EVALUATION AND MANAGEMENT OF PEST COMPLEX IN CASHEW GRAFTS

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I hereby declare that this thesis entitled "**Evaluation and management of pest complex in cashew grafts**" is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

27-01-04

Vellanikkara

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CERTIFICATE

Certified that this thesis, entitled **"Evaluation and management of pest complex in cashew grafts"** is a record of research work done independently by **Miss. K.B.Deepthy** 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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Affectionately dedicated to
Achan, Amma, Deepu and
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Introduction

INTRODUCTION

Cashew is one of the important horticultural crops in India with great commercial significance providing substantial export earnings. India holds a virtual monopoly in cashew trade, supplying more than 90 per cent of the world's demand for cashew. Total area under cashew cultivation is about 6.86 lakh ha, with a production of 5.2 lakh tonnes. Cashew cultivation has been receiving prime importance during the last one-and-a-half decades, due to its high export value. But cashew production in our country is not getting augmented with increase in area under cultivation. Infestation by insect pests has been identified as a crucial and major factor responsible for the stagnation without breaking the yield barriers.

Nearly 150 insect pests were described in cashew by Rai (1984). Among the major pests, the tea mosquito bug (TMB), *Helopeltis antonii* Signorett is the most serious pest infesting tender leaves, shoots, inflorescence and the developing nuts (Beevi *et al.*, 1991).

Both the adults and nymphs suck sap from tender shoots, panicles and immature fruits. The typical feeding damage appears as a discoloured necrotic lesion around the point of entry of the stylets (Stonedahl, 1991). Severe infestation results in the drying up of young shoots and panicles giving the infested trees a scorched appearance (Plate 1).

The average damage to tender shoots was estimated from 14 (Sathiamma, 1977) to 25 per cent (Abraham, 1958; Pillai, 1980). Damage to inflorescence results in blossom blight and as much as 48 per cent panicle damage was reported by Sathiamma (1977). Infection causes a shrivelled appearance to immature nuts, while older nuts develop a blistered or scabby appearance. Pillai (1980) reported that the yield loss due to nut damage and fruit drop was 15 and 12.29 per cent respectively.

The association of wound pathogens on TMB feeding lesions has been reported by many workers. Presence of the fungi *Gloeosporium mangiferae* P. Henn. and *Phomopsis anacardi* (CCRS, 1965); *Colletotrichum, Fusarium* and *Botryodiplodia* (CPCRI, 1983) on TMB feeding lesions were reported. Plants infested by TMB is more prone to die-back disease caused by *Colletotrichum gloeosporioides* (Nambiar *et al.*, 1973, Varma and Balasundaram, 1990 and Bindu *et al.*, 1998). Severe outbreak of TMB - anthracnose complex has resulted in huge loss of yield in the northern parts of Kerala during 1998-99. Crop loss of 80 to 100 per cent has been reported due to this pest disease complex (Mathew *et al.*, 1999).

Damage by *H. antonii* was found to be severe in young trees than in mature trees (Swaine, 1959) and the infestation persisted almost throughout the year on young trees (Sathiamma, 1977, Varma and Balasundaram, 1990). TMB infestation on young cashew grafts was very severe compared to older seedling trees at Cashew Research Station, Madakkathara (Beevi *et al.*, 1991). Cultivation of crop varieties resistant to pest infestation is the most effective and economical method of pest control. Application of *Trichoderma harzianum* and *Glomus fasciculatum,* (Arbuscular Mycorrhizal Fungi -AMF) at the time of sowing is found to enhance the growth and vigour of cashew rootstocks (Joseph *et al.*, 2002).

Softwood grafting is the commercial method of propagation in cashew. About five lakhs grafts are required per annum in Kerala. Pests and diseases are the major problems causing poor growth and establishment of grafts in the cashew nursery. Hence management of the pest-disease complex is essential to reduce the crop loss in the nursery. With this aim, the present study was undertaken with the following objectives.

(i) To assess the impact of different pesticides and AMF on pest complex in cashew nursery and

(ii) to study the varietal reactions of cashew grafts to the nursery pest complex.

Tea Mosquito Bug

Plate 1. Dieback symptoms on cashew

Review of Literature

2. REVIEW OF LITERATURE

Cashew is one of the important dollar earning crops of India. The major cashew growing areas of India are Kerala, Karnataka, Maharashtra, Tamil Nadu, Andhra Pradesh, Goa, Orissa and West Bengal. Due to its high export value, cashew production is given a prime importance. But cashew nut production in the country is not in tune with increase in area under cultivation. A drastic decline in cashew production was observed eventhough the area has been increased to a greater extent. One of the main reasons for low productivity is the occurrence of insect pests in association with cashew.

More than 150 species of insect pests are associated with cashew, during different stages of its growth (Pillai, 1980 and Rai, 1984). Among these the mirid bug, *H. antonii* Signorett, commonly known as 'tea mosquito' is considered to be the most serious pest of cashew. Incidence of tea mosquito is reported to be severe in most of the cashew growing tracts of Kerala, Karnataka, Goa and Maharashtra in the west coast and Tamil Nadu in the east cost (Rao, 2002).

Plant bugs of the genus *Helopeltis* has a palaeotropical distribution extending from West Africa to New Guinea and Northern Australia. The first record of the species, *H. antonii* from cocoa dates back to 1863 in Ceylon (Wright, 1907). Attack of this pest on cashew in India was first reported by Pillai *et al.* (1976).

The plants infested by tea mosquito is more prone to die-back disease caused by *Colletotrichum gloeosporioides* (Nambiar *et al.*,1973, Varma and Balasundaram, 1990 and Bindu *et al.*, 1998).

2.1 NATURE AND SYMPTOMS OF DAMAGE

The nature of damage caused by *H. antonii* has been described by various authors (Abraham, 1958; Pillai and Abraham, 1975). The nymphs and adults suck sap from tender shoots, leaves, panicles, developing nuts and apples.

Typical feeding damage by *Helopeltis* spp. appears as a discoloured, necrotic area or lesion around the point of entry of labial stylets into the plant tissue. The surrounding tissues become necrotised and brown or black necrotic lesions are formed due to the action of phytotoxin present in the saliva. In severe infestations the young shoots and panicles dry up, giving the infested trees a scorched appearance. Successive attack on new growth can result in stunting or death of the tree. Damage to the immature nuts causes them to shrivel, while older nuts develop a blistered or scabby appearance (Stonedahl, 1991) (Plate 2).

2.2 EXTENT OF DAMAGE

The extent of damage to plant parts and the resultant yield loss were estimated by different workers. Abraham (1958) estimated the average damage caused by *H. antonii* as 25 per cent in tender shoots and 15 per cent in tender nuts, while according to Sathiamma (1977) average of 14 per cent of shoots, 48.5 per cent of panicle and 32 per cent of fruits were damaged by this pest. Sometimes 30 to 40 per cent crop loss occurs due to the incidence of this pest (Devasahayam and Nair, 1986). A severe outbreak of TMB-anthracnose infestation has been reported in the northern parts of Kerala earning huge yield loss. Crop loss of 80 to 100 per cent has been reported due to this pest disease complex (Mathew *et al.*, 1999). In the situations of out break it has the potential to reduce the yield even up to cent per cent (Sundararaju and Sundarababu, 1999c).

2.3 MORPHOLOGY

The morphology of adults and immature stages of *H. antonii* have been studied by Ambika and Abraham (1979a). The adult bug is reddish brown with a black head, red thorax and black and white abdomen. A knobbed process arises from the dorsal aspect of the thorax of both the sexes which is erect tapering with the apex swollen and funnel shaped. Males are about 5.9 to 6.9 mm in length, dark brown or reddish brown in colour, head mostly fuscous with apex of tylus and spots ventrad and posterior of eyes pale, antennae uniformly fuscous. Legs brownish yellow moderately

On shoot

On leaves

TMB

On apple and nuts

On panicles

Plate 2. Symptoms of TMB infestation

to extensively mottled with fuscous. Females are about 7.2 to 8.0 mm in length similar to male in colour and structure only difference is in genetalia. The nymphs are small, ant like and orange coloured (Stonedahl, 1991).

2.4 BIOLOGY

Biology of *H. antonii* was studied by several workers.

The eggs are generally inserted into tender shoots, inflorescence stalks and some times on the leaf midrib and petioles either singly or in groups of 2 to 6 (Devasahayam and Nair, 1986). The site of oviposition can be recognized by the presence of a pair of silver white thread like chorionic processes of unequal size that projects out side the plant tissue. There are five nymphal instars. The incubation period lasts for 6 to 7 days and the nymphal period is 10 days at a temperature range of 24 to 32°C and a relative humidity of 47 to 100 per cent (Pillai *et al.*, 1976). The duration of the first nymphal instar was 3 to 3.5 days and the second instar for 2.4 days. The third instar moulted in about 2.4 days and fourth instar lasted for 2.5 days (Ambika and Abraham, 1979a). The adult longevity varies from 4 to 14 days for males and 4 to 24 days for females. The total life cycle occupied 22 to 35 days at Bangalore (Sudhakar, 1975) and 22.2 days in Kerala (Ambika and Abraham, 1979a) (Plate 3).

2.4.1 Seasonal abundamce

Build up of the pest population commences during October-November synchronising with the emergence of new flushes and after the cessation of monsoon showers. Population reaches its peak in January when the trees are in full bloom (Rao, 2002).

The pest was almost absent during monsoon period on older trees (Pillai and Abraham 1975). However on young trees, heavy population was observed throughout the year since the pattern of flushing in these trees is of protracted nature (Sathiamma, 1977). At Vittal, *H. antonii* was active in the field during November-April with a high incidence during January-February (Rai, 1981).

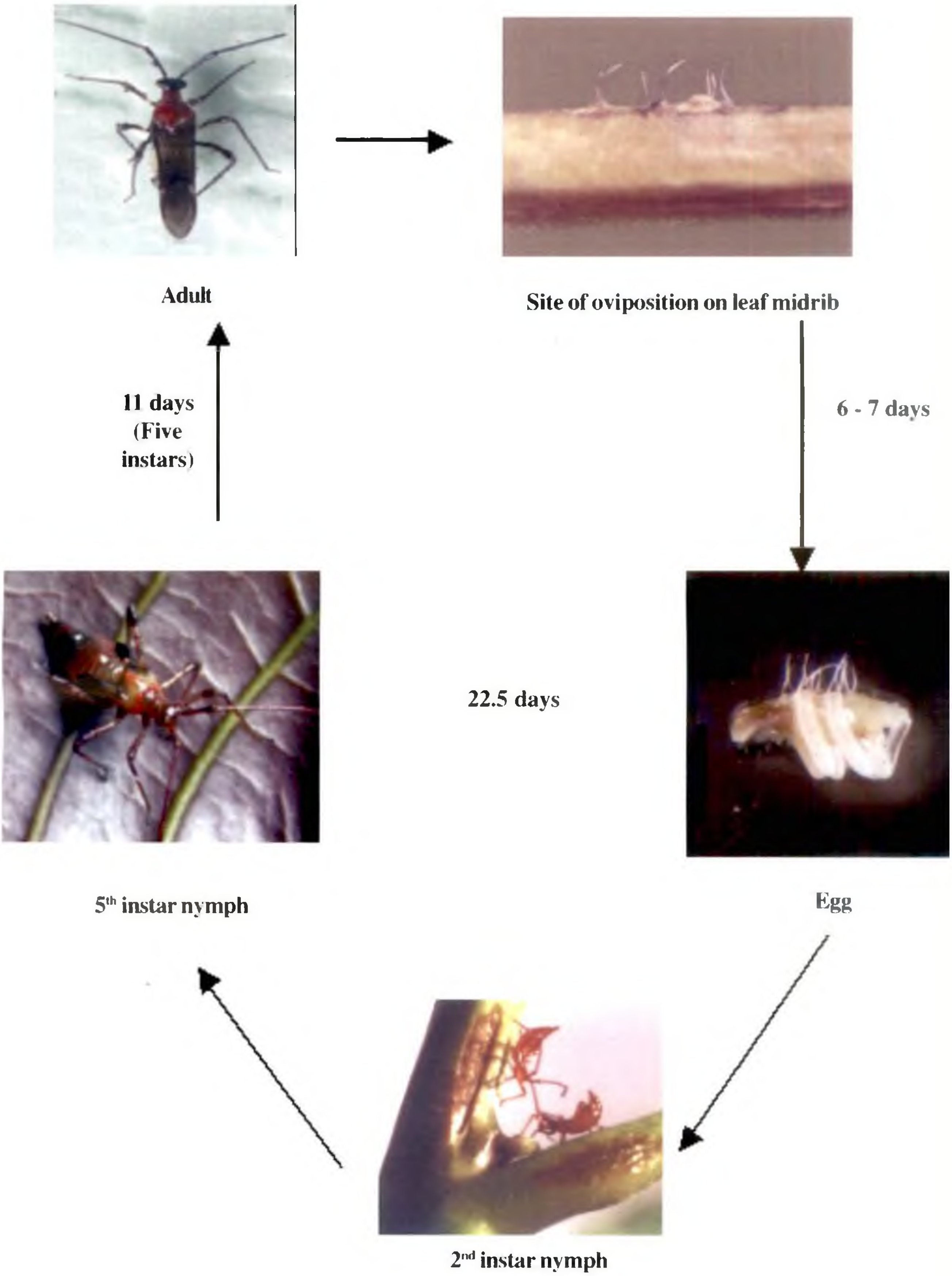

Plate 3. Life cycle of TMB

The most favourable period for rapid multiplication and population build up of the pest was from December to February when the host plant provided an abundant supply of succulent plant parts. During the monsoon period, June to September, when the succulent plant parts are not available on grown up trees, the population of the pest was completely absent (Pillai *et al.*, 1984). At Goa, the build up of pest population and its damage commenced from October-November onwards. Peak pest population observed during February and no damage was observed during June-September (Sundararaju, 1984). .

The pest population was higher during the period January to March. However during July to September the pest population was low and was seen on young trees only (Devasahayam, 1985).

Studies conducted at Agricultural Research Station, Chintamani during the period June 1987 to May 1990 indicated that the incidence of tea mosquito started during second fortnight of June and reached maximum during first fortnight of January (Thirumalaraju *et al.*, 1991).

2.5 HOST ASSOCIATION

There are about 24 host plants reported by various workers. Fletcher (1914) reported the occurrence of *H. antonii* on tea, mahogany, neem, cocoa, cinchona and anatto (*Bixa orellana*). The pest has been reported on guava (Gopalan and Perumal, 1973 and Chong, 1987). *H. antonii* is reported to cause occassional die-back of shoots and deformity of leaves of black pepper in Sarawak (Blacklock, 1954) and India (Devasahayam *et al.*, 1986).

Other economically important plants damaged by *Helopeltis* spp. include apple, grapes (Puttarudriah and Appanna, 1955), all spice (*Pimenta dioica*) (Devasahayam *et al.*, 1986) and cotton (Shivayogeshwara *et al.*, 2001).

