MANAGEMENT OF PESTS OF COWPEA USING RED ANT, *Oecophylla smaragdina* (Fab.)

by

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "**MANAGEMENT OF PESTS OF COWPEA USING RED ANT, *Oecophylla smaragdina* (Fab.)**" is a *bona fide* record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associate ship, fellowship or other similar title, of any other University or Society.

Padannakkad,

Date: 26·10·2015

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CERTIFICATE

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INTRODUCTION

INTRODUCTION

Ants make up one of the most abundant and omnipresent arthropod groups on earth and are dominant in tropics and subtropics, as the major scavengers and predators on many other arthropods. Two humid-tropic species, *Oecophylla smaragdina* (Fab.) (Hymenoptera: Formicidae) in Asia and Australia and *O. longinoda* in Africa, have their biologies similar. They are active throughout the year and their distribution and abundance depends on evergreen trees and shrubs. This 'living pesticide' is one of the most impressive members of forest landscapes because of their dominance in local habitats, large body size and the aggressiveness in addition to the peculiar nesting behaviour (Holldobler and Wilson, 1990). A number of ecologists, studying biological pest management in the tropics, have tried to test the effectiveness of bio control agents with rigorous scientific methods, and most of them have suggested that the predatory power of *Oecophylla* is most outstanding among ants in their localities (Way and Khoo, 1992; Peng *et al.*, 1997, 1999; Mele and Cuc, 2000).

Red ants live in a society where work is well divided among the different types of individuals. In each colony one or several queens in one nest in dry season or in more nests in rainy season is observed. They are easy to recognize as they have the biggest size and a yellow to brown body with a big abdomen to produce many eggs. At the beginning they have wings just like the males, but after the mating flight they lose their wings. Males are much smaller than the queen, and have a blackish body and are winged. Their only task is to mate with the queen after which they die. They live only for a short time. Small workers stay mainly inside the nest and take care of the young, so called nurse ants. Large workers are the most numerous in the colony and are responsible for a whole range of activities. They guard against intruders, collect and bring home food for the whole colony and construct nests. They transport the larvae and eggs into safer places when the nest is attacked. Under certain conditions they can also lay eggs, just like the queen (Mele and Cuc, 2007).

The first written record of biological control dating from 304 AD is the use of red ant, *Oecophylla smaragdina* in citrus (Huang and Yang, 1987). Red ant was extensively used for pest control in Africa and Asia on various crops like coconut, cocoa, coffee, citrus *etc.* Though such time tested methods went into oblivion with the introduction of pesticides, they have been staging a comeback over the past two decades across the world. Paradigm shift in pest management have led to increased focus on *Oecophylla* in pest management of other crops like cashew, mango and timber crops also (Mele, 2008). The viability of the technology in cashew plantations appear to be promising (Sreekumar*et al.*, 2011).

Oecophylla spp. workers attack many interfering animals, including humans, and kill a wide range of arthropods for food (Way, 1954). No doubt, the highly organized aggressive predatory behaviour, combined with extensive foraging throughout the area occupied by a colony, explains the success of *Oecophylla* species in killing or driving away many pests or potential pests, notably Heteroptera and foliar feeding Coleoptera (Way and Khoo, 1992). They are able to control over 50 species of insect pests on many tropical tree crops and forest trees (Way and Khoo 1992; Peng *et al.*, 1997).

Developing alternatives to pesticides is critical to maintaining agricultural production in view of the phasing out of low cost broad spectrum insecticides with newer but costly ones. This is all the more true for Kasaragod district, which has been declared as an organic district and where synthetic insecticides are no more an option.

Vegetable cowpea is an important crop of the state. This crop harbours many pests such as aphids, pod borers, pod bugs *etc.* Vegetable cowpea is harvested on every alternate day without which the pods will become fibrous and non-marketable. For most of the pesticides, a minimum of 5 days is to be observed as waiting period which is not possible in the case of cowpea. At the same time, imparting faster methods of control is imperative in the case of cowpea to reduce crop damage and to protect aesthetic value of the produce. Sreekumar *et al.* (2006) reported that augmented control by red ant is made use of by farmers in north Kerala in managing pests in kitchen gardens especially in cowpea but the effectiveness was not scientifically validated. It is in this context that the present research work is proposed with the following objectives *viz.*,

- To study the seasonal variation on the activity and population building of red antwhich will throw light on cultivation of red ant for the purpose of pest management.
- To develop suitable techniques for elimination of competitor ants since competitor ants pose strong threat to red ant spread and utilization.
- To study the effectiveness of *O. smaragdina* in managing the pests of cowpea.

To study the effect of selected pesticides on *O. smaragdina* which will generate information on the use of pesticides to manage certain pest and diseases of cowpea without affecting red ant population.

Caste of red ant

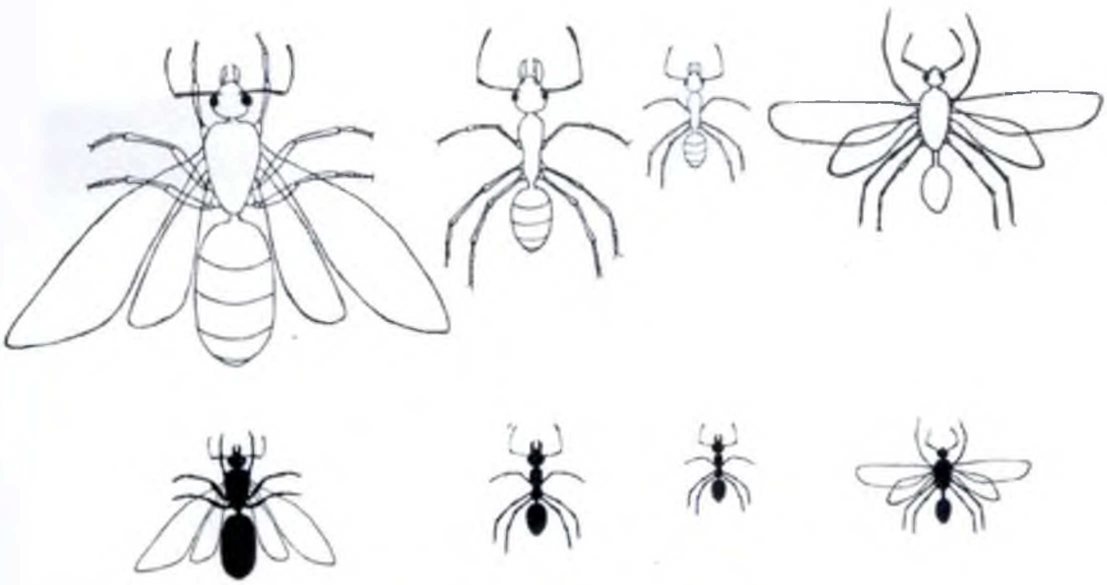


Plate 1. Queen, large worker, small worker & male

Plate 2. Queen

Plate 3. Workers along with larva and pupa

Plate 4. Male

REVIEW OF LITERATURE

REVIEW OF LITERATURE

A literature search was undertaken to review the information related to red ants. Studies on the methods of eliminating competitor ants, effect of pesticides on red ants *etc.* are very meagre. Some relevant information like the bio-ecology of red ants, association with other plants and animals, efficient utilization of red ants in managing various pests of different crops like cashew, citrus, mango, coconut, cocoa, etc., are presented in this chapter.

2.1. BIO-ECOLOGY OF RED ANTS

Way (1954), Brown (1959) and Holldobler (1979) reported that the red ants are active throughout the year and their distribution and abundance depends on evergreen trees and shrubs with suitable leaves for silk-woven leaf nest construction. The weaver ants of the genus *Oecophylla* are one of the most impressive members of forest landscapes because of their dominance in local habitats, large body size and the aggressiveness in addition to the peculiar nesting behaviour of bonding leaves together by their larval silk (Holldobler, 1983; Holldobler and Wilson, 1990; Azuma *et al.*, 2002).

Holldobler and Wilson (1990) observed that the relationship between the weaver ants and their nesting plants is facultative, as the ants use the leaves of almost any kind of plant including trees, herbs and grass. A number of ecologists, studying biological pest management in the tropics have suggested that the predatory power of *Oecophylla* is most outstanding among ants in their localities (Peng *et al.*, 1999; Mele and Cuc, 2000).

The highly organized aggressive predatory behaviour of *O. smaragdina*, combined with extensive foraging throughout the area occupied by a colony, explains its success in killing or driving away many pests or potential pests. This has been illustrated for heteropteran, lepidopteran and leaf-feeding coleopteran pests in citrus, mango, litchi, coconut and cashew (Way and Khoo, 1992).

In Asia, queen larvae and alates are sold on commercial markets for human and animal consumption (Krag *et al.*, 2010). They reported that *Oecophylla smaragdina* larvae transplanted from other colonies are readily tolerated by non nestmate workers and are reared to imagos.

Major workers of *O. longinoda* mark their territories with persistent pheromones that are distinguishable to the ants at the colony level. Workers detecting the deposits of an alien colony respond with increased amounts of aversive and aggressive behaviour, and they later recruit nest mates to the area at a higher rate. Colonies entering a field impregnated with their own scent also gain an initial advantage in warfare with other colonies. The pheromones are located at least in part in drops of rectal sac fluid deposited by workers over the territorial surface (Wilson, 1977).

Babu *et al.* (2011) reported that the castes of the weaver ant *O. smaragdina* differ in the organization of sensilla on their antennae and mouthparts. Caste-specific behaviours among social insects are known to be largely influenced by olfactory cues. It was observed that the sensilla numbers differ among the three castes, whereas all the three castes possess similar types of chemosensilla.

The molecular phylogeny of 24 *Oecophylla smaragdina* and two *O. longinoda* populations using 647 bp of the mitochondrial cyt b gene suggested that *O. smaragdina* and *O. longinoda* were separated from each other first, and after that the first within-species divergence of *O. smaragdina* occurred in early stage of their history, in which the Asian, Australian, and Sulawesian groups rose. This grouping was almost coincident with the distribution of landmass in glacial periods in Pleistocene. Thereafter, each group seemed to have independently diverged into present populations on each landmass (Azuma *et al.*, 2002).

2.2. ASSOCIATION OF ANTS WITH OTHER PLANTS AND ANIMALS

Holldobler and Wilson (1990) reported that, red ants are often mutualistic symbionts of plants such as *Acacia* and *Macalanga* and other insects such as homopterans and lycaenid butterflies, protecting them from natural enemies and competitors to reward resources they provide such as foods and nest sites. The effects of ants on abundance and survival strategies of other orgainsms are complex, usually depending on many factors that are often specific to each case of interspecific interaction in each locality (Fleming and Nicolson, 2003).

Tritrophic interactions between the weaver ant *Oecophylla smaragdina*, plants and honeydew-producing trophobionts (Hemiptera: *Sternorrhyncha* and *Auchenorrhyncha*, Lepidoptera: Lycaenidae) was studied in a rain forest canopy in Northern Queensland, Australia and the results suggested that plant-specific differences in suitability for honeydew production and the availability of preferred trophobionts have a strong influence on the vigour of *Oecophylla* colonies (Blthgen and Fiedler, 2002).

Predatory ants that are recognized as important in pest management are mostly omnivorous and rely also on plant foods. For example, a *Formica rufa* comprised 62 percent honey dew; 5 percent resin, fungi, carrion and seeds; and 33 percent insect prey. In particular, ant attended honey-dew producing Homoptera provide a dependable energy food supply needed for large stable populations of certain ants to maintain consistent protection of the plants on which they forage (Way and Khoo, 1992). Red ant protect homopteran colonies from natural enemies and the relationship confers mutual benefits to ants and Homoptera (Way, 1963).

Few works of Khoo and Chung (1989) highlights the fact that particular Homoptera are essential for biological control success. In contrast, predatory ant species that do not utilize Homoptera, such as the highly voracious army and driver ants are raiders that only temporarily suppress most prey populations in a particular locality and they have often been reported to tend honey-dew producing Homoptera, but *Oecophylla* has never been associated with outbreaks of these pests (Way, 1963; Huang and Yang, 1987).

Crozier *et al.* (2010) explained that the larvae of many lycaenid butterflies secrete ant-appeasement substances or attractants, as well as sugary food solutions, from epidermal glands. These enable them to live within the protection of ant nests. Weaver ants also derive food from a range of other insect species that excrete solutions rich in sugars, amino acids and other nutrients.

Allan and Elgar (2001) observed the relationships of red ants with the predatory spider, *Cosmophasis bitaeniata*, which is both a visual and a chemical mimic of the ant and is considered as the myrmecophilic associate of red ant. This salticid spider feeds on the ant larvae and appears to be quite comfortable inside ant nests, although it tends to avoid direct contact with major workers. Allan *et al.* (2002) indicated that the qualitative chemical mimicry of ants by *C. bitaeniata* allows the spiders to avoid detection by major workers of *O. smaragdina.*

2.3. COMPETITION WITH OTHER ANTS

As predatory effectiveness is influenced by the presence of other dominant ant species, understanding the ecological factors at work in agro ecosystems lies at the basis of conservation of biological control. The effect of ground vegetation management on the beneficial tree-nesting ant *Oecophylla longinoda* (Latreille) and its competitor, the ground-nesting ant, *Pheidole megacephala* (Fabricius), was studied in a citrus orchard in Tanzania. When ground vegetation was present, *P. megacephala* tolerated *O. longinoda* and to some extent cohabited with this ant in citrus trees. After clean cultivation, *P. megacephala* displaced *O. longinoda* from tree crowns and became the sole occupant of the majority of trees. Displacement could be reversed by reversing the weed management regime, but this took time. Two years after the establishment of ground vegetation about half of the trees were colonized by *Oecophylla* only. Maintaining ground vegetation in tree crop plantations benefits the establishment and abundance of *Oecophylla* over *Pheidole* and is recommended in order to improve the efficiency of biological control of tree pests (Seguni *et al.,* 2011).

2.4. UTILIZATION OF RED ANTS IN MANAGING PESTS OF DIFFERENT CROPS

2.4.1. Pest management in cashew

A search for alternatives to the chemical control has led to increased appreciation of the role of weaver ants, *O. smaragdina* in managing populations of several pests in a number of crops like cashew, mango *etc.*, (Mele, 2008). Peng *et al.* (2001) reported success with *Oecophylla* in cashew, controlling all major pests and significantly increasing profits and nut quality. *Oecophylla* play a crucial role in protecting tree crops against pests and enhancing the quality of fruits and nuts in Tanzania (Seguni *et al.,* 2011). In Australia, *O. smaragdina* have been successfully used to control the main insect pests of cashew plantations and red ant technology is reported to be viable even on commercial scale in cashew pest management (Peng *et al.,* 2004).

Oecophylla has been recognized as a predator of tea mosquito bug (Sundararaju, 2004). Jeevarathnam and Rajapakse (1981) reported that presence of *O. smaragdina* has reduced the incidence of tea mosquito bug in cashew. Sundararaju (2004) observed that red ant haboured cashew plants recorded 10-50 percent tea mosquito damage while trees without red ants suffered more than 50 percent damage. Sreekumar *et al.* (2011) reported that grafted cashew plants harboured with red ants yielded four times higher than unharboured plants. Study by Peng *et al.* (1997) showed that at the time when *Helopeltis pernicialis* caused serious damage to a tree without *O. smaragdina* nests, a tree with a constant ant population was only slightly damaged. It is suggested that *O. smaragdina* has high potential as a biological control agent. Peng *et al.* (2005) noted that *O. smaragdina* was the most important factor regulating fruit spotting bug, *Amblypetta lutescens* in cashew plantations in Australia.

Olotu *et al.* (2013) studied the effect of the application of three powdery mildew fungicides, namely triadimenol, triadimefon and sulphur on the African weaver ant, *Oecophylla longinoda* and found that they did not have detrimental effects on the abundance of African weaver ant in cashew fields and can, therefore, be used together with the weaver ants as important components of an integrated pest and disease management program for cashew crop in Tanzania.

Renkang *et al.* (2014) reported that in Vietnam the damage caused by mosquito bugs, brown shoot borers, blue shoot borers, and fruit- nut borers was significantly lower on trees with weaver ants compared with trees without the ants, showing that the ants were able to keep these pest damages under the control threshold. Regular monitoring of the field experiment showed that weaver ants were similar to insecticides for controlling mosquito bugs, blue shoot borers, fruit- nut borers, leaf rollers, and leaf miners. Aphids did not become major pests in plot with weaver ants. The study recommended an integrated pest management using weaver ants as a major component in cashew orchards.

