INDIGENOUS NATURAL ORGANIC MATERIALS FOR THE MANAGEMENT OF MAJOR INSECT PESTS OF RICE

By

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THESIS

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requirement for the degree of

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2005

DECLARATION

I, Smitha Revi (2002-11-06) hereby declare that this thesis entitled **'Indigenous natural organic materials for the management of major insect pests of rice'** is a bonafied record of research work done by me during the course of research and this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled **'Indigenous natural organic materials for the management of major insect pests of rice' is** a record of research work done independently by **Ms. Smitha Revi** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Smitha Revi

Affectionately dedicated to

my

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Introduction

1. INTRODUCTION

Rice is life for more than 60 per cent of the world's population, and it is deeply embedded in the cultural heritage of societies. Among the rice producing countries, India has the largest area with 4,230,000 ha. India ranks second in respect to production next to China with a production of 8,050,000 tonnes (Mathur *et al*., 1999).

Rice is grown in almost all the states in India. In Kerala, it is cultivated in an area of 322,368 ha with a production of 703,504 tonnes. The productivity of rice in Kerala is only 2.18 t ha^{-1} (FIB, 2004). Insect pests act as a great impediment in achieving desired levels of production. The major pests limiting the profitable cultivation of rice in India include stem borer (SB), rice bug (RB), brown plant hopper (BPH), gall midge (GM), leaf folder (LF), leaf and plant hoppers.

To get quick relief from these pests, synthetic organic insecticides were being used extensively. However, irrational and indiscriminate use of these chemicals has led to contamination of environment, residues in food, potential chronic toxicity, disruption of non-target organisms and development of pest resistance and resurgence (Carson, 1962). In this context, the importance of indigenous plant products in insect control has been much emphasized.

Plants have a diverse array of secondary metabolites to prevent their colonization by insects and other herbivores (Dhaliwal and Arora, 2001). The secondary metabolites, which have now been identified, belong to various chemical categories (terpenoids, alkaloids, glycosides, poly acetylene *etc.*) and have diverse biological effect on variety of pests (Singh *et al.* 1988). The plant kingdom is a vast store of phytochemical weaponry that can be well utilized against insect pest invasion. India is very rich in its flora and fauna, providing ample opportunity for studying the insect-plant relationship and exploiting the potential botanicals for insect pest management.

Botanicals are eco-friendly, effective, economic, target specific, biodegradable and compatible with nature. These botanicals are relatively safer to many natural enemies of the pest species, which bring about natural control in the sustainable systems. The use of plant products emphasizes on minimizing risk and has tremendous scope in the emerging concept of sustainable agriculture. However, many of these botanicals are not well studied to evaluate its technical efficiency. In this context, the study entitled "Indigenous natural organic material for the management of major insect pests of rice" was taken up with following objectives,

(i) to study the effect of various natural organic materials on the management of major insect pests of rice.

(ii) to assess the impact of natural organic materials on natural enemies.

(iii) to test the effect of natural organic materials on disease management.

(iv) to investigate upon the effect of natural organic materials on weed suppression.

(v) to evaluate the influence of natural organic materials on crop growth parameters.

(vi) to elucidate the influence of natural organic materials on yield parameters.

Review of Literature

2. REVIEW OF LITERATURE

A search for the publication of the use of these botanicals in rice is revealed to be scanty. Hence, similar researches carried out in other crops are reviewed here.

As plants and insects have co-evolved over millions of years, they accumulated specific secondary plant chemicals to counteract the insect damage. These bioactive chemicals include insecticides, antifeedants, insect growth regulators (IGRs), juvenile hormones, ecdysones, repellents, attractants, arrestants *etc.* Hence, plants are thought to be an important alternative source for chemical pesticides (Kannaiyan, 1999).

Chopra *et al.* (1949) listed about 700 species of plants having poisonous effects on man, livestock and insects. Out of which, 74 plants showed insecticidal and insect repellent properties. Over the years, more than 6000 species of plants have been screened and nearly 2400 plants belonging to 235 families (Grainage and Ahmed, 1988) were found to possess significant biological activity against insect pests. Isman *et al.* (1995) screened about 100 species either for antifeedant or growth regulatory activity or both, and most of them showed high to very high bioactivity against pests.

2.1 EFFECT OF DIFFERENT PLANT PARTS OF FRUIT TREES

2.1.1 Mango (*Mangifera indica*)

Kumar and Thakur (1988) reported the antifeedant activity of petroleum ether extract of seeds of mango at 1000 ppm against fourth instar larvae of the noctuid *Spodoptera litura,* and the positive activity was correlated with the per cent content of linoleic and oleic acid in the seed oil.

Ethanol extract of leaves of *M. indica* was 60 to 100 per cent effective as botanical insecticide against *Myzus persicae* in the laboratory (Stein and Klingauf, 1990).

Rao *et al*. (1993) reported the efficacy of mango powder against the pulse beetle, *Callosobruchus chinensis* L. on pigeon - pea.

Soil incorporation of chopped leaves of *M. indica* into the rice field at the time of final ploughing reduced the infestation of insect pests (Kumar, 1999).

Kumar (1999) reported the repellent activity of leaves of *M. indica* against the rice bug, *Leptocorisa acuta* in rice fields.

Saxena and Saxena (1999) evaluated the plant extract of *M. indica* (1, 1.5 and 2 %) against the cowpea weevil (*Callosobruchus maculatus*) in a laboratory study, and extract at 1.5 and 2 per cent showed 50 per cent repellency, whereas one per cent exhibited attractancy instead of repellency. But in 2000, a laboratory study conducted by Saxena and Saxena showed that the leaf extract of *M. indica* leaves at different concentrations (1, 1.5 and 2 %) was effective against the pulse beetle, *Callosobruchus maculatus* F. and the methanol extract of leaf extract gave more developmental period of pest compared to the petroleum ether extract.

Swapna (2003) documented the insect repellent property of mango leaves against the storage pests of cowpea.

2.1.2 **Cashew (*Anacardium occidentale*)**

The larvicidal property of seed extract of *A. occidentale* was tested against fourth instar larvae of *Aedes fluviatilis* at 100, 10 and 1 ppm and it was more effective at 10 ppm (Consoli *et al*., 1988).