Other important host plants of *Helopeltis* spp. include *Coffea arabica, Passiflora* spp., *Dioscorea* sp., *Capsicum annuum, Solanum nigrum, Mikania scandens, Bidens pilosa, Melostoma malabaricum, Begonia semperflorens* (Lever, 1949), *Acasia mangium* in Philippines (Luego, 1990), *Psophocarpus tetragonolobus* in Sri Lanka (Shanthichandra *et al.*, 1990), Indian long pepper (Abraham, 1991) and Eucalyptus in Indonesia (Rahardjo, 1992).

2.6 ASSOCIATION OF THE FUNGUS AND DIE-BACK IN CASHEW

Studies conducted at Cashew Research Station, Ullal, showed that the inflorescence blight in cashew was caused by the fungus *Gloeosporium* and *Phomopsis anacardi* (CCRS, 1965).

Nambiar *et al.* (1973) studied the role of *H. antonii* and the fungi *G. mangiferae* and other non-sporulating species in inciting inflorescence blight in cashew. Tea mosquito was found to be the primary causal agent of the malady and the fungi were only secondary saprophytic colonizers.

The leaf spot disease in cashew was reported to be caused by the fungus *C. gloeosporioides* in Kerala (Abraham and Padmakumari, 1980) and Orissa (Naik *et al.*, 1986).

Wounds caused by *Helopeltis* spp. facilitated the entry and development of pathogen such as *P. anacardii* and *Glomerella cingulata* (Intini and Sijaona, 1983).

Anthracnose caused by *C. gloeosporioides* and the die-back of shoots and inflorescences caused by *P. anacardi* resulted in decline of cashew cultivation in Tanzania (Intini, 1987).

According to Patnaik *et al.* (1987) the inflorescence blight incidence in the cashew varieties at Bhubaneswar, Orissa was caused by the fungus *Botryodiplodia* *theobromae*. Here the injury and abrasion caused by the flower thrips might have predisposed the inflorescence for infection by the fungal pathogens.

Varma and Balasundaram (1990) investigated the shoot die-back in cashew and a fungus *Botryodiplodia theobromae* was isolated from the dead tissues. The primary cause for the entry and establishment of the pathogen was attributed to the infestation of the insect *H. antonii*. Controlled experiments revealed that, die-back occurred only when the fungus was inoculated in the lesion caused by feeding of *H. antonii*. They also isolated the fungal pathogen *C. gloeosporioides* from the dead tissues.

A study conducted by Bindu (1996) revealed the occurrence of *C. gloeosporioides* as a predominant fungal pathogen, associated with the necrotic lesions of tea mosquito affected shoots, panicles and nuts.

2.7 MANAGEMENT OF *H. antonii*

Several control methods were reported for effective protection of cashew against *H. antonii*.

2.7.1 Chemical methods

Chemical control of *H. antonii* has been suggested as one of the short-term strategy for increasing cashew yields (Nambiar *et al.*, 1973).

Among the chemical insecticides, DDT was the first to be used against *Helopeltis* on tea (Lever, 1949). According to Damodaran and Nair (1969), two sprays of DDT given at 15 days interval provided an effective control of *H. antonii* on cashew.

Chemical control trials conducted at Kasargod; Kerala, revealed that endosulfan 0.05 per cent applied as high volume spray and 0.1 per cent as low volume spray at the time of emergence of new shoots, panicles and fruit set was effective in controlling the tea mosquito population in cashew and thus reducing the yield losses (Pillai *et al.*, 1976).

According to Muthu and Baskaran (1979), quinalphos was effective in controlling the pest population build up. The systemic insecticides were not as effective as contact insecticides in controlling the pest (Pillai, 1980). Phosphamidon 0.03 per cent was found to be as effective as carbaryl and endosulfan (Abraham and Nair, 1981). Endosulfan, carbaryl, phosphamidon and quinalphos were effective in reducing the pest population (Nair and Abraham, 1982; Abraham, 1984). Dust formulations of carbaryl and phosalone were effective in reducing the shoot damage caused by *H. antonii* (Nair and Abraham, 1983).

According to Singh and Pillai (1984), quinalphos, formothion and diazinon were effective in reducing the yield loss due to *H. antonii*. Smith *et al.* (1985) recommended spraying of endosulfan at 440 g ai/ha in 60 litres of water for control of *H. clavifer* on tea in New Guinea. Endosulfan, monocrotophos and phosalone were effective in reducing the pest population (Sundararaju, 1984). According to Chatterjee (1989) monocrotophos and endosulfan were found to be effective against tea mosquito bug. Sammiayyan *et al.* (1989) reported that methyl parathion, endosulfan and carbaryl were effective in reducing the damage caused by tea mosquito bug in cashew.

Godse *et al.* (1991) recommended the use of synthetic pyrethroids like permethrin, cypermethrin, decamethrin and fenvalerate for effective pest management. Field trials conducted at Vengurula indicated that 0.05 per cent monocrotophos, 0.1 per cent carbaryl, 0.05 per cent endosulfan and 0.07 per cent phosalone were the most effective insecticides against tea mosquito bug when applied at the time of emergence of new flushes and thereafter at an interval of one month (Godse *et al.*, 1993).

Carbaryl is found to be superior over other dust formulations (Bakthavatsalam *et al.*, 1993). Treatment with carbaryl @ 1.25 kg ai/ha caused 96 per cent mortality of *Helopeltis theivora* Waterhouse (Nair, 1998).

In view of the reported involvement of both the insect and fungus in causing inflorescence blight earlier recommendations for the control of pest was the combination spray with insecticide and fungicide, cuman 0.1 per cent in combination with dimecron 0.03 per cent (Nambiar *et al.*, 1973).

In an experiment conducted at Cashew Research Station, Madakkathara during 1999-2001 it was found that quinalphos 0.05 per cent + copper oxychloride 0.2 per cent during flushing and endosulfan 0.05 per cent + mancozeb 0.2 per cent during flowering stages effectively controlled TMB-anthracnose complex (Kurien *et al.*, 2001).

In anthracnose and tea mosquito endemic areas, application of monocrotophos 0.05 per cent + copper oxychloride 0.2 per cent at the time of flushing, quinalphos 0.05 per cent + mancozeb 0.2 per cent during flowering and carbaryl 0.1 per cent at the time of nut initiation is the current recommendation of the Kerala Agricultural University (KAU, 2002).

2.7.2 Biological control

A large number of natural enemies of *Helopeltis* spp. occurring in old world tropics (Africa and Asia) is compiled by various reports (CIBC, 1983; Cadou, 1994; Sundararaju, 1996).

2.7.2.1 Parasitoids

2.7.2.1.1 Egg parasitoids

Trichogramma minutum was reported as an egg parasitoid of *H. antonii* by Jeevaratnam and Rajapakse (1981). The mymarid *Erythmelus helopeltis* Gahan and two species of *Telenomus* were collected from the eggs of the mirid *H. theobromae* on cocoa in Malaysia (Ibrahim, 1989).

In India, occurrence of *E. helopeltis* was first reported by Devasahayam (1989). Subsequently four species of hymenopteran egg endoparasitoids namely, *Telenomus* sp., *Chaetostricha* sp., *Ufens* sp. and *Gonatocerus* spp. nr. *bialbifuniculatus* were documented (Sundararaju, 1996).

Highest parasitism by *Telenomus* sp. was 70.8 per cent in the eggs of *H. antonii*. The egg parasitism by *Telenomus* sp., *Chaetostricha* sp. and *E. helopeltis* in the eggs of *H. theivora* and *H. bradyi* is also common in the West Coast of India (Sundararaju and Sundarababu, 2000).

2.7.2.1.2 Nymphal parasitoids

The solitary nymphal endoparasitoids, *Leiophron* spp. (Hymenoptera: Braconidae) appear to be most promising in Indonesia and Africa (CIBC, 1983), but the activities of their hyper parasitoids limit their potentiality in biological control. Recently for the first time a single grub of this endoparasitoid was encountered from one adult female of *H. antonii* at coastal Karnataka region from cashew ecosystem (NRCC, 1997).

2.7.2.2 Predators

Crematogaster wroughtonii Foret (Formicidae) has been recorded as a predator on nymphs of *H. antonii* on cashew (Ambika and Abraham, 1979a; Jeevarathnam and Rajapakse 1981). Incidence of *Helopeltis* spp. was substantially reduced by the presence of *Oecophylla smaragdina* (Jeevarathnam and Rajapakse, 1981; Peng *et al.*, 1995).

Large populations of the black ant, *Dolichoderus bituberculatus* reduced the population build up of *Helopeltis* spp. to a greater extent. *Helopeltis* spp. could not tolerate the presence of ants (Graham, 1991).

Several species of spiders, namely, *Hyllus* sp., *Oxyopes* sp., *Oxyopes sehireta, Phidippus patch* and *Matidia* sp. have been observed predating on *H. antonii* (Devasahayam and Nair, 1986, Sundararaju, 1996;). Five species of reduviid bugs (*Sycanus collaris* Fab., *Sphedanolestes signatus* Dist., *Endochus inornatus* Stal., *Irantha armipes* Stal. and *Occanus typicus* Dist.) have also been recorded as efficient predators of *H. antonii* (Vennison and Ambrose, 1990; Sundararaju, 1996).

2.7.2.3 Pathogens

Two fungal pathogens viz., *Aspergillus flavus* and *A. tamarii* can cause infection in *H. antonii* (Sathiamma and Saraswathy, 1990; Karthikeyan, 1992; Satapathy, 1993).

2.7.3 Pheromones

Presence of a sex pheromone in adult females of *H. clavifer* (WK), an important pest of cocoa in Papua New Guinea was first reported by Smith in 1977. In India, presence of a sex pheromone in adult females of *H. antonii* was reported by Sundararaju *et al.* (1994).

Studies conducted by Sundararaju and Sundarababu (1999b) revealed that there exists a congeneric and conspeeific sex attraction among *Helopeltis* spp. They have developed a virgin female trap in which males were attracted. About 6 to 23 males per cage per hour were attracted. Rare congeneric mating between *H. antonii* and *H. bradyi* were also observed. But the eggs laid were infertile. In case of *Helopeltis* spp. conspecific mating is predominant over congeneric mating.

Sundararaju and Sundarababu (1999a) analysed the whole body extract of virgin female of *H. antonii* in order to separate out the pheromone components. The whole body extract was analysed through GC-MS at Natural Resources Institute (NRI), Kent, UK. The extract contained 17 significant compounds. But none of them could be implicated as sex pheromone of *H. antonii* and detailed studies are required to identify the exact pheromonal compound.

2.7.4 Use of botanicals

Many species of plants are known to possess a variety of chemical substances which act as antifeedants, repellents, juvenile hormone mimics and insecticides. Of these neem products are found to be highly effective.

Strong antifeedant effect of neem seed oil has been observed in laboratory and green house studies in China (Chiuw *et al.*, 1983).

H. theivora was recorded to cause severe damage to the tender foliage of the Indian long pepper (*Piper longum*). Application of neem kernel suspension of 2 per cent, reduced the extent of damage to 70 per cent (Abraham, 1991). In a field trial at Cashew Research Station, Vridhachalam, three sprays of neem seed kernel extract five per cent and neem oil two per cent have recorded the minimum tea mosquito damage of 6.04 and 6.90 per cent respectively (NRCC, 1993a).

Among the different plant products tested for their efficacy against tea mosquito bug, pongamia oil emulsified in water showed highest knock down action (90.8 per cent). The damage score was also lowest for this treatment. Ethanol extract of pongamia products and neem oil had higher residual activity for about seven days (NRCC, 1993b).

Laboratory experiments were conducted at College of Horticulture, Vellanikkara, to assess the efficacy of three commercial neem products namely, Godrej Achook, Rakshak and Nimbecidine against the local preparation of neem kernel suspension on *H. antonii* infesting cashew. A significant reduction in the number of egg laying sites and duration of egg laying was observed with 1.6 and 3.2 per cent doses of Godrej Achook and all tested doses of Rakshak as compared to other treatments (Angaiah, 1995).

Four commercial neem formulations were evaluated for their insecticidal property against tea mosquito under field condition along with neem oil and pongamia oil. Three sprays were given at monthly intervals starting with flushing. The per cent damage and score on shoot and panicle after 30 days of final treatments were taken. Among the plant products lowest infestation was recorded with Nimbicidine followed by Limanool (NRCC, 1996).

Commercial neem products like Achook (at 1.6 per cent and 3.2 per cent concentrations) and Rakshak were much efficient in controlling tea mosquito bugs (Radhakrishnan and Karippai, 2000).

2.7.5 Other methods

The nymphs of *H. antonii* treated with Juvenile Hormones (JH) analogues like farnesyl methyl ether, ZR 512 and MV 678 showed varying degrees of developmental complexities. Topical application of JH analogues at 0.5 μ on early 5th instar nymphs did not result in moulting, but they were transformed into 6th instar super numerary nymphs which had juvenile characters (Ambika and Abraham, 1979b).

2.7.6 Resistance spectrum of crop plants with reference to infestation by *H. antonii*

The identification of promising crop types resistant or tolerant to infestation by *H. antonii* and the vegetative propagation of such types would be the most desirable strategy to reduce the pest populations at minimum cost without causing disruption to the ecosystem.

In a preliminary study of the varietal reaction in guava to tea mosquito infestation, Perumal *et al.* (1970) reported considerable variations.

Gopalan and Perumal (1973) screened eleven guava varieties aged 10 years and eight varieties of 28 years growth for infestation by *H. antonii*. None of the varieties was immune to attack by the pest. However, there were variations in the incidence of the pest in different varieties indicating the preference of certain varieties by the pest. The variety 'Lucknow 46' suffered the maximum infestation while the variety 'Banglore' showed the least incidence of attack. Most of the older trees were almost free from pest infestation and damage.

Balasubramaniam and Kalyanasundaram (1974) evaluated nine guava varieties for their relative susceptibility to infestation by *H. antonii*. The varieties showed wide variations in the incidence of the pest. The varieties Bangalore and Red Fleshed were severely affected, while the varieties Safeda and Seedless were almost free from infestation.

Swaine (1959) indicated that damage by *Helopeltis* spp. in Tanganyika is generally heavier in younger trees than in mature trees.

Studies on the varietal reactions of 16 cashew types to tea mosquito infestation revealed that the accession VTH-34 T. No.1 (Bapatla) and VTH 151 BLA 256-4 (Anakkayam) gave comparatively low percentage of pest attack with 2.2 per cent and 3.8 per cent shoot damage and 6.8 per cent and 5.5 per cent panicle attack respectively. The highest per cent of panicle attack (11.9) was recorded in the accession VTH 1 Ansur 1 (Vengurula). The maximum shoot damage was found in VTH 36 T. No.56 (Bapatla) (CPCRI, 1977).

In an experiment conducted by Ambika *et al.* (1979) eleven accessions comprising of five year old seedling progenies were screened for their susceptibility to tea mosquito bug. Results showed that the accession number 665 was comparatively more tolerant with respect to panicle and shoot damage, where as K-10-2-1232 and K-10-2-1218 were found more susceptible. Pillai *et al.* (1979) reported tree to tree variation in the population density and intensity of incidence of *H. antonii* on cashew.

At Vittal, all the 74 accessions in the germplasm collection of cashew at the Central Plantation Crop Research Institute were tested for their resistance to tea mosquito. Based on the shoot and panicle damage and pest population the accession VTH-153 was the most resistant and VTH-54, most susceptible (Sathiamma, 1979).

