were 8.30, 8.00, 6.87, 6.60, 5.97 and 5.70 respectively and were on par.

On the seventh day, after spraying the trend was same as that of the third day. All the treatments except illipe seed oil 2 per cent (12.53) were statistically superior to control (15.60) in the population reduction of mealy bugs. The best treatment was tobacco decoction (6.03) and this was statistically similar to neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent (6.57), azadirachtin 0.004 per cent (7.13), pongamia oil 2 per cent (7.17), neem cake soil application@ 250 kg ha^{-1} +NSKE 5 per cent (7.40) and the chemical check, dimethoate 0.05 per cent(6.33).

Fifteen days after spraying all the treatments were significantly superior in containing the population of mealy bugs when compared to control (16.70), the

Table 20. Effect of botanicals on *Icerya* spp. on tulsi after spraying

Treatments	Mean number of *Icerya* spp. per plant			
	1 DAS	3 DAS	7 DAS	15 DAS
Neem cake soil application @ 250 kg ha^{-1} + Neem seed oil 2%	7.53	5.70	6.57	5.60
Illipe seed oil 2%	11.03	11.00	12.53	11.70
Neem cake soil application @ 250 kg ha^{-1} +NSKE 5%	8.33	6.87	7.40	6.17
Pongamia oil 2%	7.60	6.60	7.17	7.50
Tobacco decoction	6.23	5.97	6.03	6.20
Azadirachtin 0.004%	8.93	8.30	7.13	7.00
Dimethoate 0.05%	8.40	8.00	6.33	4.40
Control	11.27	13.60	15.60	16.70
CD (0.05)	3.03	3.67	4.34	4.49

population of *Icerya* spp. in plants treated with neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent, neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent, pongamia oil 2 per cent, tobacco decoction, azadirachtin 0.004 per cent and dimethoate 0.05 per cent were 5.60, 6.17, 7.50, 6.20, 7.00 and 4.40 respectively. These treatments were statistically similar in their effect on mealy bugs.

C.cajani

The population of *C.cajani* at different intervals after the application of treatments expressed as number of scale insects per plant is depicted in Table 21.

One day after spraying, all the treatments effectively controlled *C.cajani* compared to control (37.57). Among the botanicals, pongamia oil 2 per cent resulted in maximum suppression of the pest (23.03) and this was on par with illipe seed oil 2 per cent (26.23), tobacco decoction (26.53), neem cake soil application@ 250 kg ha^{-1}+ neem seed oil 2 per cent (27.17), azadirachtin 0.004 per cent (27.37) and neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent (27.43).

There was significant difference in the population of scale insects in treated and untreated plots three days after spraying. This indicated that the treatments effectively contained *C.cajani*. The control plot had the highest population (38.30) and the number of scale insects recorded per plant in plots treated with neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent, illipe seed oil 2 per cent, neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent, pongamia oil 2 per cent, tobacco decoction, azadirachtin 0.004 per cent were 25.60, 25.27, 27.40, 21.70, 25.13 and 27.37 respectively. These were statistically similar in their effect on population of scale insects.

All the treatments were significantly superior to control (40.27) in reducing the population of *C. cajani* seven days after spraying. The botanicals were not as effective as the chemical check, dimethoate 0.05 per cent (11.77) in controlling the scale insects. The botanicals, neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent (24.57),

Table 21. Effect of botanicals on *C.cajani* on tulsi after spraying

Treatments	Mean number of *C.cajani* per plant			
	1 DAS	3 DAS	7 DAS	15 DAS
Neem cake soil application @ 250 kg ha^{-1} + Neem seed oil 2%	27.17	25.60	24.57	25.67
Illipe seed oil 2%	26.23	25.27	23.20	24.43
Neem cake soil application @ 250 kg ha^{-1} +NSKE 5%	27.43	27.40	28.40	26.90
Pongamia oil 2%	23.03	21.70	24.67	25.80
Tobacco decoction	26.53	25.13	25.67	28.53
Azadirachtin 0.004%	27.37	27.37	24.17	20.57
Dimethoate 0.05%	13.47	12.50	11.77	10.23
Control	37.57	38.30	40.27	29.03
CD (0.05)	8.46	10.67	9.51	8.30

illipe seed oil 2 per cent (23.20), neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent (28.40), pongamia oil 2 per cent (24.67), tobacco decoction (25.67) and azadirachtin (24.17) were statistically similar with regard to control of *C. cajani*. Among the botanicals, illipe seed oil 2 per cent was the most effective against the pest.

Fifteen days after spraying , effect of the treatments in suppressing *C. cajani* was less pronounced compared to the observations on earlier days. Among the botanicals, azadirachtin 0.004 per cent treated plants had the lowest number of scale insects per plant (20.57), but was significantly higher than the population in dimethoate 0.05 per cent (10.23). The population of scale insects per plant in the other treatment plots were statistically similar to control (29.03).

P.deschampes

The population of *P.deschampes* at different intervals after the application of treatments expressed as number per plant is presented in Table 22.

One day after spraying, the botanicals illipe seed oil 2 per cent (3.60) and the pongamia oil 2 per cent (3.90) had similar effect as that of chemical check, dimethoate 0.05 per cent (2.93) and were statistically superior to control (7.60) in suppressing the population of *P.deschampes*. The botanicals, neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent (4.87), azadirachtin 0.004 per cent (5.13), neem cake soil application@ 250 kg ha^{-1} +NSKE 5 per cent (5.73), tobacco decoction (5.80) were not effective on spittle bug and were on par with the control plot.

Among the botanicals, pongamia oil 2 per cent gave the best result (3.77) by significantly suppressing the population of spittle bug, compared to control (7.30) and were on par with dimethoate 0.05 per cent (2.93) on the third day after spraying. The other botanicals were not effective and were on par with the control.

Table 22. Effect of botanicals on *P.deschampes* on tulsi after spraying

Treatments	Mean number of *P.deschampes* per plant			
	1 DAS	3 DAS	7 DAS	15 DAS
Neem cake soil application @ 250 kg ha^{-1} + Neem seed oil 2%	4.87	4.17	4.30	4.63
Illipe seed oil 2%	3.60	3.93	4.13	3.87
Neem cake soil application @ 250 kg ha^{-1} +NSKE 5%	5.73	5.27	4.93	5.17
Pongamia oil 2%	3.90	3.77	3.70	3.63
Tobacco decoction	5.80	5.33	5.13	4.90
Azadirachtin 0.004%	5.13	4.57	4.23	4.60
Dimethoate 0.05%	2.93	2.93	2.80	2.80
Control	7.60	7.30	7.43	7.63
CD (0.05)	3.66	3.44	3.07	3.19

On the seventh day after spraying, the population of *P.deschampes* recorded in plots treated with neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent, azadirachtin 0.004 per cent , illipe oil 2 per cent and pongamia oil 2 per cent were 4.30, 4.23, 4.13 and 3.70 respectively and were on par. All the treatments were on par with chemical check dimethoate 0.05 per cent (2.80). There was no significant reduction in the population of *P.deschampes* when neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent (4.93) and tobacco decoction (5.13) were sprayed and were on par with control (7.43).

Only pongamia oil 2 per cent (3.63), illipe seed oil 2 per cent (3.87) and chemical check dimethoate 0.05 per cent (2.80) were statistically superior to control (7.63) in reducing the population of spittle bug, fifteen days after spraying. All other botanicals *viz.*, neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent (5.17), tobacco decoction (4.90), pongamia oil 2 per cent (3.63) and azadirachtin 0.004 per cent (4.60) were on par with control and were not effective on *P.deschampes.*

4.2.2 Effect of Botanicals on Spiders.

The result of the study of the effect of botanicals on spiders is presented in Table 23.

After first spraying

One day after first spraying, the number spiders per plant ranged from 1.70 to 2.37 in plots receiving various treatments. The population of spiders in all the treatment plots except tobacco decoction was statistically similar to that of control (2.80). There was no significant difference in the population of spiders on the third, seventh and fifteenth day after spraying. On the third day after spraying, the spider population in the treated plots ranged from 2.37 to 2.93 per plant and was on par with control (2.97). On the seventh day, population ranged from 2.30 to 3.70 per plant and was on par with control (3.23). The highest number of spiders per plant was recorded in plants treated

Table 23. Effect of botanicals on spiders in tulsi after spraying

Treatments	Mean number of spiders per plant							
	Days after first spray				Days after second spray			
	1	3	7	15	1	3	7	15
Neem cake soil application @ 250 kg ha^{-1} + Neem seed oil 2%	1.96	2.87	3.17	3.80	2.30	2.80	3.10	2.76
Illipe seed oil 2%	2.10	2.80	3.17	3.03	2.30	2.67	3.17	3.20
Neem cake soil application @ 250 kg ha^{-1} +NSKE 5%	2.37	2.87	3.70	3.90	2.27	2.83	2.83	2.70
Pongamia oil 2%	1.97	2.93	3.13	3.63	2.43	2.9	3.00	2.76
Tobacco decoction	1.70	2.37	2.90	2.67	1.76	2.43	2.13	2.20
Azadirachtin 0.004%	1.97	2.87	2.57	2.93	2.23	2.76	2.96	2.73
Dimethoate 0.05%	1.93	2.57	2.30	1.67	2.00	1.77	2.43	2.00
Control	2.80	2.97	3.23	3.63	2.90	2.60	3.17	3.03
CD (0.05)	0.87	–	–	–	0.88	0.83	0.59	0.73

with neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent. Fifteen days after spraying, the highest number of spiders per plant was recorded in plots treated with neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent (3.90) which was on par with all other treatments and control (3.63).

After second spraying

On the first day after second spraying, all the treatments except tobacco decoction (1.76) and dimethoate 0.05 per cent (2.00) were statistically on par with control (2.90). The number of spiders per plant in plots treated with pongamia oil 2 per cent, neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent, illipe seed oil 2 per cent, neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent and azadirachtin 0.004 per cent were 2.43, 2.30, 2.30, 2.27 and 2.23 respectively.

There was no significant difference in the population of spiders recorded from control plot (2.60) and plots treated with botanicals three days after spraying. The treatments pongamia oil 2 per cent (2.90), neem cake soil application@ 250 kg ha^{-1} + NSKE 5 per cent (2.83), neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent (2.80), azadirachtin 0.004 per cent (2.76), illipe seed oil 2 per cent (2.67), tobacco decoction (2.43) were safe to spiders.