Cashew and mango plots with abundant weaver ants had similar or higher canopy arthropod and natural enemy diversity and similar ratios of natural enemies to insect pests, compared with plot where the weaver ant was absent. The application of insecticides reduced arthropod diversity and the ratio of natural enemies to insect pests in orchards. However, insecticide spray did not affect natural enemy diversity and abundance, which may be related to a high immigration rate of natural enemies in small plots surrounded by areas that were not sprayed (Peng and Christian, 2013)

Mele *et al.* (2009) conducted a study on local ecological knowledge on the weaver ant *Oecophylla longinoda* in relation to three 'invisible' intruders in orchards in Guinea, West Africa. The intruders were thieves, bats and fruit flies. They interviewed 100 cashew and mango growers. More than half of the growers reported that ants protect their orchard from thieves. Apart from deterring snakes, about 46 percent of the growers mentioned that weaver ants reduce damage by fruit-eating bats; some reported that bats do dislike the smell of weaver ants. Whereas, the relationship between ants and humans or conspicuous fruit bats is well understood, a quantitative appreciation of the effect of *Oecophylla* on small insect pests, such as fruit flies, is more complex. Despite the fact that 57 percent of the growers reported that *Oecophylla* had a positive effect on mango fruit quality, many classified *Oecophylla* as a pest due to its nuisance during harvest.

Peng *et al.* (1999) studied the effect of colony isolation of the predacious ant, *Oecophylla smaragdina,* on protection of cashew plantations from insect pests. Colonies were transplanted from native vegetation to a cashew orchard. Trees with ant colonies which were fully isolated from other colonies were significantly less damaged by the main insect pests and produced significantly higher yield than those with ant colonies which were partly isolated or were not isolated. That was because fighting events between fully isolated ant colonies were eliminated, and the populations of these colonies were high throughout the cashew flowering and fruiting period. Trees in which *O. smaragdina* colonies were transplanted suffered little damage by the main insect pests and produced high quality nuts and panicles. However, trees which were protected by pesticides produced lower quality nuts and panicles, because these trees suffered damage by the tea mosquito bug, *Helopeltis pernicialis*, and the mango tip borer, *Penicillaria jocosatrix*. It is suggested that *O. smaragdina* colony isolation, combined with ant transplantation, is an effective means both to achieve high ant populations in cashew plantations and to obtain a high yield.

Peng *et al.* (1997) conducted a study on the distribution of the green ant, *Oecophylla smaragdina,* in relation to native vegetation and the insect pests in cashew plantations. *O. smaragdina* was an efficient predator and the most abundant ant species in cashew plantations. Infestations of the main insect pests in the trees lacking ant nests were significantly higher than in those with ant nests. Although *O. smaragdina* were abundant on a wider range of native tree species, they preferred *Acacia aulacocarpa* and *Planchonia careya*, and they also thrived on cashew trees after dispersing into cashew plantations. In cashew plantations, *O. smaragdina* preferentially colonized trees with thick canopies irrespective of tree height. Fierce fights between *O. smaragdina* colonies were a major factor responsible for changes in population sizes, colonization and distribution of *O. smaragdina* in cashew plantations. The availability of preferred native trees and the distance between the native vegetation and the cashew plantation appear to play important roles in both the rate and the pattern of initial colonization of cashew plantations by *O. smaragdina*. These factors also indirectly influence the distribution and abundance of the insect pests of cashews. This study recommended the use of native trees to enhance *O. smaragdina* populations in controlling cashew insect pests.

2.4.2. Utilization of red ants in managing pests of coconut

Before World War II, British scientists working in the Solomon Islands reported: "Planters, managers and investigators alike have noticed that where *Oecophylla* is present, the trees almost invariably bear well" (Phillips, 1940). This observation was taken seriously by the young scientist, Michael Way, working in Zanzibar, who found that the 'coconut gumming disease' was actually caused by bugs sucking the nuts. Because the coreid bug *Pseudotheraptus* is a low-density pest (10 bugs per hectare can cause significant damage) this had never been observed before, nor had this 'disease' ever been successfully controlled. Way demonstrated experimentally that coreid bugs could be controlled by weaver ants (Way, 1953). Mele (2008) indicated the significant role and potential of *Oecophylla longinoda* as a predator in multiple tree crops like coconuts, cocoa, citrus, cashew and mango. Establishment of *O. longinoda* within a period of approximately one year resulted in increased nut retention and improved nut quality. Interplanting coconuts with trees such as citrus, mango and guava which are the host trees of *O. longinoda* provided the best nesting sites for the beneficial weaver ants (Mwaiko *et al.*, 1997).

The major pests of coconut which can be controlled by using red ants include coconut bugs- *Pseudotheraptus wayi* (Way, 1953; Vanderplank, 1960), *P. devastans* (Julia, 1978), *Amblypelta cocophaga* (Phillips, 1940; Brown, 1959), coconut spathe bug- *Axiagastus cambelli* (Lever, 1933), leaf beetle- *Brontispa longissima* (Stapley, 1973), coconut leaf miner- *Promecotheca* spp. (Murray, 1937).

The geographical distribution of *Amblypelta* spp. is examined against that of *O. smaragdina*. For some tropical tree crops, it is possible to produce "insecticide free products" by using *O. smaragdina* colonies to manage the main insect pests including *Amblypelta* spp. (Peng *et al.*, 2002)

2.4.3. Utilization of red ants in managing pests of mango

Most insect pests of mango can be successfully controlled by weaver ants (Peng and Christian, 2005b; Peng *et al.*, 2005) and is one of the best hosts for this ant (Peng *et al.*, 1997) which occur abundantly in unsprayed mango orchards. Use of weaver ants together with soft chemicals was more beneficial than the use of chemical insecticides (Peng and Christian, 2005a). Sreekumar *et al.* (2006) reported that mango trees with red ant nests on it flowered and yielded profusely with very little attack of mango hoppers. Even when the benefits of red ants to the quality of mango fruit are acknowledged, the ants are still often regarded as a nuisance pest during harvesting (Sinzogan *et al.,* 2008). Peng and Christian (2005b) discussed an IPM model using weaver ants as a key element with respect to organic production. Cesard (2004) observed that the use of weaver ants as a biological control agent in coffee plantations in Sri Lanka has reportedly been abandoned for this reason. Peng and Christian (2007) confirmed that in mango, weaver ants controlled major pests such as mango hoppers, thrips, seed weevils, fruit flies and tip borers.

The results from the study conducted by Materu *et al.* (2014) concluded that African weaver ant were able to control mango seed weevil and should be considered as a suitable component of Integrated Pest Management for mango seed weevil in mango growing areas in Tanzania. It is indicated that weaver ants are efficient biocontrol agents of the mango leafhopper, and that it is important to maintain the ants at high levels for successful control of the leafhopper (Peng and Christian, 2005a).

Peng and Christian (2004) suggested that the weaver ant is an effective biological control agent of the red-banded thrips. Leaf examinations revealed that newly mature leaves on trees with abundant weaver ants had significantly fewer thrips than on trees with fewer or no ants. Field experiments showed that weaver ants were as effective as chemical insecticides in limiting fruit damage by thrips. In laboratory trials, seedlings without weaver ants were heavily damaged, and lost all their leaves within six weeks, while seedlings with weaver ants grew well and lost no leaves.

Adandonon *et al.* (2009) investigated the effect of *Oecophylla* pheromones on fruit fly oviposition behaviour. It is observed that the density of ant pheromone sources significantly affected the oviposition time and the number of fruit fly pupae collected per kg fruit under green house conditions. However, field data did not show any difference in damage for fruit collected within 1-3 m distance from ant nests, suggesting that physical or visual mechanisms complement the repellency effect of ant pheromones against fruit flies. Peng and Christian (2013) suggested that weaver ant marks are positively correlated with internal fruit quality, do not induce fruit rot and can be used as an indicator of better fruit quality and safety.

The main insect pests in mango orchards in the Northern Territory of Australia are the leafhopper, *Idioscopus nitidulus* (Walker) (Hemiptera: Cicadellidae), the red-banded thrips, *Selenothrips rubrocinctus* (Giard) (Thysanoptera: Thripidae), the mango tip borer, *Penicillaria jocosatrix* (Guenee) (Lepidoptera: Noctuidae), the fruit spotting bug, *Amblypelta lutescens lutescens* (Distant) (Hemiptera: Coreidae), the seed weevil, *Sternochetus mangiferae* (Fab) (Coleoptera: Curculionidae), the fruit fly, *Bactrocera jarvisi* (Tryon) (Diptera: Tephritidae), various leaf rollers and flower caterpillars and the giant termite, *Mastotermes darwiniensis* (Froggatt) (Isoptera: Mastotermitidae) (Chin *et al.*, 2002; Pena *et al.*, 2002; Peng and Christian 2002, 2003). Peng and Christian (2002; 2003; 2004) found that except the giant termite, these pests can be successfully controlled by weaver ants, *Oecophylla smaragdina*. However, weaver ants protect soft scales, damage fruits with deposits of formic acid and annoy harvest (Peng and Christian 2002, 2003). Further research addressing these constraints showed that certain chemicals can reduce soft scale numbers without seriously affecting weaver ant populations, the isolation of ant colonies reduces fruit damage by formic acid, and water spray reduces the ant activity during harvest (Peng and Christian, 2005b).

Peng and Christian (2008) proposed that the weaver ant is an efficient bio-control agent of the dimpling bug, *Campylomma austrina* Malipatil (Hemiptera: Miridae), and to limit the bug damage, high levels of weaver ant populations are required. In mango orchards marble-sized fruit damage levels on trees bearing abundant weaver ants, *Oecophylla smaragdina*, were similar to those protected by chemical insecticides, however both suffered less damage than trees bearing fewer or no weaver ants or black ants, *Iridomyrmex* spp.

Peng and Christian (2006) conducted field experiments in orchards in northern Australia to study the potential of weaver ants in controlling Jarvis's fruit fly and the data showed that the treatment with weaver ants plus soft chemicals produced lower levels of rejected fruits (0 – 0.4 percent) than the treatment with chemical insecticides (0.9 – 4.7 percent). In organic or insecticide-free orchards, fruits were much less damaged on trees with weaver ants (1 percent) than on trees without the ants (1.5 – 5.1 percent). Fewer fruit fly puparia were produced from fruits collected in the weaver ant treatment (0 – 0.6 puparia / fruit) than from fruits collected in the insecticide treatment (1.2 – 3.7 puparia / fruit). Green mature fruits produced fewer fruit fly puparia (1.2 puparia / fruit) than ripe fruits (3.7 puparia / fruit). More fruit fly adults were observed in the insecticide treatment (0.8 adult / tree) than in the weaver ant treatment (0.2 adult / tree). This work indicated that weaver ants are efficient biocontrol agents of Jarvis's fruit fly.

Sinzogan *et al.* (2008) studied implications of on-farm research for local knowledge related to fruit flies and the weaver ant *Oecophylla longinoda* in mango production. Over 80 percent of the farmers involved in on-farm research reported *Oecophylla* to be beneficial. All fruit-pickers knew that ants protected mango from fruit flies, with 60 percent attributing better mango quality in terms of appearance, shelf-life and sweetness to the presence of *Oecophylla.* Nevertheless, 40 percent of the pickers still considered weaver ants a nuisance pest during harvest.

2.4.4. Utilization of red ants in managing pests of cocoa

With a focus on export-oriented plantation crops and its success in coconut plantations, research on *Oecophylla* was initiated in cocoa plantations (Majer, 1976). Way and Khoo (1991) highlighted that *Oecophylla smaragdina* have long been recognized as valuable or potentially valuble biological control agent especially against pest Heteroptera. They also protect cocoa from *Helopeltis theobromae* in Penisular Malaysia (Way and Khoo, 1989). Leston (1973) found the effect of this biological control agent against *Distantiella theobroma. Pantorhytes* spp. and *Amblypelta theobromae* (Room and Smith, 1975) also can be managed by using *Oecophylla.*

Ayenor (2007) did a study on facilitating the use of alternative capsid control methods towards sustainable production of organic cocoa in Ghana. To control capsids, formal research recommends application of synthetic insecticides. Three alternative control methods were tested: mass trapping using sex pheromones; applying crude aqueous neem *Azadirachta indica* (Meliaceae) seed extract (ANSE) and using the predatory ant *Oecophylla longinoda* (Hymenoptera: Formicidae) as a biological control agent. ANSE was effective against capsids and other cocoa insect pests and did not affect the predatory ant. When *O. longinoda* occurred in high numbers, capsid incidence was low. Shade did not influence ant or capsid abundance significantly. The sex pheromone was as effective as ANSE or ants in suppressing capsids. All the three methods were effective and compatible; hence, they can be used in an integrated pest management strategy for cocoa, including organic production in Ghana.

2.4.5. Utilization of red ants in managing pests of citrus

Citrus farmers in the Mekong Delta, Vietnam have a long tradition of managing the weaver ant, *Oecophylla smaragdina* (Barzman *et al.,* 1996; Mele, 2000). Preliminary experiments in the Mekong Delta indicated that some of the main citrus pests such as the stink bug *Rhynchocoris humeralis* (Hemiptera: Pentatomidae), the aphids *Toxoptera aurantii* and *T. citricidus* (Hemiptera: Aphididae), the leaf miner *Phyllocnistis citrella* (Gracillaridae: Lepidoptera) and several other lepidopteran species could be controlled by *O. smaragdina* (Mele *et al.,* 2002). Mele and Cuc (2000) found that external shining and fruit juiciness in citrus were improved when ants were present and the weaver ant was traditionally used by citrus farmers in the Mekong Delta, mainly for improvement of fruit quality. The studies conducted by Ativor *et al.* (2012) on the effectiveness of *Oecophylla longinoda* as a biocontrol agent of fruit flies was compared with insecticide, Cypermethrin + Dimethoate at Forest and Horticultural Crops Research Centre, Kade, in the Eastern Region of Ghana and suggested that *Oecophylla* can be used as a biocontrol agent for IPM programs in citrus orchards.

Barzman *et al.* (1996) suggested that ant wastes are nutrients for the plant, altering the physiology of individual developing fruit. In China, yield of oranges under biological control with red ant was as good as under chemical control (Huang and Yang, 1987). Mele and Cuc (2000) observed that the mean expenditure for insecticides and fungicides was about 50 percent lower when *O. smaragdina* was abundant.

Mele and Cuc (2000) reported that expenditure on pesticides was reduced by half when *O. smaragdina* was abundant, without affecting either the yield or the farmer's income and they suggested that *O. smaragdina* husbandry is a good example of a traditional practice which should be further promoted as an important component of sustainable citrus production.

From the review of literature it is clear that some basic information about red ants such as effect of food provision, effect of competition with other ants *etc.*, is not generated till now. Information on pest management using red ants in perennial crops is available, but on seasonal crops like vegetable cowpea is available only as ITK of the farmers which was not scientifically validated. Hence this study is relevant.

MATERIAL AND METHODS

MATERIAL AND METHODS

Red ant is most promising as a self perpetuating and effective biological control agent. The present study on red ant, entitled "Management of pests of cowpea using red ant, *Oecophylla smaragdina* (Fab.)" was undertaken to study the seasonal variation in the activity and population build of red ant, to develop suitable techniques for elimination of competitor ants, to study the effectiveness of *O. smaragdina* in managing the pests of cowpea and to study the effect of selected pesticides on *O. smaragdina*. The studies were carried out in the fields of College of Agriculture Padannakkad, Kasaragod during 2013-15.

The whole study has two major parts *i.e.*,ecology of red ant and augmentative biological control. Under ecological studies, seasonal variation in population of red ants and effect of biotic factors were included. Observations on live nest counting and ant activity measurement were included under the studies on seasonal variation. The effect of biotic factors on the population of red ant was studied by observing the interaction between red ant and competitor ants and effect of food provisioning. Augmentative biological control include the studies on the eradication of competitive ants for establishment of red ant colonies, pest management efficacy study and the impact of selected pesticides on the efficiency of red ant.The material and methods used in the study are described in this chapter.

3.1 EXPERIMENT 1

3.1.1. Seasonal variation in population of red ant

Variations in the population of red ant in different seasons were studied by counting the live nests constructed and measuring the ant activity.

3.1.1.1. Live nest counting

The number of live nests present on ten host plants were counted throughout the year at 15 days interval.The host plants include 3 mango trees and 7 cinnamon trees. The observations were taken from 15th March 2014 to 30th March 2015.

3.1.1.2. Ant activity measurement

Ant activity measurement was done on two mango trees and three cinnamon trees. To measure the ant activity, the number of ant movements over 15 cm length of the chest height of the host plant in 120 seconds time period was counted. Ant activity was measured at different temperature and rain fall regimes during rainy (June- July), winter (December) and summer (March- April) seasons for a period of 30 days in each. The measurement was done daily at 7 am, 11 am, 3 pm and 6 pm. Temperature and relative humidity in the microclimate were also recorded by using thermo and hygrometer.