The relative susceptibility of 14 accessions of cashew to the infestation by *H. antonii* was studied by Thomas (1981) at Cashew Research Station, Madakkathara.

The accessions 22, 1112, 1430 and 1097 were least susceptible with reference to the intensity of natural field infestation of the vegetative shoots and the accessions 22, 1112, 1352, 1469 and 1097 were significantly less susceptible to panicle infestation.

In a study conducted at Jhargam, West Bengal, Ghosh and Chatterjee (1987) observed lowest shoot, leaf and panicle damage against tea mosquito in types BLA-39-A and TN-119. Highest per cent of tea mosquito attack and lowest yield was observed in the type NLR-2/1. Sundararaju and John (1993) conducted studies on four months old softwood grafts with tender flushes and it was observed that the accession numbers Goa-11/6 and VTH 153/1 were moderately resistant to mirid damage while all others were susceptible. Least damage of tea mosquito was observed in the type 9/78 and the incidence of damage was highest in the types 2/48 and 1/95 (Uthiah *et al.*, 1994). Among 56 accessions screened, the accession Goa 11/6 was the least susceptible type against tea mosquito bug (Sundararaju, 1999).

2.8 LEAF MINER INCIDENCE ON CASHEW

The cashew leaf miner, *Conopomorpha syngramma* M. is distributed all over the cashew growing tracts of India (Satapathy *et al.*, 1990). It is one of the serious pests infesting post harvest and post monsoon flushes in India (Choudhari, 1962; Rai and Vasantha, 1980; Ayyanna *et al.*, 1985).

Leaf miner causes considerable damage by feeding on the parenchymatous tissues between the epidermal layers of the tender leaves. On an average 26 per cent of leaves in a tree were damaged by this pest (Abraham, 1958). Leaf damage to the tune of 75 to 80 per cent in Kerala (Choudhary, 1962), 8.4 per cent in Orissa (Jena *et al.*, 1985) and 6.20 per cent in Andhra Pradesh (Ayyanna *et al.*, 1985) has been reported.

The caterpillars make tortuous mines by the sides of the veins or in leaf margins on the dorsal and ventral surface of leaves (Jena, 1988). The feeding activity by the larvae between the epidermal layers of the tender leaves results in a blotch, and thus reduce the photosynthetic area (Jacob and Belavadi, 1990; Jacob, 1993).

The nursery seedlings and young plants are more prone to the infestation (Pillai, 1980; Jena, 1988).

2.8.1 Control of cashew leaf miner

Endosulfan and quinalphos were effective in reducing the damage (Sammiayyan *et al.*, 1984). Methyl parathion 0.05 per cent caused the highest (94.81%) mortality of the leaf miner larvae after 12 hours of treatment followed by quinalphos, chlorpyriphos and monocrotophos (Satapathy *et al.*, 1990).

2.9 DISEASE PROBLEMS IN CASHEW NURSERY AND ITS MANAGEMENT

Important diseases observed in cashew nursery were seedling rot caused by *Pythium* and *Phytophthora*, seedling blight caused by *Phythium* sp., *Phytophthora palmivora*, *Cylindrocladium scoparium* and *Fusarium* sp., root rot caused by *Pythium* sp., leaf blight caused by *C. gloeosporioides*, *Phytophthora palmivora* and *Pestalotia* sp. and drying of shoots caused by *C. gloeosporioides* (Kurien *et al.*, 2001).

Application of *Trichoderma* @ 2 g/poly bag or AMF @ 10 g/poly bag effectively controlled the soil borne diseases such as seedling rot, seedling blight and root rot (Kurien *et al.*, 2001 and Joseph *et al.*, 2002).

Seedling rot, seedling blight and root rot were effectively controlled by the fungicides mancozeb, copper oxychloride and metalaxil. For controlling drying of shoots caused by *C. gloeosporioides*, Bordeaux mixture (1%), mancozeb, copper oxychloride (0.2%) and tridemorph (0.05%) were found to be very effective. Against the leaf blight disease the fungicides mancozeb, zineb and copper oxychloride (0.2%) were highly effective (Kurien *et al.*, 2001).

2.10 INFLUENCE OF AMF

2.10.1 On crop growth

Arbuscular Mycorrhizal Fungi (AMF) are beneficial symbiotic microorganisms that colonize the root and increase the growth and yield of several crop plants (Sempavalan *et al.*, 2001).

Improved growth and nutrient uptake due to AMF association has been demonstrated in many horticultural crops including pepper and cocoa (Mosse, 1973; Bagyaraj and Manjunath, 1980).

Palipane and Bandara (1985) observed that inoculation with mycorrhizal root fragments resulted in increase of growth rate in coffee and cocoa seedlings compared to uninoculated seedlings. In sterilized soils inoculation of *Calapagonium cacruleum* with *Glomus fasciculatum* increased dry weight (Ikram *et al.*, 1985).

According to Sreeramulu and Bagyaraj (1986), nursery beds of chilli inoculated with *Glomus* sp. increased growth, flowering and yield. The study by Tang and Chang (1986) revealed that citrus seedlings inoculated with AMF together with phosphate application gave best growth response and increase in fresh weight of aerial parts.

Khaliel and Elkhider (1987) reported that inoculation with AMF in low 'P' soils resulted in increased dry weight, number of nodes, lateral branches, leaves and higher percentage of survival of tomato. They also observed better growth response.

Inoculation with different AMF increased the mycorrhizal infection, colonisation intensity and the uptake of total phosphorous by cashew plants (Sivaprasad *et al.*, 1992). Significant increase in growth parameters like plant height, stem girth, number of leaves, root length, number of roots and plant biomass were recorded in AMF treated cashew plants compared to control (Remesh *et al.*, 1998; Lakshmipathy *et al.*, 2000 and Usha, 2001).

2.10.2 On pest and disease resistance

Hegde and Rai (1984) reported that tomato plants showed resistance to damping off disease when inoculated with *Glomus fasciculatum*. AMF excerted an inhibitory effect on the development of pigeon pea blight (Bight *et al.*, 1985).

Incidence of *Fusarium oxysporum* in tomato was reduced by inoculating with AMF (Caron *et al.*, 1986). Mycorrhizal fungi stimulated seedling growth and reduced the *F. oxysporum* population in the rhizosphere (Chakravarty and Mishra, 1986).

Reddy *et al.* (1988) studied the effect of inoculation with AMF and *F. oxysproum* f.sp. ciceris on wilt incidence in chickpea. They found that incoulation with *Fusarium* alone produced 35 per cent wilt and inoculation with AMF and *Fusarium* together produced 25 per cent wilt. Kobayashi (1990) reported that combined use of AMF and charcoal compost drastically reduced damping off caused by *Pythium splendens* or *Rhizoctonia solani* in two and three week old cucumber seedlings. They also reported that combined use of AMF and charcoal compost reduced the level of bacterial wilt of tomato caused by *Pseudomonas solanacearum*.

Biocontrol of damping off of cardamom caused by *Fusarium moniliforme* and *R. solani* using AMF was reported by Thomas *et al.* (1994).

Materials and Methods

3. MATERIALS AND METHODS

The experiments were conducted during September 2002 to April 2003 at Cashew Research Station, Madakkathara and also in the Entomology and Plant pathology laboratories of the College of Horticulture, Vellanikkara. The studies involved screening of cashew grafts of selected varieties against tea mosquito bug - *Colletotrichum* complex in cashew and the management of the above pest complex in cashew nursery.

3.1 REARING OF TEST INSECTS

The stock culture of *H. antonii* was developed in the laboratory from field collected fourth and fifth instar nymphs. The nymphs were reared on tender seedlings of cashew in which some leaves were clipped off to reduce the transpiration loss. The pulled out seedlings were then kept in glass bottles filled with water and the mouth was plugged with cotton. The seedlings along with the glass bottles were placed in bell jars (Plate 4) and the nymphs at the rate of five per cage were released into it. Muslin cloth pre-soaked in water was spread around the bell jar internally to serve as a wet pack. Fresh seedlings were provided at two days interval, to ensure continuous availability of host plants.

Nymphs on attaining maturity were sexed and transferred into mating and oviposition chamber (size 1.0 x 0.5 m^2). The male-female ratio was maintained at 1:1 in each cage. Inside the mating cage, ten tender potted seedlings were kept for egg laying. Seedlings on which oviposition is noted were transferred to rearing cages (size 0.5 x 0.5 m^2) for emergence of young ones. Most of the eggs hatched within an incubation period of 5-7 days. Newly hatched nymphs were kept on the same plant up to second instar stage. Tender shoots moistened with cotton were provided as feed. The second instar nymphs were then transferred to seedlings using a camel hair brush and then covered with bell jars. They were reared to adulthood by changing the seedlings every 2 days. Just emerged adults were used for the study.

Observation was recorded for an interval of 24 hours for a period of 7 days and thereafter at weekly intervals.

The intensity of damage due to TMB and *C. gloeosporioides* was rated on the following scale used by Ambika and Abraham (1979a).

0 - no necrotic lesions/streaks
1 - up to 3 necrotic lesions/streaks - general vigour of flushes unaffected
2 - 4-6 coalescing or non-coalescing lesions/streaks - general vigour of flushes affected
3 - above 6 coalescing or non-coalescing lesion/streaks - general vigour of flushes affected
4 - lesions or streaks confluent and drying of affected flushes.

3.1.2 Field screening of selected cashew varieties

In order to evaluate the consistency of the level of tolerance if any revealed by the grafts, in older trees also a field experiment was carried out.

Sample trees from each variety were selected for observations randomly. A metallic frame of 1 m^2 was placed on the canopy and then the total number of shoots, panicles, nuts and new flushes inside the frame were recorded. Along with this, the number of shoots, panicles, and nuts attacked by tea mosquito were also recorded. Observations were taken from all the four quadrants of the same tree and continued up to a period of five months. Intensity of damage was scored based on 0-4 scale as mentioned previously. Per cent damage was calculated using the following formula.

$$\text{Per cent damage} = \frac{\text{Number of infected twigs}}{\text{Total number of twigs observed}} \times 100$$

Table 1. Details of plant protection chemicals used for the study

Generic Names	Formulations	Selected dosage of chemicals (%)
A. Insecticides		
Imidacloprid	Confidor 200 SL	0.005
Quinalphos	Ekalux 25 EC	0.05
Azadirachtin	Econeem 1500 ppm	1.0
Carbaryl	Sevin 50 WP	0.1
B. Fungicides		
Carbendazim	Bavistin 50 WP	0.1
Copper oxychloride	Fytolan 50 WP	0.2
Zineb	Dithane - Z - 78 50 WP	0.2

3.2 EXPERIMENT II - MANAGEMENT OF PEST COMPLEX IN CASHEW NURSERY

The experiment was conducted at Cashew Research Station, Madakkathara, during 2002-2003.

The potting mixture consisting of sand, soil and cowdung in the ratio of 1:1:1 was filled in polythene bags of 15 x 20 cm size for sowing cashew seeds and AMF culture was placed at a depth of 5 cm @ 10 g/bag. Seeds of variety Madakkathara-1 was placed at a depth of 2.5 cm @ 1 seed per bag. Seedlings were maintained under natural conditions and were irrigated regularly. Grafting was done on seedlings at 60 days after sowing and treatments were imposed at monthly intervals.

Observations on per cent germination was taken on 15 days and 30 days after sowing. Biometric characters , such as height of the plant and number of leaves were taken at fortnightly intervals. Fresh and dry weight of plant and number of roots were also recorded on 60 days and 120 days after sowing respectively.

Infection of pest complex was scored on 0-4 scale.

Leaf miner damage was also observed and per cent damage was calculated according to the formula mentioned earlier.

Details of the treatments are as follows.

A - With AMF inoculation

A_0 - Without AMF inoculation

Insecticides

I_0 - Control

I_1 - Imidacloprid 0.005 per cent

I_2 - Quinalphos 0.05 per cent

3.3 *IN VITRO* EVALUATION OF FUNGICIDES AND INSECTICIDES ON THE GROWTH OF *Colletotrichum gloeosporioides*

To find out the effectiveness of the selected chemicals against *C. gloeosporioides*, a bioassay study was conducted by adopting poison food technique (Zentmayer, 1955).

Sixty ml of Potato Dextrose Agar (PDA) medium was taken in 250 ml conical flasks and sterilised in an autoclave at 1.05 kg cm^{-2} pressure for 20 minutes.

The chemicals were mixed with the PDA medium in suitable proportion to get the desired concentrations and poured into sterilized petridishes @ 20 ml/plate. Mycelial discs of size 5 mm were cut out from actively growing seven day old culture of the fungus and were placed at the centre of each Petri plate. Petri dishes were then incubated at room temperature (28 ± 2°C). Mycelial disc placed in Petri dish containing medium without chemical served as control. Three replications were maintained for each treatment. The colony diameter was measured at regular interval till the growth in the control fully covered the medium in the Petri dish.

The percentage inhibition was calculated by using the formula

$$\frac{(C-T)}{C} \times 100$$

where C and T were the colony diameters in control and treatment respectively (Vincent, 1927).

Treatments used in the Experiment

T_1 - Carbendazim 0.1 per cent

T_2 - Zineb 0.2 per cent

T_3 - Copper oxychloride 0.2 per cent

T_4 - Imidacloprid 0.005 per cent

T_5 - Quinalphos 0.05 per cent

T_6 - Azadirachtin 1500 ppm 1.0 per cent

T_7 - Carbaryl 0.1 per cent

T_8 - Carbendazim 0.1 per cent + Imidacloprid 0.005 per cent

T_9 - Carbendazim 0.1 per cent + Quinalphos 0.05 per cent

T_{10} - Carbendazim 0.1 per cent + Azadirachtin 1500 ppm 1.0 per cent

T_{11} - Carbendazim 0.1 per cent + Carbaryl 0.1 per cent

T_{12} - Zineb 0.2 per cent + Imidacloprid 0.005 per cent

T_{13} - Zineb 0.2 per cent + Quinalphos 0.05 per cent

T_{14} - Zineb 0.2 per cent + Azadirachtin 1500 ppm 1.0 per cent

T_{15} - Zineb 0.2 per cent + Carbaryl 0.1 per cent

T_{16} - Copper oxychloride 0.2 per cent + Imidacloprid 0.005 per cent

T_{17} - Copper oxychloride 0.2 per cent + Quinalphos 0.05 per cent

T_{18} - Copper oxychloride 0.2 per cent + Azadirachtin 1500 ppm 1.0 per cent

T_{19} - Copper oxychloride 0.2 per cent + Carbaryl 0.1 per cent

T_{20} - Control

3.4 STATISTICAL ANALYSIS

Statistical analysis was done using analysis of variance technique (Panse and Sukhatme, 1985). MSTAT C and MS-Excel soft wares were used for computation and analysis.

Results

4. RESULTS

The results of the experiments were tabulated and analysed statistically and presented in this chapter. The results are also graphically presented in Fig.1 to Fig. 4 and Plates 5, 6, 7, 8 and 9.

4.1 SCREENING OF CASHEW GRAFTS OF SELECTED VARIETIES AGAINST PEST DISEASE COMPLEX

The data on the tea mosquito bug and *Colletotrichum gloeosporioides* damage on cashew grafts under *in vivo* conditions were analysed and mean score values are presented in Table 2 and depicted in Fig. 1 & 2.