Seven days after second spraying, the population of spiders in plots treated with botanicals *viz.,* illipe seed oil 2 per cent (3.17), neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent (3.10), pongamia oil 2 per cent (3.00), azadirachtin 0.004 per cent (2.96), neem cake soil application@ 250 kg ha^{-1} +NSKE 5 per cent (2.83), were statistically on par with control (3.17). In dimethoate 0.05 per cent (2.43) and tobacco decoction (2.13) treated plots, the population of spiders was significantly lower than the control.

A similar trend as that of the seventh day in population of spiders was observed fifteen days after spraying also. Except tobacco decoction (2.20) and dimethoate (2.00),

all the botanicals *viz.*, illipe seed oil 2 per cent (3.20), neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent (2.76), pongamia oil 2 per cent (2.76), azadirachtin 0.004 per cent (2.73), neem cake soil application@ 250 kg ha^{-1} +NSKE 5 per cent (2.70) were statistically on par with control (3.03).

4.3 ASSESSMENT OF PATHOGENICITY OF DISEASE CAUSING ORGANISMS OF TULSI

4.3.1 Pathogenicity of Virus

Inoculation with plant extract containing viral inoculum was done on tulsi plants and local lesion host, *Chenopodium amaranticolor* L. On tulsi leaves, symptoms were observed as chlorotic spots and in *C.amaranticolor*, symptoms developed as local lesions with yellow halo on the seventh day after inoculation (Plate 9).

4.3.2 Pathogenicity of Fungus

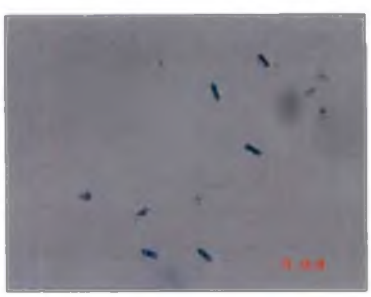
Four days after inoculation, diseased tulsi leaf bits kept in PDA plates developed fungal colonies having white mycelium, which later turned light pink due to the production of pinkish spore mass. The conidia were straight and bullet shaped with an oil globule at the centre, which measured 3x1.5 mm (Plate 10). Based on the cultural and microscopic characters, the pathogen was identified as *Colletotrichum gloeosporioides* Penz. Three days after inoculation on healthy leaves, lesions developed which were identical to the symptoms observed earlier in the field (Plate 10).

4.4 YIELD OF TULSI AND BENEFIT: COST RATIO OF THE TREATMENTS IN FIELD EXPERIMENT.

The yield obtained and benefit: cost ratio worked out are presented in Table 24.

Plate 9. Symptoms produced by virus on local lesion host *C.amaranticolor*

***C.gloeosporioides* (mycelia)**



***C.gloeosporioides* (conidia)**

Initial symptoms

Leaf necrosis at the final stage

Plate 10. Different stages of *C.gloeosporioides* and its symptoms on tulsi plant.

All the treatments recorded significantly higher yield compared to control (2.07t ha^{-1}). The highest yield of leaves among the botanical treated plots was recorded in azadirachtin 0.004 per cent (6.17t ha^{-1}) treated plots and the yield was statistically similar to that recorded from dimethoate 0.05 per cent treated plots (7.07t ha^{-1}). This was followed by pongamia oil 2 per cent (4.93t ha^{-1}). The yield recorded from plots treated with tobacco decoction (4.33t ha-1), illipe seed oil 2 per cent (3.90t ha^{-1}), neem cake soil application@250 $kgha^{-1}$ + NSKE 5 per cent (3.65t ha^{-1}) and neem cake soil application@ 250 kg ha^{-1} + neem seed oil 2 per cent (3.57t ha^{-1}) were statistically on par.

The benefit: cost ratio was the highest in azadirachtin 0.004 per cent treated plots (2.80) followed by pongamia oil two per cent treated plots (2.20). The benefit: cost ratio ranged from 1.18 to 1.79 among other treatments.

Discussion

5. DISCUSSION

Medicinal plants are the foundation on which the tenets of Indian systems of Medicine like Ayurveda, Unani and Sidha exist. Upto the nineteen fifties, the medicines were prepared from wild sources. Since the middle of the twentieth century, there has been a global demand for medicinal and aromatic plants for food, pharmaceutical, perfumery, flavour and cosmetic industries. The practice of Ayurveda in Kerala for example has acquired an enormous degree of popularity. This has accelerated the growth of cultivation of medicinal and aromatic plants or mediculture. In mediculture, the productivity has to be increased by improved crop husbandry including Integrated Pest and Disease Management. In this context, it is worthwhile to note that one of the medicinal plants being raised in Kerala is tulsi (*Ocimum tenuiflorum* L).

Pests and diseases adversely affect the successful cultivation of a plant like tulsi. Tulsi *ipso facto* being a medicinal plant wherein pest control using chemicals is implausible. One approach is the use of phytochemicals or botanicals which are safe to the agro ecosystem. They possess antifeedant, insect growth regulator and other effects which can be utilized to contain the pests of tulsi.

5.1 OCCURRENCE OF PESTS AND NATURAL ENEMIES IN TULSI

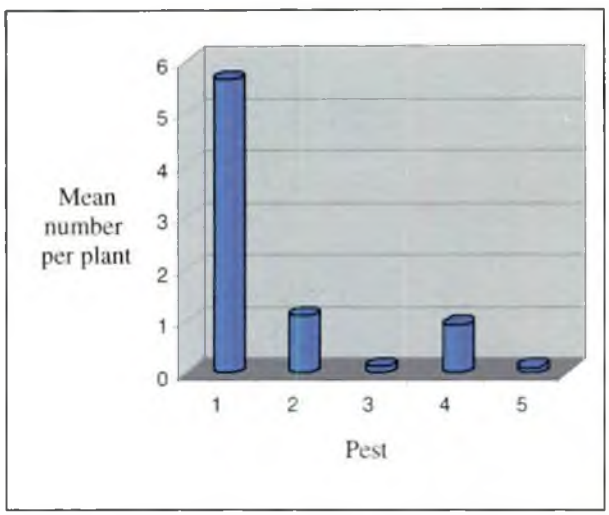
The survey conducted for one year from July 2005 to June 2006 in five locations *viz.,* Perumpazhuthoor, Parasuvaikkal, Poojapura, Peroorkada and Vellayani of Thiruvananthapuram district revealed that tulsi was infested by five major pests *viz., Monanthia globulifera* W., *Aphis gossypii* Glover, *Icerya* spp., *Cajanus cajani* Maskell, *Phymatostetha deschampes* L. and ten minor pests *viz., Anchon pilosum* L. *Lygaeus* sp., *Agonoscelis* sp., *Leptocorisa acuta* (Thunb.), *Pseudococcus* sp.,

Cyrtacanthacris sp., *Syngamia abruptalis* Wlk., *Anisephyra ocularia* Fab., *Lasius* sp. and *Solenopsis* sp. (Table 1). The assessment of total pest population over twelve months from July 2005 to June 2006 indicated that *M.globulifera* was the dominant pest (Fig.1). The second most important pest was *A.gossypii* followed by *Icerya* spp. *C.cajani* and *P.deschampes*. Hitherto, the information on pest status in tulsi was limited. *M.globulifera* and *C.cajani* were earlier reported as major pests of tulsi (Ayyar, 1963; Nair, 1999 and Rajan, 2003). Rajan (2003) observed *Myllocerus viridanus* Fab., *Cyrtacanthacris* sp. and *Nezara* sp. as minor pests of tulsi. *Aleurodicus dispersus* Russell was observed as pest on tulsi by Rani (2004).

Tulsi is one of the member plants of the homestead farms of Kerala (Rejeena *et al.*, 2004). So the insects observed in the survey might have co-evolved with the plant. Another important fact that had understood in the study was that the major pests were euryphagous. They might have acquired adaptive strategies to feed on a variety of plant species.

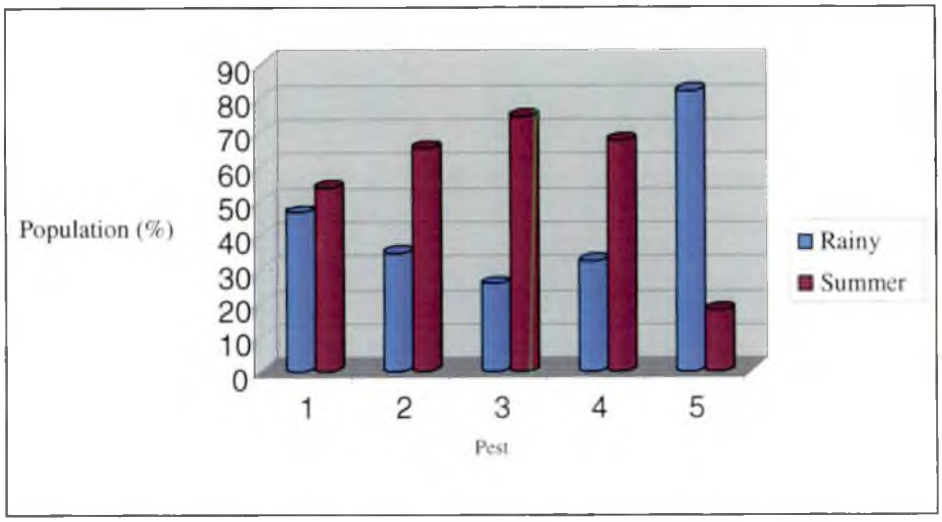
M.globulifera

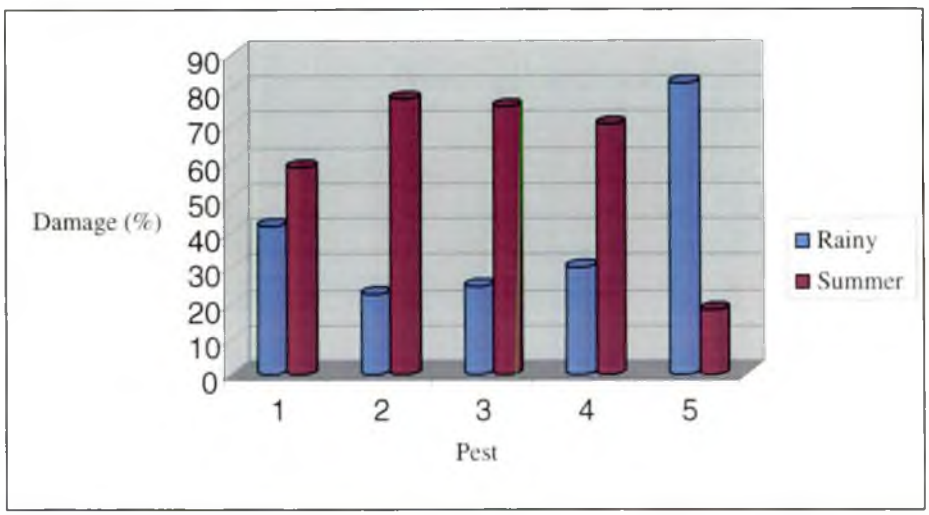
The lace wing bug, *M.globulifera* was present on the crop throughout the year. The population was comparatively high during July to September 2005 and later it decreased to a significant level during October to December 2005. From January 2006 onwards, there was significant increase in the population. The population was at its peak during the summer months of March and April 2006. Bhattacharya and Chakravorthy (1984) also made similar observations. There was variation in the population observed in rainy and summer months. The population was high during the summer months (Fig.2.A). This was supported by the correlation



Pest
1: *M.globulifera*
2: *A.gossypii*
3: *Icerya* spp.
4: *C.cajani*
5: *P. deschampes*

Fig. 1. Distribution of major pests of tulsi in Thiruvananthapuram district.