3.1.2. Biotic factors

The biotic factors such as interaction with other ants and effect of food provisioning which influence the population of red ant were also studied in this experiment.

3.1.2.1. Interaction between red ant and other ants

Interaction between *O. smaragdina* and other ant species was studied by observing colonization by red ant on plants dominated by other ant species. Two red ant nests were placed on such plants and the interaction between ants were noticed. The experiment was done on 10 selected cashew trees and 6 cowpea trellises. The study was conducted in cashew trees which were dominated by the two black ant species namely *Tetraponera nigra* Jerdon and *Paratrechina longicornis* (Latreille) and in cowpea trellises which were dominated by yellow crazy ant, *Anoplolepis gracilipes*. Ant species collected from cashew trees were identified by Dr. Karmaly, Professor, Department of Zoology, St. Xavier's college for women, Aluva. The behaviour (aggressive / submissive) of the red ant towards other ants and colony establishment by red ant on the host plants were noted.

Red ant nests were collected from different trees like sapota, nut meg *etc.* Small branches on which the nests were built were cut carefully and collected directly in to plastic covers and tied properly. These nests were taken to the host trees and carefully tied on the host plant branches. Up on opening the cover, if the red ant is found to be very aggressive and attacking, the opened plastic covers were kept as such on the tree safely. The red ant will move from the plastic cover to the host tree branches and start constructing new nest when the old nest in the plastic cover is getting wilted and dried.

3.1.2.2. Effect of food provisioning

The study on food provision was done in 6 selected cashew trees. The experiment was conducted in November- December months. The number of live nests constructed on 3 trees which were provided with artificial food such as fish offal or chicken shank (lower part of leg

Plate 5. Anoplolepis gracilipes

Plate 6. Tetraponera nigra

Plate 7. *Paratrechina longicornis*

Plate 8. Cowpea raised on single trellis

Plate 9. Cowpea trellises in the field

During food provision

After few hours

After few days

After few weeks

Plate 10. Stages of food provision on cashew

without meat and with spur, claw and skin) was counted and compared with that of 3 trees which were not provided with food over a period of two months.

3.2 EXPERIMENT 2

3.2.1. Study on the eradication of competitive ants for establishment of red ant colonies

Experiments were done in cashew and cowpea plants which were laid out in completely randomized design. Different species of competitive ants were eradicated by spraying various chemicals and the red ant colonies were harboured after a waiting period of three days. The red ant nests were collected from different trees like sapota, nut meg, mango *etc.*, Establishment of the red ant and the number of nests made within a period of 7 days was recorded and the ant activity was measured.

3.2.1.1. Eradication of competitive ants on cashew trees

The experiment was conducted on cashew trees in which the two black ant species namely *Tetraponera nigra* Jerdon and *Paratrechina longicornis* were present. The effective dose of azadirachtin for eradication of competitive ants was fixed by spraying different concentrations of azadirachtin on cashew trees *viz.*, 0.00225 %, 0.01 %, 0.05 %, and 0.1 %. It was found that spraying of 0.1 % concentration is required for the effective eradication of competitive ants. Hence the experiment was conducted by spraying 0.1 % azadirachtin and 0.5 % soap solution at different plant parts (entire crop, plant base and soil). A waiting period of 3 days was given post treatment to introduce ant nests. The experiment was done with 5 treatments and 4 replications.

Treatments were as follows:

T_1: Eradication of competitive ant species by spraying Azadirachtin 0.1 % on the entire crop

T_2: Eradication of the competitive ant species by spraying Azadirachtin 0.1 % at the plant base and soil

T_3: Eradication of competitive ant species by spraying soap solution 0.5 % on the entire crop

T_4: Eradication of the competitive ant species by spraying soap solution 0.5 % at the plant base and soil

T_5: Absolute control

Plate 11. Spraying at the base of the tree

Plate 12. Spraying on the entire tree

Plate 13. Steps in red ant nest collection

3.2.1.2. Eradication of competitive ants on cowpea plants

The study on the eradication of yellow crazy ant *Anoplolepis gracilipes* was done on cowpea plants with 5 treatments and 4 replications. The experiment was a failure when the treatments were applied before clearing the dried leaves and other debris from the plant base which act as a living and breeding place for *Anoplolepis*. So the whole experiment was repeated after clearing the plant base. The treatments were given either by spraying on entire cowpea plant or by spraying on plant base. A waiting period of 1 day post treatment was given to introduce red ant nests.

Treatments were as follows:

T_1: Spraying of Malathion 50 EC @ 0.1 % on the entire crop

T_2: Spraying of DDVP 76 EC @ 0.076 % on the entire crop

T_3: Spraying of DDVP 76 EC @ 0.076 % at the plant base

T_4: Spraying of Azadirachtin 0.03 EC @ 0.0003 % on the entire crop

T_5: Absolute control

3.2.2. Pest management efficacy studies

Experiment was laid out in randomized block design with 3 treatments and 7 replications. One replication contains one trellis and one trellis contains 3 plants. The cowpea variety Lola was raised in the month of October 2013 and trailed on trellises separately and red ant was harboured on the plant at young stage itself. The observations noted were the number of damaged plant parts due to attack by major pests which include aphid (*Aphis craccivora*) and leaf folder (*Nacoleia vulgaris*), number of adults and larval / nymphal stages of major pests and the Yield. The yield parameters taken were the pod length, pod number and fresh weight of the pods.

Treatments were as follows

T_1: Crop harbouring red ant

T_2. Pest management as per Package of Practices Recommendations

T_3: Untreated control

3.3 EXPERIMENT 3

3.3.1 Impact of selected pesticides on red ant

Experiment was laid out in randomized block design with 5 treatments and 4 replications. One replication contains one trellis and one trellis contains 3 plants. The cowpea variety Lola was raised in December 2014 and trailed over trellises and red ant colonies were established on it. Then the following treatments were applied on the crop. The experiment was done in the flowering stage of the crop.

T_1: DDVP 76 EC 0.076 %

T_2: Bordeaux mixture 1 %

T_3: Tobacco decoction 2.5 %

T_4: Azadirachtin0.03 EC 0.0003 %

T_5: Control

Impact was assessed by observing the ant activity and number of live nests made on the trellises. Establishment of the ant was noted by observing the number of live nests and ant activity.

The data collected on different experiments were tabulated and the treatments were compared using ANOVA.

Pods from different treatments

Plate 14. T_1: Red ant

Plate 15. T_2: POP

Plate 16. T_3 : Control

Plate 17. Field- impact of selected pesticides

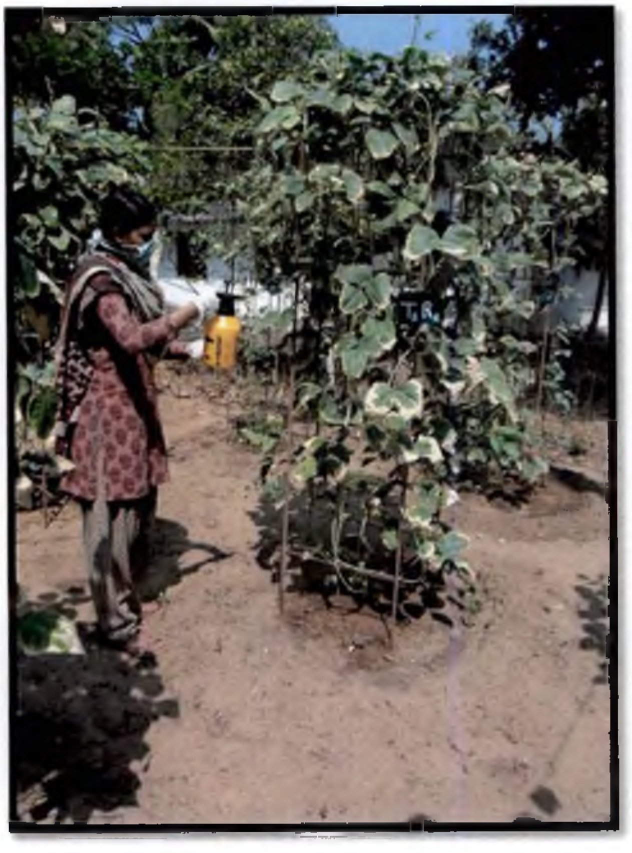


Plate 18. Spraying of pesticides

RESULTS

RESULTS

Results of the different studies on red ant are presented in this chapter. The data on various observations made in each experiment were statistically analyzed and presented.

4.1. SEASONAL VARIATION IN POPULATION OF RED ANTS

4.1.1. Live nest counting

The number of live nests constructed on ten host plants were counted throughout the year at 15 days interval and the monthly average is presented in Table 1. The table shows that there is a general tendency of decrease in the number of nests during monsoon period. At the beginning the average numbers of live nests were 9.3 per host plant which increased to 9.65 in April which then decreased to 6.7 in May 2014. Thereafter, a decreasing tendency was observed till September 2014. Then onwards increasing trend was seen till January 2015 followed by a decreasing trend.

Table.1 Mean number of live nests constructed on 10 host trees in every month from March 2014 to March 2015

Month	Range of no. of live nests per host plant	Mean no. of live nests per host plant	SD	CV
March 2014	2-26	9.30	7.17	77.09
April 2014	1-25	9.65	7.08	73.36
May 2014	0-21	6.70	6.03	90
June 2014	0-18	5.65	5.84	103.36
July 2014	0-14	4.00	5.11	127.75
August 2014	0-13	2.95	4.88	165.42
September 2014	0-11	2.55	3.99	156.47
October 2014	0-15	3.25	5.03	154.76
November 2014	0-17	3.55	5.49	154.64
December 2014	0-21	4.65	6.58	141.50
January 2015	0-19	4.70	6.11	130.00
February 2015	0-15	3.20	5.10	159.37
March 2015	0-14	3.05	4.69	153.77

4.1.2. Ant activity measurement in different seasons

Ant activity was measured during rainy, winter and summer months for a period of 30 days in each season daily at 7 am, 11 am, 3 pm and 6 pm and the data is presented. The mean ant activity and temperature of 30 days in each season is shown in Table 2. Temperature was higher in summer which directly influences the ant activity and a positive correlation was found between the ant activity and temperature. During the whole summer period, the average temperature was 31.56 and the ant activity was 58.56 where a weak positive correlation coefficient of 0.193 was seen. In rainy season, the temperature was less and so the ant activity also was less. It was observed that during rainy season, red ant prefer to keep inside the nest. Here ant activity was reduced with the reduction in temperature which indicates a positive correlation. During rainy season the average temperature was only 2° C less than that of summer, but the ant activity was only 28.79. This severe reduction during rainy season is due to the rains. It was observed that the average ant activity during the winter season was 12.79 with a temperature average of 28.16. It can be concluded that in all the three seasons the relation between ant activity and temperature was positively correlated.

Ant activity was measured during rainy, winter and summer months for a period of 30 days in each season daily at 7 am, 11 am, 3 pm and 6 pm and the data is presented. The mean ant activity and relative humidity of 30 days in each season is shown in Table 3. RH was higher in rainy season and a negative correlation was found between the ant activity and RH. During the whole summer period, the average RH was 69.29 and the ant activity was 58.56 where negative correlation coefficient of -0.246 was observed. In rainy season, the RH was high and the ant activity was less. Here ant activity was reduced with the increase in RH which indicates a negative correlation. It was observed that the average ant activity during the winter season was 12.79 with RH average of 70.95. Here a positive correlation was obtained and the relation between ant activity and RH was negatively correlated in the other two seasons.

Table 2. Mean ant activity and temperature during the period of 30 days observed in three seasons

Sl. No	Summer season		Rainy season		Winter season	
	Activity	Temperature	Activity	Temperature	Activity	Temperature
1	66.35	30.63	3.20	28.96	12.10	27.07
2	54.4	31.55	2.80	28.62	11.00	26.83
3	76.00	32.38	2.15	29.27	13.95	28.19
4	56.35	31.77	4.60	28.38	14.65	27.77
5	64.55	31.45	3.20	28.55	12.80	28.07
6	61.05	31.62	6.80	28.75	17.10	28.13
7	63.95	31.36	2.85	28.34	15.15	29.12
8	62.65	31.97	1.65	29.06	12.00	29.49
9	57.45	31.33	6.35	29.19	13.25	29.37
10	52.25	31.96	7.20	29.17	14.95	29.85
11	54.55	30.90	5.40	30.46	12.70	27.78
12	57.55	30.56	5.10	28.39	13.60	25.64
13	60.25	30.66	5.15	28.71	12.05	26.87
14	55.05	30.87	3.10	28.33	12.60	26.24
15	59.85	31.12	6.40	28.65	14.20	27.77
16	55.50	30.34	2.90	28.68	11.95	27.82
17	53.60	31.40	5.35	28.45	14.40	28.63
18	61.10	31.35	2.95	28.79	11.05	29.14
19	51.10	30.85	3.55	28.94	9.25	29.32
20	52.60	31.03	3.80	28.37	10.90	27.70
21	58.00	31.24	5.00	28.73	11.45	29.60
22	67.30	32.48	4.80	28.75	14.95	28.87
23	56.75	32.82	2.25	28.76	12.85	29.39
24	61.60	31.6	3.60	29.28	11.90	28.78
25	55.45	31.34	4.00	28.44	10.55	27.92
26	56.90	31.17	5.80	28.89	15.25	27.49
27	52.45	31.84	4.30	28.49	12.50	27.55

28	60.15	33.46	2.75	28.85	10.70	27.70
29	57.35	32.84	3.45	28.65	11.15	28.62
30	54.75	32.87	4.50	28.94	13.00	28.12
Mean	58.56	31.56	4.16	28.79	12.79	28.16
Correlation coefficient		0.193		0.140		0.018

Table 3. Mean ant activity and relative humidity during the period of 30 days in three seasons

Sl. No	Summer season		Rainy season		Winter season	
	Activity	Relative Humidity	Activity	Relative Humidity	Activity	Relative Humidity
1	66.35	70.15	3.20	83.50	12.10	73.85
2	54.40	66.70	2.80	80.90	11.00	71.05
3	76.00	67.30	2.15	81.85	13.95	74.50
4	56.35	68.05	4.60	81.80	14.65	69.25
5	64.55	71.85	3.20	80.25	12.80	65.50
6	61.05	69.55	6.80	81.90	17.10	65.85
7	63.95	70.90	2.85	81.70	15.15	70.50
8	62.65	67.75	1.65	81.00	12.00	74.00
9	57.45	69.30	6.35	80.80	13.25	74.25
10	52.25	70.20	7.20	82.45	14.95	78.00
11	54.55	69.70	5.40	72.35	12.70	78.25
12	57.55	71.25	5.10	82.20	13.60	72.25
13	60.25	69.00	5.15	80.75	12.05	72.50
14	55.05	71.00	3.10	84.50	12.60	72.50
15	59.85	68.70	6.40	82.70	14.20	73.25
16	55.50	72.05	2.90	81.25	11.95	73.75
17	53.60	72.60	5.35	83.25	14.40	69.75

18	61.10	72.40	2.95	83.50	11.05	71.25
19	51.10	71.80	3.55	81.85	9.25	65.00
20	52.60	70.40	3.80	81.60	10.90	72.75
21	58.00	69.35	5.00	82.05	11.45	67.50
22	67.30	66.95	4.80	81.50	14.95	74.00
23	56.75	66.25	2.25	84.35	12.85	68.50
24	61.60	67.30	3.60	80.30	11.90	66.75
25	55.45	71.60	4.00	80.95	10.55	68.75
26	56.90	71.20	5.80	83.25	15.25	67.00
27	52.45	68.90	4.30	81.05	12.50	68.00
28	60.15	62.00	2.75	82.60	10.70	67.00
29	57.35	66.50	3.45	81.25	11.15	68.75
30	54.75	68.25	4.50	83.45	13.00	74.50
Mean	58.56	69.29	4.16	81.69	12.79	70.95
Correlation coefficient	-0.242		-0.128		0.157	

Mean ant activity and temperature at 7 am, 11 am, 3 pm and 6 pm in all the seasons are presented in Table 4. The ant activity was found less during morning hours when the temperature was less. Comparatively high activity was found in all other times. The average ant activity at 7 am was 12.84 where as it was 33.65 at 11 am, 32.06 at 3 pm and 30.70 at 6 pm.