Incorporation of cashew (*A. occidentale*) leaves into the rice field as green leaf manure before transplanting controlled the insect pests (Kumar, 1999).

Shankar and Solanki (2000) reported the insecticidal effect of phenolic compounds in the shell oil of *A. occidentale* and in 2003, the effect of cashew nut shell liquid (CNSL) of two per cent against rice leaf folder, *Cnaphalocrocis medinalis* was reported by Swapna.

2.2 EFFECT OF DIFFERENT PLANT PARTS OF MEDICINAL PLANTS

2.2.1 Garadi (*Cleistanthus collinus*)

Jyotsana and Srimannarayana (1987) reported the significant antifeedant activity (80.2%) and insecticidal activity (73.5%) of ethyl acetate extract of *C. collinus* leaves at 2000 ppm concentration.

Manuring soil using garadi leaves prior to transplanting repelled the insects from rice field and foliage application of leaf extract reduced the stem borer and gall midge attack (Preetha, 1997).

Kumar (1999) reported that the incorporation of *C. collinus* leaves into the rice field reduced the green caterpillars, which were affecting the basal portion of rice plants.

Sulaja (1999) recorded the repellent activity of *C. collinus* leaves against rice bug, *L. acuta*. She also documented the insecticidal property of garadi leaves against leaf eating caterpillars in rice nursery.

Leaf extract of *C. collinus* was found to possess insecticidal property against the stem borer of rice, *Scirpophaga incertulus* (Kumar, 1999; Swapna, 2003).

Leaf extracts of *Azadirachta indica*, *Ipomea carnea*, *Cleistanthus collinus and Melia azadarach* (10%)*;* neem seed extract (5%); neem oil based preparation (Neemark at 1%); tobacco decoction (2%); and *Pongamia glabra* kernel extract (5%) were evaluated in comparison to endosulfan (0.07%), for bioefficacy against pod borers of pigeon-pea (*Helicoverpa armigera*, *Exelastis atomosa*, and *Melanagromyza obtusa*). The plant based products were inferior to endosulfan, although these treatments performed better than the untreated control (Baviskar *et al*., 2002).

2.2.2 Snake wood (*Strychnos nux-vomica*)

Strychnos nux-vomica is renowned for its poisonous alkaloids, 'strychnin' and 'brucin' and the leaf extract of *S. nux-vomica* is found to be having insecticidal property (CSIR, 1976).

CSIR (1976) reported the insecticidal property of *S. nux-vomica* and in 2003 Swapna also recorded the insecticidal property of leaf extract at two per cent concentrtion.

Tanweer *et al*. (1995) extracted phytochemicals from leaves, stem and fruit of *S. nux-vomica* and they were treated against *Dysdercus similis* F. and *Musca domestica* L. to observe the insecticidal and insect growth regulatory activity. They also observed that at higher dosages, the extracts showed insecticidal activity, whereas at lower dosages, they acted as effective insect growth regulators inflicting morphological and reproductive alternations.

Leaf extract of *A. indica*, *Chromolaena odorata* and *S. nux-vomica,* neem oil and neem seed kernel extract were evaluated in laboratory for their antifeedant activity against *Longitarsus nigripennis* and it was found that the leaf extract of *S. nux-vomica* showed the highest antifeedant effect (Devasahayam *et al*., 1998).

Murugan *et al.* (1998) conducted bioassays with crude ethanol extracts (CEE) of leaves of 28 plant species belonging to 25 families for their feeding deterrency and toxicity to the larvae of *S. litura*, and *S. nux-vomica* showed the highest feeding deterrency and mortality (100 and 98% respectively).

Leaf extract of *S. nux-vomica* was found to possess high repellent activity against the rice bug, *L. acuta* and banana pseudo stem weevil, *Odoiporus longicollis* Olovier (Sulaja, 1999).

Insect pests in rice field were reduced by the incorporation of leaves of *S. nux-vomica* leaves into the field at the rate of five t ha^{-1} (Kumar, 1999; Swapna, 2003).

Desai and Desai (2000) have carried out a study on insecticidal property of *S. nux-vomica* showed that the extract gave 30 per cent mortality against *S. litura* and *Lipaphis erysimi*. At the same time Tripathy *et al.* (2001) reported that the plant powder of *S. nux-vomica* at 20 and 40 mg kg^{-1} was not much protective against *C. chinensis* attacking black - gram.

Suresh (2002) reported that plant extract of *S. nux-vomica* at one per cent showed ovipositional deterrency against tobacco cut worm, *S. litura* resulted in pupal and adult malformation (16.67%). It also caused lower approximate digestibility (31.93 %).

Twenty nine solvent extracts from 20 Sri Lankan plants were examined for their antifeedant activity against the fourth instar larvae of Mexican bean beetle, *Epilachna varivestis* and extract of *S. nux-vomica* showed strong antifeedant activity (Jayasinghe *et al*., 2003).

Basins of bitter gourd were mulched with leaves of *S. nux-vomica* reduced the infestation of sucking pests (Swapna, 2003).

2.2.3 Glycosmis (*Glycosmis pentaphylla*)

Deshpande *et al*. (1990) evaluated the synergistic activity of acetone extracts of *G. pentaphylla* in combination with equal amounts of extracts of *Catharanthus roseus*, *Salvadora oleododes* and *Breneya* sp., and exhibited a significant increase in ovipositional deterrent activity against *Phthorimaea operculella* Zell. compared with the activity of individual extracts.

Rahmani *et al*. (1992) isolated the active quinazolone alkaloid, arborine from the leaves of *G. pentaphylla* and showed an effect on the larval mortality and pupation of *Drosophila melanogaster* Kent (LC 50 = 8.5 ppm).

Studies on bioenergetics of larvae of *Achaea janata* after feeding on leaves of castor that had been dipped in the leaf extracts (0.01 to 0.5%) of *G. pentaphylla* showed that the active ingredients significantly reduced food energy consumption and utilization, despite extending the duration of larval stage (Muthukrishnan and Ananthagowri, 1994).