Pest

1: *M.globulifera*

2: *A.gossypii*

3: *Icerya* spp.

4: *C.cajani*

5: *P. deschampes*

Fig. 2. Seasonal variations in the population and damage of major pests of tulsi.

studies (Table.15). The difference in the population might be due to high fecundity and shorter life cycle during the summer months.

The population of *M.globulifera* was different in five locations (Fig.3.A). The highest population of *M.globulifera* was recorded in Vellayani. The lace wing bug is mainly a pest of plants belonging to the family Lamiaceae. Plants like *Ocimum basilicum* L. and *Coleus aromaticus* L. of family Lamiaceae were commonly available in Vellayani during the period of survey. The availability of different hosts might have contributed to the increased population of lace wing bug on tulsi in this location compared to the other places. The comparatively lower population in other locations might be due to the lesser number of other host plants.

Both the nymphs and adults desapped the foliage, which resulted in curling and deying up of leaves (Plate 1). Chandra (1992) also made similar observations on the damage by *M.globulifera* on tulsi. The feeding by the lacewing bug, *Urentius hystricellus* (Richt.) also resulted in similar symptoms on brinjal leaves (Nair, 1999). The percentage damage was higher during the summer months compared to the rainy months. This was obviously due to the feeding of higher population of insects in summer months.

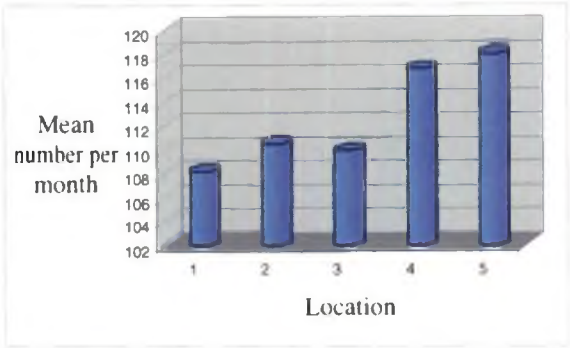
A.gossypii

During the period of study, *A.gossypii* was found as a major pest of tulsi (Fig.1). *A.gossypii* has not yet been reported as a pest of *O. tenuiflorum*. However, the aphid was reported as a pest of cotton, guava, brinjal, bhindi, cucurbits and ornamentals by Nair (1975). Anil *et al.*, (2004) observed this aphid on tomato, potato and cotton. Chadha (2002) reported this aphid on *O.basilicum*.

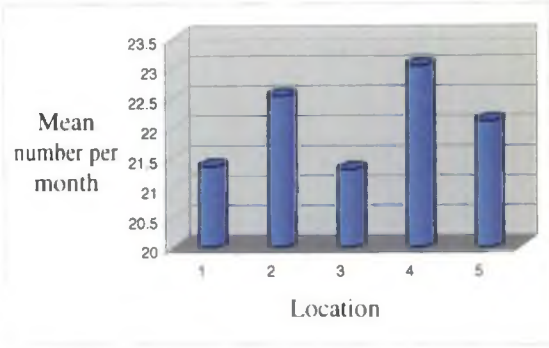
There was seasonal variation in the population of aphids. The percentage of total population (65.37) during summer months was almost double compared to that of (34.63) rainy months (Fig.2.A). The variation might be due to the shorter life cycle and increased fecundity in summer months compared to rainy months. A longer developmental period for the insect and wash off of various stages might have occurred during the rainy season. Rainfall was clearly a limiting abiotic factor for the development of aphids. This was clear from the correlation studies which showed significant negative correlation between rainfall and aphid population and the extent of damage. Similar findings were made by Satar *et al.,* (1999) on *Gossypium hirsutum* L.

Among the five locations, the population of *A.gossypii* was the highest in Peroorkada followed by Parasuvaikkal and Vellayani. The population was more or less similar in Perumpazhuthoor and Poojapura (Fig.3. B). Since *A.gossypii* is a polyphagous pest, the difference in the distribution of other host plants in the vicinity and climatic factors might have contributed to the variation in the population observed.

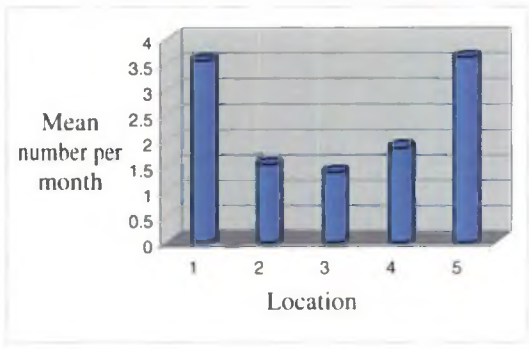
The nymphs and adults of *A.gossypii* desapped both inflorescences and branches. During the period of survey from July to November 2005, tulsi plants were in the inflorescence stage and the aphids congregated on the panicle and preferred inflorescence to branches. The preference for inflorescences over branches might be due to the concentration of more nutrients required by the aphids in the inflorescence. The percentage of inflorescences damaged ranged from 38.69 to 66.57. From December 2005 to June 2006, aphids caused damage to branches, the infestation ranging from 26.04 per cent to 77.85 per cent. The desapping resulted in the weakening of the plants.



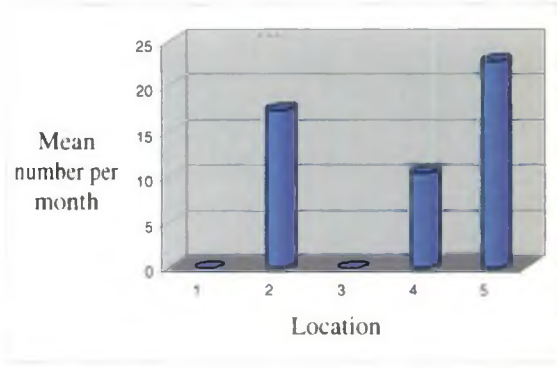
A. *M.globulifera*



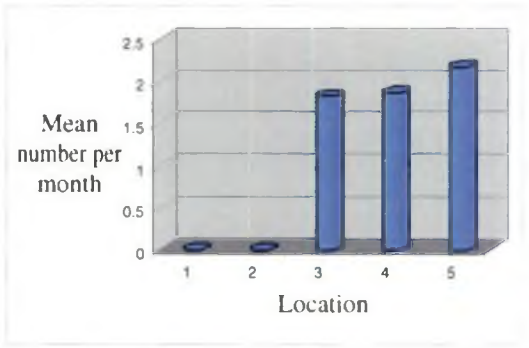
B. *A.gossypii*



C. *Icerya* spp.



D. *C.cajani*



E. *P. deschampes*

Locations

1: Perumpazhuthoor

2: Parasuvaikkal

3: Poojapura

4: Peroorkada

5: Vellayani

Fig. 3. Distribution of major pests of tulsi in different locations

***Icerya* spp.**

The giant mealy bugs, *Icerya aegyptiacum* (Dgl.) and *Icerya seychellarum* (Westw.) are being reported for the first time on tulsi plants (Plate 2). These have earlier been recorded as pests of guava, mango, jackfruit, banana and arecanut. The mealy bugs were present throughout the year in varying intensities. From July to December 2005, the population was low and the mean population ranged from 0.17 to 1.72 per plant. The population increased from January 2006 onwards and the highest population was recorded during May 2006. The population slightly declined in June 2006.

The population of mealy bugs was the highest in Vellayani closely followed by Perumpazhuthoor. The count of mealy bugs was lesser in Peroorkada, Parasuvaikkal and Poojapura (Fig.3.C). The presence of host plants of the mealy bugs *viz.*, guava, mango and jackfruit in Vellayani and Perumpazhuthoor might have provided alternate food source, thereby resulting in increased pest population. Perusal of the season wise incidence of mealy bugs indicated that they were more in the summer months than in the rainy months (Fig.2.A). The cottony cushion scale *Icerya purchasi* Maskell, had been reported to multiply in the dry hot season in citrus (Nair, 1975). The population of mealy bugs had strong positive correlation with maximum temperature and significant negative correlation with relative humidity and rainfall (Table.15). Ghanim *et al.*, (2004) reported that temperature had positive correlation and relative humidity had negative correlation with population density of *I.seychellarum* and *I.aegyptiacum* infesting guava.

The population of the mealy bugs was not only related to the density independent factors but also density dependent factors like availability of food. Alternate hosts like guava, mango, jackfruit etc. were present in the locations where

Icerya spp. infested tulsi. The extent of damage caused by *Icerya* spp. ranged from 0.99 percent to 56.30 per cent during the period of study (Table.9). The damage was more during summer months than in rainy months (Fig.2.B). The extent of damage had significant positive correlation with maximum temperature and negative correlation with rainfall. The extent of branches of tulsi infested mirrored the population density of the mealy bugs.

C.cajani

C.cajani which infested the branches was a major pest of tulsi. It was reported as a pest of tulsi by Ayyar(1963). Nair (1975) reported *C.cajani* on redgram, lablab, ber, tea etc. There was significant difference in the distribution of *C.cajani* in the various locations surveyed (Fig.3.D). The pest was not observed in Perumpazhuthoor and Poojapura during the period of survey. There was two fold increase in the population (75.80 to 158.98) of scale insects during summer months compared to the rainy period (Fig.2.A). Heavy precipitation was highly detrimental to the scale insect. The population had strong negative correlation with rainfall (Table 15).