Table 4. Mean ant activity and temperature at 7 am, 11 am, 3 pm and 6 pm during 30 days period

Sl. no	**7 am**		**11 am**		**3 pm**		**6 pm**	
	Activity	Temperature	Activity	Temperature	Activity	Temperature	Activity	Temperature
1	12.10	25.10	40.20	31.10	27.50	30.20	37.40	29.20
2	11.40	25.70	25.00	31.00	25.70	30.50	37.50	28.80
3	12.90	25.50	46.70	31.60	34.30	33.00	36.70	29.80

4	11.70	24.70	26.80	30.60	32.10	31.90	37.90	30.00
5	11.50	24.90	40.30	31.50	33.70	31.60	29.50	29.50
6	12.90	25.50	41.50	29.80	36.70	32.10	29.90	30.60
7	12.60	25.90	37.10	31.00	33.40	31.00	34.40	30.50
8	12.40	26.80	33.30	31.70	36.70	31.80	29.10	30.40
9	12.50	25.90	39.30	30.80	32.80	32.30	28.10	30.90
10	14.10	27.10	29.50	31.10	33.50	32.50	32.30	30.60
11	12.80	26.50	33.60	30.90	29.70	31.70	30.60	29.70
12	14.00	26.10	29.70	29.60	34.00	29.90	33.00	27.20
13	12.50	26.60	32.90	29.90	36.10	29.30	30.60	29.20
14	13.40	25.50	28.10	31.10	30.10	29.80	30.80	27.50
15	12.00	25.50	40.10	31.50	33.80	30.80	30.50	28.90
16	13.80	26.40	26.40	31.40	34.90	30.50	27.90	27.50
17	14.20	25.90	31.50	31.70	30.30	31.40	30.20	29.00
18	12.80	26.30	31.10	31.10	33.80	32.20	31.20	29.48
19	12.90	25.60	26.00	31.50	26.20	32.20	29.80	29.50
20	12.00	25.00	29.30	31.30	31.20	29.50	25.30	30.30
21	14.80	27.00	31.40	31.40	35.80	31.30	26.90	29.80
22	12.90	25.80	39.90	31.20	41.50	32.20	31.00	30.90
23	13.40	27.50	33.10	31.10	30.20	31.40	28.70	31.20
24	12.60	26.70	31.90	31.30	34.40	30.80	32.30	30.80
25	13.30	25.70	33.90	31.20	27.00	30.50	27.00	29.50
26	12.90	25.40	37.10	30.40	32.90	30.90	28.60	30.00

27	11.80	25.30	31.90	30.80	26.90	31.10	27.90	30.00
28	11.30	26.50	34.90	31.30	30.70	31.60	29.70	30.50
29	13.70	26.70	34.40	31.20	26.50	31.70	29.10	30.50
30	14.20	26.90	32.90	31.70	29.90	31.00	27.10	30.40
Mean	12.84	26.00	33.65	31.06	32.06	31.22	30.70	29.73

4.1.3. Effect of biotic factors

4.1.3.1. Interaction between red ant and other ants

4.1.3.1.1. Interaction between red ant and black ants

Interaction between *O. smaragdina* and *Tetraponera nigra* and *Paratrechina longicornis* was studied by observing the number of nests built by red ant on 10 cashew trees dominated by the other two ant species for a period of one month and the data is presented in Table 5. The data showed that out of 10, on 5 trees red ants could not be established. But on 4 trees they could built one new nest each and on one tree 2 new nests were built. On first, third and sixth tree, there was no increase in nest construction during the period. But on fifth plant, the number of nest increased to 2, then to 3 and again to 2 during the period. The same trend was seen on ninth tree also.

There was no direct fight was noticed between black ants and red ant. The interaction between them was found as submissive and they coexist.

Table 5. Number of nests constructed by red ant on the trees dominated by black ants

Sl. NO	Tree 1	Tree 2	Tree 3	Tree 4	Tree 5	Tree 6	Tree 7	Tree 8	Tree 9	Tree 10
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	1	0	0	0	0	0

3	1	0	1	0	1	1	0	0	1	0
4	1	0	1	0	2	1	0	0	2	0
5	1	0	1	0	3	1	0	0	2	0
6	1	0	1	0	2	1	0	0	1	0
7	1	0	1	0	2	1	0	0	1	0
8	1	0	1	0	2	1	0	0	1	0
Mean	0.75	0	0.75	0	1.62	0.75	0	0	1	0

4.1.3.1.2. Interaction between red ant and yellow crazy ant

Interaction between red ant and yellow crazy ant, *Anoplolepis gracilipes* was studied by observing the number of nests build by red ants on six cowpea trellises dominated by the yellow crazy ant. Here, the interaction between yellow crazy ants and red ant was found as aggressive and yellow crazy ant was dominant over red ant.

When a red ant colony was introduced on a cowpea trellis colonised by yellow crazy ant, fierce fighting between the individuals of the two species was observed. Severe mortality was inflicted on the side of red ants when compared to yellow crazy ants. No red ant nest could be established on trellises harbored by yellow crazy ant and repeated introduction yielded the same result. Within 3 to 4 hours all the individuals of intruder were completely decimated.

4.1.3.2. Effect of food provisioning

The data on food provision done in six selected cashew trees are presented in Table 6. Students t test for unequal variance was conducted and the t stat value, 4.486 was greater than t critical value, so the null hypothesis was rejected and there was significant difference between the values. On an average, the number of nests on the cashew trees provisioned with food increased 10 times where as it was only 1.35 times when food was not provided over a period of 33 days which is significant.

Table 6. Number of nests constructed by red ant on cashew trees with / without food provision

Day	No. of nests constructed							
	Trees with food provision			Mean	Trees without food provision			Mean
	Tree 1	Tree 2	Tree 3		Tree 1	Tree 2	Tree 3	
1st day	1	1	1	1	2	2	2	2
4th day	2	3	2	2.3	2	2	2	2
7th day	2	4	2	2.7	2	2	2	2
10th day	5	6	4	5	2	2	2	2
13th day	8	9	7	8	2	2	2	2
16th day	9	10	11	10	3	2	2	2.3
19th day	11	11	13	11.7	3	2	3	2.7
22nd day	12	11	13	12	3	2	3	2.7
25th day	12	11	13	12	3	2	3	2.7
28th day	11	11	13	11.7	3	2	3	2.7
31st day	11	9	11	10.3	3	2	3	2.7
33rd day	11	9	11	10.3	3	2	3	2.7
Fold increased on 33rd day	11	9	11	10.3	1.5	1	1.5	1.35

4.2.1. Study on the eradication of competitive ants for establishment of red ant colonies

The experiment was undertaken with the objective of developing suitable techniques for the elimination of competitor ants. Experiments were done in cashew and cowpea plants which were laid out in completely randomized design.

4.2.1.1. Eradication of competitive ants on cashew trees

The experiment was conducted on cashew trees in which the two black ant species namely *Tetraponera nigra* Jerdon and *Paratrechina longicornis* were present. The data on the red ant activity within first seven days of treatment are presented in Table 7. The highest activity of red ants for the first day was obtained in the first treatment which was 0.1 %

Azadirachtin sprayed on the entire tree, followed by the treatment 2 which was 0.1 % Azadirachtin sprayed at the base of the tree. The lowest activity of 4.25 was recorded in T_5 which was the untreated control followed by the treatments done with 0.5 % soap solution. The similar trend was shown in other days also. On the first day T_1 was significantly higher from T_5 and was on par with all other treatments. On the second day and third day T_1 was significantly higher from T_3, T_4 and T_5 and was on par with T_2. Then from forth day till last T_1 was significantly higher than other treatments.

The data on the number of nests made within first seven days are presented in Table 8. The trend which was seen in the case of ant activity hold true for the nest building too. The highest value of one nest was observed in T_1 (Azadirachtin 0.1 % on the entire plant), followed by T_2 (Azadirachtin 0.1 % on plant base only) on the first day of observation *i.e.* on the next day of the release of red ant nests on the cashew trees. In control, the experimental value was zero for all the seven days which indicate that no red ant nest were present on such trees for all the seven days. T_1 and T_2 were significantly higher than all other treatments for most of the days.

Table 7: Activity of red ant on the cashew trees post insecticides treatment to ward off competitive ants.

Treatments	#Mean activity of red ant							Mean
	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day	
T1:Azadirachtin (0.1 %) on entire plant	19.50	21.00	26.00	23.75	22.50	23.00	19.25	22.14
T2:Azadirachtin (0.1 %) at plant base only	14.50	12.75	15.00	11.25	11.00	8.0	9.00	11.64
T3:Soap solution (0.5 %) on entire plant	10.50	9.00	5.75	7.25	1.75	3.25	2.25	5.67
T4:Soap solution (0.5 %) at plant base only	11.25	8.75	10.50	6.25	2.25	4.50	3.75	6.75
T5: Control	4.25	0.25	0.0	0.0	0.0	0.0	0.0	0.64
SE(+/-)	2.262	2.210	2.591	2.580	2.046	2.397	2.269	
CD(0.05)	4.823	4.711	5.523	5.499	4.361	5.110	4.838	

Mean of 4 observations

Table 8: Mean number of nests made by red ant on the cashew trees post insecticide treatment to ward off competitive ants

Treatments	# Mean number of nests made by red ant							Mean
	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day	
T1:Azadirachtin (0.1 %) on entire plant	1.00	1.00	1.25	1.25	1.25	1.00	1.00	1.10

T2:Azadirachtin (0.1 %) at plant base only	0.75	1.00	1.00	0.75	0.50	0.50	0.50	0.71
T3:Soap solution (0.5 %) on entire plant	0.25	0.75	0.50	0.50	0.25	0.25	0.25	0.39
T4:Soap solution (0.5 %) at plant base only	0.50	0.50	0.50	0.50	0.25	0.25	0.25	0.39
T5:Control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SE(+/-)	0.144	0.120	0.151	0.170	0.164	0.144	0.144	
CD(0.05)	0.307	0.257	0.322	0.364	0.350	0.307	0.307	

Mean of 4 observations

Presence of the competitive ants *i.e.* black ants on the cashew trees are presented in Table 9 by considering all the replications in each treatment. On T_1, during the entire 7 days competitive ants were not present on the treated host tress. In T_2, competitive ants were observed on 4^{th} day onwards. In T_3 and T_4 on the first day 1 host tree had competitive ant and on second and third day 2 host trees had competitive ants. In control, competitive ants were present throughout the experimental period.

Table 9: Presence of competitive ants on the cashew trees

Treatments	Presence of competitive ants on four cashew trees						
	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day
T_1:Azadirachtin 0.1% on entire plant	0/4	0/4	0/4	0/4	0/4	0/4	0/4
T_2:Azadirachtin 0.1% at plant base only	0/4	0/4	0/4	1/4	2/4	2/4	2/4

T_3:Soap solution 0.5% on entire plant	1/4	2/4	2/4	2/4	3/4	3/4	3/4
T_4:Soap solution 0.5% at plant base only	1/4	2/4	2/4	3/4	3/4	3/4	3/4
T_5: Control	4/4	4/4	4/4	4/4	4/4	4/4	4/4

4.2.1.2. Eradication of competitive ants on cowpea

The data on the activity of red ants on the cowpea plants from which yellow crazy ant- *A. gracilipes* was eradicated are presented in Table 10. Among the five treatments, T_2 (DDVP 76 EC @ 0.076 % sprayed on entire crop) gave highest activity of 21.50 in the first day after introduction of red ant colonies. But in T_3 where DDVP was sprayed at the plant base, the activity was less. In T_4 (Azadirachtin 0.03 % EC on entire crop) ant activity was 16.0 followed by 13.75 in T_1 (Malathion 50 EC @ 0.1 % on entire crop), 13.0 in T_3 (DDVP .076 % EC at the plant base) and the least activity of 2.75 in T_5 on the first day. From the second day onwards, no ant activity was present in control. Ant activity in T_2 was found significantly high compared to control and on par with T_4 and T_3 on all the days.

Data on the number of nests made by the red ants on the cowpea plants in which competitive ants were eradicated is shown in Table 11. Here also the highest value was recorded in T_2 (DDVP .076 % EC on entire crop) for all the seven days which means that the red ants were able to maintain the nests on the cowpea plants for the period. The red ants could not establish any nest on control plants during the entire period.

Presence of the competitive ant *i.e. Anoplolepis gracilipes* on the host plants are presented in Table 12 by considering all the replications in each treatment. On T_1, *Anoplolepis* was absent on cowpea only on the first day. Where as in the case of T_2 during the entire 7 days *Anoplolepis* was absent. In T_3 and T_4 *Anoplolepis* was absent only on the first day. But recolonisation was slow as evidenced by low presence till 7^{th} day.

Table 10: Activity of red ant on cowpea plants post insecticide treatment to ward off competitive ants

Treatments	# Mean activity of red ant							Mean
	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day	
T_1:Malathion 50 EC @ 0.1 % on entire crop	13.75	10.75	8.50	4.50	2.25	4.50	3.75	6.85
T_2:DDVP 76 EC @ 0.076 % on entire crop	21.50	25.25	29.25	24.25	20.50	22.75	19.25	23.25
T_3:DDVP 76 EC @ 0.076 % at the plant base	13.00	12.25	14.00	12.50	11.75	9.25	9.25	11.71
T_4:Azadirachtin 0.03 EC @ 0.03 % on entire crop	16.00	16.50	16.50	15.50	12.75	13.25	9.25	14.25
T_5: Control	2.75	0.0	0.0	0.0	0.0	0.0	0.0	0.39
SE(+/-)	2.972	3.064	3.450	2.689	2.80	3.295	2.841	
CD(0.05)	6.336	6.532	7.354	5.731	5.982	7.024	6.056	

Mean of 4 observations

Table 11: Mean number of nests made by the red ant on cowpea plants post insecticide treatment to ward off competitive ants.

Treatment	# Mean number of live nest made by red ant							Mean
	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day	
T_1:Malathion 50 EC @ 0.1 % on entire crop	0.50	0.75	0.50	0.25	0.25	0.25	0.25	0.39
T_2:DDVP 76 EC @ 0.076 % on entire crop	1.00	1.25	1.50	1.50	1.25	1.25	1.25	1.28

T_3:DDVP 76 EC @ 0.076 % at the plant base	0.25	0.75	1.00	1.00	0.75	0.75	0.75	0.75
T_4:Azadirachtin 0.03 EC @ 0.0003 % on entire crop	0.25	0.75	0.75	0.75	0.50	0.50	0.50	0.57
T_5: Control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SE(+/-)	0.144	0.158	0.198	0.193	0.209	0.209	0.209	
CD(0.05)	0.307	0.337	0.424	0.412	0.445	0.445	0.445	

Mean of 4 observations

Table 12: Presence of *Anoplolepis* on cowpea plants

Treatments	Presence of *Anoplolepis* on cowpea plants						
	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day
T_1:Malathion 50 EC @ 0.1 % on entire crop	0/4	1/4	3/4	3/4	3/4	3/4	3/4
T_2:DDVP 76 EC @ 0.076 % on entire crop	0/4	0/4	0/4	0/4	0/4	0/4	0/4
T_3:DDVP 76 EC @ 0.076 % at the plant base	0/4	1/4	1/4	1/4	2/4	2/4	2/4
T_4:Azadirachtin 0.03 EC @ 0.0003 % on entire crop	0/4	1/4	1/4	1/4	2/4	2/4	2/4
T_5: Control	4/4	4/4	4/4	4/4	4/4	4/4	4/4

4.2.2. Pest management efficacy studies

This experiment was done with the objective of assessing the number of damaged plant parts due to attack by major pests, number of adult or larval / nymphal stages of major pests and the yield of cowpea in different treatments.

Acephate 0.15 % was sprayed on 10^{th} day of sowing to manage stem fly population and Malathion 0.1 % was sprayed on 51 days of sowing to manage aphid population. Leaf folder population was present in the initial stage of the crop for which no specific control measure was adopted.

4.2.2.1. Number of damaged plant parts due to attack by major pests

The analyzed data on the number of damaged plant parts *i.e.* pods and leaves, due to the attack of aphids is presented in table 13. Maximum number of pods were attacked in T_3 (Control) followed by T_1 (Red ants) and minimum in T_2 (POP). But the values were not significantly different. Number of damaged leaves were significantly high in control. T_1 and T_2 were on par. Less number of leaves were affected in T_2 in which is POP recommendations were followed. In both the parameters, plants under T_3 (control) were affected more followed by T_1 and T_2 respectively.

The data on the number of damaged plant parts due to attack by leaf folder is presented in Table 14. There is no significant difference found between the treatments in the case of damaged plant parts by leaf folder. Leaf folder infestation was found in the initial stage of cowpea (first month) against which no control measure was adopted. It was a natural infestation.