Ito *et al*. (1999) studied the chemical constituents of the methanolic extract of stem of *G. pentaphylla* and isolated a novel naphthoquinone (glycoquinone) and a new acridone alkaloid (glycocitrine-III) along with 12 known compounds.

Lapointe *et al.* (1999) assessed host plant resistance of *G. pentaphylla* by incorporating the roots into the diet of root weevil and it increasingly inhibited the growth of neonate larvae with increased concentration of roots. This assay led to the fractionation of an active compound, amide dehydrothalebanin B.

Petroleum ether extract of the root of *G. pentaphylla* was found to be lethal to the larvae of *Culex quinquefasciatus*, *C. sitiens*, *Aedes aegypti* and *Anopheles stephensi* with LC 90 values of 54.20, 42.66, 57.14 and 43.85 mg l^{-1} respectively and the stock solution was active for one year (Latha and Joseph, 1999).

Insect pests in rice field were reduced by the incorporation of *G. pentaphylla* leaves into the rice field at the time of final ploughing (Kumar, 1999).

Muthukrishnan *et al*. (1999) reported that ethyl acetate fracion of *G. pentaphylla* leaf extract inhibited the juvenile hormone III - biosynthesis *in vitro* of corpora allata of three day old females of the field cricket, *Gryllus bimaculatus*. The bioactive compound was identified as the quinozolone alkaloid, arborine, which showed larvicidal activity against the mosquito, *Culex quinquefasciatus*.

Shapiro *et al.* (2000) carried out a diet-incorporation assay using the root of a citrus relative, *G. pentaphylla* (orangeberry) and this was shown to inhibit the growth and survival of larvae of the citrus root weevil, *Diaprepes abbreviatus*. This assay was used to guide the isolation of an active compound, amide dehydrothalebanin B from the acetone extract of *G. pentaphylla* roots.

2.3 EFFECT OF PLANT PARTS OF GREEN LEAF MANURE CROP

2.3.1 Glyricidia (*Glyricidia maculata)*

Leaves, petioles and bark of *G. maculata* is reported to be having insecticidal property, and powdered seeds, leaves and bark were mixed with rice and used as bait for the destruction of pests (CSIR, 1956).

Cruz and De-las-Llagas (1994) reported the repellent activity of *G. sepium* lotion against outdoor biting mosquitoes, and it provided protection for 1.4 hr.

Stoll (1996) observed the toxic effect of ethanol extract of *G. maculata* against the cabbage pyralid, *Plutella xylostella*.

Parvathy and Jamil (1999) reported the strong antifeedant activity of methanol leaf extract of *G. sepium* against *Achaea janata* L. and *Spodoptera litura* F.

Soil incorporation of leaves of *G. maculata*, two weeks prior to transplanting reduced the pest infestation in rice field (Kumar, 1999; Swapna, 2003).

2.4 ORGANIC SPRAYS

2.4.1 Karanj (*Pongamia pinnata*) oil

Kumar and Singh (2002) have reported that many biopesticides have been developed from indigenous trees and among these, neem and karanj are most commonly used against pests of economic importance. Karanj is reported to be effective against insect pests of stored grains, field and plantation crops, and household commodities. More than 19 biologically active components have been identified from this plant. Oil, methanolic seed extract, acetone leaf extract, aqueous seed extract, chloroform seed extract and petroleum ether seed extract of karanj were evaluated and found to act as oviposition deterrents, antifeedants, repellents and larvicides against a wide range of insect pests.

The oil of pungam and its active component ‘karanjin’ possess insecticidal property and two per cent pongam oil - rosin soap was effective against the adults and grubs of the green bug of coffee, *Coccus viridis* (CSIR, 1969). Detailed phytochemical and biological investigations on *P. pinnata* have enabled the isolation of a number of new phytochemicals like ‘lanceoletin –B’, an angular furanoflavone and other phenolic constituents, which were possessing pesticidal properties (Samanta *et al*., 1987). Srimannarayana (1993), and Dhaliwal and Arora (2001)) were also reported the insecicidal property of pongamia (*P. pinnata*). *P. pinnata* seed oil contain an active principle, ‘karanjin’, which was found to possess repellent and insecticidal property (Ignacimuthu, 2004).

Under laboratory conditions, 0.1 per cent water emulsion of oil showed antifeedant activity against *Amsacta moorei* Butler (Verma and Singh, 1985).

Repellent action of pungam oil (10. 38 mg cm^{-3}) and plant extract on stored grain pests of rice, *Tribolium castaneum* was reported (Prakash and Rao, 1986).

Ahmed and Koppel (1987) reported the efficiency of karnaja (*P. glabra*) leaves in protecting the stored rice from pests.

Seeds of *Vigna radiata* were treated with pongamia oil at 5 and 10 ml kg^{-1} and it resulted in reduced oviposition of *Callosobruchus chinensis* (Babu *et al*., 1989).

Sridhar and Chetty (1989) conducted a laboratory study to evaluate the efficiency of acetone extract of *P. pinnata* by feeding the fifth instar larvae of *Euproctis fraterna* with castor leaves soaked in 250, 500, 750 and 1000 ppm of the extract, and the rate of food consumption, assimilation and production showed a negative correlation with the concentration of extract. They reported that leaf extract reduced the activity of digestive enzymes, invertase, amylase and protease with increasing concentration and at 1000 ppm, larval pupal intermediaries were produced, which emerged as deformed adults.

Seed extract of karanja at two per cent reduced the emergence of adults of rice brown plant hopper, *Nilaparvata lugens* (Ramraju and Babu, 1989).

Reddy *et al*. (1990) observed that the petroleum ether extract of karanja at one per cent was effective in reducing the larvae of epilachna beetle, *Henosepilachna vigintioctopunctata* in brinjal.

Seed extract of pongam (1% and 2%) was found to possess insecticidal property against *Toxoptera citricidus* on lime (Jothi *et al*., 1990).

Water and methanol extract of karanja leaves at two per cent caused larval mortality of stored grain pest of rice, *Corcyra cephalonica* (Dakshinamurthy, 1993).