In treatment T_3 where *C. gloeosporioides* alone was inoculated symptoms of disease was not at all observed throughout the period. Similar trend was observed in the control treatment. Hence these treatments were avoided during statistical analysis.

One day after inoculation, the variety, Anakkayam-1 recorded maximum infestation with a mean score value of 1.167 in treatment T_1. Sulabha recorded a mean score value of 1.0 in both the treatments. No infection was recorded in the varieties H-1610 and Kanaka under the treatment T_1.

Two days after inoculation showed that in case of treatment T_1 the variety H-1610 recorded minimum pest incidence with a mean score value of 0.333.Under treatment T_2 lowest infestation was observed in the variety H-1600 with a mean score value of 0.333. Maximum infestation under treatment T_1 was recorded by the variety Anakkayam-1 with a mean score value of 1.5. Under treatment T_2, the variety H-1610 recorded highest mean score value of 1.667.

After three days of inoculation, under treatment T_1, the variety Anakkayam-1 recorded maximum infestation with a mean score value of 1.833. Under treatment T_2, higher infestation was recorded by the variety Madakkathara-1 with a mean score value of 1.833. In the case of treatment T_1, lowest infestation was recorded

Plate 5. Screening trials (field view)

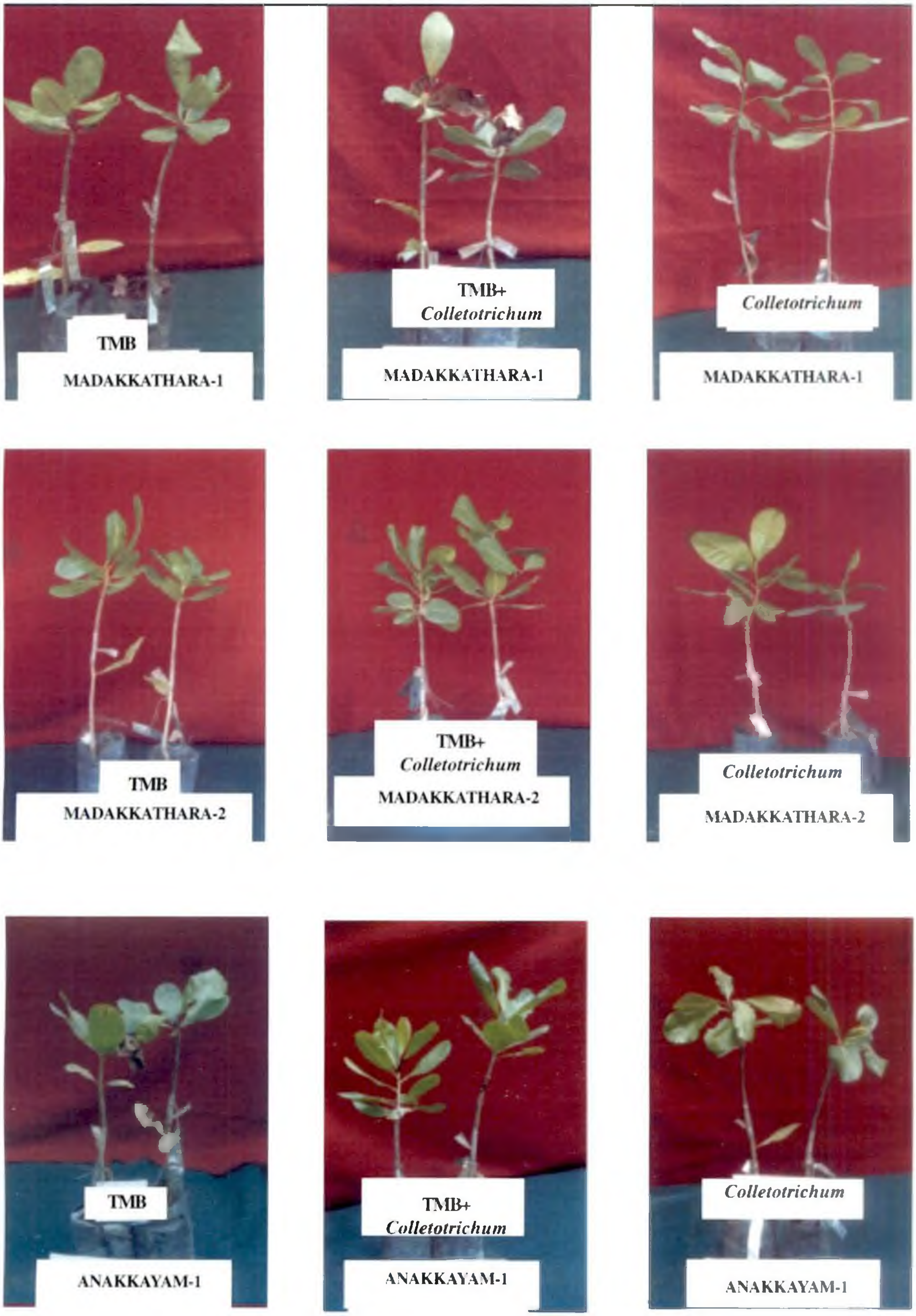

Plate 6: Varietal screening of Madakkathara - 1, Madakkathara - 2 and Anakkayam - 1

Plate 7. Varietal screening of Kanaka, Dhana and Priyanka

Plate 8. Varietal screening of Sulabha, H-1600 and H-1610

Plate 9. Varietal screening of H-1593 and control

by the varieties Madakkathara-2 and H-1610 with the same mean score value of 0.667. Variety H-1600 recorded minimum infestation under treatment T_2 with a mean score value of 0.5.

Four days after inoculation showed that the variety H-1600 recorded lowest pest incidence with a mean score value of 0.500 in treatment T_2. Under treatment T_1, the variety Anakkayam-1 recorded highest infestation with a mean score value of 1.833 and under treatment T_2, Madakkathara-1 recorded maximum infestation with the same mean score value of 1.833.

During fifth day of inoculation, lowest infestation under treatment T_1 was recorded by the varieties Madakkathara-2 and H-1610 with the same mean score value of 0.667 each and under the treatment T_2, H-1600 recorded minimum infestation with a mean score value of 0.5. Highest infestation under treatment T_1 was recorded by the variety Anakkayam-1 with a mean score value of 2.0. Under treatment T_2, the variety Madakkathara-1 recorded maximum infestation with a mean score value of 1.833.

Sixth day after inoculation showed that the variety Madakkathara-2 recorded minimum infestation with a mean score value of 0.667 under treatment T_1 and the variety H-1600 recorded minimum pest incidence under treatment T_2, with a mean score value of 0.500. Highest infestation under treatment T_1 was recorded by the variety Anakkayam-1 with a mean score value of 2.0. Under treatment T_2, maximum infestation was recorded by the variety Dhana with a mean score value of 2.0. The varieties Madakkathara-1, Anakkayam-1, Sulabha, H-1610 and Priyanka also recorded higher pest incidence under treatment T_2 with mean score values of 1.833, 1.667, 1.5, 1.667 and 1.5 respectively and they were on par (Table 2 and Fig.1).

Observations after 7 days of inoculation revealed that the variety Madakkathara-2 recorded lowest infestation under the treatment T_1 with a mean score value of 0.667. Variety H-1600 recorded lowest pest infestation under treatment T_2 with a mean score value of 0.500. Highest infestation for both the treatments (T_1 and T_2) was recorded by the variety Anakkayam-1 with a mean score value of 2.0. Variety

Dhana also recorded a higher tea mosquito damage with a mean score value of 2.0 under treatment T_2.

During the first seven consecutive days of inoculation, the variety, H-1610 recorded lowest infestation under the treatment T_1 with a mean score value of 0.571. Variety Madakkathara-2 also recorded lower infestation with a mean score value of 0.620. Under treatment T_2, minimum infestation was recorded by the variety H-1600 with a mean score value of 0.429. In case of treatment T_1, maximum infestation was recorded by the variety Anakkayam-1 with a mean score value of 1.762. Varieties Dhana and Madakkathara-1 recorded highest infestation under treatment T_2 with mean score value of 1.667 and 1.600 respectively.

After fifteen days of inoculation, under treatment T_1 H-1600 recorded lowest infestation to both the treatments T_1 and T_2 with mean score values of 0.833 and 0.500 respectively. Variety Sulabha recorded highest infestation in both the treatments T_1 and T_2 with mean score values of 2.5 each. The varieties Madakkathara-1, Anakkayam-1 and Dhana also recorded higher pest incidence under the treatment T_2 with the same mean score value of 2.5 each.

Observations taken after 30 days of inoculation revealed that the variety H-1600 recorded lowest infestation to both the treatments T_1 and T_2 with mean score values of 0.833 and 0.500. Variety Madakkathara-2 also recorded lower pest infestation under treatment T_1 with a mean score value of 1.0. In the case of treatment T_2, highest infestation was recorded by the varieties Madakkathara-1, Anakkayam-1, Sulabha and Dhana with mean score values of 2.667, 3.00, 2.667 and 2.667 respectively and they were on par. Variety Sulabha recorded higher pest incidence to both the treatments (T_1 and T_2) with mean score values of 2.5 and 2.667.

Sixty days after inoculation revealed that the same variety H-1600 recorded minimum pest infestation in both the treatments T_1 and T_2 with mean score values of 0.833 and 0.50. Under treatment T_1, the varieties Madakkathara-2 and H-1610 also recorded lower pest incidence with mean score values of 1.00 and 1.167 and higher

Table 2. Screening of cashew grafts against TMB and *C. gloeosporioides* complex under *in vivo* conditions (mean score values)

	Treatment	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	Mean of 7 days	15 days	30 days	60 days
Madakkathara-1	T_1	0.667^{abc} (1.040)	1.000^{abc} (1.213)	1.500^{ab} (1.407)	1.500^{ab} (1.407)	1.500^{ab} (1.407)	1.500^{ab} (1.407)	1.500^{ab} (1.407)	1.310	2.33^{abc} (1.618)	2.33^{abc} (1.618)	2.33^{abc} (1.618)
	T_2	0.833^{abc} (1.115)	1.167^{abc} (1.276)	1.833^{a} (1.525)	1.833^{a} (1.525)	1.833^{a} (1.525)	1.833^{ab} (1.525)	1.833^{abc} (1.525)	1.600	2.500^{ab} (1.628)	2.667^{a} (1.774)	2.667^{a} (1.774)
Madakkathara-2	T_1	0.333^{abc} (0.902)	0.667^{abc} (1.075)	0.667^{bc} (1.075)	0.667^{abc} (1.075)	0.667^{bc} (1.075)	0.667^{bc} (1.075)	0.667^{cd} (1.075)	0.620	1.000^{abcd} (1.225)	1.000^{cde} (1.225)	1.000^{cde} (1.225)
	T_2	0.667^{abc} (1.075)	0.833^{abc} (1.138)	0.833^{abc} (1.138)	0.833^{abc} (1.138)	0.833^{abc} (1.138)	0.833^{abc} (1.138)	0.833^{abcd} (1.138)	0.833	1.833^{abc} (1.503)	2.167^{abcd} (1.622)	2.167^{abcd} (1.622)
Anakkayam-1	T_1	1.167^{a} (1.228)	1.500^{ab} (1.414)	1.833^{a} (1.520)	1.833^{a} (1.520)	2.000^{a} (1.576)	2.000^{a} (1.576)	2.000^{a} (1.576)	1.761	2.333^{abc} (1.682)	2.333^{abc} (1.682)	2.333^{abc} (1.682)
	T_2	0.657^{abc} (1.052)	0.833^{abc} (1.150)	1.333^{abc} (1.351)	1.333^{abc} (1.351)	1.333^{abc} (1.351)	1.667^{ab} (1.470)	2.000^{a} (1.576)	1.309	2.500^{ab} (1.706)	3.000^{a} (1.862)	3.000^{a} (1.862)
Sulabha	T_1	1.000^{ab} (1.179)	1.333^{ab} (1.332)	1.333^{abc} (1.332)	1.500^{abc} (1.382)	1.500^{abc} (1.382)	1.500^{abc} (1.382)	1.500^{abcd} (1.382)	1.380	2.500^{abc} (1.693)	2.500^{abc} (1.693)	2.500^{abc} (1.693)
	T_2	1.000^{ab} (1.213)	1.333^{ab} (1.351)	1.333^{ab} (1.351)	1.500^{ab} (1.407)	1.500^{ab} (1.407)	1.500^{ab} (1.407)	1.500^{ab} (1.407)	1.380	2.500^{a} (1.732)	2.667^{a} (1.778)	2.667^{a} (1.778)
H-1600	T_1	0.500^{abc} (1.000)	0.833^{abc} (1.150)	0.833^{abc} (1.150)	0.833^{abc} (1.150)	0.833^{abc} (1.150)	0.833^{abc} (1.150)	0.833^{abcd} (1.150)	0.785	0.833^{cd} (1.150)	0.833^{de} (1.150)	0.833^{de} (1.150)
	T_2	1.167^{bc} (0.805)	0.333^{c} (0.880)	0.500^{c} (0.943)	0.500^{c} (0.943)	0.500^{c} (0.943)	0.500^{c} (0.943)	0.500^{d} (0.943)	0.429	0.500^{d} (0.943)	0.500^{d} (0.943)	0.500^{d} (0.943)
H-1610	T_1	0.000^{c} (0.707)	0.333^{c} (0.902)	0.667^{bc} (1.040)	0.667^{bc} (1.040)	0.667^{bc} (1.040)	0.833^{abc} (1.115)	0.833^{abc} (1.115)	0.571	1.000^{bcd} (1.179)	1.167^{bcde} (1.234)	1.167^{bcde} (1.234)
	T_2	1.000^{ab} (1.213)	1.667^{a} (1.462)	1.667^{ab} (1.462)	1.667^{ab} (1.462)	1.667^{ab} (1.462)	1.667^{ab} (1.462)	1.667^{abc} (1.462)	1.577	2.167^{abc} (1.631)	2.333^{abc} (1.678)	2.333^{abc} (1.678)
H-1593	T_1	0.500^{abc} (1.000)	0.500^{bc} (1.000)	0.833^{abc} (1.150)	0.833^{abc} (1.150)	1.167^{abc} (1.288)	1.333^{abc} (1.351)	1.500^{abc} (1.414)	0.953	1.833^{abc} (1.525)	1.833^{abcd} (1.525)	1.833^{abcd} (1.525)
	T_2	0.667^{abc} (1.075)	0.833^{abc} (1.150)	0.833^{abc} (1.150)	0.833^{abc} (1.150)	1.000^{abc} (1.225)	1.167^{abc} (1.288)	1.167^{abcd} (1.288)	0.928	1.833^{abc} (1.525)	2.167^{abcd} (1.622)	2.167^{abcd} (1.622)
Kanaka	T_1	0.000^{c} (0.707)	0.500^{bc} (1.000)	0.833^{abc} (1.150)	0.833^{abc} (1.150)	0.833^{abc} (1.150)	0.833^{abc} (1.150)	0.833^{abcd} (1.150)	0.666	1.500^{abcd} (1.407)	1.500^{abcde} (1.407)	1.500^{abcde} (1.407)
	T_2	0.167^{bc} (0.805)	1.000^{abc} (1.225)	1.167^{abc} (1.288)	1.167^{abc} (1.288)	1.167^{abc} (1.288)	1.167^{abc} (1.288)	1.167^{abcd} (1.288)	1.000	1.500^{abcd} (1.407)	1.833^{abcd} (1.525)	1.833^{abcd} (1.525)
Dhana	T_1	0.333^{abc} (0.902)	1.167^{abc} (1.276)	1.333^{abc} (1.351)	1.333^{abc} (1.351)	1.333^{abc} (1.351)	1.333^{abc} (1.351)	1.333^{abcd} (1.351)	1.166	1.667^{abcd} (1.470)	1.667^{abcd} (1.470)	1.667^{abcd} (1.470)
	T_2	1.167^{a} (1.288)	1.500^{ab} (1.407)	1.667^{ab} (1.457)	1.667^{ab} (1.457)	1.667^{ab} (1.457)	2.000^{a} (1.563)	2.000^{a} (1.563)	1.667	2.500^{ab} (1.715)	2.667^{ab} (1.756)	2.667^{ab} (1.756)
Priyanka	T_1	0.167^{bc} (0.805)	0.667^{bc} (1.040)	1.000^{abc} (1.171)	1.000^{abc} (1.171)	1.000^{abc} (1.171)	1.167^{abc} (1.234)	1.167^{abcd} (1.234)	0.881	1.667^{abcd} (1.374)	1.667^{abcde} (1.374)	1.667^{abcde} (1.374)
	T_2	0.167^{bc} (0.805)	1.000^{abc} (1.225)	1.000^{abc} (1.225)	1.000^{abc} (1.225)	1.000^{abc} (1.225)	1.500^{ab} (1.414)	1.500^{abc} (1.414)	1.023	2.000^{abc} (1.566)	2.167^{abcd} (1.622)	2.167^{abcd} (1.622)

* Figures in parentheses denote square root transformation. In a column, means followed by a common letter are not significantly different at 5 per cent level by DMRT.