Table 13: Mean number of damaged cowpea plant parts due to attack by aphid (*Aphis craccivora*) under different treatments

Treatments	# Mean no. of damaged plant part					
	Pod	DMRT	SD	Leaf	DMRT	SD
T_1: Red ant	16.4	2	5.36	34.6	2	43.84
T_2: POP	15.4	3	13.50	16	3	21.69
T_3: Control	20	1	9.61	96.4	1	45.59
CD (0.05%)	14.802 (NS)			45.607		

Mean of 7 observations

Table 14: Mean no. of damaged cowpea plant parts due to attack by leaf folder (*Nacoleia vulgaris*) under different treatments

Treatment	# Mean no of damaged leaves	DMRT	SD	CD (0.05 %)
T_1: Red ant	24	2	29.45	31.935 (NS)
T_2: POP	28.8	1	18.61	
T_3: Control	1.8	3	4.02	

Mean of 7 observations

4.2.2.2. Number of major pests on plants

The data on the number of aphids on plants are shown in the Table 15. More number of aphids were found on T_3 (Control) and it was significantly higher than other two treatments. T_1 and T_2 were on par. Aphid population was found less in T_2 in which recommendations were followed based on Package of Practices compared to the other two treatments.

In Table 16, the number of Leaf folder larvae recorded on the cowpea plants were analysed and presented. There is no significant difference between these three treatments.

Table 15: Mean number of Aphids (*A. craccivora*) on cowpea under different treatments

Treatment	# Mean no. of aphids	DMRT	SD	CD (0.05 %)
T_1: Red ant	297.14	2	400.86	
T_2: POP	120.42	3	145.98	262.380
T_3: Control	559.85	1	533.21	

Mean of 7 observations

Table 16: Mean number of Leaf folder (*Nacoleia vulgaris*) under different treatments

Treatment	# Mean no. of leaf folders	DMRT	SD	CD (0.05 %)
T_1: Red ants	2.6	2	3.78	4.638 (NS)
T_2: POP	3.4	1	2.96	
T_3: Control	0.2	3	0.44	

Mean of 7 observations

4.2.2.2. Yield parameters of cowpea

The yield parameters noted were the pod length, pod number and fresh weight of the pods which are presented in table 17 after statistical analysis. There is no significant difference between the treatments in the case of pod number and pod length. More number of pods were harvested from T_2 (POP) followed by T_1 (red ant) and T_3 (control). An average pod length of 42.61cm was recorded in T_2 and 41.12 cm in T_1 where as in T_3 it was only 37.61 cm. Fresh weights of the pods were significantly low in control but T_1 and T_2 were on par.

Table 17: Yield parameters of cowpea under different treatments

Treatments	# Mean pod number	SD	# Mean pod length (cm)	SD	# Mean fresh weight (kg)	SD
T_1: Red ant	157.8	42.19	41.12	3.35	2.23	0.80
T_2: Pop	228.2	33.27	42.61	2.82	3.14	0.51
T_3: Control	157.8	70.45	37.61	3.90	1.49	0.62
CD (0.05 %)	79.889 (NS)		5.740 (NS)		0.996	

Mean of 7 observations

4.3. IMPACT OF SELECTED PESTICIDES ON RED ANT

4.3.1. Impact of selected pesticides on the number of live nests of red ant

The impact of pesticides was assessed by observing the number of live nests present and ant activity on cowpea. Data on the impact of selected pesticides on the nest building of red ants are presented in Table 18. The numbers of live nests present were significantly lowest in DDVP treated plants consistently during the observation period of 7 days. The impact on nest building was found more in T_1 (DDVP 0.076 %) from the next day after spraying till the seventh day which was followed by T_4 (Azadirachtin 0.0003 %). The live nests present on all the plants before spraying was on par. One week after the treatment, number of live nests present on the sprayed plants were low compared to the pre-treatment count. The impact was low in T_3 (Tobacco decoction 2.5 %).

4.3.2. Impact of selected pesticides on the activity of red ant

Data on the impact of selected pesticides on the activity of red ants are presented in Table 19. The impact on the activity of red ants was found more in T_1 (DDVP 0.076 %) followed by T_4 (Azadirachtin0.03 %), T_2 (Bordeaux mixture 1 %), T_3 (Tobacco decoction 2.5 %) and T_5 (Control) respectively immediately after spraying. T_5 was found significantly high compared to all other treatments on the first readings taken after spraying. The impact was found lesser in T_5 followed by T_3 and T_2 one week after spraying. The treatment T_1 have much impact on the activity of red ants from the first day followed by T_4.

Table 18: Impact of selected pesticides on the nest building of red ant on cowpea

Treatments	# Mean number of live nests of red ant on cowpea trellises								Mean
	Day before spray	Day one	Day two	Day three	Day four	Day five	Day six	Day seven	
T_1: DDVP 0.076 %	2.75	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
T_2: Bordeaux mixture 1 %	2.75	1.50	1.00	1.00	1.00	0.50	0.50	0.50	0.85

T_3: Tobacco decoction 2.5 %	2.50	2.00	1.75	1.75	1.75	1.75	1.75	1.75	1.78
T_4: Azadirachtin 0.03 %	2.75	1.00	1.00	0.50	0.50	0.50	0.50	0.25	0.60
T_5: Control	2.75	1.75	1.25	1.25	1.25	1.25	1.25	1.25	1.32
SE (+/-)	0.228	0.344	0.247	0.230	0.230	0.211	0.211	0.196	
CD (0.05)	0.497 (NS)	0.750	0.540	0.502	0.502	0.461	0.461	0.427	

Mean of 4 observations

Table 19: Impact of selected pesticides on the activity of red ant

Treatments	# Mean activity of red ant on cowpea trellises									Mean
	Day before spray	After spray on the same day	Day one	Day two	Day three	Day four	Day five	Day six	Day seven	
T_1: DDVP 0.076 % *	56.75	14.25	12.50	8.50	10.75	8.75	8.50	10.25	7.50	10.13
T_2: Bordeaux mixture 1 %	44.50	23.00	17.50	18.75	20.75	15.00	15.75	15.50	16.00	17.78
T_3: Tobacco decoction 2.5 %	50.25	25.00	27.75	33.75	33.00	32.00	23.25	31.50	32.25	29.81
T_4:Azadirac	62.00	20.50	17.25	13.75	9.25	11.25	10.75	9.00	7.50	12.41

htin 0.03 %										
T_5: Control	54.75	57.25	40.50	42.25	43.25	42.25	46.25	37.00	43.25	44
SE (+/-)	2.407	2.480	3.685	3.779	3.912	4.369	4.449	4.246	3.702	
CD (0.05)	5.244	5.403	8.031	8.234	8.524	9.521	9.695	9.251	8.067	

Mean of 4 observations

*Immediate mortality was noticed after the spray of DDVP

The present study shows that the yields in plants raised as per POP recommendation and in plants in which red ants introduced for pest management are comparable. There are limitations in the use of pesticides in cowpea since waiting period available is less. Harboring red ant is an organic way of pest management which is desirable. For cultivating red ant, food provisioning is highly beneficial. For competitive ant's management especially for *Anoplolepis,* insecticides such as DDVP and Azadirachtin are useful. Manaagement of cowpea pests by tobacco decoction 2.5 % will not adversely affect red ant activity.

This is only a preliminary study in order to know whether red ants are effective in managing various pests of cowpea, more elaborate studies are needed. Red ants harbour cowpea aphids. So, managing cowpea aphids without affecting red ant population may be further explored.

DISCUSSION

DISCUSSION

Results found in different studies on red ant are discussed and presented in this chapter.

4.1 SEASONAL VARIATION IN THE POPULATION OF RED ANT

There is a general tendency of increase in the number of nests during summer months and decrease during monsoon period as shown in the figure 2. In the months of June- July when the heavy rain started, the population evidenced by the number of nests of red ant started decreasing and reached the lowest in September. From October onwards the number of live nest constructed started showing an increasing trend and reached maximum in January. But, there after a decreasing trend was set in. Recolonisation of red ant after the rainy season was less. When the red ant population was diminished on many host plants, *Anoplolepis* got established and dominated. Heavy mulching given at the base of the coconut trees provided during winter months provided a very good environment for *Anoplolepis* to harbour and multiply leading to the dominance of *Anoplolepis* in that area. So recolonization of red ant was less. In addition to this, in December- January months weeding and subsequent tillaging led to ground vegetation clearing of the area. This human intervention also made the recolonization of red ant difficult. In such areas, co existence of *Anoplolepis* and *Oecophylla* did not occur and *Anoplolepis* was dominated. Mele and Cuc (2007) reported that if red ant's environment is disturbed by weeding, spraying, pruning *etc.,* they will move to a quieter environment. This is in line with the results by Seguni *et al.,* (2011), who reported that, the effect of ground vegetation management on *Oecophylla longinoda* and its competitor, the ground-nesting ant, *Pheidole megacephala,* in a citrus orchard in Tanzania. When ground vegetation was present, *P. megacephala* tolerated *O.longinoda* and to some extent cohabited with this ant on citrus trees. After clean cultivation, *P. megacephala* displaced *O. longinoda* from tree crowns and became the sole occupant of the majority of trees. Displacement could be reversed by reversing the weed management regime, but this took time.

The red ant is predatory and for its survival and multiplication, continues and efficient foraging is essential. During rainy season, the foraging activity was very low as evident from the Table 2. They forage for other insects which is a source of protein. Moreover, homopteran population such as aphids, mealy bugs, scales which is a source of honey dew secretion will be very low during this season. When the temperature is high, the foraging activity will be high and the homopteran population also will be more. So there will be a general trend that, ant activity will be higher during summer months and less in monsoon. The host plants *viz.,* mango and cinnamon were without any new flushes during rainy season. It is during winter months, these plants put forth new flushes or flowers attracting herbivores. The ant activity will be less during morning hours because of the low temperature. Comparatively higher temperature will be there during day time from 10 to 6 which encourage the ant activity.

Ant activity is severely reduced by rains. During rains they stay inside their nests. A simulation of rain like a spray of water also makes them less active and forces them to stay inside the nest, which is helpful in collecting the nests for spread to crops for pest management purpose. Peng and Christian (2005) reported that ant aggressiveness is greatly reduced by spraying water on trees prior to harvest. Their observations suggest that green ants either go back to their nests or stay on the underside of twigs and leaves when it is raining. In a field experiment, the activity of green ants was reduced by 88 % for the first 20 minutes after spraying water onto trees at a rate of 2000 L / ha and by 61 % after a further 30 minutes.

From the forgoing discussion, it can be concluded that collection of ant nests in the morning hours is convenient for spreading on crops for augmentative biological control.

4.1.2 Effect of biotic factors

4.1.2.1 Interaction between red ant and other ants

4.1.2.1.1 Interaction between red ant and black ants

Tetraponera nigra and *Paratrechina longicornis* are not dominant over *Oecophylla.* On trees where red ants were colonized, these two species of ants could be observed. Upon encounter between the individuals of these two black ant species and red ant no fighting was observed. The interaction between them was found as submissive and they coexist.

4.1.2.1.2 Interaction between red ant and yellow crazy ants

The interaction between yellow crazy ant and red ant was found as aggressive and yellow crazy ant was dominant over red ant. Red ant is arboreal though they require a connection with the ground whereas, yellow crazy ant is terrestrial though they are present on the shoot region on the plants. Nests of the yellow crazy ant are found either in the soil or below the dead organic matter like dried leaves and plant debris. So, if we want to establish red ant on cowpea, removal of plant debris from the field is necessary. Once the red ant get established on cowpea trellises they dominate and can effectively prevent yellow crazy ant ingression.

4.1.2.2. Effect of food provisioning

Food provision greatly increases the multiplication potential of the red ant evidenced by the increase in the number of nests. Chicken shank which was usually discarded by chicken shop was used in the experiment. Meat, dead rats and fish offal are also effective as a protinaceous food source as reported by Mele and Cuc (2007). This is in line with the results by Sreekumar (2010) who reported that the provision of food in the initial days helps in the early establishment of the new colony and connecting the plants harboured by red ants using nylon ropes is found to be easy, if the colonies found to be nearby. It was observed that, once provided these materials act as a source of food for about a month. The food material is not greatly decayed because of the antibacterial activity of the ant secretions. Das (2013) reported that the gastric secretions of *Oecophylla* have strong antibacterial activity against a range of gram negative and gram positive bacteria.

Fig.1. Activity of *O. smaragdina* at 7 am, 11 am, 3 pm and 6 pm

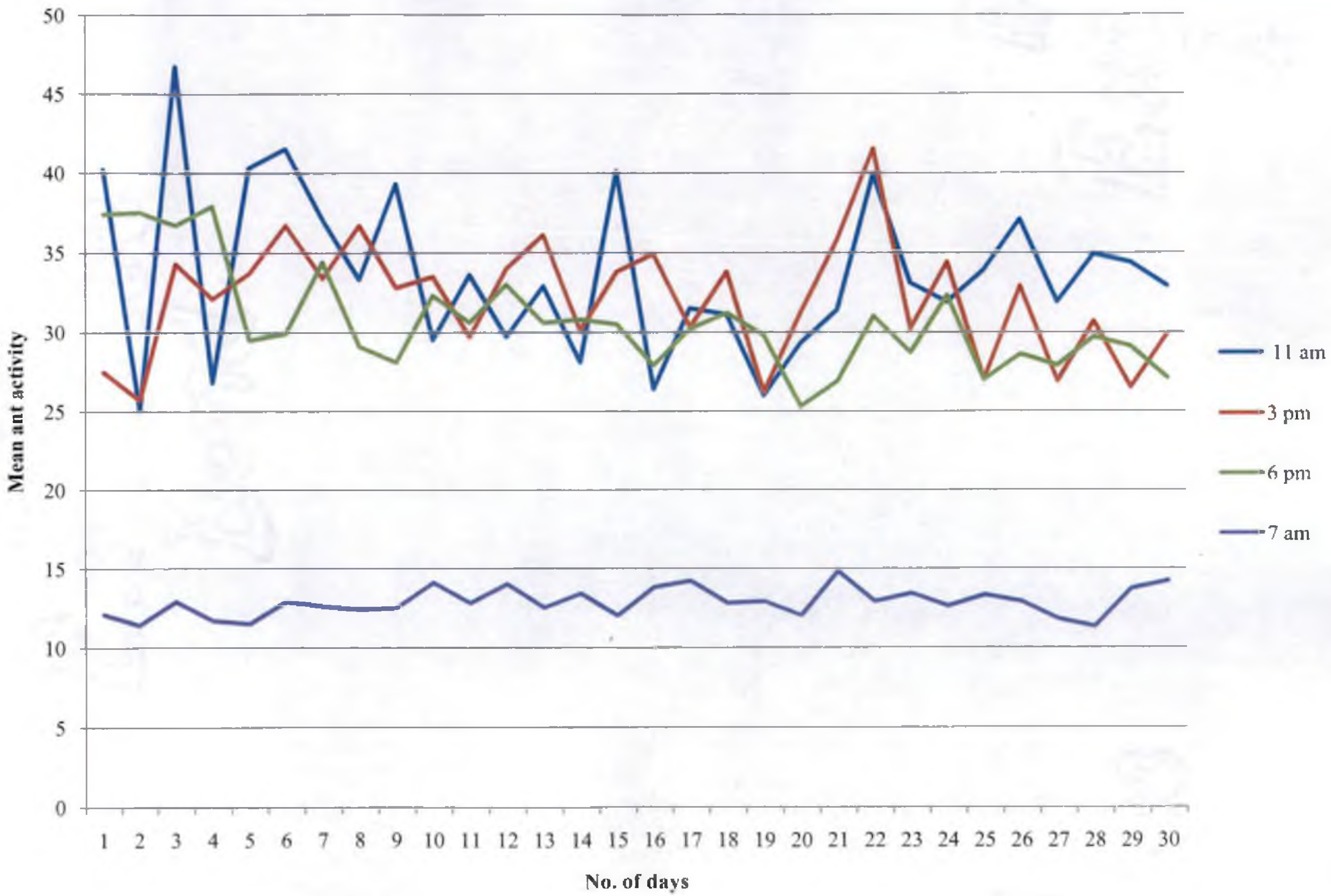


Fig.2. Mean no. of live nests constructed on host plants in every month from March 2014 to March 2015