Srinivasulu and Jeyarajan (1993) reported that pre-inoculation spray with seed oil of pungam (*P. pinnata*) decreased the incubation period of tungro virus complex in paddy and the leafhoppers died on the sixth day of application of oil.

Different plant parts of pongamia was found to show strong repellent activity against different pests of crops. Strong repellent activity of pongam oil at one per cent against the pulse beetle, *C. chinensis* on *Cajanus cajan* was well documented by Khaire *et al. (*1993).

Kulat *et al*. (1997) conducted field trials to determine the efficacy of six plant extracts and two insecticides for the control of *Aphis gossypii* and *Empoasca devastans* on okra. Aqueous leaf extract of *P. pinnata* (at 5%) gave a similar level of control compared to endosulfan (0.06%) and monocrotophos (0.05%).

Padmanabhan *et al.* (1997) conducted a field trial using the commercially available oil cakes neem, karanj and mahua and they were applied to pots containing two year old arecanut (*Areca catechu*) seedlings growing in sterile soil with third instar grubs of *Leucopholis burmeisteri*, at rates equivalent to 1000, 1500, 2000 and 2500 kg ha^{-1}, and karanj gave the highest mortality.

Sahayaraj and Paulraj (1998) conducted a laboratory study to evaluate the effect of water extract of *P. pinnata* at various concentrations (0.5, 1, 2, 4 and 6%) against last instar larvae of the groundnut pest, *Spodoptera litura* showed the toxic property.

Rajappan *et al.* (1999) reported the effect of pongam oil on the survival of *Nephotettix virescens* and the transmission of rice yellow dwarf disease (RYD), caused by a phytoplasma. The combination of pongam oil and neem oil was as effective as monocrotophos and considerably reduced RYD transmission by *N. virescens*.

Green Mark (0.4%), Neem Guard (0.4%), Achook (0.4%), neem oil (2.0%), neem seed kernel water extract (5.0%), karanj oil (2.0%), nicotine sulfate 40 w/v (0.2%) and endosulfan (0.07%) were tested against *H. armigera* infesting chickpea in a field experiment. Endosulfan gave the highest pest control in terms of decreasing pod damage and increasing chickpea yield and among the botanical insecticides, karanj oil resulted in the highest grain yield (1.29 t ha^{-1}) with 44 per cent pod damage (Bajpai and Sehgal, 1999).

Meshram (2000) tested crude extracts of the fresh leaves of 14 different plant species against third instar larvae of the *Dalbergia sissoo* defoliator, *Plecoptera reflexa*, in order to evaluate their antifeedant and insecticidal activities. The investigation revealed that extracts of *Melia azedarach*, followed by extracts of *Eucalyptus* hybrid and *P. pinnata* were the most effective and potent antifeedants and insecticidal agents.

Mallapur *et al.* (2001) evaluated the efficacy of different plant products against the safflower aphid, *Uroleucon compositae* and five per cent *P. pinnata* exhibited safflower aphid control comparable to that obtained with the insecticide. These products are ecologically and environmentally safe and possess high benefit cost ratio.

Saminathan and Jayaraj (2001) compared pungam oil at 3% with 30% dimethoate against *Ferrisia virgata* using leaf dip method and pest mortality was recorded at 24, 48 and 72 h after treatment. Pungam oil reccorded 50 % mortality at 72 h, and dimethoate recorded 63.33 per cent mortality at 48 h, which increased to 66.67 per cent at 72 h.

Black - gram seeds were treated with pongamia oil at two different doses (2 ml kg^{-1} and 4 ml kg^{-1}) to protect it from the attack of storage pest, *C. chinensis,* and both of these concentrations were superior in protecting the seeds from pulse beetle attack than malathion treatment (6 ppm) (Tripathy *et al.*, 2001).

Plant extract of karanj (*Pongamia pinnata*) applied at 1.0, 2.5 and 5.0 ml 100 g^{-1} of sorghum seeds to evaluate the oviposition deterrency against *T. castaneum* and it was found that the plant extract significantly reduced the oviposition. No egg laying was observed on seeds treated with karanj at 5.0 ml 100 g^{-1} of seeds (Singhvi *et al.*, 2001).

Karanja oil at different concentrations ranging from 0.5 to 5 per cent caused 22.5 to 58.6 per cent inhibition of egg hatching on *Clavigrella gibbosa* eggs (Singh, 2002).

Raghavani and Kapadia (2003) conducted a laboratory study showed that karanj (*P. pinnata*) at 2.5, 5.0 and 10.0 ml kg^{-1} protected the pigeon - pea seeds from *C. maculatus* and karanj oil at 5 ml kg^{-1} seed gave more than 94 per cent protection up to four months of storage.

Karanj oil protected the pigeon pea seeds from *C. chinensis* (8 ml kg^{-1}) up to nine months and these oils prevented egg laying and controlled the population build up of beetle (Singh, 2003).

2.4.2 Hydnocarpus (*Hydnocarpus laurifolia*) oil

Petroleum ether extract of seeds of *H. laurifolia* at 1000 ppm showed antifeedant activity against *S. litura* and positive activity is correlated with the per cent content of linoleic and oleic acid in the seed oil (Kumar and Thakur, 1988).

Kumar (1999) reported the effect of seed cake of *H. laurifolia* on green caterpillars of rice. Seed cake and fruits of *H. laurifolia* was effective against rhinoceros beetle, *Oryctes rhinocerus* on coconut (Swapna, 2003).

2.4.3 Cow's urine

Kyorku *et al.* (1990) reported the use of cow's urine as odour bait in traps to attract tse-tse fly, *Glossina longipennis*. At the same time Kangasabhapathi (1991) and Babu (1995) reported the insecticidal property of cow's urine against different insect pests.

Strong repellent activity of cow dung-urine extract against insect pests of cotton was documented (Lingaiah, 1998).

Kasyap (1998) reported the ovipositional deterrency of cow dung-urine-water (3-5 L+ 35 kg+50L) extract on *Helicoverpa armigera* and the spray contributed to the added advantage of ameliorating the crop health and flower retension of the stand by means of trace elements present on it.