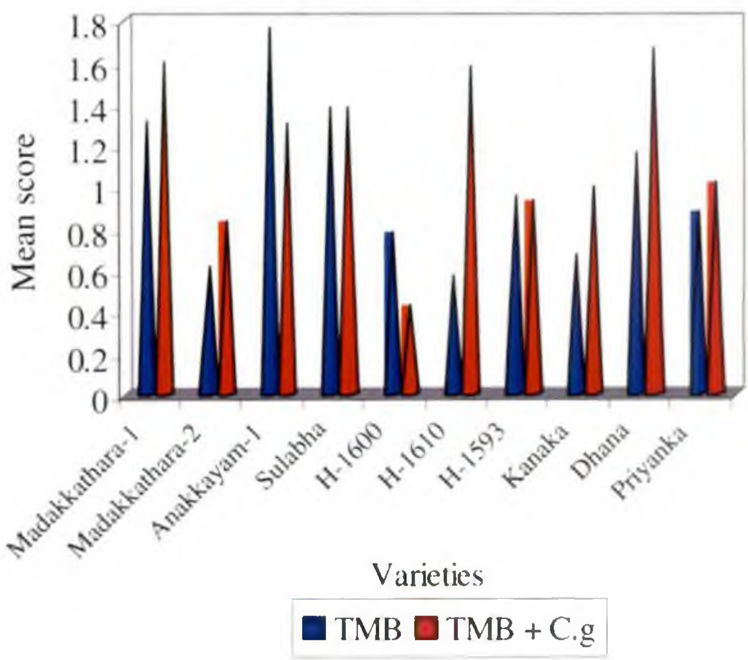

Fig. 1. Varietal screening of cashew grafts under *in vivo* conditions (mean of first 7 consecutive days)

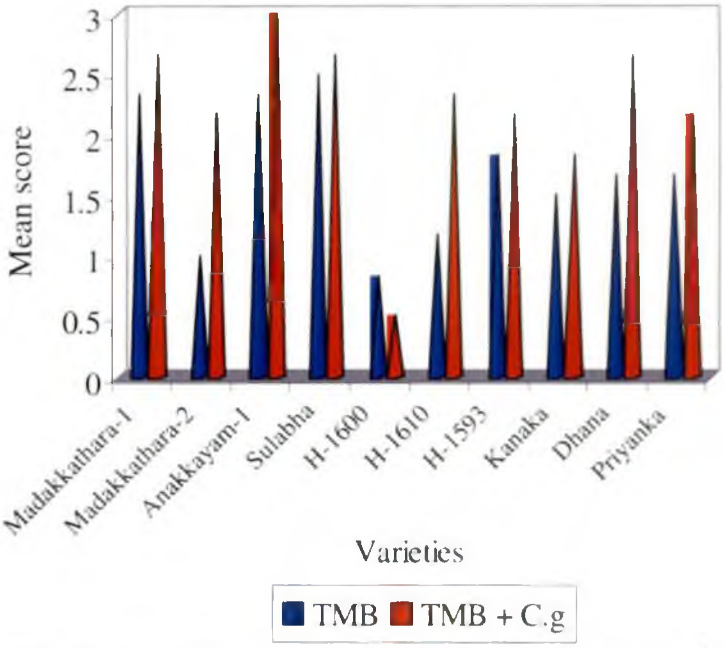

Fig. 2. Varietal screening of cashew grafts under *in vivo* conditions (30 days after inoculation)

damage was noted in the varieties Madakkathara-1, Anakkayam-1 and Sulabha with mean score values of 2.333, 2.333 and 2.50 and were on par. In the case of treatment T_2, The varieties Madakkathara-1, Anakkayam-1, Sulabha and Dhana recorded maximum pest incidence with mean score values of 2.667, 3.00, 2.667 and 2.667 respectively (Table 2 and Fig.2).

4.2 FIELD SCREENING OF CASHEW VARIETIES AGAINST TEA MOSQUITO BUG

All the varieties included in the former experiment were evaluated in this screening also under natural field condition. Observations on tea mosquito damage in shoots with new flush, panicle and nuts were recorded at fortnightly intervals for a period of five months starting from October 2002 to February 2003. The results of this experiment were statistically analysed and presented from Table 3 to 5. The results were also graphically depicted from Fig.3 to 4.

Variety Madakkathara-1 recorded 18.33 per cent shoot infection during October and reached a highest value of 32.5 per cent during February. Mean score damage for the same period was 0.471 and 0.695 respectively. Panicle infection was started in the month of December with 31.27 per cent incidence and gradual increase was observed over the months and during February it recorded a value of 36.25 per cent infection. Nut infection for Madakkathara-1 recorded a highest value of 41.76 per cent infection during February. Mean score analysis revealed that Madakkathara-1 has got panicle infection of 0.978 and nut infection of 1.204 during February.

For the variety Kanaka, shoot infection for the month of December was 24.40 per cent and reached a value of 40.00 per cent during February. Panicle infestation started in the month of December with 28.98 per cent incidence and reached a maximum of 42.03 per cent during February. Nut infection was highest in February with 44.38 per cent.

Mean score damage for the same period was 0.628 and 1.205 in case of shoot infection, 0.706 and 0.930 in case of panicle infection and 0.959 in case of nut infection.

In the case of the variety Anakkayam-1, shoot damage was higher during February with a percent infection of 33.9 per cent and a mean score value of 0.788. Panicle infection for Anakkayam-1 was highest during February with 42.03 per cent and a mean score damage of 1.309. Nut infection was also highest during February with 43.84 per cent incidence and with a mean score damage of 1.24.

Variety H-1600 recorded comparatively lower pest incidence over the months. Shoot infection was more in February with 26.92 per cent infection and a mean score damage of 0.700. Variety H-1600 has got a panicle infection of 37.58 per cent and a mean score damage of 1.014 during February. Nut infection was also lower for the variety H-1600 with a mean per cent incidence of 25.53 and a mean score damage of 0.504.

In the case of variety H-1610, shoot infection was highest during February with 44.28 per cent infection and a mean score damage of 0.871. Panicle infection was highest for the variety H-1610 and recorded a pest incidence of 48.75 per cent and a mean score damage of 1.035. In case of nut infection also the variety H-1610 recorded a highest incidence of 53.75 per cent and a mean score damage of 0.885.

In the case of variety Madakkathara-2 shoot infection was lower during October with 16.8 per cent incidence and a mean score damage of 0.491 and during February shoot infection was 35 per cent and mean score damage was 0.805. Panicle infection for Madakkathara-2 was highest during February with 35 per cent incidence and a mean score damage of 0.725. Nut infection was comparatively lower and recorded 30 per cent incidence and a mean score damage of 0.610 during February.

Dhana recorded a higher shoot infection of 42.50 per cent and a mean score damage of 1.273. Panicle infection was comparatively low for Dhana with 37.5 per cent and a mean score damage of 0.843. Nut infection was lowest for the variety Dhana with 27.5 per cent incidence and a mean score damage of 0.615.

Variety H-1593 recorded comparatively lower shoot infection with 35 per cent incidence and a mean score damage of 0.788. Panicle infection was 45.22 per cent with a mean score damage of 0.983 and it recorded a nut infection of 38.75 per cent infection and a mean score damage of 0.663.

Table 3. Reaction of cashew varieties (10 year old trees) to TMB damage at flushing

Varieties	October		November		December		January		February		Mean	
	Per cent damage	Mean score	Per cent damage	Mean score	Per cent damage	Mean score	Per cent damage	Mean score	Per cent damage	Mean score	Per cent damage	Mean score
Madakkathara-1	18.33^{a}	0.471^{def}	25.08^{cde}	0.530^{e}	26.61^{cd}	0.613^{c}	30.89^{bc}	0.671^{c}	32.50^{cd}	0.695^{c}	26.68	0.596
Kanaka	24.40^{abc}	0.628^{bc}	29.69^{bc}	0.786^{abc}	32.54^{bc}	0.863^{b}	37.00^{b}	1.130^{ab}	40.00^{abc}	1.205^{a}	32.72	0.923
Anakkayam-1	22.16^{bcd}	0.566^{bcde}	24.40^{cde}	0.703^{bcd}	28.02^{bc}	0.751^{bc}	32.46^{bc}	0.773^{c}	33.90bcd	0.788^{bc}	28.18	0.716
H-1600	16.07^{d}	0.431^{ef}	20.07^{e}	0.533^{e}	23.10^{e}	0.641^{c}	26.40^{c}	0.694^{c}	26.92^{d}	0.700^{c}	22.35	0.600
H-1610	21.00^{cd}	0.543^{bcdef}	25.09^{cde}	0.651^{cde}	27.84^{cde}	0.731^{bc}	37.99^{b}	0.880^{bc}	44.28^{cd}	0.871^{bc}	31.24	0.736
Madakkathara-2	16.80^{d}	0.490^{cdef}	21.05^{e}	0.602^{de}	24.30^{de}	0.663^{c}	32.61^{bc}	0.771^{c}	35.00^{bcd}	0.805^{bc}	25.91	0.667
Dhana	29.51^{a}	0.800^{a}	37.11^{a}	0.911^{a}	38.91^{a}	1.075^{a}	39.46^{ab}	1.195^{a}	42.50^{abc}	1.273^{a}	37.50	1.050
H-1593	18.19^{cd}	0.411^{f}	21.97^{de}	0.595^{de}	25.08^{de}	0.667^{c}	32.33^{bc}	0.765^{c}	35.00^{bcd}	0.788^{bc}	26.50	0.645
Priyanka	27.82^{cd}	0.665^{ab}	33.95^{ab}	0.831^{ab}	37.20^{ab}	1.071^{a}	46.26^{a}	1.085^{ab}	47.50^{a}	1.075^{ab}	38.50	0.945
Sulabha	21.19^{bcd}	0.592^{bcd}	27.72^{cd}	0.787^{abc}	29.44^{cd}	0.840^{b}	37.41^{b}	1.050^{ab}	39.33^{abc}	1.080^{ab}	31.02	0.870

Table 4. Reaction of cashew varieties(10 year old trees) to TMB damage during flowering stage

Varieties	December		January		February		Mean	
	Per cent damage	Mean score	Per cent damage	Mean score	Per cent damage	Mean score	Per cent damage	Mean score
Madakkathara-1	31.27^{abc}	0.814^{ab}	33.58^{b}	0.874^{ab}	36.25^{ab}	0.978^{ab}	33.70	0.888
Kanaka	28.98^{abcd}	0.706^{abc}	38.83^{ab}	0.873^{ab}	42.03^{ab}	0.930^{ab}	36.61	0.836
Anakkayam-1	37.15^{ab}	1.010^{a}	41.13^{ab}	1.225^{a}	42.30^{ab}	1.309^{a}	40.19	1.181
H-1600	23.91^{bcd}	0.554^{bcd}	35.37^{ab}	0.863^{ab}	37.58^{ab}	1.014^{ab}	32.28	0.810
H-1610	44.35^{a}	0.900^{ab}	47.96^{a}	1.028^{ab}	48.75^{a}	1.035^{ab}	47.02	0.988
Madakkathara-2	16.06^{cd}	0.348^{cd}	35.00^{ab}	0.725^{b}	35.00^{ab}	0.725^{b}	28.68	0.599
Dhana	29.73^{abcd}	0.716^{abc}	36.88^{ab}	0.838^{ab}	37.50^{ab}	0.843^{b}	34.70	0.799
H-1593	40.93^{a}	0.890^{ab}	44.46^{ab}	1.010^{ab}	45.22^{ab}	0.983^{ab}	43.53	0.961
Priyanka	40.55^{a}	0.799^{ab}	48.75^{a}	1.030^{ab}	48.75^{a}	1.030^{ab}	46.01	0.953
Sulabha	14.48^{d}	0.294^{d}	31.42^{b}	0.640^{b}	32.50^{b}	0.658^{b}	26.13	0.530

*In a column, means followed by a common letter are not significantly different at 5 per cent level by DMRT

Table 5. Reaction of cashew varieties to TMB damage at nut initiation stage

Varieties	December		January		February		Mean	
	Per cent damage	Mean score	Per cent damage	Mean score	Per cent damage	Mean score	Per cent damage	Mean score
Madakkathara-1	26.54^{b}	0.783^{a}	35.55^{bcd}	0.914^{b}	41.76^{abcd}	1.204^{ab}	34.61	0.966
Kanaka	14.06^{de}	0.261^{c}	37.21^{bcd}	0.746^{bc}	44.38^{abc}	0.959^{abc}	31.88	0.655
Anakkayam-1	38.83^{a}	1.154^{a}	42.25^{abc}	1.217^{a}	43.84^{abc}	1.240^{a}	41.64	1.203
H-1600	12.90^{e}	0.285^{c}	31.19^{cd}	0.604^{c}	32.50^{cde}	0.625^{c}	25.53	0.504
H-1610	25.74^{bc}	0.425^{c}	51.92^{a}	0.818^{bc}	53.75^{a}	0.885^{bc}	43.80	0.709
Madakkathara-2	12.84^{e}	0.281^{c}	30.00^{cd}	0.610^{c}	30.00^{de}	0.610^{c}	24.28	0.500
Dhana	13.21^{e}	0.296^{c}	27.50^{d}	0.615^{bc}	27.50^{e}	0.615^{c}	22.73	0.509
H-1593	17.40^{bcde}	0.304^{c}	36.8^{bcd}	0.635^{bc}	38.75^{bcde}	0.663^{c}	30.98	0.533
Priyanka	24.08^{bcd}	0.400^{c}	48.84^{ab}	0.840^{bc}	47.50^{ab}	0.845^{c}	40.14	0.695
Sulabha	15.71^{cde}	0.330^{c}	32.50^{cd}	0.675^{bc}	32.50^{cde}	0.675^{c}	26.90	0.560