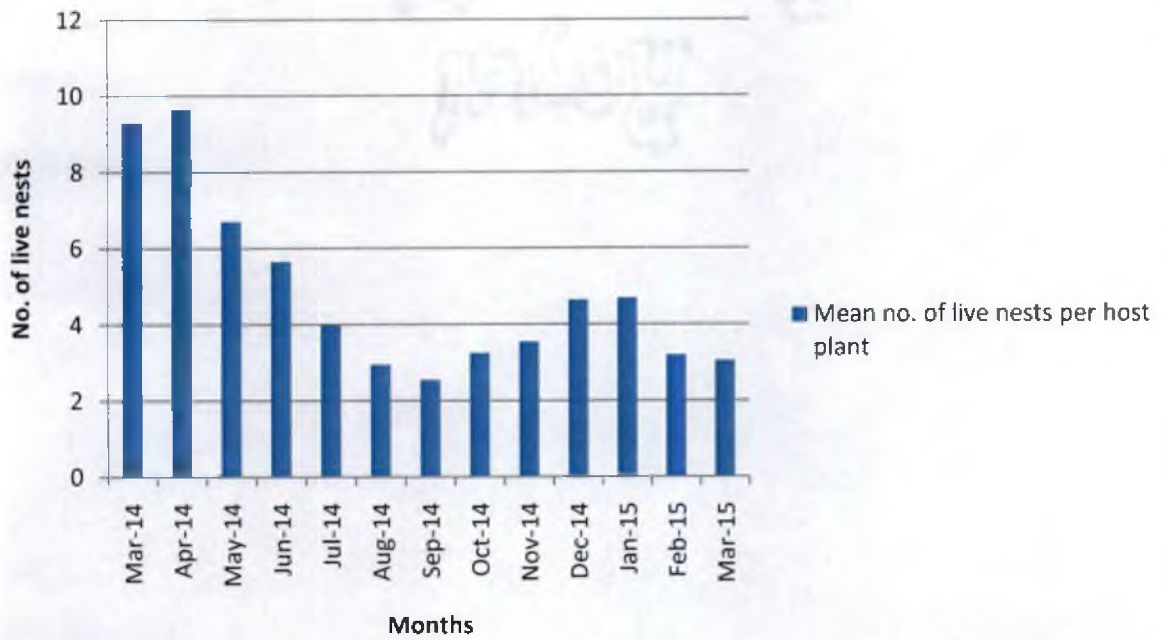
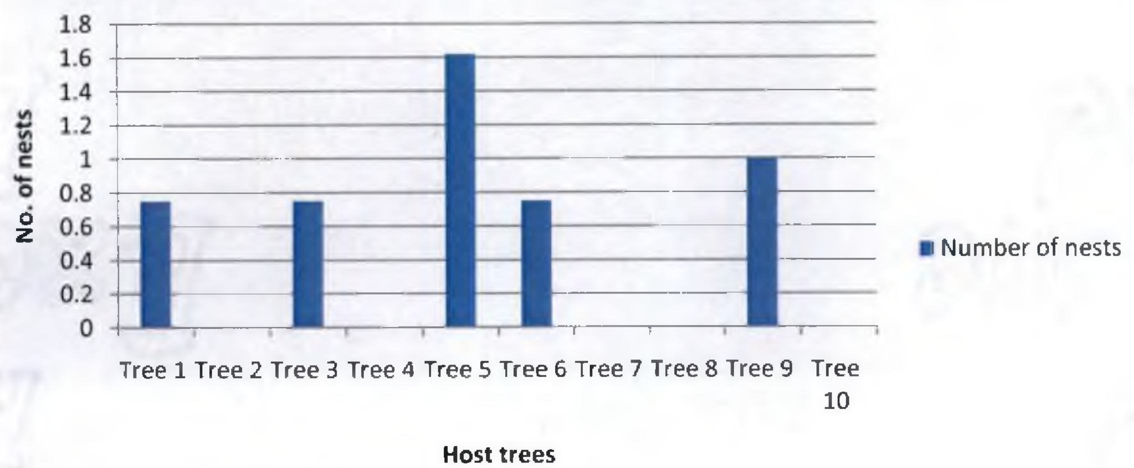


Fig.3. Mean number of nests constructed by red ant on the trees dominated by black ants



4.2.1 Study on the eradication of competitive ants for establishment of red ant colonies

4.2.1.1 Eradication of competitive ants on cashew trees

In the treatments with soap solution even at the beginning red ant activity was less, highly reduced with the progress of time and in control also red ant activity was very low. This is because of the ingression by black ants as the soap solution could not control black ants. Finally the red ants could not be established on the cashew trees except on those trees which were treated with Azadirachtin 0.1 % on the entire plant.

Peng and Christian (2005) reported that, incidence of scale insects or mealy bugs are significantly reduced by spraying one of several environmentally friendly soft chemicals that do not disrupt green ants. White oil (2 %), D.C.Tron oil (1 %) or Neem oil (0.1 %) reduces flat scale numbers by up to 90 %. Potassium soap (1.5 %), white oil (2 %) or Applaud (0.03 %) reduces mealy bugs numbers by 40 %, 40 % and 70 % respectively. In organic orchards, the use of Potassium soap and white oil is approved, while the use of Neem oil and D.C.Tron oil is restricted. Their field experiments showed that the use of green ants plus soft chemicals can greatly reduce mango pests.

Peng and Christian (2005) reported that competitive ant species were eradicated by using ant bait. Against big headed ant or Ginger ant, AMDRO (1 – 2 g/tree) was found as effective and for black ants, 10 % sugar solution with borax or cat food mixed with AMDRO was effective.

4.2.1.2 Eradication of competitive ants on cowpea

Anoplolepis is considered as the major enemy of red ants which is a main reason for the non establishment of red ants in cowpea field. DDVP 0.076 % sprayed on entire plant and Azadirachtin 0.0003 % gave comparatively better results in the eradication of this competitive ant. Complete eradication of *Anoplolepis* without using chemical was a difficult task and removal of the crop debris and dried leaves from the field especially is helpful in preventing the establishment of red ant colonies in cowpea field.

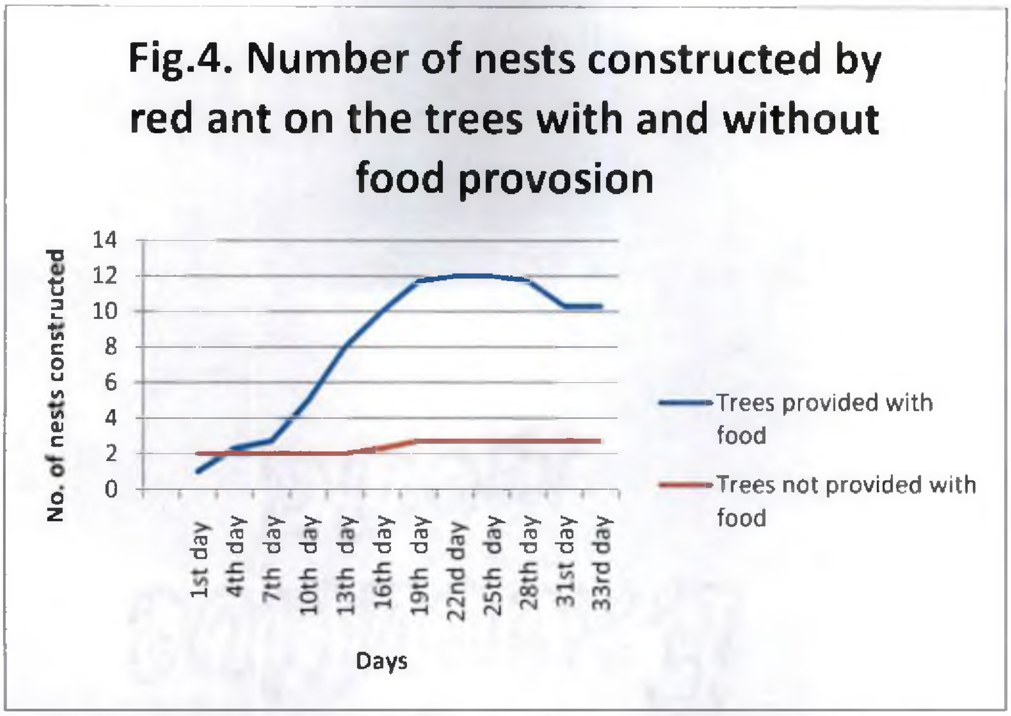


Fig.4. Number of nests constructed by red ant on the trees with and without food provosion
No. of nests constructed
14
12
10
8
6
4
2
0
1st day
4th day
7th day
10th day
13th day
16th day
19th day
22nd day
25th day
28th day
31st day
33rd day
Days
Trees provided with food
Trees not provided with food

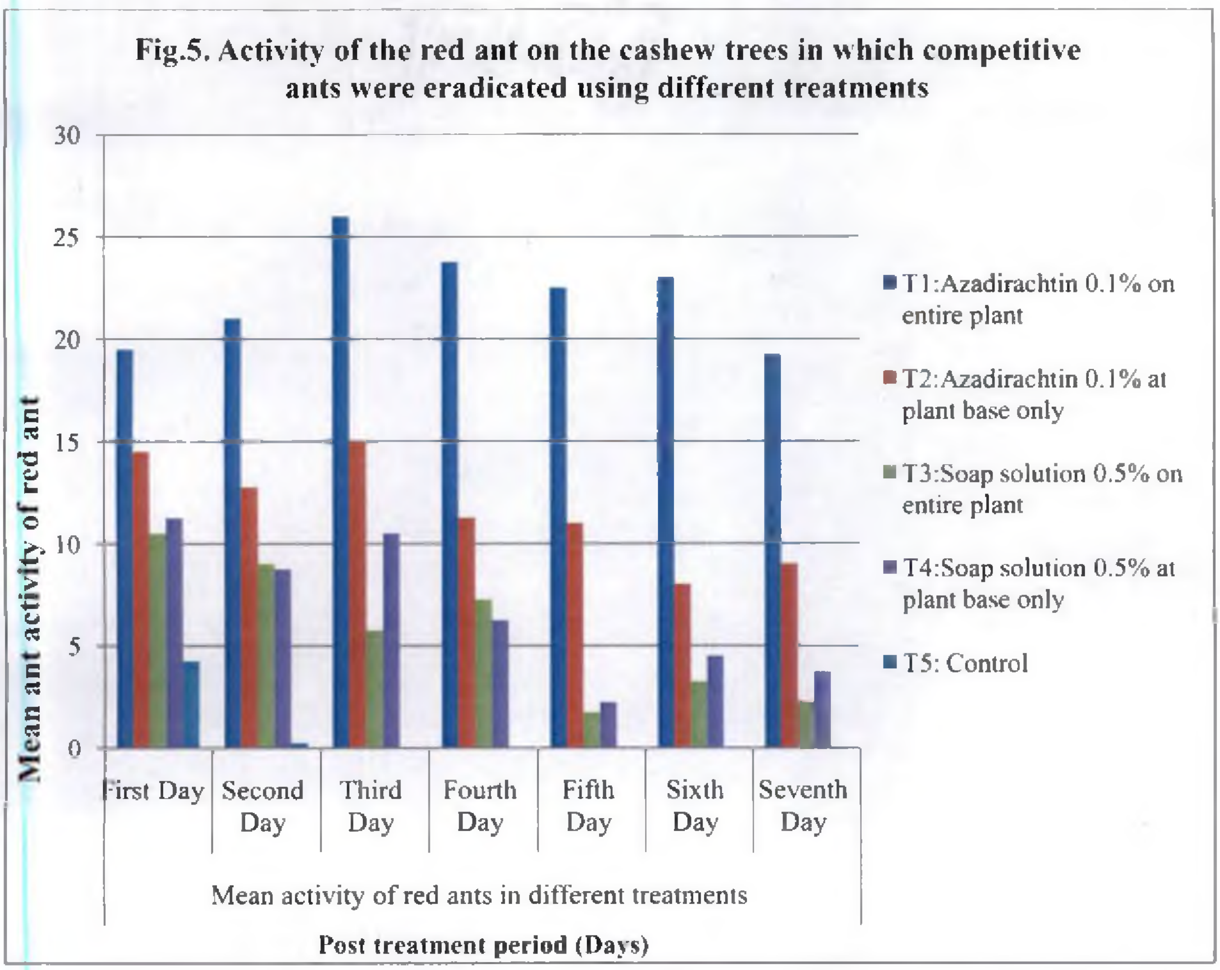


Fig.5. Activity of the red ant on the cashew trees in which competitive ants were eradicated using different treatments
Mean ant activity of red ant
30
25
20
15
10
5
0
First Day
Second Day
Third Day
Fourth Day
Fifth Day
Sixth Day
Seventh Day
Mean activity of red ants in different treatments
Post treatment period (Days)
T1:Azadirachtin 0.1% on entire plant
T2:Azadirachtin 0.1% at plant base only
T3:Soap solution 0.5% on entire plant
T4:Soap solution 0.5% at plant base only
T5: Control

Fig.6. Mean number of nests made by the red ant on the cashew trees in which competitive ants were eradicated using different treatments

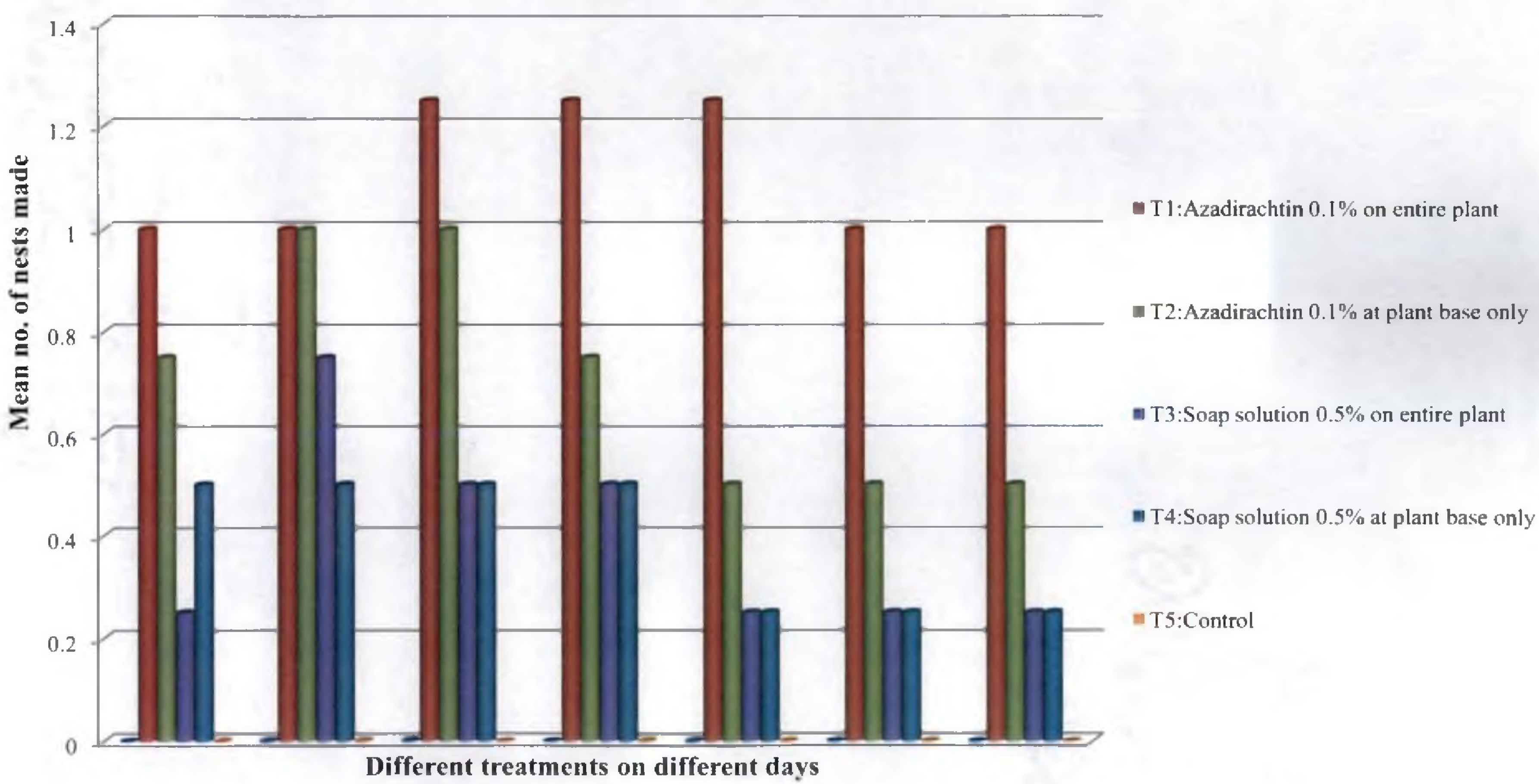


Fig.7. Activity of the red ant on the cowpea plants in which competitive ants were eradicated by different treatments