Both the nymphs and adults desapped the branches which later resulted in complete drying up of plants (Plate 3). Damage by scale insect was not observed in July 2005. The percentage of branches damaged ranged from 5.20 to 74.34 during the different months from August 2005 to June 2006. The extent of damage had positive correlation with maximum temperature and negative correlation with rainfall.

P.deschampes

Nair (1975) and David (2001) mentioned *P.deschampes* as a minor pest of banana. During the study, the spittle bugs were found on tulsi. This is the first report of its incidence on tulsi. There was significant difference in the occurrence of *P.deschampes* in various locations. It was completely absent in Perumpazhuthoor and Parasuvaikkal during the period of survey. The highest population was recorded in Vellayani followed by Poojapura and Peroorkada (Fig.3.E). This may be due to the reason that the major crop host, banana was well distributed at Vellayani. The spittle bugs were noticed on weeds also. Similar observations have been mentioned by Nair (1975). At Poojapura and Peroorkada the situation was almost similar, but at Perumpazhuthoor and Parasuvaikkal the weed fauna as well as banana were sparse in the locations surveyed.

Unlike the distribution of the other pests discussed earlier, the population of *P.deschampes* was higher in rainy months compared to summer months. They were present in the field from July 2005 to January 2006 and the population ranged from 3.75 to 4.11 per plant. Nair (1999) reported that *P.deschampes* was present in banana and cocoa only during the rainy season. The population of spittle bug had significant negative correlation with maximum temperature and positive correlation with rainfall. Spittle mass of cercopids protected the nymphs from desiccation. The nymphs were probably unable to withstand high temperature as the spittle mass dry up. This may be the reason for the low population of *P.deschampes* during summer months (Fig.2.A).

The presence of spittle mass on tulsi gave an obnoxious appearance to the crop (Plate 3). The percentage of branches damaged by *P.deschampes* ranged from 41.12 to 47.02 during the different months from July 2005 to January 2006. The total

quantum of plant sap removed by the spittle bug to form the protective spittle mass is considerable. Since the spittle bugs were also found infesting weeds, in the event of raising crops like banana and tulsi, weed management would be an effective option in cultural control of *P.deschampes* especially during the rainy season.

Minor Pests of Tulsi.

Hemipteran Pests

The sucking pests *viz., A.pilosum, Lygaeus* sp., *Agonoscelis* sp., *L.acuta* and *Pseudococcus* sp. were found infesting tulsi in very low numbers (Table 2). Rajan (2003) reported *Agonoscelis* sp. as a minor sucking pest of tulsi. All the other insects are being reported from tulsi for the first time.

A.pilosum infested branches and it secreted honey dew which attracted ants. This rendered harvesting difficult. *A.pilosum* infested pulse crops like cowpea, lab lab and fruit crops like mango (Nair, 1999). The root mealy bug, *Pseudoccocus* sp. infested the tap root and root hairs of tulsi, which resulted in the wilting of the plant. Similar damage was made by *Pseudococcus citri* (Risso) in citrus (Nair, 1999). *Agonoscelis* sp. and *L.acuta* infested the seeds at milky stage and *Lygaeus* sp. infested the matured seeds. This adversely affected the development and viability of the seeds.

Orthopteran Pest

The grasshopper, *Cyrtacanthacris* sp. is a polyphagous pest seen in large numbers in cotton fields (Balakrishnan *et al.*, 2004). The grasshopper was reported as a pest of

tulsi from Kerala in 2003 by Rajan. In the present study also, *Cyrtacanthacris* sp. was found feeding on tulsi plants in Parasuvaikkal, Peroorkada and Vellayani.

Lepidopteran Pests

During the survey, two butterfly pests *viz.*, *S.abruptalis* and *A.ocularia* were found infesting tulsi leaves. *S.abruptalis* was earlier recorded as a leaf folder of tulsi by Nayar *et al.*, (1976) and Anont (1990). The larvae folded together the leaves and fed from within. When disturbed the adults undertook short flights. Rajan (2003) reported *A.ocularia* as a pest of chetthikoduveli (*Plumbago rosea* L.). In this study, the larvae of *A.ocularia* were found feeding on tulsi leaves and this is the first report of its incidence on tulsi.

Hymenopteran Pests

The ants, *Lasius* sp. and *Solenopsis* sp. are being reported for the first time from tulsi plants. They caused both direct and indirect damage. In the inflorescence stage of the crop, ants fed on the pollen grains and seeds from tulsi panicles. They also transported *A.gossypii* from one plant to another. The presences of ants were an annoyance especially during harvest. The minor pests were either absent or present only in very negligible numbers which did not warrant explanation on their frequency, distribution and analysis. However, these pests cannot be taken for granted as minor ones especially in agro ecosystems.

The pest distribution in the surveyed locations which were within an area of 40 square kilometers must have varied mainly due to the presence of other hosts for the polyphagous pests rather than climatic factors. The locations surveyed had a wide range of host crops. These played a critical role in the survival, growth and

reproduction of insects. The relationship between pests and their host plants are affected by climatic factors. The pest population varied during the different months due to the change in temperature, relative humidity and rainfall. The distribution of rainfall over the year was an extremely limiting factor for the major pests of tulsi except the spittle bug. Temperature, rainfall and relative humidity controlled the seasonal activities of insects also. Thus, it could be stated that in general, high temperature, low rainfall and moderate humidity contributed to the abundance of insect pests and consequent damage in *O.tenuiflorum*.

Natural Enemies

Predators

During the survey, eight species of spiders (Plate 6) and a syrphid (Plate 7) were recorded as predators of pests of tulsi (Table 2). The spiders observed were *Argiope* sp., *Cheiracanthium* sp., *Hyllus semicupreus* (Simon), *Neoscona mukherjee* Tikader, *Oxyopes shwetha* Tikader, *Oxyopes birmanicus* Thorell, *Peucetia viridana* (Stoliczka) and *Tetragnatha* sp. Thamilvel (2004) and Manu (2005) earlier recorded these spiders from vegetable ecosystems of Kerala. The spiders were found feeding on *A.gossypii, Icerya* spp. and larvae of S.*abruptalis*. They were present throughout the year in all the five locations. There was very significant negative correlation between spider count and maximum temperature and relative humidity. Seasonal comparison showed that the population during summer months was higher compared to rainy months. This may be due to the higher population of pests in tulsi during the summer period. The findings agreed with the studies of Rejirani (1995) on the aphid dependent increase of predators in cowpea. The syrphid *Paragus serratus* Fabr. was

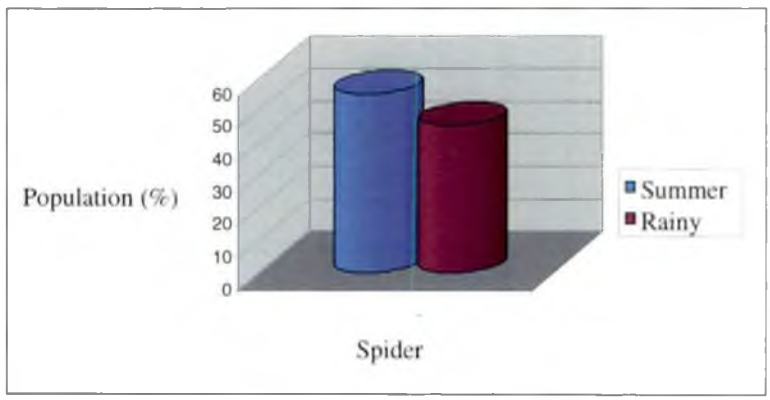


Fig. 4. Seasonal variation in the population of spiders

found feeding on *A.gossypii* in Vellayani. *P.serratus* was parasitised by a pupal parasitoid belonging to the family Encrytidae (Plate.7).

Parasitoids.

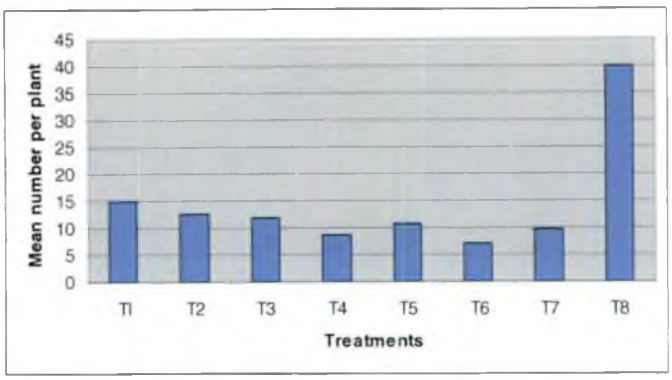
Two parasitoids were recorded at Vellayani during the period of survey. *Coccophagus tschirchii* (Madhihassan) was the adult parasitoid of *C.cajani* and *Bracon* sp. was the larval parasitoid of *S. abruptalis* (Plate 8).

5.2 EFFECT OF BOTANICALS ON PESTS AND SPIDERS IN TULSI

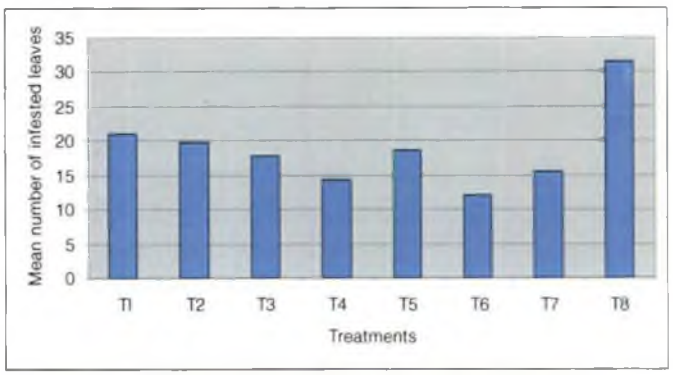
An experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani from August 2005 to March 2006 to evaluate the efficacy of botanical pesticides for the management of pests of tulsi and their impact on spiders. The results obtained from the experiment are discussed below.