*In a column, means followed by a common letter are not significantly different at 5 per cent level by DMRT

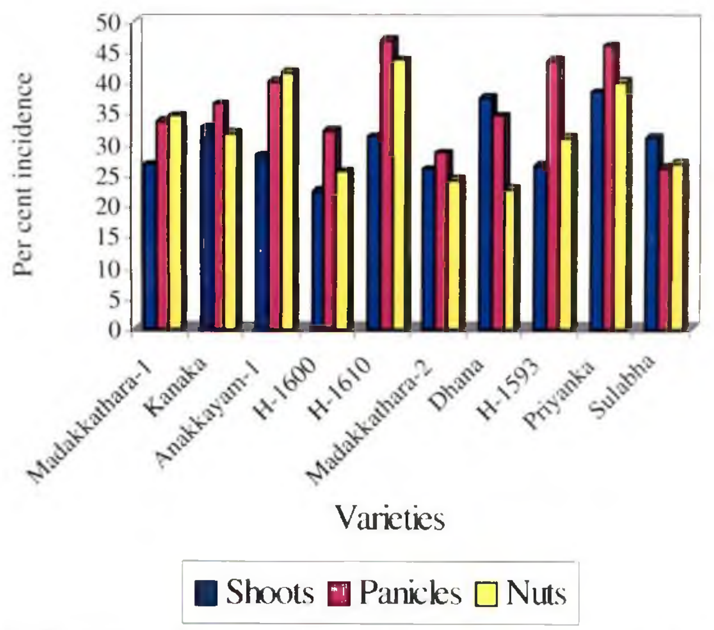

Fig. 3. Per cent damage of tea mosquito bug in shoots, panicles and nuts for a period of five months

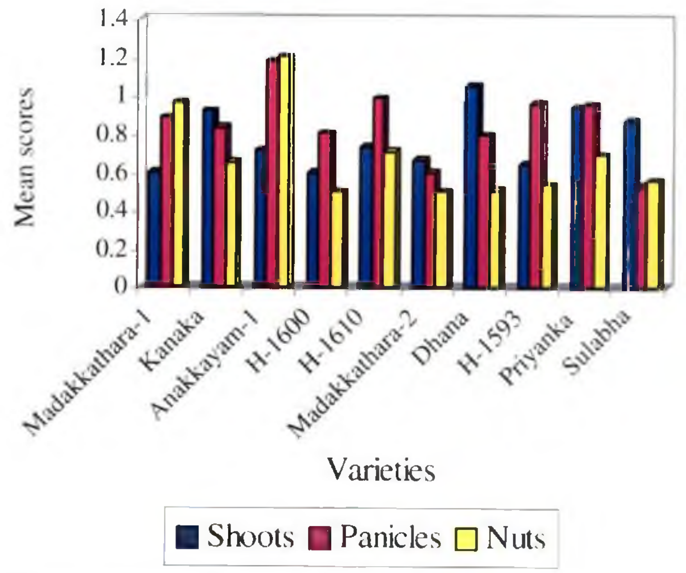

Fig. 4. Mean scores of tea mosquito bug damage in shoots, panicles and nuts for a period of five months

In the case of variety Priyanka, highest shoot infection was recorded in the month of February with 47.5 per cent occurrence and a mean score damage of 1.075. Highest panicle infestation was recorded by the variety Priyanka with 48.75 per cent incidence and a mean score damage of 1.030. Nut infection was also higher for Priyanka with 47.5 per cent infection and a mean score damage of 0.845.

Variety Sulabha recorded a higher shoot infection of 39.33 per cent and a mean score damage of 1.080 during February. Lowest panicle infection was recorded by the variety Sulabha with 32.5 per cent infection and a mean score damage of 0.658. Nut infection was also lower for the variety Sulabha with 32.5 per cent infection and a mean score damage of 0.675.

4.3 INFLUENCE OF AMF ON CROP GROWTH

4.3.1 Germination percentage

More germination percentage was observed on AMF treated plants (88%) while non AMF treated plants recorded a value of 80 per cent.

4.3.2 Graft success percentage

There is no significant difference between the success percentage of grafts produced in AMF treated plants and those without AMF.

4.3.3 Biometric observations

Biometric observations taken during the period of study were plant height, number of leaves, fresh weight, dry weight and number of roots. Significant results were obtained for vegetative characters in AMF inoculated plants. Data on vegetative characters were analysed and the mean values were presented in Table 6.

In case of plant height, the highest value of 36.62 cm was recorded by AMF plants, while for plants treated without AMF the value obtained was 32.85 cm. Superior values were also observed for number of leaves, fresh weight, dry weight and number of roots in case of AMF plants with values 16.6, 21.52 g, 6.13 g and 10.6

respectively, while for plants without AMF, the values obtained were 13, 12.11 g, 4.21 g and 5.4 respectively.

Table 6. Vegetative characters as influenced by AMF

Treatment	Height (cm)	No. of leaves	Fresh weight (g)	Dry weight (g)	No. of roots
A	36.62	16.6	21.52	6.13	10.60
A_0	32.85	13.0	12.11	4.21	5.40
CD (0.05)	2.28	1.44	1.71	0.47	1.45

4.3.4 Management of pest complex in cashew nursery

Major pest observed during the period of study was *H. antonii.* Observations of tea mosquito damage was taken at fortnightly intervals and the data were analysed and the mean values are presented in the Tables 7, 8, 9, 10, 11 and 12. There is no significant difference of tea mosquito damage between AMF and non AMF treated plants.

Occurrence of leaf miner in general was sparsely distributed. The statistical analysis revealed that there was no significant difference in any of the treatments under consideration.

4.3.4.1 Leaf damage

In the month of January the lowest incidence of leaf damage was observed in the treatment T_9 (I_2F_0) and T_{17} (I_4F_0) with mean score values of 0.4013 and 0.3456 respectively. Maximum damage was observed on the treatment T_1 (I_0F_0) with a mean score value of 0.975 (Table 7).

In case of non AMF plants, lowest damage was observed in the treatments T_9 (I_2F_0) and T_{17} (I_4F_0) with mean score values of 0.4362 and 0.4171 respectively (Table 7).

In the case of insecticides alone treatments leaf damage score values were considerably reduced in the treatments I_2 and I_4 with mean score values of 0.547 and 0.565 and were on par (Table 8).

Fungicides alone have no effect in reducing tea mosquito population (Table 9).

During February, the treatments T_9 (I_2F_0) and T_{17} (I_4F_0) recorded minimum tea mosquito damage in AMF plants with mean score values of 0.449 and 0.457 respectively. Highest damage was observed in the treatments T_3 (I_0F_2) and T_{13} (I_3F_0) with mean score values of 0.6250 and 0.6315. All other treatments were on par (Table 7). In the case of non AMF plants, the treatments T_9 (I_2F_0), T_{10} (I_2F_1) and T_{17} (I_4F_0) recorded lower incidence of tea mosquito with mean score values of 0.3028, 0.466 and 0.426 respectively (Table 7).

Observations taken during the month of March revealed that in case of AMF plants, the minimum tea mosquito damage was recorded in the treatment T_{10} (I_2F_1) with a mean score value of 0.445. The treatments T_{12} (I_2F_3) and T_{17} (I_4F_0) were also recorded lower tea mosquito damage with mean score value of 0.506 and 0.507. Highest damage was observed in the treatment T_3 (I_0F_2) with a mean score value of 0.658 (Table 7). In non AMF plants, the treatments T_9 (I_2F_0), T_{17} (I_4F_0) and T_{18} (I_4F_1) were effective in reducing the pest population with mean score values of 0.459, 0.460 and 0.471 respectively. Highest damage was observed in the treatment T_8 (I_1F_3) with a mean score value of 0.668 (Table 7).

During the month of April, in AMF treated plants, the treatments T_{10} ((I_2F_1) and T_{12} (I_2F_3) recorded lower incidence of tea mosquito with mean score values of 0.325 and 0.408. Highest damage was observed in the treatment T_{13} (I_3F_0) with a mean score value of 0.549 (Table 7). In case of non AMF plants, the treatments T_9 (I_2F_0) and T_{17} (I_4F_0) recorded lower tea mosquito damage with mean score values of 0.374 and 0.393 respectively. Damage intensity was higher in the treatments T_{13} (I_3F_0), T_{16} (I_3F_3), T_{19} (I_4F_2) and T_{20} (I_4F_3) with mean score values of 0.525, 0.522, 0.532 and 0.522 respectively (Table 7).

Table 7. Effect of insecticides, fungicides and their combinations on leaf damage due to TMB in AMF treated and non-treated cashew grafts

Treatments	Mean score values											
	January		February		March		April		May		June	
	AMF	No AMF	AMF	No AMF	AMF	No AMF	AMF	No AMF	AMF	No AMF	AMF	No AMF
T_1	0.9749^{a}	0.7058^{ab}	0.5947^{abc}	0.6362^{bcd}	0.5887^{bcd}	0.6081^{bc}	0.5792^{cd}	0.5060^{abcd}	0.3811^{abc}	0.3438^{bcde}	0.2702^{a}	0.2410^{d}
T_2	0.6006^{bcd}	0.6220^{abc}	0.5536^{abc}	0.5061^{def}	0.5671^{bcde}	0.5316^{e}	0.4898^{abcd}	0.4475^{def}	0.3542^{bcd}	0.3319^{de}	0.2732^{a}	0.2664^{bcd}
T_3	0.6308^{bc}	0.6387^{abc}	0.6250^{a}	0.6522^{bcd}	0.6584^{a}	0.6559^{ab}	0.5052^{abcd}	0.5188^{ab}	0.4122^{a}	0.4014^{a}	0.2815^{a}	0.2816^{bcd}
T_4	0.5625^{cd}	0.6343^{abc}	0.5381^{abc}	0.5952^{cde}	0.5563^{def}	0.5373^{de}	0.5791^{cd}	0.4567^{bcde}	0.3818^{abc}	0.3381^{cde}	0.2510^{a}	0.2519^{cd}
T_5	0.6444^{bc}	0.6366^{abc}	0.6010^{abc}	0.6744^{bc}	0.6014^{bcd}	0.6127^{abc}	0.5050^{abcd}	0.5090^{abcd}	0.3952^{ab}	0.4030^{a}	0.2800^{a}	0.2808^{bcd}
T_6	0.9108^{a}	0.6298^{abc}	0.5592^{abc}	0.5765^{cde}	0.6238^{ab}	0.5873^{cd}	0.4744^{cd}	0.4897^{abcd}	0.3788^{abcd}	0.3858^{a}	0.2679^{a}	0.2679^{bcd}
T_7	0.5423^{cd}	0.6651^{abc}	0.5730^{abc}	0.6767^{bc}	0.6011^{ab}	0.6600^{ab}	0.4928^{abcd}	0.5143^{abc}	0.3905^{ab}	0.3821^{ab}	0.2769^{a}	0.2785^{bcd}
T_8	0.6000^{bcd}	0.6286^{abc}	0.5886^{abc}	0.5679^{cde}	0.5861^{bcd}	0.6684^{a}	0.4876^{abcd}	0.5288^{a}	0.4098^{a}	0.3659^{abcd}	0.2800^{a}	0.2638^{bcd}
T_9	0.4013^{e}	0.4362^{d}	0.4491^{c}	0.3018^{g}	0.5136^{ef}	0.4586^{f}	0.4167^{e}	0.3735^{g}	0.3421^{cd}	0.3233^{e}	0.2612^{a}	0.2612^{bcd}
T_{10}	0.5139^{d}	0.5593^{c}	0.5105^{abc}	0.4659^{ef}	0.4445^{g}	0.5076^{ef}	0.3254^{f}	0.4244^{efg}	0.3403^{d}	0.3257^{de}	0.2612^{a}	0.3134^{abcd}
T_{11}	0.6479^{bc}	0.6901^{ab}	0.5988^{abc}	0.6674^{bc}	0.5810^{bcd}	0.6300^{abc}	0.5443^{ab}	0.5461^{a}	0.3999^{a}	0.3630^{abcde}	0.2868^{a}	0.2432^{cd}
T_{12}	0.5186^{d}	0.6109^{bc}	0.5110^{abc}	1.1580^{a}	0.5062^{b}	0.4861^{ef}	0.4084^{e}	0.4290^{efg}	0.2950^{e}	0.2651^{b}	0.2449^{a}	0.3304^{ab}
T_{13}	0.5856^{bcd}	0.6299^{abc}	0.6315^{a}	0.6522^{bcd}	0.5877^{abc}	0.6235^{abc}	0.5488^{a}	0.5250^{a}	0.4022^{a}	0.4053^{a}	0.2876^{a}	0.2876^{a}
T_{14}	0.5719^{cd}	0.6331^{abc}	0.5554^{abc}	0.6262^{bcd}	0.5813^{bcd}	0.6261^{abc}	0.5175^{abc}	0.4974^{abcd}	0.3936^{ab}	0.3735^{abc}	0.2445^{a}	0.2410^{d}
T_{15}	0.6139^{bcd}	0.6264^{abc}	0.6055^{abc}	0.6037^{cde}	0.6180^{abc}	0.5892^{cd}	0.5066^{abcd}	0.5097^{abcd}	0.3960^{ab}	0.3628^{abcde}	0.2824^{a}	0.2600^{cd}
T_{16}	0.6906^{b}	0.6153^{bc}	0.5644^{abc}	0.6003^{cde}	0.5964^{bcd}	0.6377^{abc}	0.4821^{bcd}	0.5221^{a}	0.3850^{ab}	0.3936^{a}	0.2717^{a}	0.2625^{bcd}
T_{17}	0.3456^{e}	0.4171^{d}	0.4576^{bc}	0.4264^{fg}	0.5068^{f}	0.4604^{f}	0.4415^{de}	0.3932^{fg}	0.3565^{bcd}	0.3250^{de}	0.2612^{a}	0.2459^{cd}
T_{18}	0.5774^{cd}	0.6332^{abc}	0.5566^{abc}	0.5326^{def}	0.5592^{cdef}	0.4705^{f}	0.4821^{bcd}	0.4543^{cde}	0.3843^{ab}	0.2182^{g}	0.2717^{a}	0.3467^{a}
T_{19}	0.6479^{bc}	0.6556^{abc}	0.6089^{ab}	0.5818^{cde}	0.6222^{ab}	0.6141^{abc}	0.5050^{abcd}	0.5319^{a}	0.3960^{ab}	0.3837^{ab}	0.2777^{a}	0.2653^{bcd}
T_{20}	0.5108^{d}	0.7311^{a}	0.5991^{a}	0.7661^{b}	0.6276^{ab}	0.6217^{abc}	0.4990^{abcd}	0.5221^{a}	0.4106^{a}	0.3928^{a}	0.2623^{a}	0.2770^{bcd}

*In a column, means followed by a common letter are not significantly different at 5 per cent level by DMRT

Table 8. Effect of insecticides alone on leaf damage due to TMB - *Colletotrichum* complex

Insecticides	Mean score values					
	January	February	March	April	May	June
I_0	0.6711^{a}	0.5876^{a}	0.5879^{b}	0.4853^{ab}	0.3681^{b}	0.2646^{a}
I_1	0.6572^{ab}	0.6022^{a}	0.6176^{a}	0.5002^{ab}	0.3889^{a}	0.2745^{a}
I_2	0.5473^{c}	0.5828^{a}	0.5160^{d}	0.4335^{c}	0.3318^{c}	0.2753^{a}
I_3	0.6209^{b}	0.6049^{a}	0.6075^{ab}	0.5137^{a}	0.3890^{a}	0.2672^{a}
I_4	0.5648^{c}	0.5663^{a}	0.5603^{c}	0.4787^{b}	0.3584^{b}	0.2760^{a}

Table 9. Effect of fungicides alone on leaf damage due to TMB - *Colletotrichum* complex

Fungicides	Mean score values					
	January	February	March	April	May	June
F_0	0.5777^{b}	0.5425^{b}	0.5561^{c}	0.4698^{b}	0.3678^{b}	0.2677^{a}
F_1	0.6252^{a}	0.5442^{b}	0.5499^{c}	0.4603^{b}	0.3486^{c}	0.2754^{a}
F_2	0.6359^{a}	0.6193^{a}	0.6230^{a}	0.5175^{a}	0.3887^{a}	0.2734^{a}
F_3	0.6103^{ab}	0.6490^{a}	0.5824^{a}	0.4815^{a}	0.3638^{bc}	0.2696^{a}

*In a column, means followed by a common letter are not significantly different at 5 per cent level by DMRT

In May, the treatments T_{12} (I_2F_3) and T_{10} (I_2F_1) were recorded lower tea mosquito damage in case of AMF plants and the mean score values were 0.295 and 0.340 respectively. Treatments T_3 (I_0F_2), T_8 (I_1F_3), T_{11} (I_2F_2), T_{13} (I_3F_0) and T_{20} (I_4F_3) were on par with higher tea mosquito damage (Table 7).