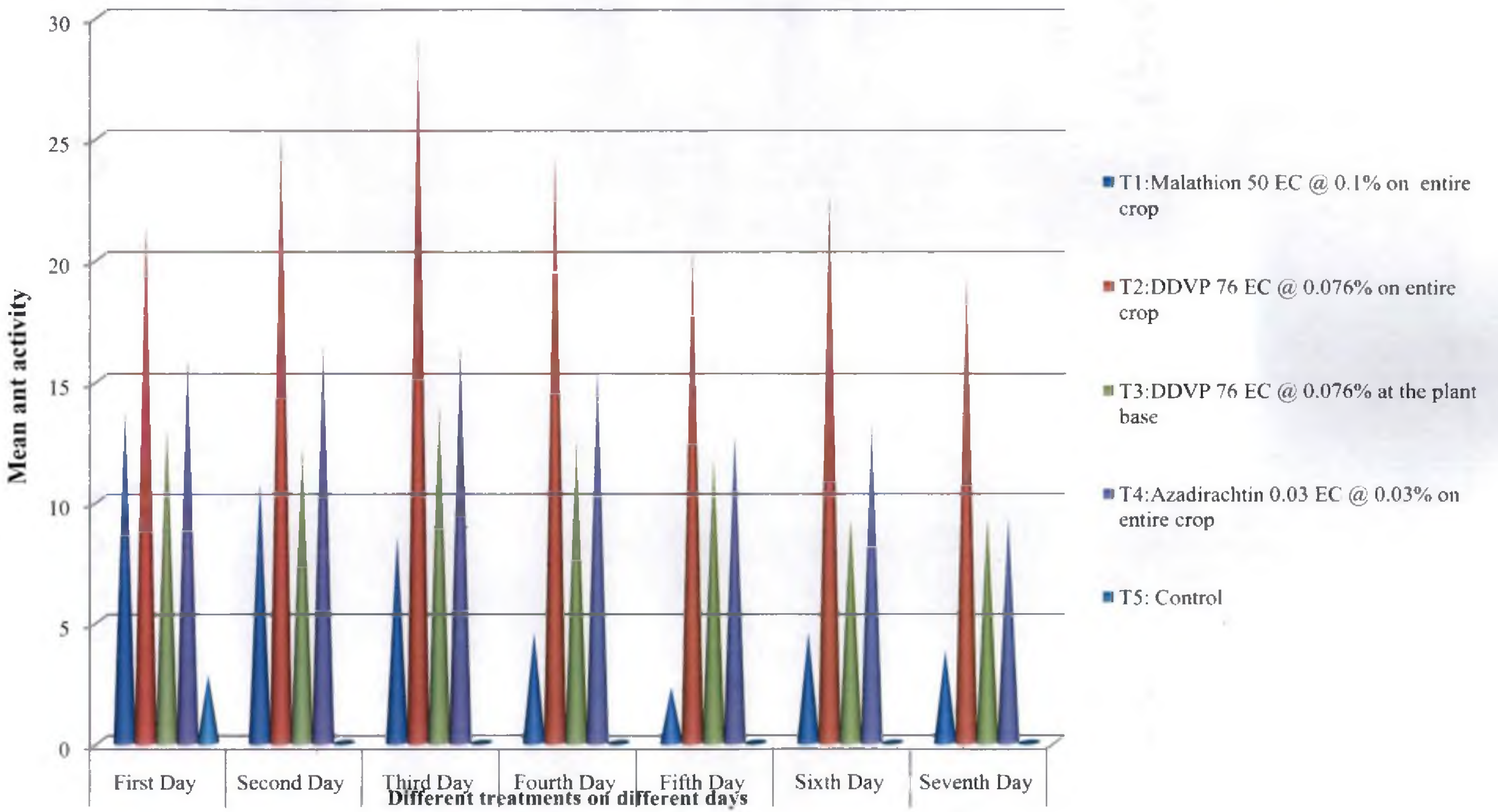
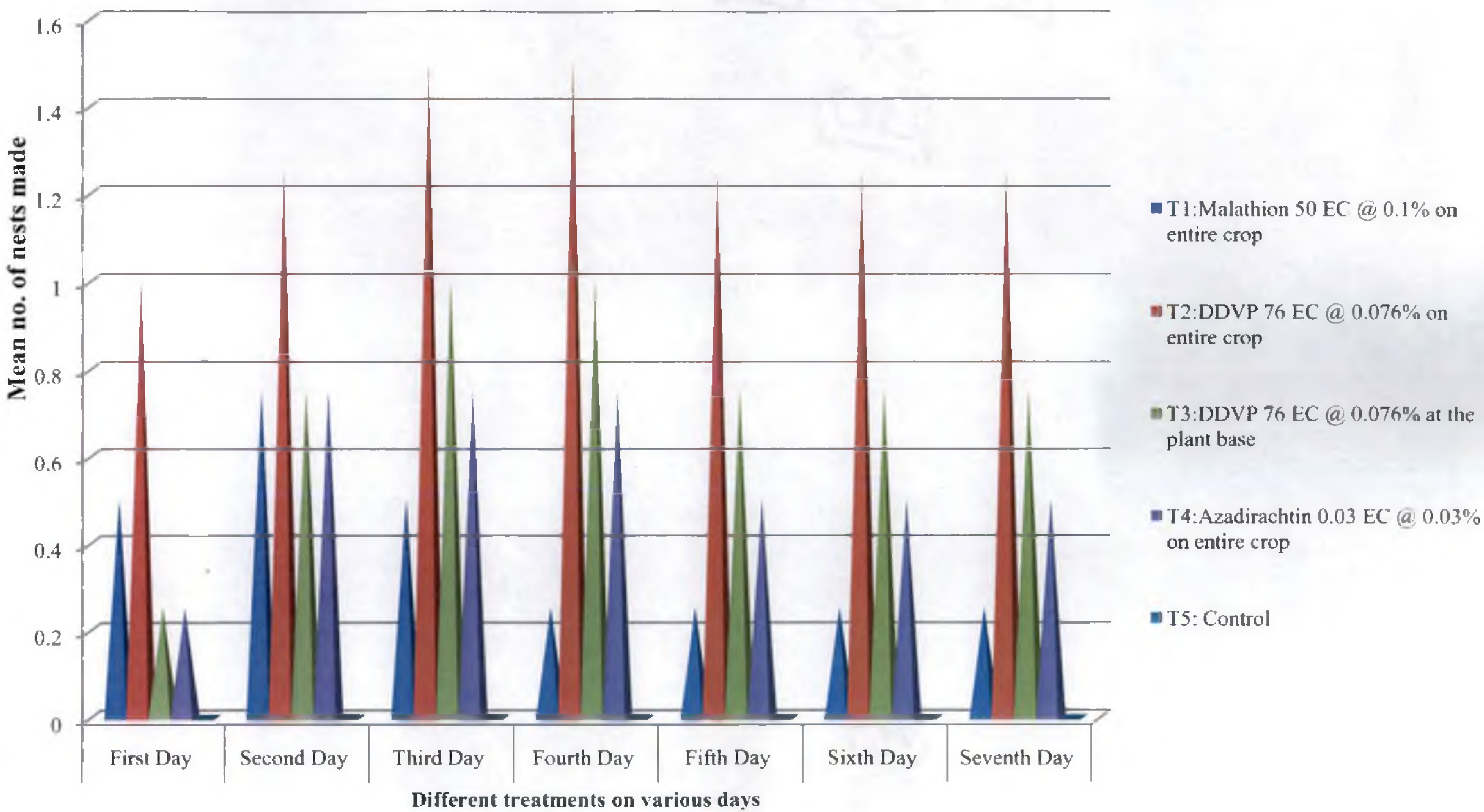


Fig.8. Mean number of nests made by the red ant on the cowpea plants in which competitive ant was eradicated by different treatments



4.2.2 Pest management efficacy studies

4.2.2.1 Number of damaged plant parts due to attack by major pests

The major pests which infested the cowpea during the crop period were aphids and leaf folder. The attack of aphid was higher and that of leaf folder was negligible. Spraying of Malathion was done in T_2 (POP) for the management of cowpea. But no spraying was done for leaf folder even in POP recommended treatment.

4.2.2.2 Number of major pests on cowpea

The number of aphids was higher compared to leaf folder. The population of leaf folder was too less to initiate any management measure. The population of aphid was more in control than in the other two treatments. The plants harboured with red ant also were infested by a higher population of aphids because of their association with red ant. Red ant used to feed on the honey dew produced by aphids and in turn they protect aphids from natural enemies which are the basis of their mutual relationship. But Mele and Cuc (2007) reported that this relationship never associated with the outbreak of aphids.

Aphid is a regular pest of vegetable cowpea throughout the year. Aphids congregate on the tender parts thus preventing the normal growth. They congregate on tender pods also, making them malformed and adversely affect its aesthetic value. So, development of a management strategy to manage the aphid population without affecting the red ant on cowpea is essential.

4.2.2.2 Yield parameters of cowpea

The mean pod number was not significant between treatments but the highest value was observed in T_2 (POP). The pod number is basically a varietal character. A higher pod number in T_2 though it is statistically non significant is due to the better protection of the crop. The same is the trend with mean pod length also.

The mean fresh weight of the pods was significantly high in T_2 (POP) which is on par with T_1 (red ant) which shows that red ant protects cowpea pods from attack by pests.

The cowpea harvested from red ant harboured plants had more lusture and more preferred by the consumers in the initial stage which lasted up to two months. There after there was aphid infestation which reduced the aesthetic value of the produce entailing low

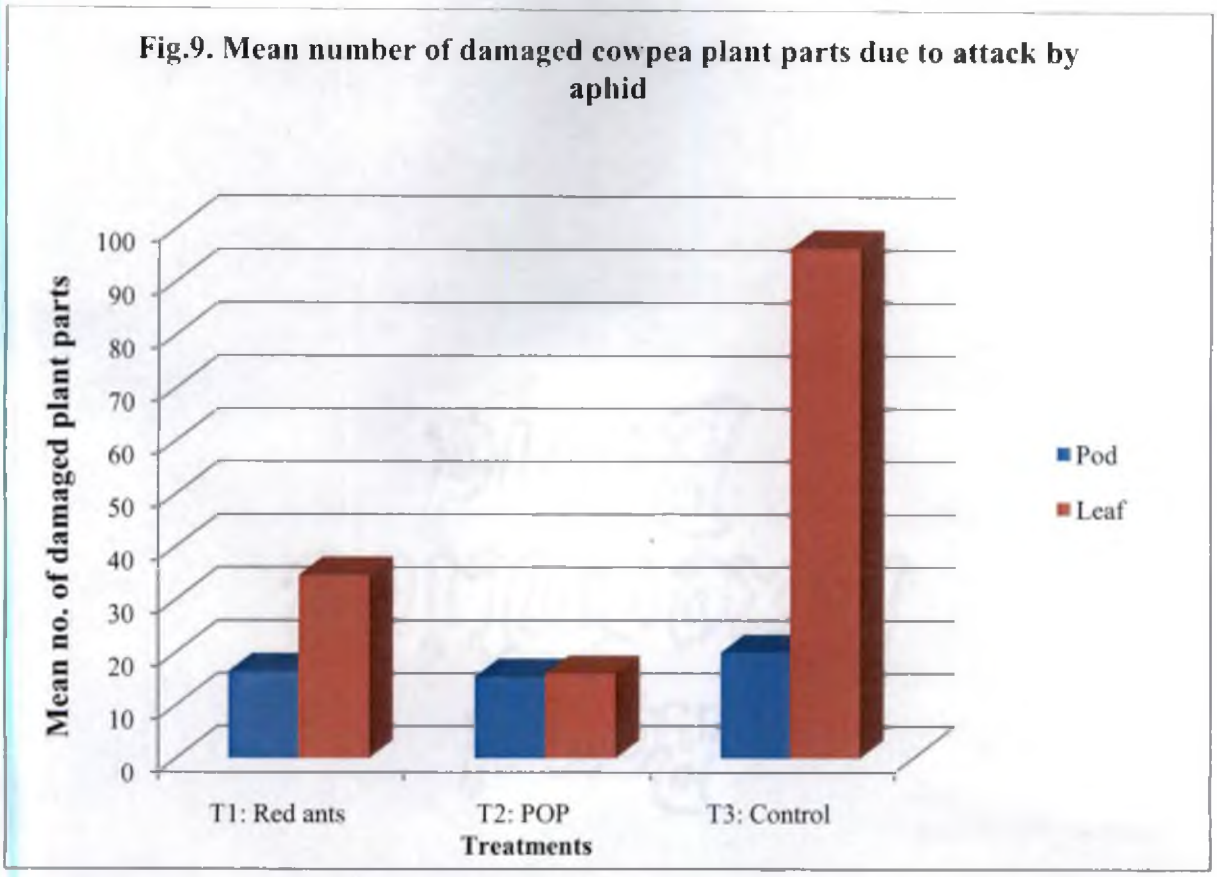


Fig.9. Mean number of damaged cowpea plant parts due to attack by aphid
Mean no. of damaged plant parts
100
90
80
70
60
50
40
30
20
10
0
T1: Red ants
T2: POP
T3: Control
Treatments
Pod
Leaf

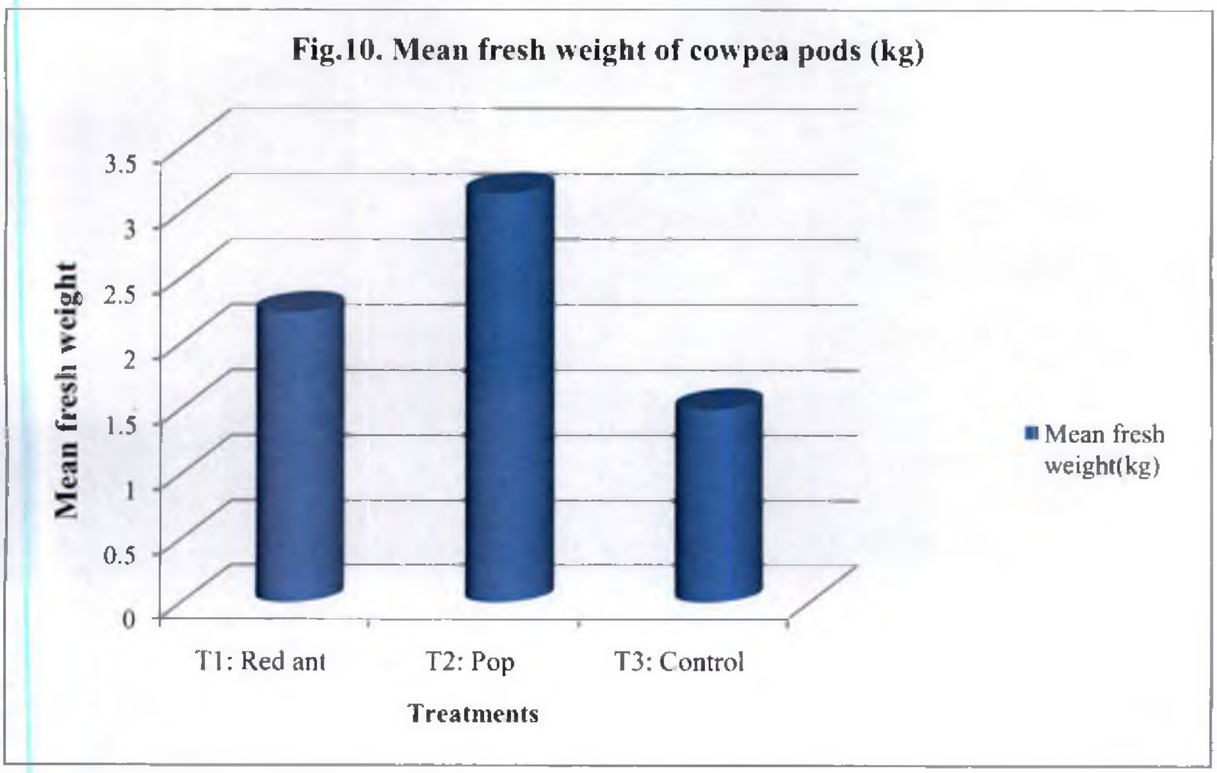


Fig.10. Mean fresh weight of cowpea pods (kg)
Mean fresh weight
3.5
3
2.5
2
1.5
1
0.5
0
T1: Red ant
T2: Pop
T3: Control
Treatments
Mean fresh weight(kg)

consumer preference. The aphid population lasted till the end of the harvesting season both in T_1 (red ant) and T_3 (control). In T_2 (POP) aphids were managed by spraying Malathion for two times.

4.3. IMPACT OF SELECTED PESTICIDES ON RED ANT

The impact of DDVP was more on the ant activity and nest building of red ants. The mean numbers of nests were 2.75 before spraying and from the next day of spraying itself it become 0.5 till the seventh day. The mean ant activity was 56.75 before spraying and it is reduced to 7.50 on the seventh day. The results are in agreement with the findings of Mele and Cuc (2007) who reported that only less toxic and highly selective pesticides should be used in the fields where red ants are present and organo phosphates and pyrethroids should be avoided. Mele and Cuc (2000) reported that nearly all chemicals are harmful to *Oecophylla.*

When compared to DDVP, Azadirachtin which is a derivative of neem has less influence on red ant activity and nest building. Azadirachtin is recommended in organic farming practices. Spraying of Azadirachtin reduced the number of live nests from 2.75 to 0.25 on the seventh day. The ant activity was reduced from 62 on the day before spray to 7.5 on the seventh day.