The application of cow's urine in rice field reduced the grasshopper infestation (Kumar, 1999), and Swapna (2003) reported the efficiency of diluted cow's urine (ten times) against insect pests of bitter gourd.

2.4.4 Asafoetida (*Feruala foetida*)

Preetha (1997) recorded the effect of asafoetida on rice bug (*L. acuta*) at panicle emergence and grain setting stages.

The latex of *Ferula foetida* dissolved in water provided control of rice aphid (Akhavan, 1998).

Asafoetida plant extract at one to three per cent was applied to an okra crop in the rainy season for the control of the viral vector, *Empoasca devastans in vitro* and in field trial showed strong insect repellent activity against *E. devastans*, leading to reduced yellow vein mosaic viral infection levels (Mishra *et al*., 1999).

Extract of asafoetida (*F. foetida*) was found to be effective against rice bug and sucking pests of bitter gourd (Swapna, 2003).

Materials and Methods

3. MATERIALS AND METHODS

The present study on “Indigenous natural organic materials for the management of major insect pests of rice” was conducted during 2003-2004. The details of materials used and methods followed for the conduct of experiment are presented in the following sections.

3.1 GENERAL DETAILS

3.1.1 Location

Field trial was carried out at A.R.S., Mannuthy. It is located at 10^0 31^1 N latitude and 76^0 13^1 E longitude and altitude of 40.29 m above mean sea level. It is situated about 6 km east of Thrissur on the Southern side of Thrissur – Palakkad National Highway No. 47.

3.1.2 Climate and soil

The area enjoys a typical humid tropical climate and the soil type of the experimental area was laterite loamy sand of the Ultisol group with a pH of 5.3.

3.1.3 Season

The study was taken up during the second crop season (mundakan) during October 2003 to February 2004.

3.1.4 Cropping intensity

The experiment site was a double – cropped wetland in which a semi dry crop (May – September) and wet crop (September – December) are regularly cultivated. The land is usually left fallow during summer season.

3.1.5 Rice variety used

The rice variety used in the experiment was Jyothi (PTB-39), which is of 110-125 days duration. It is a high yielding red kernelled variety with long bold grains and is moderately tolerant to BPH and blast disease. It is susceptible to sheath blight and suitable for transplanting and direct sowing (KAU, 2004).

3.2 EXPERIMENTAL DETAILS

The experiment was laid out in split plot in RBD with seven main plots, three sub plots and three replications. The plot size allocated in each individual treatment was 5m x 4m. The crop was transplanted at a spacing of 15cm x 10 cm. The lay out plan is presented in Fig. 1. The details of treatments followed during the experiment are given below.

Main plot treatments (Organic manures used in the field @ 5 t ha^{-1})

T_1 – Green leaf manuring with mango leaves (*Mangifera indica)*

T_2 – Green leaf manuring with cashew leaves (*Anacardium occidentale*)

T_3 – Green leaf manuring with garadi leaves (*Cleistanthus collinus*)

T_4 – Green leaf manuring with snake wood leaves (*Strychnos nux-vomica*)

T_5 – Green leaf manuring with glycosmis leaves (*Glycosmis pentaphylla*)

T_6 – Green leaf manuring with glyricidia leaves (*Glyricidia maculata*)

T_7 – Cow dung

Sub plot treatments (Organic materials used as spray)

S_1 – Karanj oil (20 ml L^{-1})

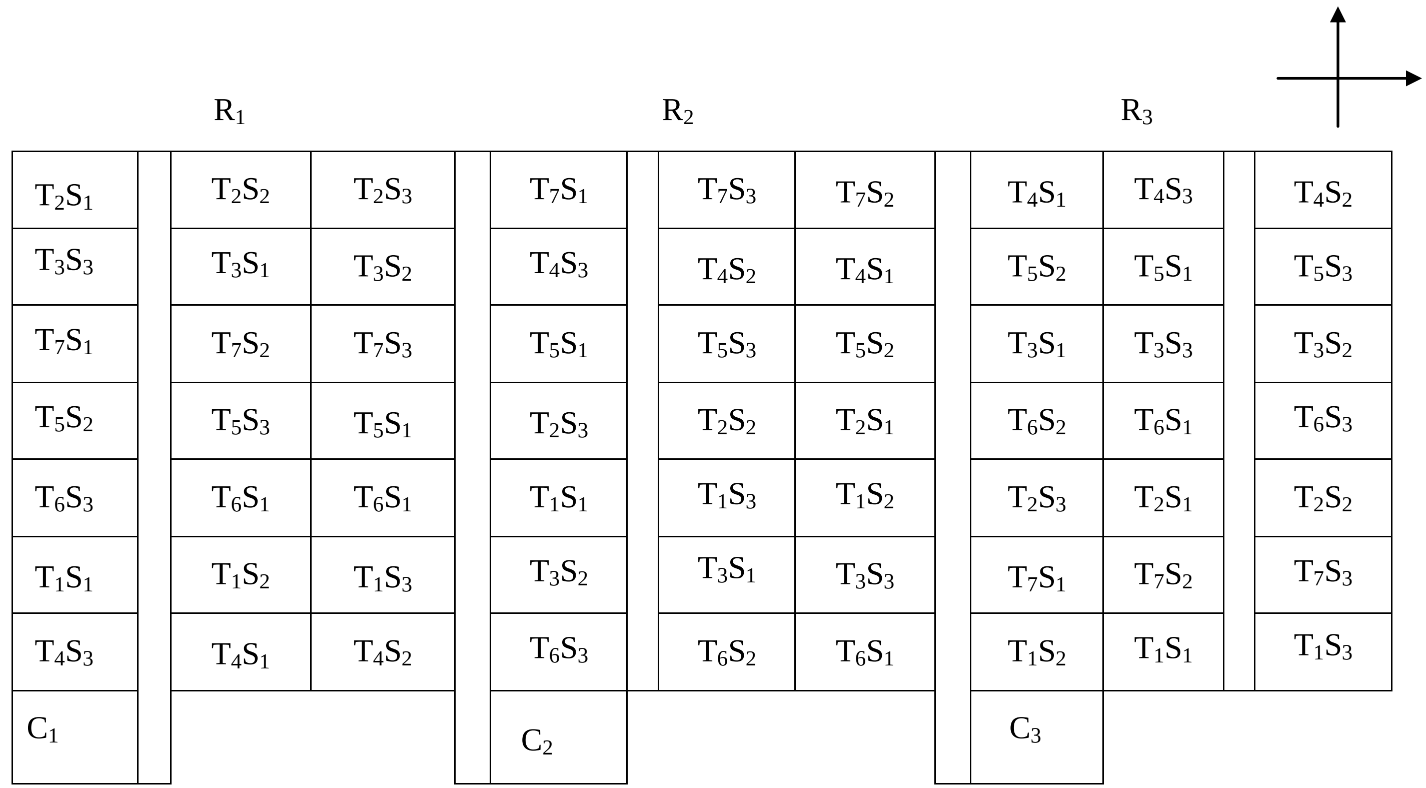
S_2 – Hydnocarpus oil (20 ml L^{-1})