In case of non AMF plants, the treatments T_{12} (I_2F_3) and T_{18} (I_4F_1) recorded lowest tea mosquito damage with a mean score values of 0.265 and 0.218 respectively. Highest damage was observed in the treatments T_3 (I_0F_2), T_5 (I_1F_0), T_6 (I_1F_1), T_{13} (I_3F_0), T_{16} (I_3F_3) and T_{20} (I_4F_3) and they were on par (Table 7).

During June, since the pest attack was very low, there is no significant difference between the treatments in case of both AMF and non AMF plants.

4.3.4.2 Shoot damage

During January, the control plants of AMF recorded highest shoot damage with a mean score value of 1.565. Lowest shoot damage was recorded in the treatments T_9 (I_2F_0) and T_{17} (I_4F_0) with mean score value of 0.828 and 0.917 respectively (Table 10). In case of plants without AMF, treatments T_9 (I_2F_0) and T_{10} (I_2F_1) recorded lower incidence of tea mosquito infection with mean score values of 0.717 and 1.007. All other treatments were on par with each other (Table 10).

Observations taken during February showed that in case of AMF plants, the treatments T_2 (I_0F_1), T_9 (I_2F_0) and T_{17} (I_4F_0) recorded lower incidence of tea mosquito infestation with mean score values of 0.7958, 0.8462 and 0.8627 respectively. Highest damage was observed in the treatment T_{14} (I_3F_1) with a mean score value of 1.397 (Table 10).

In the case of non AMF plants, the treatments T9 (I_2F_0) and T_{17} (I_4F_0) recorded lowest shoot damage with mean score values of 0.378 and 0.446 respectively. Highest shoot damage was observed in the treatments T_5 (I_1F_0) and T_{13} (I_3F_0) with the same mean score value of 1.562 (Table 10).

In March, the treatments T_9 (I_2F_0) and T_{10} (I_2F_1) recorded lowest pest incidence with the same mean score value of 0.856. Shoot damage was highest in the treatments T_3 (I_0F_2) with a mean score value of 1.523 in case of AMF plants (Table 10). In case of non AMF plants the treatments T_9 (I_2F_0), T_{12} (I_2F_3), T_{17} (I_4F_0) and T_{18} (I_4F_1) were on par and they effectively reduced the pest incidence with mean score values of 0.816, 0.801, 0.786 and 0.847 respectively. Highest damage was observed in the treatments T_7 (I_1F_2) and T_{16} (I_3F_3) with the same mean score value of 1.423 (Table 10).

During April the treatment T_9 (I_2F_0) recorded minimum pest incidence in case of AMF plants. All other treatments were on par. In non AMF plants the treatments T_9 (I_2F_0) and T_{17} (I_4F_0) were effective in reducing the pest incidence with mean score values of 0.621 and 0.785 respectively. The treatments T_3 (I_0F_2) and T_{13} (I_3F_0) recorded higher shoot incidence with mean score values of 1.056 and 1.071 and they were on par. Highest incidence was noted in the treatment T_{11} (I_2F_2) with a mean score value of 1.435 (Table 10).

In May, the treatments T_9 (I_2F_0) and T_{17} (I_4F_0) were effective in reducing the pest incidence in AMF plants with mean score values of 0.726 and 0.735 respectively. All other treatments were on par. In the case of non AMF plants, the treatments T_9 (I_2F_0) and T_{17} (I_4F_0) were effective in reducing the pest incidence with mean score values of 0.679 and 0.730 respectively (Table 10).

During June the effective treatment among AMF plants was T_{12} (I_2F_3) with a mean score value of 0.618. All other treatments were on par with each other. In case of non AMF plants also, the same treatment recorded lower incidence of pest with a mean score value of 0.619. All other treatments were on par (Table 10).

Throughout the observation period, the treatments I_2 and I_4 recorded minimum pest incidence with mean score values of 0.886 and 0.989 respectively (Table 11).

Fungicides alone have no effect in reducing shoot damage caused by tea mosquito bug (Table 12).

Table 10. Effect of insecticides, fungicides and their combinations on shoot damage due to TMB in AMF treated and non-treated cashew grafts

Treatments	Mean score values											
	January		February		March		April		May		June	
	AMF	No AMF	AMF	No AMF	AMF	No AMF	AMF	No AMF	AMF	No AMF	AMF	No AMF
T_1	1.565^{a}	1.476^{b}	1.097^{abcde}	1.279^{ab}	1.271^{abc}	1.292^{ab}	1.007^{a}	0.9421^{bcd}	0.8347^{a}	0.8370^{ab}	0.7189^{a}	0.7194^{a}
T_2	1.396^{abc}	1.327^{b}	0.7958^{e}	0.8289^{c}	1.101^{cde}	0.9315^{cde}	1.192^{a}	0.9065^{bcd}	0.8393^{a}	0.8358^{ab}	0.7194^{a}	0.7185^{a}
T_3	1.207^{cde}	1.348^{b}	1.196^{abcd}	1.345^{ab}	1.523^{a}	1.238^{ab}	1.092^{a}	1.056^{bc}	0.8620^{a}	0.8586^{ab}	0.7238^{a}	0.7223^{a}
T_4	1.086^{cdefg}	1.296^{b}	1.163^{abcd}	1.130^{b}	1.147^{bcd}	1.116^{bcd}	0.9350^{a}	0.9994^{bcd}	0.8415^{a}	0.8381^{ab}	0.7204^{a}	0.7185^{a}
T_5	1.227^{bcde}	1.338^{b}	1.345^{ab}	1.562^{a}	1.323^{abc}	1.383^{ab}	1.063^{a}	0.8989^{bcd}	0.8529^{a}	0.9041^{a}	0.7209^{a}	0.7233^{a}
T_6	1.217^{cde}	1.327^{b}	1.212^{abc}	1.163^{b}	1.177^{bcd}	1.116^{bcd}	0.9492^{a}	1.007^{bcd}	0.8415^{a}	0.8393^{ab}	0.7204^{a}	0.7185^{a}
T_7	1.217^{cde}	1.538^{b}	1.212^{abc}	1.362^{ab}	1.177^{bcd}	1.423^{a}	1.042^{a}	1.063^{bc}	0.8506^{a}	0.8529^{ab}	0.7223^{a}	0.7218^{a}
T_8	1.296^{bcd}	1.338^{b}	1.196^{abcd}	1.162^{b}	1.162^{bcd}	1.323^{ab}	1.028^{a}	0.8563^{cd}	0.8461^{a}	0.8518^{ab}	0.7213^{a}	0.7213^{a}
T_9	0.8275^{h}	0.7171^{d}	0.8462^{de}	0.3786^{d}	0.8556^{e}	0.8163^{e}	0.9710^{a}	0.6208^{e}	0.7256^{a}	0.6797^{ab}	0.7165^{a}	0.7165^{a}
T_{10}	0.8756^{gh}	1.007^{c}	0.9966^{abcde}	0.5958^{cd}	0.8556^{e}	0.8708^{de}	0.9710^{a}	0.9852^{bcd}	0.8279^{a}	0.8279^{ab}	07175^{a}	0.7165^{a}
T_{11}	1.296^{bcd}	1.317^{b}	1.196^{abcd}	1.212^{b}	1.062^{cde}	1.262^{ab}	1.035^{a}	1.435^{a}	0.8461^{a}	0.8472^{ab}	0.7209^{a}	0.7213^{a}
T_{12}	0.9963^{efgh}	1.286^{b}	1.146^{abcd}	0.6289^{cd}	0.9011^{de}	0.8011^{e}	0.9852^{a}	0.8781^{cd}	0.8324^{a}	0.7790^{bc}	0.6180^{b}	0.7165^{a}
T_{13}	1.296^{bcd}	1.296^{b}	1.329^{ab}	1.562^{a}	1.407^{ab}	1.268^{ab}	1.178^{a}	1.071^{bc}	0.8575^{a}	0.8575^{ab}	0.7233^{a}	0.7233^{a}
T_{14}	1.138^{cdef}	1.348^{b}	1.397^{a}	1.279^{abc}	1.116^{bcde}	1.131^{bcd}	1.021^{a}	1.041^{bcd}	0.8393^{a}	0.8393^{ab}	0.7194^{a}	0.6189^{a}
T_{15}	1.286^{bcd}	1.317^{b}	1.179^{abcd}	1.196^{b}	1.277^{abc}	1.307^{ab}	1.035^{a}	1.042^{bcd}	0.8461^{a}	0.8484^{ab}	0.7213^{a}	0.7213^{a}
T_{16}	1.486^{ab}	1.265^{b}	1.212^{abc}	1.429^{ab}	1.177^{bcd}	1.423^{a}	1.035^{a}	1.149^{b}	0.8461^{a}	0.8472^{ab}	0.7204^{a}	0.7204^{a}
T_{17}	0.9171^{fgh}	0.7067^{b}	0.8627^{cde}	0.4455^{d}	1.071^{cde}	0.7859^{e}	0.9994^{a}	0.7852^{de}	0.7347^{b}	0.7301^{cd}	0.7185^{a}	0.7165^{a}
T_{18}	1.217^{cde}	1.348^{b}	1.163^{abcd}	1.379^{ab}	1.131^{bcde}	0.8467^{e}	1.021^{a}	1.007^{bcd}	0.8415^{a}	0.7893^{bc}	0.7204^{a}	0.7194^{a}
T_{19}	1.317^{bcd}	1.517^{b}	1.229^{ab}	1.212^{b}	1.192^{bcd}	1.377^{ab}	1.042^{a}	1.042^{bcd}	0.8506^{a}	0.8495^{ab}	0.7218^{a}	0.7213^{a}
T_{20}	1.055^{defgh}	1.765^{a}	1.097^{abcde}	1.379^{ab}	1.171^{bcd}	1.192^{abc}	0.9994^{a}	1.042^{bcd}	0.8370^{a}	0.8404^{ab}	0.7194^{a}	0.7194^{a}

*In a column, means followed by a common letter are not significantly different at 5 per cent level by DMRT

Table 11. Effect of insecticides alone on shoot damage due to TMB - *Colletotrichum* complex

Insecticides	Mean score values					
	January	February	March	April	May	June
I_0	1.338[a]	1.104[b]	1.2020[ab]	1.016[a]	0.8424[ab]	0.7201[a]
I_1	1.312[a]	1.277[a]	1.2600[a]	0.9885[a]	0.8620[a]	0.7212[a]
I_2	1.040[b]	0.8751[c]	0.9280[c]	0.9852[a]	0.7827[c]	0.7055[a]
I_3	1.304[a]	1.323[a]	1.2630[a]	1.0680[a]	0.8481[ab]	0.7085[a]
I_4	1.230[a]	1.096[b]	1.0960[b]	0.9922[a]	0.8023[ab]	0.7196[a]

Table 12. Effect of fungicides alone on shoot damage due to TMB - *Colletotrichum* complex

Fungicides	Mean score values					
	January	February	March	April	May	June
F_0	1.137[c]	1.071[b]	1.147[b]	0.9536[b]	0.8011[b]	0.7197[a]
F_1	1.220[bc]	1.081[b]	1.028[c]	1.007[ab]	0.8263[ab]	0.7089[a]
F_2	1.336[a]	1.23[a]	1.284[a]	1.008[a]	0.8513[a]	0.7218[a]
F_3	1.287[ab]	1.154[ab]	1.141[b]	0.9908[ab]	0.8313[ab]	0.7096[a]

*In a column, means followed by a common letter are not significantly different at 5 per cent level by DMRT

Throughout the observation period, in case of AMF plants the treatments T_9 (carbendazim 0.1% + quinalphos 0.05%) and T_{17} (copper oxychloride 0.2% + quinalphos 0.05%) recorded lowest TMB damage and served as best treatments. Maximum infestation was recorded in treatment T_3 (copper oxychloride 0.2%).

In case of non AMF plants the best treatments were T_9 (carbendazim 0.1% + quinalphos 0.05%) and T_{17} (copper oxychloride 0.2% + quinalphos 0.05%) and severe infestation was noted in the control plants.

4.4 *IN VITRO* EVALUATION OF FUNGICIDES AND INSECTICIDES ON THE GROWTH OF *Colletotrichum gloeosporioides*

The inhibitory effect of different fungicides, insecticides and their combinations on the growth of *C. gloeosporioides* was studied by poisoned food technique using Potato Dextrose Agar (PDA) medium. The results of the experiment are given in Table 13.

Among the different treatments cent per cent inhibition was observed in T_1 (carbendazim 0.1%), T_3 (copper oxychloride 0.2%) and their combinations with all insecticides. Zineb (T_2) was found to be least effective as it gave only 13.14 per cent inhibition. However in combination with insecticides zineb showed good fungicidal property by recording 50.55 to 76.29 per cent inhibition of the pathogen and maximum inhibition was observed in zineb + quinalphos combination.

Among the insecticides tested, quinalphos and azadirachtin showed fungicidal activity against *C. gloeosporioides* by giving 50.0 and 42.2 per cent inhibition.