Bordeaux mixture is an essential plant protection chemical which is used for managing many diseases of cowpea such as anthracnose, web blight, cercospora and alternaria leaf spot *etc.,* from the data, it can be discerned that spraying of BM (1%) reduced the number of live nests from 2.75 to 0.5 on the seventh day. The ant activity was reduced from 44.5 on the day before spray to 16 on the seventh day. Tobacco decoction is usually prepared and applied by farmers for pest management in cowpea. The impact of Tobacco decoction on the nest building and ant activity was less. The ant activity was 50.25 before spraying which reduced to 32.25 on the seventh day.

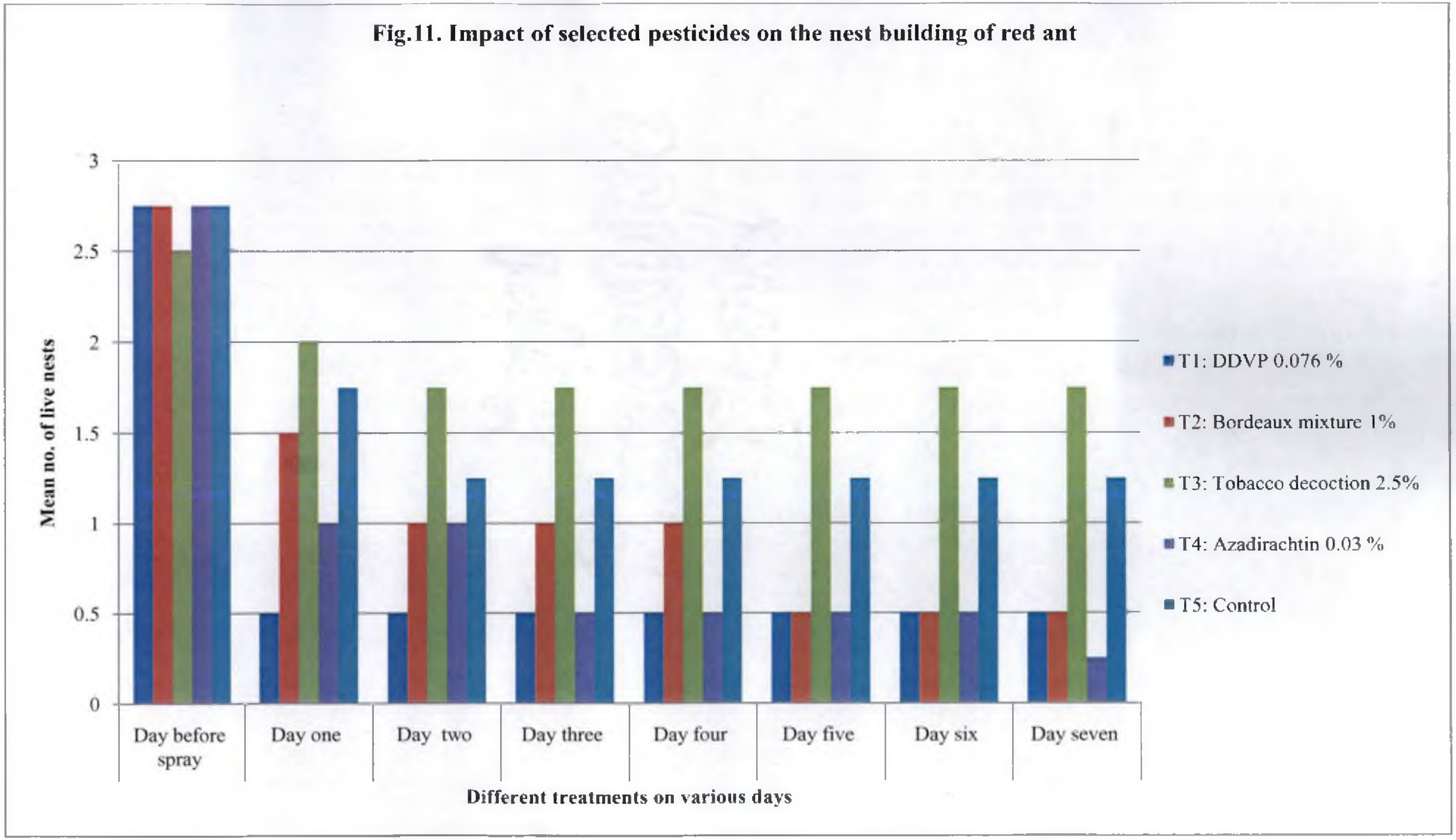
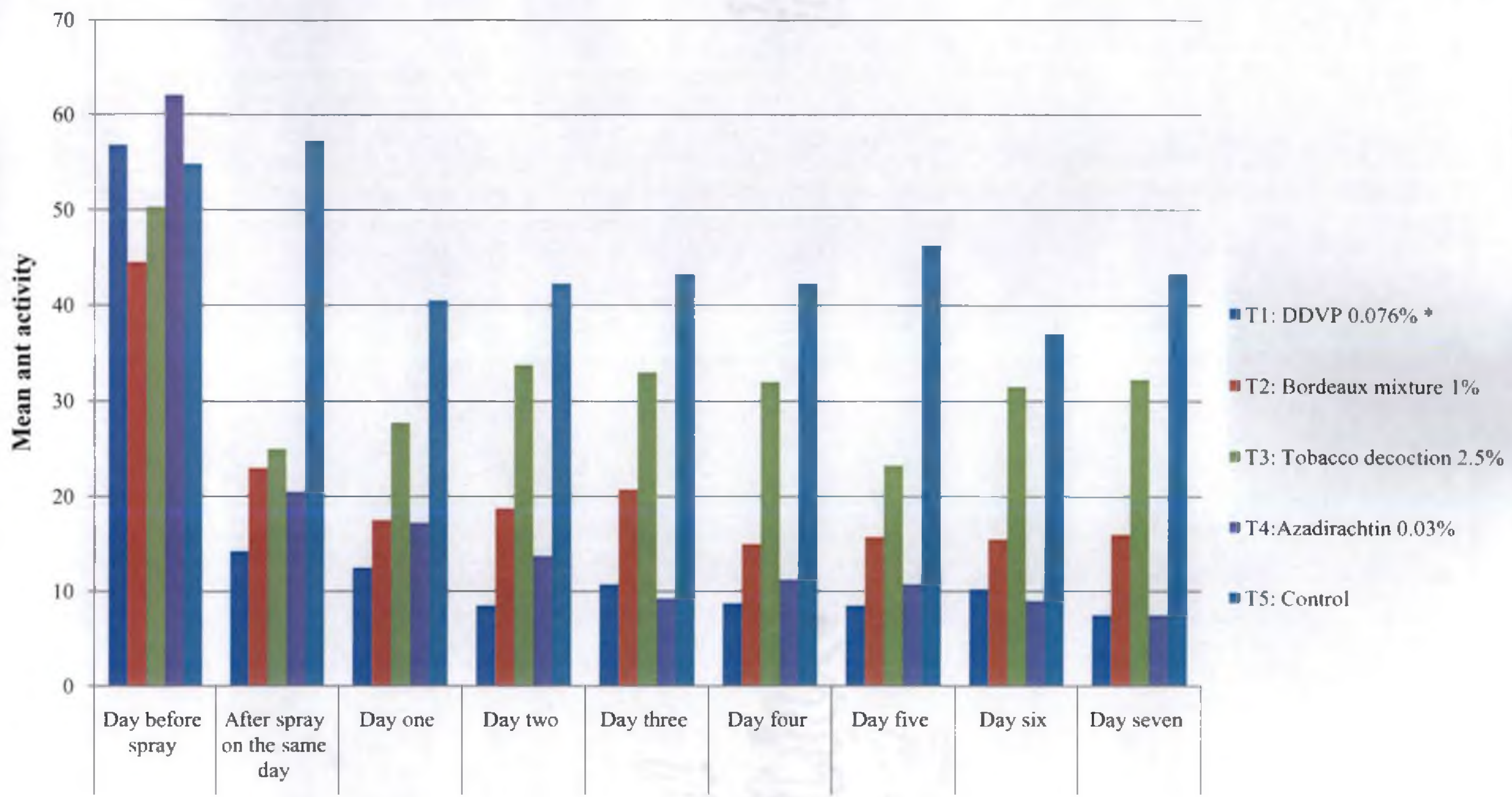


Fig.11. Impact of selected pesticides on the nest building of red ant
3
2.5
2
1.5
1
0.5
0
Mean no. of live nests
Day before spray
Day one
Day two
Day three
Day four
Day five
Day six
Day seven
Different treatments on various days
T1: DDVP 0.076 %
T2: Bordeaux mixture 1%
T3: Tobacco decoction 2.5%
T4: Azadirachtin 0.03 %
T5: Control

Fig.12. Impact of selected pesticides on the activity of red ant



SUMMARY

SUMMARY

The experiment entitled "Management of pests of cowpea using red ant, *Oecophylla smaragdina* (Fab.)" was undertaken at the College of Agriculture, Padannakkad during the period from March 2014 to June 2015. The main objectives of the study were- to study the seasonal variation on the activity and population building of red ant; to develop suitable techniques for elimination of competitor ants; to study the effectiveness of *O. smaragdina* in managing the pests of cowpea and to study the effect of selected pesticides on *O. smaragdina*.

The seasonal variation in population of red ant was measured by counting the number of live nests over one year period on 10 host plants. The ant activity was measured on 5 host plants during 3 seasons for a period of 30 days in each season. The interaction was measured by colonizing red ants on plants dominated by other ants and counting the live nests of red ant. The effect of food provisioning on the multiplication of red ant colonies was measured by counting the live nests constructed on host plants provided with and without artificial food. The experiment on the eradication of competitive ants was done on cashew and cowpea. The experiment was laid out in completely randomized design. In cashew it comprised of 5 treatments *viz.*, T_1 (Azadirachtin 0.1 % on the entire crop), T_2 (Azadirachtin 0.1 % at the plant base), T_3 (soap solution 0.5 % on the entire crop), T_4 (soap solution 0.5 % at the plant base and soil), T_5 (Absolute control) with 4 replications. A waiting period of 3 days was given before harboring red ant colonies. The same experiment was conducted in cowpea also with the treatments- T_1 (Malathion 50 EC @ 0.1 % on the entire crop), T_2 (DDVP 76 EC @ 0.076 % on the entire crop), T_3 (DDVP 76 EC @ 0.076 % at the plant base), T_4 (Azadirachtin 0.03 EC @ 0.03 % on the entire crop), T_5 (Absolute control) with 4 replications. A waiting period of 1 day was given before harboring red ant colonies. The Pest management efficacy study was laid out in randomized block design with 3 treatments *viz.*, T_1 (Crop harboring red ants), T_2 (Pest management as per Package of Practices Recommendations), T_3 (Untreated control) with 7 replications. The study on the impact of selected pesticides on the efficiency of red ants was also laid out in randomized block design with 5 treatments *viz.*, T_1 (DDVP 76 EC @ 0.076 %), T_2 (Bordeaux mixture 1 %), T_3 (Tobacco decoction 2.5 %), T_4 (Azadirachtin 0.03 EC @ 0.03 %), T_5 (Control) with 4 replications. Cowpea variety 'Lola' was raised for all the experiments.

In the study on seasonal variation in red ant population, it was observed that there is a general tendency of decrease in the number of nests during monsoon period. The mean ant activity, temperature and relative humidity for 30 days period in each season show that in all the three seasons the relation between ant activity and temperature was positively correlated. The relationship between the ant activity and RH was positively correlated in winter season only. The ant activity was found less during morning hours (7 am) when the temperature was less. Comparatively high activity was found at 11 am, 3 pm and 6 pm. The interaction between *O. smaragdina* and *Tetraponera nigra* and *Paratrechina longicornis* was found submissive and they coexisted. *Anoplolepis gracilipes* was found as the major competitor ant species against red ant. No nest could be established by red ants on the plants which were harbored by *Anoplolepis*. On an average, the number of nests on the cashew trees provisioned with food increased 10 times where as it was only 1.35 times when food was not provided over a period of 33 days and the difference is significant.

In the competitive ant eradication experiment, T_1 (Azadirachtin 0.1 % on the entire crop) followed by T_2 (Azadirachtin 0.1 % at the plant base) were observed as significant on cashew. In cowpea T_2 (DDVP 76 EC @ 0.076 % on the entire crop) was the best followed by T_4 (Azadirachtin 0.03 EC @ 0.03 % on the entire crop) and T_3 (DDVP 76 EC @ 0.076 % at the plant base). In the pest management efficacy study, maximum number of pods were attacked by aphids in T_3 (Untreated control) followed by T_1 (Crop harboring red ants) and minimum in T_2 (Pest management as per Package of Practices Recommendations). But the values were not significantly different. Number of damaged leaves were significantly high in control. More number of aphids were found on T_3 (Untreated control). The result on yield parameters shows that there is no significant difference between the treatments in the case of pod number and pod length. Fresh weights of the pods were significantly low in control but T_1 (Crop harboring red ants) and T_2 (Pest management as per Package of Practices Recommendations) were on par.

In the study on the impact of pesticides, the numbers of live nests present and ant activity were significantly lowest in T_1 (DDVP 76 EC @ 0.076 %) followed by T_4 (Azadirachtin 0.03 EC @ 0.03 %) and T_2 (Bordeaux mixture 1 %).

The study shows that, red ant can be cultured on host plants by providing artificial food and can be used for pest management in cowpea. Further studies are required to manage cowpea aphids without affecting red ant adversely.

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ANNEXURE

Month	Temperature (C)		Humidity (%)		Sunshine hours BSS	Rainfall (mm)
	Maximum	Minimum	I	II		
March 2014	33.20	22.20	86.90	61.40	7.70	0
April 2014	34.40	25.10	82.50	65.20	6.20	0
May 2014	33.40	24.00	85.20	68.90	6.80	4.60
June 2014	31.70	23.70	89.40	76.20	2.90	19.80
July 2014	29.74	22.87	91.77	82.26	1.07	30.18
August 2014	28.90	22.90	93.90	82.60	1.50	37.60
September 2014	30.30	23.10	91.90	73.00	4.10	11.70
October 2014	31.40	23.60	89.70	70.20	3.40	6.00
November 2014	32.40	22.00	87.80	65.90	4.40	1.30
December 2014	32.01	21.44	89.7	60.6	3.80	1.90
January 2015	31.66	19.34	89.68	57.90	6.10	0
February 2015	32.56	19.97	91.32	58.21	6.76	0
March 2015	33.10	23.00	86.90	61.33	7.60	0

Source: Agrometeorological observatory RARS, Pilicode.

ABSTRACT

MANAGEMENT OF PESTS OF COWPEA USING RED ANT,
Oecophylla smaragdina (Fab.)

by

AMIDA SAPARYA

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ABSTRACT OF THE THESIS

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ABSTRACT

The experiment entitled "Management of pests of cowpea using red ant, *Oecophylla smaragdina* (Fab.)" was undertaken at the College of Agriculture, Padannakkad during the period from March 2014 to June 2015. The seasonal variation in population of red ant was measured by counting the number of live nests over one year and the ant activity was measured during 3 seasons for a period of 30 days in each. The interaction was measured by colonizing red ant on plants dominated by other ants. The effect of food provisioning was studied by counting the live nests constructed on host plants provided with and without artificial food. The experiment on the eradication of competitive ants was done on cashew and cowpea. Pest management efficacy and impact of commonly used pesticides on red ant were also studied.

In the study on seasonal variation in red ant population, it was observed that there was a general tendency of decrease in the number of nests during monsoon period. The mean ant activity, temperature and relative humidity in each season show that relation between ant activity and temperature was positively correlated. The ant activity was found less during morning hours when temperature was less. The interaction between *O. smaragdina* and *Tetraponera nigra* and *Paratrchina longicornis* was found submissive and they coexist. The yellow crazy ant *Anoplolepis gracileps* was found dominant over *O. smaragdina* and severely affected red ant colony establishment. On an average, the number of nests on cashew trees provisioned with food increased 10 times where as it was only 1.35 times when food was not provided over a period of 33 days.

In the competitive ant eradication experiment, Azadirachtin 0.1 % sprayed on the entire crop was observed as best on cashew and DDVP 76 EC @ 0.076 % sprayed on entire crop in cowpea. In the pest management efficacy study, maximum number of pods and leaves were attacked by aphids in control and red ant harboured plants and POP treated plants were on par. The result on yield parameters shows that there is no significant difference between the treatments in the case of pod number and pod length. Fresh weights of the pods were significantly low in control but POP treated and red ant colonized plants were on par.

In the study on the impact of pesticides on red ant, DDVP 0.076 % treatment most adversely affected the red ant nest building and activity followed by Azadirachtin 0.03 % and Bordeaux mixture 1 % and least by Tobacco decoction 2.5 %