M.globulifera

Two sprays of the treatments were given and the mean effect of treatments on the population of *M.globulifera* and its damage on tulsi plants were assessed. The study revealed that all the botanicals were effective in containing the pest (Fig.5.A) and its damage (Fig.5.B). Among the botanicals, azadirachtin 0.004 per cent gave the maximum suppression of the pest population and the damage, followed by pongamia oil two per cent. Neem Azal at 0.50 per cent and 0.30 per cent was effective against lace bugs, *Honosteria* sp. in ber (Kavitha and Savithri, 2001). Mariam and Chandramohan (2000) reported the efficiency of pongamia oil in reducing the population of *A.dispersus* in mulberry. The efficiency of other botanical treatments



A. Population



B. Damage

T1: Neem cake soil application @ 250 kg ha^{-1} + Neem seed oil2%

T2: Illipe seed oil 2%

T3: Neem cake soil application @ 250 kg ha^{-1} +NSKE 5%

T4: Pongamia oil 2%

T5: Tobacco decoction

T6: Azadirachtin 0.004%

T7: Dimethoate 0.05%

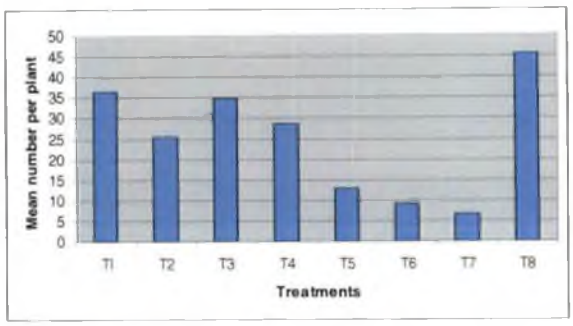
T8: Control

Fig. 5. Effect of botanicals on the population and damage of *M.globulifera*

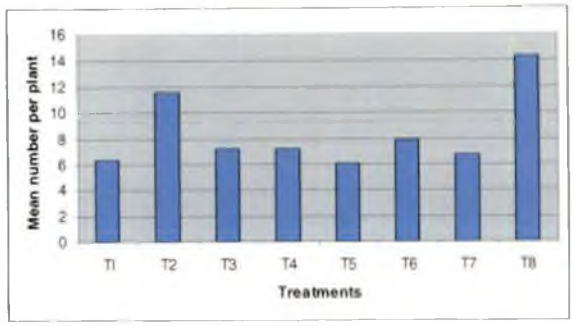
was lesser in limiting the population of *M.globulifera* when compared to azadidrachtin 0.004 per cent and pongamia oil two per cent. The treatments, neem cake soil application @ 250 kg ha^{-1}+ NSKE five per cent was more effective than neem cake soil application @ 250 kg ha^{-1}+ neem seed oil two per cent. The various effects other than toxicity of neem have been studied by a number of workers. Krishnamoorthy *et al.*, (2001) reported the efficiency of neem cake @ 250 kg ha^{-1} in managing the grubs of *Myllocerus* sp. in brinjal and hoppers in bhindi. Neem oil two per cent acted as a feeding inhibitor and insect growth regulator against *M.globulifera* (Smith,2001).

A.gossypii

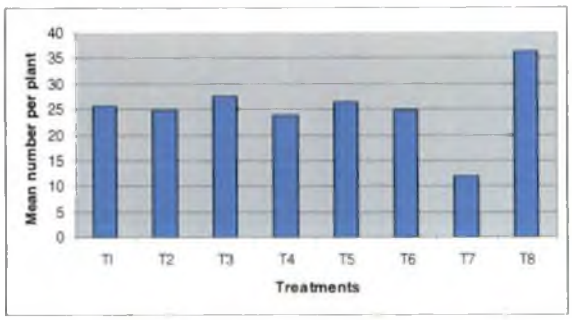
All the botanicals effectively reduced the population of *A.gossypii* (Fig. 6.A). Among the botanicals, azadirachtin 0.004 per cent and tobacco decoction gave the best results. The effect of azadirachtin 0.004 per cent was on par with the chemical check, dimethoate 0.05 per cent. Chandrasekaran (2001) and Regupathy *et al.*, (2003) confirmed the effectiveness of Neem Azal and other neem based formulations against *A. gossypii.* Tobacco decoction was recommended for the control of soft bodied insects like aphids (KAU, 2002). The oils *viz.*, illipe and pongamia at two per cent were more effective than the neem cake soil application @ 250 kg ha^{-1}+ NSKE five per cent and neem cake soil application @ 250 kg ha^{-1}+ neem seed soil two per cent against *A. gossypii.* However, Premsagar (1992) opined that both neem oil and pongamia oil at one per cent concentration reduced the population of *A. gossypii* in *Plantago ovata* L. Illipe oil (one per cent and two per cent) was very effective against the rose aphid *Macrosiphum rosae* L. according to Reddy *et al.*, (2002)



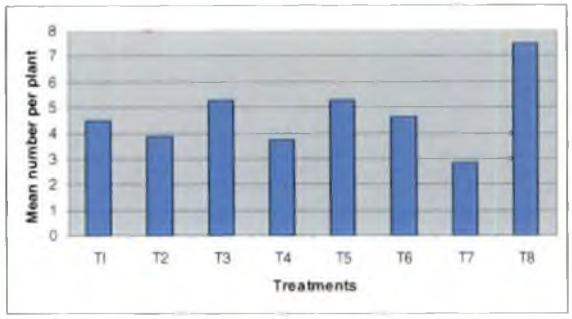
A. *A.gossypii*



B. *Icerya* spp.



C. *C.cajani*



D. *P. deschampes*

T1: Neem cake soil application @ 250 kg ha^{-1} + Neem seed oil 2%

T2: Illipe seed oil 2%

T3: Neem cake soil application @ 250 kg ha^{-1} +NSKE 5%

T4: Pongamia oil 2%

T5: Tobacco decoction

T6: Azadirachtin 0.004%

T7: Dimethoate 0.05%

T8: Control

Fig. 6. Effect of botanicals on the population of major pests of tulsi.

***Icerya* spp.**

All the treatments except illipe seed oil 2 per cent were superior to control in managing *Icerya* spp. (Fig.6.B). Tobacco decoction was the best among the botanicals. The treatments, neem cake soil application @ 250 kg ha^{-1}+ NSKE five per cent and pongamia oil two per cent, followed tobacco decoction in their effectiveness in control of *Icerya* spp. Verghese (1997) reported that maximum mortality of first instar nymphs of mealy bugs was achieved with five per cent NSKE. Neem seed oil two per cent also kept the population of *Icerya* spp. under check. The effectiveness of neem oil in controlling the mealy bug *Ferrisia virgata* Cockrell was reported by Saminathan and Jayaraj (2001).

C. cajani

The study of on the effect of botanicals on *C. cajani* revealed that they were not as effective as the chemical check dimethoate in curtailing the pest (Fig.6.C). Among the botanicals, pongamia oil and illipe oil were more effective against the scale insect. Premkumar and Devasahayam (1988) recommended the spraying of dimethoate 0.05 per cent against scale insects. In another study, Vijayasree (2006) concluded that botanicals failed to control the scale insect *Saissetia hemispherica* (Targ.) in cocinia. *C.cajani* is a hardy and tenacious pest with protective covering and remained at one point for feeding. The crawlers also moved and settled on fresh shoots. This enabled the pest to escape the adverse effect of botanicals to a great extent. However, dimethoate being systemic was able to exert its insecticidal action and hence was effective.

P. deschampes

Among the various treatments tested, only illipe seed oil two per cent, pongamia oil two per cent and dimethoate 0.05 per cent could be recommended against *P.deschampes* (Fig.6.D). Among the five major pests studied on tulsi, the spittle bugs were probably the least important. The spittle bug was a rain loving insect and seen in the rainy season when other hosts like banana, cocoa and weeds had a comparatively good growth. So management of the pest, if required should include its control on other hosts especially weeds.

Spiders

The population of spiders in different treatment plots except in tobacco decoction and dimethoate 0.05 per cent treated plots were statistically on par with the population in control plot (Fig.7). All the botanicals except tobacco decoction were benign to spiders. The results corroborated with the findings of Thamilvel (2004), Manu (2005) and Vijayasree (2006). The chemical check dimethoate 0.05 per cent was toxic to spiders which concurred with the reports of Manu (2005).

One of the important constraints in chemical pesticide application is its biocidal effect on natural enemies like spiders. On the contrary, botanicals effectively manage pests and at the same time conserve natural enemies to a great extent. This statement was indubitably confirmed by the results of the present study.

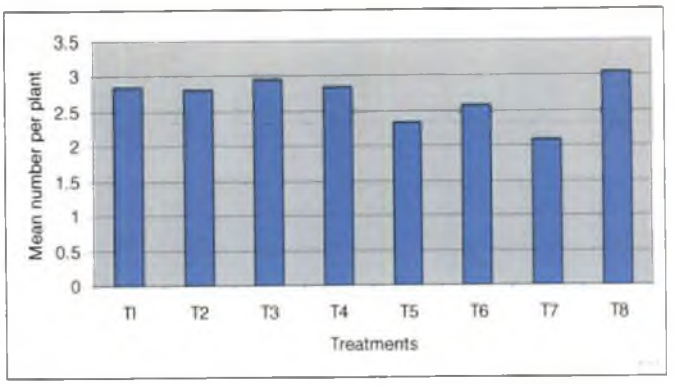


Fig. 7. Effect of botanicals on the population of spiders

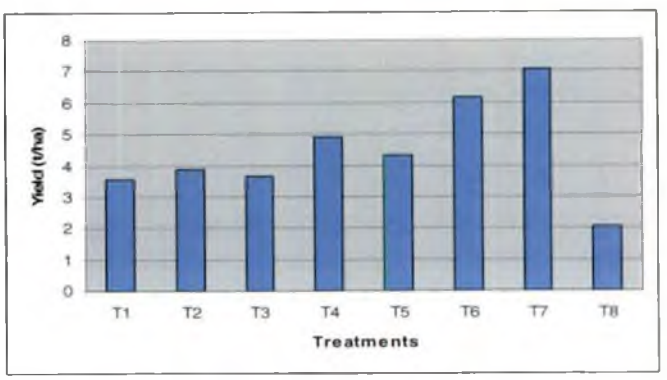


Fig. 8. Effect of botanicals on the yield of tulsi

T1: Neem cake soil application @ 250 kg ha^{-1} + Neem seed oil 2%

T2: Illipe seed oil 2%

T3: Neem cake soil application @ 250 kg ha^{-1} +NSKE 5%

T4: Pongamia oil 2%

T5: Tobacco decoction

T6: Azadirachtin 0.004%

T7: Dimethoate 0.05%

T8: Control

5.3 DISEASES AFFECTING TULSI

During the period of study, two diseases affecting *O.tenuiflorum* were observed. One was a viral disease and other a fungal one. The virus was inoculated on the leaves of a local lesion host, *Chenopodium amaranticolor* L. The localized lesions developed on *C. amaranticolor* confirmed that the disease was caused by virus (Plate 9). This was the first report of a viral disease of tulsi from Kerala. Earlier Ahlawat and Srivastava (1998) recorded Gemini virus in *O. tenuiflorum* from New Delhi. Insects, besides directly damaging the crops sometimes become responsible for the spread of virus, mycoplasmal and bacterial disease in plants. Most of the insect vectors belong to the order Hemiptera. The ability of sucking insects to transmit plant disease is closely linked to feeding mode and target tissue. As the major pests of tulsi were belonging to order Hemiptera, they could serve as vectors. David (2001) reported *A.gossypii* as a vector of viruses causing cucumber mosaic, chilli mosaic and papaya mosaic. Since the pests of tulsi are polyphagous chances for spread of this disease in other crops cannot be ruled out. Further studies are required to establish the identity of the virus infecting tulsi and vectors involved.