Table 13. *In vitro* evaluation of fungicides and insecticides against *C. gloeosporioides*

Treatments	Mean colony diameter (cm)	Per cent inhibition over control
T_1	0.00	100.00
T_2	7.98	13.14
T_3	0.00	100.00
T_4	5.62	26.40
T_5	4.50	50.00
T_6	5.20	42.20
T_7	6.80	24.40
T_8	0.00	100.00
T_9	0.00	100.00
T_{10}	0.00	100.00
T_{11}	0.00	100.00
T_{12}	3.37	62.77
T_{13}	2.13	76.29
T_{14}	3.12	65.37
T_{15}	4.45	50.55
T_{16}	0.00	100.00
T_{17}	0.00	100.00
T_{18}	0.00	100.00
T_{19}	0.00	100.00
T_{20}	9.00	0.00

Discussion

5. DISCUSSION

Cashew is one of the most important cash crops of India. Eventhough cashew cultivation in our country is increasing steadily, cashewnut production is showing a decreasing trend. One of the reasons attributed to the drastic decline in production is the occurrence of tea mosquito bug, *Helopeltis antonii* Signorett and the fungus *Colletotrichum gloeosporioides* which causes severe die back. A severe outbreak of this pest complex occurred during 1998-99 in northern parts of Kerala.

Continuous desapping by tea mosquito bug will result in necrotic lesions and the surrounding tissues becoming brown and later turn black coloured. In severe infestations, the young shoots and panicles dry up, giving the infested trees a scorched appearance. Successive attack in new growths can result in stunting or death of the tree.

The plants infested by tea mosquito is more prone to the disease die back caused by *C. gloeosporioides* (Nambiar *et al.*, 1973; Varma and Balasundaram, 1990 and Bindu *et al.*, 1998).

Identification of a variety resistant or tolerant to infestation by *H. antonii* would be the most desirable strategy for pest management. Tree to tree variation in the population density and intensity of incidence of *H. antonii* on cashew was reported by Pillai *et al.*, 1979.

Work done by Ambika *et al.* (1979) revealed that the accession number 665 was more tolerant with respect to panicle and shoot damage, whereas K-10-2-1233 and K-10-2-1218 were found more susceptible. In a similar experiment conducted by Sathiamma (1979) found that the accession VTH-153 was comparatively tolerant to tea mosquito based on the shoot and panicle damage and the accession VTH-54, most susceptible.

Studies were also conducted on the reaction of tea mosquito bug on grafts. Among the 34 accessions screened against tea mosquito bug, the accession numbers

Goa 11/6 and VTH 153/1 were moderately resistant to mirid damage while all others were susceptible (Sundararaju and John, 1993). Among the 56 accessions screened, the accession Goa 11/6 was the least susceptible type against tea mosquito bug (Sundararaju, 1999).

The results of screening of cashew grafts under the no choice situation to tea mosquito bug and *Colletotrichum gloeosporioides* are discussed in the light of survival of the grafts. The results relating to the resistance/tolerance to tea mosquito and also to *C. gloeosporioides* under field conditions have also been discussed.

As a measure for increasing the vigour and growth attributes and there by to assess the feasibility of inducing vigour tolerance in cashew grafts, incorporation of AMF in the potting mixture has also been tried and these results discussed.

5.1 SCREENING OF CASHEW GRAFTS OF SELECTED VARIETIES AGAINST PEST- DISEASE COMPLEX

A graded difference was observed in the development of symptoms in various treatments. In the presence of the fungus *C. gloeosporioides*, the feeding lesions due to TMB became dark brown to black on second day in treatment T_2 where both TMB and *C. gloeosporioides* were inoculated. The development of die-back symptoms in different treatments were monitored at periodic intervals and the severity of symptom was observed in the combined inoculation except in the variety, H-1600, which indicate the role of the fungus *C. gloeosporioides* in aggravating the seedling die back when inoculated on grafts infested by TMB (Plate 8). It was also observed that without the association of the fungus, the typical die-back symptoms did not develop. Inoculation of the fungus alone without making any injury did not produce any lesions or disease symptoms. From this, it is clear that the fungus *C. gloeosporioides* normally gain entry through the feeding injuries caused by TMB and cause die-back symptoms. Other injuries on the flushes, shoots and immature nuts may also aid in the development of the fungus. This is in confirmation with the findings of Bindu (1996).

In the present study, it was observed that plants infested by TMB alone, cause slight damage and regained the growth after a period of time, whereas in case of plants inoculated with TMB and *Colletotrichum*, the plants could not regain the growth once die-back symptoms were produced.

Varietal screening under confined conditions revealed that none of the varieties were immune to tea mosquito. However all the varieties showed variability in their degrees of susceptibility. Throughout the observation period, the variety H-1600 recorded minimum tea mosquito damage, while the varieties Anakkayam-1, Madakkathara-1 and Sulabha recorded higher damage. The varieties Madakkathara-2, H-1610 and Kanaka also recorded less TMB damage.

Thus the present study indicate that the variety H-1600 is comparatively more tolerant to both TMB alone and TMB + *Colletotrichum* infection.

5.2 FIELD SCREENING OF SELECTED VARIETIES TO INFESTATION BY TEA MOSQUITO

Under the field condition also the variety H-1600 recorded minimum shoot, panicle and nut infection. Hence the variety H-1600 can be considered as a tolerant variety. The varieties Madakkathara-2, H-1610 and Kanaka recorded less damage under field conditions also. Variety Dhana is highly susceptible to shoot infection, but less susceptible to panicle and nut infection. Highest panicle and nut infection was recorded by the variety Anakkayam-1. Beevi *et al.* (2001) also observed that the varieties H-1600 and H-1610 were less susceptible to TMB infestation.

5.2.1 Comparison of varietal reaction under natural and *in vivo* conditions

Under natural and confined conditions the variety H-1600 recorded minimum damage of tea mosquito. Hence it can be considered as a variety comparatively more tolerant to both TMB and TMB + *Colletotrichum* complex.

Varieties Anakkayam-1 and Madakkathara-1 were highly susceptible to both TMB alone and TMB + *Colletotrichum* treatments under *in vivo* conditions. In the field conditions also, Anakkayam showed higher panicle and nut infection. The varieties that are more prone to TMB + *Colletotrichum* complex need a combination spray of both insecticide and fungicide to provide protection against TMB and *Colletotrichum* particularly in situations where rainfall is received during the flowering phase (November-February) causing increase in atmospheric humidity. Work done by Nambiar *et al.* (1973) showed that a combination spray of cuman 0.1 per cent with dimecron 0.03 per cent reduced the inflorescence blight in cashew.

The variety Dhana shows higher shoot infection in both confined and natural conditions. But it shows lesser panicle and nut infection under field conditions indicating that pesticide application can be restricted to twice, first at flushing and the second in between the panicle and nut initiation based on the pest population trends. In Anakkayam-1 all the three prophylactic sprays are required as infection on shoot, panicle and nut are equally severe.

The study brings out the need for popularising the varieties H-1600, H-1610 and Kanaka which are more tolerant to TMB and *Colletotrichum* for augmenting cashew production in the state of Kerala.

5.3 INFLUENCE OF AMF ON CROP GROWTH

5.3.1 Germination percentage

alone indicate the actual usefulness of AMF. performance in the field over the years would

5.3.3 Biometric observations

Significant differences in plant height, number of leaves, number of roots, fresh weight and dry weight were observed in AMF treated plants. Increase in the growth parameters of AMF inoculated plants over the uninoculated plants could be attributed to many reasons viz., increased nutrient uptake or production of biologically active metabolites like B vitamins, indole acetic acid, gibberellins and cytokinins by the microorganisms (Azcon and Barea, 1975; Horeman *et al.*, 1986) or indirectly by affecting the balance between harmful and beneficial organisms in the rhizosphere (Jackson and Brown, 1966) or by the production of antibiotics and quinones, which are known to give protection to plants against plant pathogens and also affect the oxidative phosphorylation of plants (Mishustin, 1966; Robert *et al.*, 1967). Any one or all these factors may contribute to the enhanced growth of the AMF inoculated plants. These findings were in consonance with the reports obtained by Khaliel and Elkhider (1987), Sivaprasad *et al.* (1992), Sreeramulu and Bagyaraj (1998), Remesh *et al.* (1998) and Lakshmipathy *et al.* (2000).

5.3.4 Management of pest complex in cashew nursery

The major pest observed during the study period was tea mosquito bug (*H. antonii*). No significant differences were obtained between the AMF treated plants and untreated plants in respect of the pest-disease occurrence.

Imidacloprid did not perform well under natural infestation. Neem formulation, azadirachtin 1500 ppm also failed to manage the pest in the nursery. Throughout the observation period, the treatments I_2 (quinalphos) and I_4 (carbaryl) were highly effective in reducing the pest incidence. These results were in agreement with the findings of Muthu and Baskaran (1979), Abraham and Nair (1981), Nair and Abraham (1982), Abraham (1984). Singh and Pillai (1984), Godse *et al.* (1993), Bakthavatsalam *et al.* (1993) and Nair (1998).

Combination sprays of quinalphos + carbendazim, carbaryl + carbendazim and quinalphos + copper oxychloride were found most effective throughout the observation period. Nambiar *et al.* (1973), and Bindu (1996) also reported that a combined application of insecticide and fungicide was more effective in the control of inflorescece blight and die-back symptoms. Effectiveness of quinalphos + copper oxychloride in controlling TMB-anthracnose complex was also reported earlier by Kurien *et al.* 2001. The present results revealed the involvement of *C. gloeosporioides* in the die-back symptoms caused by the TMB.

5.3.5 *In vitro* evaluation of fungicides and insecticides on the growth of *C. gloeosporioides*

The fungicides, carbendazim, copper oxychloride and their combinations with imidacloprid, quinalphos, azadirachtin and carbaryl gave cent per cent inhibition of the pathogen. The fungicide carbendazim was found to be very effective in reducing the infestation of *C. lindemuthianum* in cowpea (Sohi and Rawal, 1984 and Praveenkumar, 1999). Studies conducted by Sreenivasan and Gunasekaran (1998) and Vrinda (2002) also observed that the fungicides copperoxychloride and carbendazim were very effective in controlling the infection of *C. gloeosporioides* causing leaf rot in coconut.

In the present study, the insecticide quinalphos also showed maximum fungicidal action. This is in conformity with the results reported by Kalpana (1992) who detected fungicidal property of quinalphos against *Pyricularia oryzae*.

The treatment combinations of the fungicides carbendazim and copper oxychloride with all the four insecticides also resulted in cent per cent inhibition of the pathogen. It is also interesting to note that, zineb which recorded only 13.14 per cent inhibition has recorded 50.55 to 76.29 per cent inhibition when used in combination with insecticides, showing the possible synergetic effect. This is in confirmation with

6. SUMMARY

Cashew is an important cash crop of India and is remunerative in all types of soil. Commercial method of propagation in cashew is soft wood grafting. Many insects and pathogens are reported in the cashew nursery resulting in poor growth and establishment of the grafts. Present study has been taken up with the objectives of identifying high yielding cashew variety possessing resistance to the pest both in the juvenile (grafts) and adult stages and also to develop an effective and safer management strategy. As a measure for increasing the vigour and growth attributes of cashew grafts incorporation of AMF in the potting mixture was also tried.

Screening of selected cashew grafts against tea mosquito bug (TMB) and *Colletotrichum* complex revealed that plants infected with TMB alone, cause slight damage and may regain their growth and recover later, but when the plants were inoculated with TMB and *Colletotrichum* in conjunction, the plants cannot regain the growth. Inoculation of the fungus without making any injury did not produce any lesions or disease symptoms. From this it is clear that the fungus *C. gloeosporioides* normally gain entry through lesions caused by TMB feeding and cause die back symptoms.

The variety, H-1600 was observed as the better one as this showed more tolerance to TMB and TMB-*Colletotrichum* complex. Considering the attack of TMB alone, the varieties Madakkathara-2, H-1610 and Kanaka recorded lesser incidence and these rated as comparatively tolerant varieties.

Varieties Anakkayam-1 and Madakkathara-1 were highly susceptible to both TMB and TMB + *Colletotrichum* complex under *in vivo* conditions. In field conditions also the variety Anakkayam-1 showed higher panicle and nut infection. Under field conditions, variety Dhana showed higher shoot infection, but less panicle and nut infection.

The study brings out the need for popularising the varieties H-1600, H-1610 and Kanaka which are more tolerant to TMB and *Colletotrichum* for augmenting cashew production in the state of Kerala.

Incorporation of AMF resulted in greater germination percentage, growth attributes like height, number of leaves, number of roots, fresh weight and dry weight of plants. But no significant differences were obtained for pest infestation among AMF treated plants and plants treated without AMF. Actual utility of AMF can be judged only after serial long term experiment.

Among the insecticides, quinalphos and carbaryl were effective in reducing the TMB infestation. Combination sprays of carbendazim/copper oxychloride with quinalphos were effective against tea mosquito bug - *Colletotrichum* pest complex. Laboratory studies conducted to test the effectiveness of different pesticides and their combinations against *Colletotrichum* revealed that the fungicides carbendazim and copper oxychloride and also their combinations with all the four insecticides were effective in preventing the growth of the fungus.

The main finding is that TMB + *C. gloeosporioides* complex is responsible for causing crop losses, particularly so in situations characterized by high atmospheric humidity levels. The rational strategy seems to be a joint application of selected insecticides and fungicides for hot spot situations.

Depending upon the varieties, varietal susceptibility on flushing, flowering and nut initiation, prevailing weather conditions and population of pest in the field, a judicious application of insecticides/fungicides may be advocated to smother infestation by tea mosquito bug, *C. gloeosporioides* or both.

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EVALUATION AND MANAGEMENT OF PEST COMPLEX IN CASHEW GRAFTS

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ABSTRACT OF THE THESIS

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ABSTRACT

Experiments were conducted at Cashew Research Station, Madakkathara and the Departments of Entomology and Pathology, College of Horticulture, Vellanikkara with the objectives of identifying high yielding cashew variety possessing resistance or tolerance to the Tea Mosquito Bug - *Colletotrichum gloeosporioides* complx and also to develop an effective and safer management strategy using pesticides.

Screening of selected cashew grafts against tea mosquito bug (TMB) and *Colletotrichum* complex revealed that plants infected with TMB alone cause slight damage and may regain their growth after a period of time, but when the plants were inoculated with *Colletotrichum* and infected by TMB, the plants cannot regain their growth, once the die-back symptoms were incited.

The variety H-1600 was observed to be better as it is comparatively tolerant to both TMB and TMB-*Colletotrichum* complex. The varieties Madakkathara-2, H-1610 and Kanaka also recorded lesser TMB damage.

Inoculation with AMF resulted in greater germination percentage and enhanced growth attributes like height, number of leaves, number of roots, fresh weight and dry weight of plants. Among the insecticides, quinalphos and carbaryl were effective in reducing the TMB infestation. Combination sprays of carbendazim/ copper oxychloride with quinalphos also proved effective against TMB-*Colletotrichum* pest complex.

The scope of rationalising TMB management has been discussed in the light of the relative tolerance of the varieties and the need for judicious application of selected insecticides to contain TMB and of selected fungicides in conjunction to control the subsequent invasion by *Colletotrichum gloeosporioides* that may aggravate the die- back symptoms highlighted.