S_3 – Cow's urine + Asafoetida (20 ml + 20 g L^{-1})

Table 1. List of botanicals used in the study

Sl. No	Malayalam name	Common name	Botanical name	Family	Plant part used
1.	*Mavu*	Mango	*Mangifera indica* L.	Anacardiaceae	Leaves
2.	*Kashumavu*	Cashew	*Anacardium occidentale* L. (Kaju.)	Anacardiaceae	Leaves
3.	*Oduku*	Garadi	*Cleistanthus collinus* (Roxb.) Bent &Hook.	Euphorbiaceae	Leaves
4.	*Kanjiram*	Snake wood	*Strychnos nux-vomica* L.	Loganiaceae	Leaves
5.	*Panal*	Glycosmis	*Glycosmis pentaphylla* (Retz.) Correa	Rutaceae	Leaves
6.	*Sheemakonna*	Glyricidia	*Glyricidia maculata* (Jacq.) Syn. *G. sepium* (H.B. &K.) Steud	Leguminosae	Leaves
7.	*Ungu*	Karanj	*Pongamia pinnata* Pierre. Syn. *P. glabra* Vent.	Leguminosae	Seed oil
8.	*Maroti*	Hydnocarpus	*Hydnocarpus laurifolia* (Dennst.) Sleumer Syn. *H. wightiana* (Blume.)	Flacourtiaceae	Seed oil
9.	*Kayam*	Asafoetida	*Ferula foetida* Regel.	Umbelliferae	Latex

Source : CSIR (1950, 1956, 1959, 1969, 1976, 1998)



Main plot (Organic manuring)

T_1 –Mango leaves (*Mangifera indica)*
T_2 – Cashew leaves (*Anacardium occidentale*)
T_3 – Garadi leaves (*Cleistanthus collinus*)
T_4 – Snake wood leaves (*Strychnos nux-vomica*)
T_5 – Glycosmis leaves (*Glycosmis pentaphylla*)
T_6 – Glyricidia leaves (*Glyricidia maculata*)
T_7 – Cowdung

Sub plot (Organic sprays)

S_1- Karanj (*Pongamia pinnata*) oil
S_2- Hydnocarpus (*Hydnocarpus laurifolia*) oil
S_3- Cow's urine+asafoetida(*Ferula foetida*)

Fig. 1. Lay out of the experiment

Plate 1a. General view of the experimental plot (Vegetative stage)

Plate 1b. General view of the experimental plot (Reproductive stage)

A control plot was also laid out in trial and cow dung was used as organic manure. Cultural practices and plant protection measures were followed as per the Package of Practices Recommendations of KAU. Carbofuran was used @ 0.75 kg ai ha^{-1} to control stem borer. Leaf roller was controlled using carbaryl (0.3%). At milky stage of the crop, methyl parathion (0.2%) was used against the sucking pest, rice bug.

Organic manuring was done two weeks before transplanting and the organic spraying was done at three critical stages of the crop *i.e.,* active tillering, maximum tillering and milky stages. Green leaves were collected from different areas and well incorporated into the field.

A pneumatic hand compression knapsack sprayer of nine litre capacity was used for spraying of oils. The volume of the liquid used was at the rate of 500 litres per hectare. Bar soap was used @ 0.5% of spray solution to emulsify the oil.

At 54 DAT, *Pseudomonas fluorescens* (2%) was used for controlling the brown spot disease. At 64 DAT, Carbendazim (0.1%) was used for the control of sheath rot.

3.3 FIELD OPERATIONS

The soil was ploughed using a tractor and individual plots were then made. Organic manures for individual plots were weighed separately and incorporated into the field using spade. Twenty days old seedlings of uniform growth were transplanted at the rate of three seedlings per hill.

The normal fertilizer recommendation for high yielding short duration varieties *viz*., 70:35:35 kg N, P and K per hectare was followed. Full dose of phosphorus was given at the time of incorporation of organic manures. Two third of nitrogen and half dose of potash were given at the time of transplanting. One third dose of nitrogen and another half of potash were given at panicle initiation stage.

Gap filling of missing or dead hills was done on the tenth day after transplanting. Water level was maintained at 5 to 6 cm of standing water in the field. Hand weeding was done at 21 DAT.

Harvesting was done at 100 DAT. Two rows at the periphery of each individual plot was harvested and removed first. The individual plots were then harvested and threshed separately.

3.4 FIELD OBSERVATIONS

3.4.1 Observations on pest incidence

3.4.1.1 Stem borer (Scirpophaga incertulus)

Ten hills were randomly selected from each plot, and number of tillers and dead heart or white ear head was counted. Then the percentage infestation was worked out.

3.4.1.2 Leaf folder (Cnaphaocrocis medinalis)

Total number of leaves and damaged leaves were counted from ten random hills, and percentage of infestation was calculated.

3.4.1.3 Rice bug (Leptocorisa acuta)

Ear heads of ten random hills were examined and number of bugs was expressed as number of bugs hill^{-10}.