The leaf spot caused by *Colletotrichum gloeosporioides* Penz. was also the first report of a fungal disease of tulsi from Kerala. The leaf blight of *O.basilicum* by *Colletotrichum capsici* V. was reported from India by Alam and Janardhanan (1994). During the initial stage, circular, white coloured spots appeared on the leaves, which later coalesced and resulted in necrosis of leaves (Plate 10). *C. gloeosporioides* is a common organism causing leaf spot disease (anthracnose) in a wide array of fruit trees, spices and medicinal plants in Kerala. This has to be taken note of in the context of cultivating tulsi in farming systems with susceptible crops.

5.4 YIELD

The yield varied from 2.07 tha^{-1} to 7.07 tha^{-1} among the treatments and control. Among the botanical treatments, the highest yield was obtained from plots treated with azadirachtin 0.004 per cent (6.17 tha^{-1}). This was followed by Pongamia oil two per cent (4.93t ha^{-1}) and tobacco decoction (4.33 t ha^{-1}). Compared to control, there was significant increase in the yield in treated plots (Fig.8). The benefit cost ratio was calculated by fixing an additional 50 per cent in the price obtained from botanical treatments compared to chemical treatment. The highest cost benefit ratio was obtained from azadirachtin treated plots followed by pongamia oil two per cent.

The result of the ranking of the six botanical treatments based on their efficacy against the pests of tulsi, safety to spiders and yield is presented in Table 25. Pongamia oil two per cent was the best treatment closely followed by azadirachtin 0.004 per cent. The third best treatment was neem cake soil application @ 250 kg ha^{-1} +NSKE five per cent.

The study revealed that fifteen insect pests and two diseases were present at different growth stages of tulsi. The pests like *M.globulifera, A.gossypii, C.cajani, Icerya* spp. were not only important but also polyphagous. This calls for an assiduous surveillance of the pests and diseases in the event of raising *O.tenuiflorum*.

Based on the findings of the present investigation, any one of the following botanicals can be recommended for the management of the pests of tulsi.

(1) Pongamia oil 2 %.

(2) Azadirachtin 0.004 %

(3) Neem cake soil application (basal) @ 250 kg ha^{-1} +NSKE 5 %

Table 25. Ranking of botanicals based on their efficacy against pests, their safety to spiders and theirimpact on yield.

Treatments	*M.globulifera* (population)	*M.globulifera* (damage)	*A.gossypii* (population)	*Icerya* spp. (population)	*C.cajani* (population)	*P.deschampes* (population)	Spiders (population)	Yield	Total marks	Overall rank
	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank		
T1	f	f	f	b	e	c	b	f	20	V
T2	e	e	c	f	f	b	d	c	21	VI
T3	d	c	e	c	c	e	a	e	27	III
T4	b	b	d	d	a	a	c	b	37	I
T5	c	d	b	a	d	f	f	d	27	IV
T6	a	a	a	e	b	d	e	a	36	II

T1: Neem cake soil application @ 250 kg ha + Neem seed oil 2%

T2: Illipe seed oil 2%

T3: Neem cake soil application @ 250 kg ha^{-1} +NSKE 5%

T4: Pongamia oil 2%

T5: Tobacco decoction

T6: Azadirachtin 0.004%

This could be of immense help in plant protection of *O.tenuiflorum* not only in homesteads but also in commercial mediculture.

Insects and plants evolve contemporaneously and co-evolution takes place over several generations. However, ecological and biogeographical changes can occur faster without co-evolution *per se* in insect plant relationships. Several plant feeding insect species are euryphagous and vagile. This can result in frequent shifting of hosts which is more common in agriculture systems with larger areas under crops. Therefore, wherever possible crops which are hosts for polyphagous pests should not be grown close to one another in multiple cropping systems. For example in Kerala, raising a medicinal plant like tulsi in vegetable or fruit agro ecosystems should be done with utmost caution. Whereas, tulsi can be commercially grown in rubber and coconut gardens. Thus agriculture and mediculture should go hand in hand.

Strategies have to be formulated to achieve the maximum output, both in agricultural and medicinal crops through optimum utilization of resources. In the multicrop scenario, the feeding guilds of the phytophagous insects especially the polyphagous ones might change with the introduction of new medicinal plant species. The future line of work could include development of technologies including plant protection for raising medicinal plants along with agricultural crops. There is an immense scope for research and development in non-chemical methods for pest management in mediculture

Summary

6. SUMMARY

The tulsi (*Ocimum tenuiflorum* L.), a medicinal herb of the homesteads of Kerala is now grown only on a small scale. Of late, the demand for medicinal plants like tulsi has fuelled the need for mediculture. Tulsi, a shade tolerant plant can be cultivated as an intercrop in the crop production system based on coconut and rubber. In this context, improved crop husbandry practices including plant protection are required for increased productivity. Hitherto, the information on the status of pests and their management is meagre. Hence the present investigation was undertaken to study the pests of tulsi, their nature and extent of damage, correlation with weather parameters and their natural enemies. A field experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani to evolve a phytochemical based plant protection strategy against the pests of tulsi.

The survey revealed that tulsi was infested by five major pests and ten minor pests The major pests were *Monanthia globulifera* W, *Aphis gossypii* Glover, *Icerya* spp., *Cajanus cajani* Maskell and *Phymatostetha deschampes* L. and the minor pests were *Anchon pilosum* L., *Lygaeus* sp. *Agonoscelis* sp., *Leptocorisa acuta* (Thunb.), *Pseudococcus* sp., *Cyrtacanthacris* sp., *Syngamia abruptalis* Wlk., *Anisephyra ocularia* Fab., *Lasius* sp. and *Solenopsis* sp. One viral disease and a fungal disease by *Colletotrichum gleosporioides* Penz. were also recorded on tulsi.

Out of the fifteen pests documented, the incidence of *A.gossypii, Icerya* spp. *P.deschampes, A.pilosum, L.acuta, A.ocularia, Pseudococcus* sp., *Lasius* sp. and *Solenopsis* sp. are being reported for the first time as pests of tulsi. The diseases affecting tulsi are also being reported for the first time from Kerala.

M.globulifera was the most important pest of tulsi and it was present throughout the year in all the surveyed locations. However, the population varied among different locations and months. The population and damage was higher during summer months than in the rainy months. Both the nymphs and adults desapped the foliage which resulted in extensive curling and drying up of the leaves. The damage ranged from 38.34 per cent to 72.44 per cent. The population and damage had positive correlation with temperature and negative correlation with rainfall. The botanicals, azadirachtin 0.004 per cent and pongamia oil two per cent were very effective against lace wing bugs.

A.gossypii was the next important pest of tulsi. The population of aphids showed a two fold increase in summer months compared to rainy months. Temperature had positive relation with the pest population. The population varied among different months and locations. They were present throughout the year in all the locations. Nymphs and adults desapped both inflorescences and branches. The damage ranged from 26.04 per cent to 77.85 per cent. The treatments which gave maximum suppression of aphids were azadirachtin 0.004 per cent and tobacco decoction.

Two margarorids recorded as infesting tulsi were *Icerya aegyptiacum* (Dgl.) and *Icerya seychellarum* (Westw.). They were observed in all the five locations. Temperature had positive correlation and rainfall had negative correlation with the pest population. The nymphs and adults desapped the branches and the damage ranged from 0.99 per cent to 56.30 per cent. Neem cake soil application (basal) @ 250 kg ha^{-1}+ neem seed oil two per cent and pongamia oil two per cent reduced the population of mealy bugs significantly.

C.cajani infested tulsi plants in three locations *viz.*, Parasuvaikkal, Peroorkada and Vellayani. The population and damage varied among locations and months. Both the nymphs and adults were vigorous sap suckers. The percentage of infested branches exceeded sixty during summer months. Temperature had positive correlation with population and damage. Among the botanicals, pongamia oil two per cent or illipe oil two per cent could be used against scale insects.

Tulsi plants in Poojapura, Peroorkada and Vellayani were infested by the spittle bug, *P.deschampes.* The population and damage varied among locations. The presence of spittle mass gave an obnoxious appearance to the crop. The damage ranged from 41.12 per cent to 47.02 per cent. The population and damage was higher during rainy months in contrast to the distribution of other major pests. Pongamia oil two per cent and illipe oil two per cent suppressed the population of spittle bugs effectively.

Fifty per cent of the minor pests belonged to the order Hemiptera. *A.pilosum* infested tender branches and due to its honey dew secretion attracted ants, which made harvesting difficult. *Agonoscelis* sp. and *L.acuta* were more in the field during the early inflorescence stage of the crop, feeding on seeds at milky stage. *Lygaeus* sp. fed on matured seeds. *Psceudococcus* sp. was found on tulsi plants grown in dry soil. The mealy bugs infested root portion and resulted in the wilting of the plant. The grasshopper, *Cyrtacanthacris* sp. and two lepidopterans *viz.*, *S.abruptalis* and *A.ocularia* were leaf feeders. The ants, *Lasius* sp. and *Solenopsis* sp. caused direct damage by infesting inflorescence and indirect damage as carriers of aphids.

During the survey, eight species of spiders and one dipteran were recorded as predators of pests of tulsi. The spiders were present throughout the year in all locations and predated on aphids, mealy bugs and leaf folder larva. The botanicals

except tobacco decoction were not harmful to spiders. The maggots of the dipteran, *Paragus serratus* Fabr. were predators of aphids. An encyrtid pupal parasitoid infesting *P.serratus* was also recorded. *Coccophagus tschirchii* (Madhihassan) parasitized adults of *C. cajani* and *Bracon* sp. parasitized larvae of *S. abruptalis*.