3.4.2 Observations on natural enemy population

3.4.2.1 Sweep netting

The sampling of natural enemy population was done using standard sweep net (32 cm diameter). From each 20 m^2 plot, two samples were taken from two locations as three double stroke sweeps. Specimens were identified and number was recorded in the field book. The available published records were referred for the identification of unknown natural enemies with the help of specialists.

3.4.2.2 Visual counting

Population of important predators like mirid bugs, coccinellid beetles, carabid beetles and spiders were recorded randomly from ten hills and was expressed as number of insects $hill^{-10}$.

3.4.3 Observations on disease incidence

3.4.3.1 Per cent disease severity

Severity of disease was worked out using the 0 – 9 SES scale of IRRI (1996). Ten hills were randomly selected avoiding two border rows. Per cent disease severity was calculated using the formula suggested by Wheeler (1969).

$$\text{Per cent disease severity} = \frac{\text{Sum of all numerical ratings x 100}}{\text{No. of hills observed x maximum disease grade}}$$

Scale for brown spot and sheath rot is given below,

Brown spot (BS) (*Helminthosporium oryzae)*

Scale		Description
0	:	No incidence
1	:	Less than 1%
2	:	1 – 3%
3	:	4 – 5%
4	:	6 – 10%
5	:	11 – 15%
6	:	16 – 25%
7	:	26 – 50%
8	:	51 – 75%
9	:	76 – 100%

Sheath rot (Sh R) *(Sarocladium oryzae)*

Scale		Description
0	:	No incidence
1	:	Less than 1%
3	:	1 – 5%
5	:	6 – 25%
7	:	26 – 50%
9	:	51 - 100%

3.4.3.2 Per cent disease incidence

Ten random hills were randomly selected avoiding two border rows. Number of infected tillers was recorded and per cent disease incidence was worked out.

$$\text{Per cent disease incidence} = \frac{\text{No. of tillers infected x 100}}{\text{Total no. of tillers}}$$

3.4.3.3 Co-efficient of disease index (CODEX)

Co-efficient of disease index (CODEX) was calculated by taking into account the disease incidence and disease severity. CODEX value was calculated using the formula suggested by Datar and Mayee (1981).

$$\text{CODEX value} = \frac{\text{Per cent disease incidence x Per cent disease severity}}{100}$$

3.4.4 Observations on weed incidence

The observations on weeds were taken from the sampling strip using a 50 cm x 50 cm (0.25 m^2) iron quadrate. The count of weeds was taken and recorded as number m^{-2}.

3.4.5 Observations on crop growth parameters

Sixteen hills were randomly selected from each plot for recording the growth observations. The following observations were recorded at different growth stages of the crop.

3.4.5.1 Height of the plant

Plant height was measured from the base to the tip of the top most leaf at active tillering stage (ATS) and panicle initiation stage (PIS). At harvest, the height was recorded from the base of the plant to the tip of the longest panicle and the mean height was computed and expressed in cm.

3.4.5.2 ***Number of tillers per plant***

Number of tillers per plant was also recorded at active tillering stage, panicle initiation stage and harvest and the mean number was computed.

3.4.5.3 Days to fifty per cent flowering

Number of days taken by 50 per cent of the plants to come to flowering from the date of sowing was recorded from each plot.

3.4.6 Observations on yield parameters

3.4.6.1 Number of panicles per hill

At harvest, sixteen plants were randomly selected from each plot for counting the number of panicles per hill and the mean number was calculated.

3.4.6.2 Per cent of filled grains

Sixteen panicles were randomly selected and threshed. The number of filled and unfilled grains was counted and average was worked out and expressed in percentage.

3.4.6.3 1000 grain weight

100 uniformly dried grains were counted and weighed. Thousand grain weight was computed from it.

3.4.6.4 Yield of grain and straw

The paddy harvested from each net plot area was harvested, threshed, cleaned, winnowed, dried and weighed. This was expressed as yield of grain in kg ha^{-1}. Straw weight was also expressed as kg ha^{-1}.

3.4.6.5 Grain : Straw ratio

From the paddy harvested from each net plot, grain and straw yield was weighed separately and grain: straw ratio was worked out.

3.4.7 Analysis of data

Data were analysed following the analysis of variance for split plot design (Gomez and Gomez, 1984). Multiple comparisons among treatment means were done using DMRT. To compare treatment combinations with control, ANOVA for RBD was done. Abridged ANOVA of RBD is given in appendix.

Results

4. RESULTS

Field experiment was carried out to evaluate the bio efficacy of botanicals against insect pests of rice *viz.*, stem borer, leaf folder and rice bug. Also an assessement of their relative

- safety to natural enemies
- effect on disease management
- influence on weed population
- effect on crop growth parameters
- effect on yield parameters

were made. The results are presented in this chapter.

4.1 EFFECT OF ORGANIC MATERIALS ON INSECT PESTS OF RICE

4.1.1 Insect pests of rice

The insect pests recorded for the crop raised during second crop (Mundakan) of 2003-04 has been depicted as Table 2.

4.1.2 Effect of natural organic materials on insect pests of rice

Organic manures were incorporated into the rice field at required quantity and different organic sprays were given at three critical stages (*i.e.*, active tillering stage, maximum tillering stage and milky stage) of crop growth to manage the insect pests. The efficacy of treatments on insect pests was compared.