The viral disease of tulsi was confirmed with the development of localized lesions on virus inoculated local lesion host, *Chenopdium amaranticolor* L. The leaf spot disease of tulsi was observed in all locations.

The results of the field experiment revealed that pongamia oil two per cent; azadirachtin 0.004 per cent and neem cake soil application @ 250 kg ha^{-1}+ NSKE five per cent were the most effective phytochemicals against the pests of tulsi. These treatments were benign to spiders also. The yield obtained from plots receiving various treatments was significantly higher than the control plot. Azadirachtin 0.004 per cent treated plots gave the highest yield followed by pongamia oil two per cent.

The investigation brought to the focus the status of the pest complex in tulsi. The results highlighted the need for assessment of the pests and their damage before adopting plant protection measures. In situations where pest control is warranted, the following ecofriendly measures could be recommended.

Application of a spray of pongamia oil two per cent, azadirachtin 0.004 per cent or neem cake soil application (basal) @ 250 kg ha^{-1}+NSKE five per cent.

References

7. REFERENCES

Ahlawat, Y.S. and Srivastava, K.P. 1998. *Ocimum sanctum*: A natural host of Gemini virus and its vector, *Bemisia tabaci* during off-season. *Indian J. Ent.* 60: 213-215.

Alam, M. and Janardhanan, K.K. 1994. A new leaf blight of French basil caused by *C.capsici* in India. *Indian J. Mycol. Pl. Pat.*.10 (2): 99.

Anil, K., Ramkishore and Parihar, S.B.S. 2004. Population build up of *Aphis gossypii* Glover on different crops. *Insect Environ.* 10 (1): 6-7.

*Anont, S.T. 1990. Studies on biology of Ocimum leaf folder, *Syngamia abruptalis* Walker and its host plants. *Kaen Kaset Kohn Kaen Agric. J.* 18: 178-181.

Ayyar,T.V.R. 1963. *Handbook of Economic Entomology for South India*, Government Press, Chennai, 373 p.

Balakrishnan, N., Kanibane, M. and Bhaskaran, M. 2004. Diversity of grasshoppers in rainfed cotton ecosystem. *Insect Environ.* 10 (1): 37-38.

Bharpoda, T.M., Koshiya, D.J. and Korat, D.M. 2006. Survey of insect pests and their natural enemies on Aonla (*Emblica officinalis* Geartn.). *Insect Environ.*12 (2): 26-27.

Bhattacharya, S. and Chakravorthy, S. 1984. Incidence of the insect, *Cochlochila bullita* Horv. on the tulsi plant at Kalyani. *Environ. Ecol.* 2 (1): 73-74.

Borges, M. 1999. Host plants of *Bemisia tabaci* Genn. (Homoptera: Aleyrodidae) *Rev. Biol. Trop.* 5 (3): 143.

Chadha, K.L. 2002. *Handbook of Horticulture*. Directorate of Information and Publications of Agriculture, New Delhi, 1031 p.

Chandra, K. 1992. Occurrence of the lacewing bug *Monanthia globulifera* W. on tulsi in South Andaman. *J. Andaman Sci. Assoc.* 8: 178-180.

Chandrasekaran, M. 2001. Development of integrated pest management on bhendi. Ph.D. thesis, Tamil Nadu Agricultural University, Coimbatore, 175 p.

Cherian, M.C. and Menon, E.R.G. 1944. Preliminary trials with oil emulsion for the control of insect pests. *Madras agric. J.* 1: 10-11.

Dahiya, A.S., Lakra, P.K. and Singh, Z. 1988. Predatory behaviour and development of two species of syrphids aphidophagous to *A.gossypii*. *Proceedings of National Symposium on Integrated Pest Control- Progress and Perspectives,* October 15-17, 1987. Bangalore, pp. 200-207.

David, B. V. 2001. *Elements of Economic Entomology*. Popular Book Depot, Chennai, 562 p.

Davis, R.M., Masshal, K.D. and Valeneria, J. 1993. First report of Fusarium wilt in basil in California. *Pl. Dis.* 77 (5): 537.

Dennis, S.H. 1994. *Agricultural Entomology*. Cambridge University Press, UK,212 p.

Dhadke, A. P., Khaindal, V.S. and Rahalkar, S.R. 1988. Use of neem products in insect resistant management in cotton. *Pesticides*. 22 (4): 36-37.

Fransworth, N. R. and Soejarto, D.D. 1991. Global importance of medicinal plants. *Conservation of Medicinal Plants*. (eds. Akerale, D., Heywood, V. and Synoge, H.). Cambrige University Press, UK, 250 p.

Geetha, B. 2000. Biology and management of spiralling white fly, *Aleurodicus dispersus* (Homoptera: Aleyrodidae). Ph.D. thesis, Tamil Nadu Agricultural University, Coimbatore, 196 p.

Gelman, D.B. and Gerling, A. 2005. Host –parasitoid interactions between *B.tabaci* and *Eretmocerus mundus*. *J. Insect Sci.* 5(2): 14-15.

Ghanim, A.A., Heneidy, A.H. and Serafi, H. 2004. Ecological studies on certain insects infesting guava orchards and their predatory insects. *J. Biol. Control.* 14 (1): 77-85.

*Guerrieri, E. and Noyes, J.S. 2000. Revision of European species of the genus *Metaphycus mercet* M. parasitoids of scale insects. *Sys. Ent.* 25 (2): 147-222.

*Gullino, M.L., Garibald, A. and Minuto, A. 1995. First report of black spot of basil incited by *Colletotrichum gloeosporioides* Penz. in Italy. *Pl. Dis.*79 (2):539.

Horvath, A. 1981. Susceptibility of members of family Lamiaceae to viral diseases. *J. Gen. Virol.*79 (2): 142.

*Icuma, I.M. and Hirose, Y. 1996. Effects of temperature and survival of the egg parasitoid *Telenomus triptus* Nixon (Hymenoptera: Scelionidae) in two pentatomid hosts. *J. Appl. Ent. Zool.* 31(1): 168-170.

Kambrekar, D.N., Awaknavar, J.S. and Kulkarni, K. A. 2003. Insecticidal toxicity against spiralling white fly, *Aleurodicus dispersus* Russell. *J. Ent. Res.* 27(1): 77-80.

KAU, 2002. *Package of Practices Recommendations: 'Crops'*. Twelfth edition. Directorate of Extension, Kerala Agricultural University, Thrissur, 278 p.

Kavitha, Z. and Savithri, P. 2001. Efficacy of certain botanical and conventional insecticides against major insect pests of *Ziziphus jujuba*. *IPM in Horticultural crops: Emerging trends in the new millennium* (eds. Verghese, A., and Reddy, P.P.). Proceedings of Second National Symposium of Integrated Pest Management in Horticultural Crops, 2001. Association of Advancement of Pest management in Horticultural Ecosystems (AAPMHE), Bangalore, 45 p.

Krishnamoorthy, P.N., Krishnakumar,N.K. and Raja, M.E. 2001. Neem and Pongamia cakes in the management of vegetable pests. *IPM in Horticultural crops: Emerging trends in the new millennium* (eds. Verghese, A. and Reddy, P.P.). Proceedings of Second National Symposium of Integrated Pest Management in Horticultural Crops, 2001. Association of Advancement of Pest management in Horticultural Ecosystems (AAPMHE), Bangalore, pp. 74-75.

*Livingstone, D. and Yacoob, M. 1983. A new subgenus of *Lathromeromyia* sp. (Hymenoptera: Trichogrammatidae) an egg parasite of Tingidae from India. *Entomophaga.* 28 (3): 303-308.

Mani, M. and Krishnamoorthy, A. 1989. Impact of insect predators in the control of *Aphis gossypii* Glover on guava. *J. Biol. Control.* 3: 128-139.

Mani, M. and Krishnamoorthy, A.1999. Natural enemies and host plants of spiralling white fly, *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae) in Bangalore. *Entomon.* 24: 75-80.

Mann, G.S. and Dhaliwal, G.S. 2001. Impact of neem based insecticides on beneficial arthropods in cotton ecosystem. *Ann. Pl. Prot. Sci.* 9 (2): 225-229.

Manu, P.M. 2005. Major spiders in vegetable ecosystem and their predatory potential. M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur,104 p.

Mariam, M.A. and Chandramohan, N. 2000. Evaluation of chemical insecticides and botanicals against various stages of spiraling white fly, *Aleurodicus dispersus* Russell. *Madras agric. J.* 87: 379-381.

Masoodkhan, M.A., Reddy, J.D. and Rao, V. 2001. Efficacy of selected insecticides against pest complex in okra, *Abelmoschus esculentus* Linn. *Pestology* 25 (9): 44-48.

Mathur, A.C. 1962. Food-plant spectrum of *Diascrisia obliqua* (Wlk.) (Arctiidae:Lepidoptera). *Indian J. Ent.* 24: 286-287.

Nair, M.R.G. K. 1975. *Insects and Mites of Crops in India.* Second edition. Indian Council of Agricultural Research, New Delhi, 408 p.

Nair, M.R.G. K. 1999. *A monograph of Crop Pests of Kerala and Their Control.* Third edition. KAU Press, Mannuthy, 215 p.

Nandakumar, C. and Saradamma, K. 1996. Botanical pesticides are benign to natural enemies of epilachna beetle. *Insect Environ.* 2 (1): 27.

Natarajan, K. and Sundaramurthy, V.T. 1990. Effect of neem oil on *Bemisia tabaci* Genn. *Indian J. agric. Sci.* 60 : 290-291.

Nayar, K.K., Ananthakrishnan, T.N., and David, B.V. 1976. *General and Applied Entomology.* Tata Mc Graw Hill Publishing Company Limited, New Delhi, 573 p.

Nema, K.K. 2006. Record of a predator, *Baisticus flavus* (Distant) on *Nezara viridula* L. in India (Hemiptera: Reduvidae). *Insect Environ.* 12 (1): 69-70.

Palaniswami, M.S. and Pillai, K.S. 1983. Biology of *Cochlochila bullita* Horv. a pest on Chinese potato. *J. Root Crops.* 9 (1-2): 59-62.

Panse, V.G. and Sukhatme, P.V. 1985. *Statistical methods for Agricultural Workers.* Fourth edition. Indian Council of Agricultural Research, New Delhi, 381 p.

Pradhan, S. 1969. *Insect Pests of Crops.* National Book Trust, New Delhi, 175 p.

Premkumar, T. and Devasahayam, S. 1988. Management of insect pests for higher yield in black pepper. *Indian Cocoa, Arecanut, Spices J.* 2: 121-122.

Premsagar, 1992. Efficacy of insecticides against the aphid, *Aphis gossypii* Glover on Isabgol, *Plantago ovata* L. *Indian J. Ent.*, 54 (4): 399-401.

*Price, J.F. and Schuster, D.J. 1991. Effects of natural and synthetic insecticides in *Bemisia tabaci. Fla. Entomol.* 74: 60-68.

Pruthi, T.S. 1969. *Text Book on Agricultural Entomology.* Job Press Pvt. Ltd. Kanpur, 380 p.

Puspangadan, P. and Bradu. B.L. 1995. Basil. *Advances in Horticulture:.11-Medicinal and Aromatic Plants* (eds. Chadha K.L. and Rajendragupta), Malhotra Publishing House, New Delhi, pp.627-655.

Rajan, V.P. 2003. Insect pests of medicinal plants: Bionomics and Management. M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur, 87 p.

Ramani, S. 2000. Introduction of an aphelinid parastoid of *Aleurodicus dispersus* Russell into Lakshadweep islands. *J. Biol. Control.* 14 (2): 55-60.

Ramani, S., Poorani, J. and Bhumannavar,B.S. 2002. Spiralling whitefly in India. *J. Biol. Control.* 23 (2): 55-56.

Rani, B.J. 2001. Pest Management in Ornamental, Medicinal and Aromatic crops. *Integrated pest management in Horticultural Ecosystems.* (eds. Reddy, P.P.,

Verghese, A, and Krishnakumar, N.K.), Capital Publishing Company, New Delhi, 263 p.

Rani, J. 2004. Bioecology and management of spiralling white fly *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae). M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur, 86 p.

Reddy, K.M.S., Rajgopal, B.K., Reddy, R.N.S. and Reddy, N.S. 2002. Effect of botanical insecticides against rose aphid (*Microsiphum rosae* L.). *J. Ornm. Hort.* New series. 5 (1): 84-85.

Regeena, S., John, J., Ravi, S., Krishnakumar,V. and Geetha, K. 2004. *Homestead Farms - Agricultural Heritage Systems of Kerala.* Technical Bulletin, Directorate of Extension, Kerala Agricultural University, Thrissur, 24 p.

Regirani, O.P. 1995. Bioecology and life table of the pea aphid, *Aphis craccivora* Koch. and its natural enemies. M.Sc. (Ag.) thesis, Kerala Agricultural Universty, Thrissur, 106 p.

Regupathy, A., Palaniswamy, S., Chandramohan, N. and Gunathilagaraj, K. 2003. *A Guide on Crop Pests.* Fourth edition. Soorya Desktop Publishers, Coimbatore, 264 p.

Saminathan, V.R. and Jayaraj, S. 2001. Evaluation of botanical pesticides against the mealy bug, *Ferrisia virgata* Cockrell. (Homoptera: Pseudococcidae) on cotton. *Madras agric. J.* 88: 535-537.

*Satar, S., Kersting, U. and Uygun, N. 1999. Effect of temperature on development rate and fecundity of apterous *Aphis gossypii* Glover. (Homoptera: Aphididae) reared on *Gossypium hirsutum* L. *J. Appl. Ent.* 123 (1): 23.

Sharma, D.C. and Kashyap, N.P. 2002. Impact of pesticidal spray on seasonal availability of natural predators and parasitoids in the tea ecosystem. *J. Biol. Control* 16(1): 31-35.

Sharma, J.R. 1999. PGR Issues: National concern and global conflicts with special reference to medicinal and aromatic plants. *J. Med. Arom. Pl. Sci.* 21: 1111-1118.

Sharma, K.K. and Borah, B.K. 2004. Natural parasitisation of Bihar Hairy Caterpillar, *Spilosoma obliqua* Wlk. by *Blepharella lateralis* Macquart. *Insect Environ.* 10 (1): 15.

Singh, A.N. 2002. Preliminary studies on the ovicidal actions of some ecofriendly insecticides against *S.obliqua. Insect Environ.* 8 (2): 65-66.

Singh, S.K. 2004. Record of coccid, *Ceroplastodes cajani* Maskell on pigeon pea in Uttar Pradesh. *Insect Environ.* 8 (2): 64.

Smith, D. 2001. Lace bugs: Life cycle, monitoring and pest management. *J. Insect Sci.* 5 (2): 101-105.

Thamilvel, D. 2004. Management of insect pest complex in okra (*Abelmoschus esculentus* Linn.). M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur, 107 p.

Verghese, A. 1997. Effect of neem on first instar crawlers of mealy bug, *Maconellicoccus hirsutus* Green. *Insect Environ.* 2: 121-122.

Vijayasree, V. 2006. Pests of coccinia (*Coccinia grandis* (L.) Voigt.) and their management. M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur, 106 p.

*Originals not seen.

Appendix

APPENDIX-1

Weather parameters recorded during June 2005 to June 2006

Months	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Number of rainy days
	Maximum	Minimum	Morning	Evening		
June 2005	29.60	22.50	91.90	75.60	242.40	17
July 2005	29.80	23.30	93.50	77.90	321.40	20
August 2005	30.18	23.10	90.10	71.10	89.50	9
September 2005	30.00	26.20	92.30	75.90	201.40	17
October 2005	30.50	23.02	91.90	71.50	180.10	22
November 2005	29.80	23.20	94.40	73.80	165.40	21
December 2005	31.04	23.00	94.90	70.06	88.90	7
January 2006	31.03	22.30	93.30	70.80	22.45	3
February 2006	32.30	22.10	92.30	65.50	0.40	1
March 2006	32.50	24.10	94.20	66.60	30.30	5
April 2006	32.90	25.10	90.50	68.30	35.00	5
May 2006	31.60	25.20	90.60	75.50	175.50	11
June 2006	31.50	26.10	90.90	75.80	123.20	7

APPENDIX- II

Pre-count of treatments

Treatments	Pre-count									
	Population of lace wing bugs		Damage by lace wing bugs		Population of aphids	Population of mealy bugs	Population of scale insects	Population of spittle bugs	Population of spiders	
	I spray	II spray	I spray	II spray					I spray	II spray
T_1	30.21	32.18	12.15	8.12	37.12	8.51	33.15	6.21	2.30	1.75
T_2	32.28	33.12	15.32	9.25	39.07	7.95	34.27	7.81	1.87	2.36
T_3	30.71	30.25	11.42	8.35	39.15	9.28	32.81	5.45	1.93	1.85
T_4	34.12	31.52	15.12	7.14	35.21	10.15	35.79	7.29	2.10	2.42
T_5	35.15	34.13	14.72	9.10	32.35	8.27	33.28	8.19	1.72	1.97
T_6	32.13	32.22	13.18	8.07	30.18	9.05	30.18	6.07	1.83	2.15
T_7	31.11	32.15	12.26	10.17	34.27	8.48	32.15	5.50	2.34	2.17
T_8	36.25	35.27	19.03	8.43	41.43	11.27	37.57	7.60	2.80	2.90

T1: Neem cake soil application @ 250 kg ha^{-1} + Neem seed oil2%

T2: Illipe seed oil 2%

T3: Neem cake soil application @ 250 kg ha^{-1} +NSKE 5%

T4: Pongamia oil 2%

T5: Tobacco decoction

T6: Azadirachtin 0.004%

T7: Dimethoate 0.05%

T8: Control

PESTS OF TULSI (*Ocimum tenuiflorum* L.) AND THEIR MANAGEMENT

MALINI NILAMUDEEN

Abstract of the
thesis submitted in partial fulfilment of the requirement
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ABSTRACT

The seasonal occurrence and the extent of damage caused by pests of tulsi were assessed in a survey conducted at monthly intervals for one year in five locations *viz.,* Perumpazhuthoor, Parasuvaikkal, Poojapura, Peroorkada and Vellayani of Thiruvananthapuram district. A field trial was carried out in the Instructional Farm, College of Agriculture, Vellayani to evaluate the effect of various botanicals against the pests, the spiders and on herbage yield of tulsi.

The five major hemipteran pests recorded on tulsi were *Monanthia globulifera* W., *Aphis gossypii* Glover, *Cajanus cajani* Maskell, *Phymatostetha deschampes* L. and *Icerya* spp. The minor pests recorded were *Anchon pilosum* L., *Lygaeus* sp., *Agonoscelis* sp., *Leptocorisa acuta* (Thunb.), *Pseudococcus* sp., *Cyrtacanthacris* sp., *Syngamia abruptalis* Wlk., *Anisephyra ocularia* Fab., *Lasius* sp. and *Solenopsis* sp. A viral disease and a fungal leaf spot caused by *Colletotrichum gloeosporioides* Penz. were also recorded.

The infestation by *A. gossypii., Icerya* spp., *P. deschampes, A. pilosum Lygaeus* sp., *Agonoscelis* sp., *L. acuta, Pseudococcus* sp., *A .ocularia, Lasius* sp. and *Solenopsis* sp. are being reported for the first time. The diseases are also being reported for the first time from Kerala.

All the five major pests were polyphagous in nature. The incidence of the pests and magnitude of damage caused by them varied among the different locations as well as during the different months. Both the density dependent factors like availability of other host plants and density independent factors like temperature, relative humidity and rainfall played a major role in the distribution of pests in various locations. Except *P. deschampes*, the population and infestation of all the

other major pests were high during summer months compared to the rainy months. The population and damage by *P. deschampes* had positive correlation with rainfall.

The natural enemies of the pests included eight species of spiders and a dipteran (syrphid). The spiders were observed in all locations throughout the year. The syrphid *Paragus serratus* Fabr. was a predator of *A.gossypii*. An encyrtid pupal parasitoid of *P.serratus* was also observed. The adults of *C.cajani* were parasitized by *Coccophagus tschirchii* (Madhihassan) and the larvae of *S. abruptalis* were parasitized by *Bracon* sp.

The results of the pest management trial revealed that the botanicals were not only effective in containing the pests but also safe to the spider fauna. The treatments gave higher yield also. Among the botanicals, pongamia oil two per cent or azadirachtin 0.004 per cent or neem cake soil application @ 250 kg ha^{-1}+ NSKE five per cent could be recommended for the control of the pests of tulsi. This would be of use in the protection of tulsi in homesteads as well as in mediculture.