The observations on insect pests before the start of organic sprays were taken at 20 DAT. After that, the observations were taken at regular intervals to compare the treatment combinations with the control (chemical treated plot). At

Table 2. List of insect pests studied during the crop period

Sl. No.	Common name	Scientific name
1.	Yellow stem borer	*Scirpophaga incertulus* (Walker) Lepidoptera: Pyraustidae
2.	Leaf folder	*Cnaphalocrocis medinalis* Guen. Lepidoptera: Pyraustidae
3.	Rice bug	*Leptocorisa acuta* (Thunb.) Hemiptera: Alydidae

Plate 2. Larvae of rice stem borer (*Scirpophaga incertulus*)

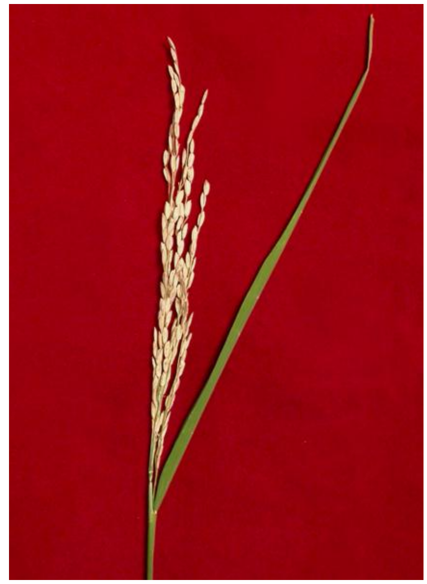


Plate 3. White ear head caused by stem borer (*Scirpophaga incertulus*)

Plate 4. Attack of leaf folder larvae (*Cnaphalocrocis medinalis*)

Plate 5. Adult rice bug (*Leptocorisa acuta*)

this instance, the separate effect of organic manures and sprays on different insect pests was also studied.

4.1.2.1 Stem borer (Scirpophaga incertulus)

The effect of these natural organic materials on stem borer was recorded on the basis of mean per cent of infestation.

4.1.2.1.1 Individual effect of organic manures

The individual effect of organic manures on stem borer infestation was significantly different at all days of observations (Table 3a). At 20 DAT, the infestation of stem borer ranged from 1.29 (T_4) to 7.06 per cent (T_2). T_4 recorded the lowest infestation of stem borer throughout the crop period. T_7 recorded the maximum infestation from 32 DAT to harvest.

4.1.2.1.2 Individual effect of organic sprays

The different organic sprays showed significant influence on stem borer infestation at all days of observations (Table 3a). Before the first spray the mean per cent of infestation ranged from 2.35 to 4.54. In all the treatments, a slight decline of infestation of stem borer was recorded at two DAS consequent to the second spray. At two and 10 DAS, S_2 recorded the lowest infestation (1.56 and 1.10 % respectively) and S_1 recorded the highest infestation (2.61 and 1.75% respectively). Increase in population was recorded upto 20 DAS. A slight reduction in infestation was observed consequent to the second spray and reached its minimum at 10 DAS. The same trend of changes in infestation was noticed in the third spray also. S_2 retained the superiority through out the crop period in the control of stem borer.

Table 3a. Effect of organic manures and sprays on stem borer (*S. incertulus*) infestation (%)

Treatments	Organic manures	First Spray			Second Spray			Third Spray		
	20 DAT	2 DAS (24 DAT)	10 DAS (32 DAT)	20 DAS (42 DAT)	2 DAS (46 DAT)	10 DAS (54 DAT)	20 DAS (64 DAT)	2 DAS (68 DAT)	10 DAS (76 DAT)	20 DAS (86 DAT)
Main plot T_1	1.70 (1.48)^{cd}	1.25 (1.26)^{d}	0.59 (1.02)^{e}	2.92 (1.83)^{b}	2.76 (1.80)^{f}	1.37 (1.36)^{f}	8.43 (2.90)^{b}	8.25 (2.88)^{d}	4.99 (2.32)^{b}	2.59 (1.75)^{b}
T_2	7.06 (2.50)^{a}	3.14 (1.89)^{a}	1.94 (1.54)^{b}	5.52 (2.41)^{a}	5.16 (2.37)^{b}	2.65 (1.77)^{b}	5.70 (2.46)^{c}	5.67 (2.46)^{e}	4.84 (2.31)^{bc}	1.78 (1.50)^{d}
T_3	3.46 (1.97)^{bc}	3.09 (1.88)^{a}	2.18 (1.61)^{a}	4.67 (2.28)^{ab}	4.54 (2.24)^{c}	2.50 (1.71)^{c}	4.31 (2.19)^{d}	8.07 (2.93)^{c}	2.52 (1.74)^{bc}	1.57 (1.43)^{e}
T_4	1.29 (1.28)^{d}	1.01 (1.17)^{e}	0.59 (0.97)^{e}	3.18 (1.93)^{b}	2.29 (1.84)^{f}	0.86 (1.12)^{g}	3.72 (2.04)^{e}	3.17 (1.90)^{g}	2.23 (1.61)^{c}	1.53 (1.41)^{e}
T_5	2.78 (1.80)^{bc}	1.95 (1.55)^{c}	1.65 (1.46)^{c}	4.60 (2.29)^{ab}	4.34 (2.19)^{d}	2.19 (1.63)^{d}	10.62 (3.32)^{a}	10.12 (3.25)^{b}	4.35 (2.20)^{bc}	2.38 (1.69)^{c}
T_6	2.87 (1.83)^{bc}	1.85 (1.52)^{c}	1.43 (1.39)^{d}	4.32 (2.35)^{ab}	3.99 (2.11)^{e}	1.97 (1.57)^{e}	6.07 (2.50)^{c}	5.66 (2.42)^{f}	2.73 (1.77)^{bc}	1.44 (1.38)^{f}
T_7	3.90 (2.09)^{ab}	2.93 (1.84)^{b}	2.26 (1.65)^{a}	5.54 (2.45)^{a}	5.54 (2.45)^{a}	3.67 (2.03)^{a}	10.70 (3.34)^{a}	10.60 (3.30)^{a}	10.92 (3.00)^{a}	3.45 (1.99)^{a}
Sub plot S_1	4.54 (2.06)$_{a}$	2.61 (1.74)$_{a}$	1.75 (1.45)$_{a}$	4.27 (2.16)$_{ab}$	4.20 (2.15)$_{b}$	2.57 (1.72)$_{a}$	7.55 (2.75)$_{b}$	7.76 (2.80)$_{b}$	3.81 (2.03)$_{b}$	2.15 (1.60)$_{a}$
S_2	2.35 (1.63)$_{b}$	1.56 (1.36)$_{c}$	1.10 (1.22)$_{b}$	4.14 (2.13)$_{b}$	3.80 (2.06)$_{c}$	1.71 (1.44)$_{c}$	5.95 (2.45)$_{c}$	6.37 (2.52)$_{c}$	3.47 (1.95)$_{b}$	2.13 (1.59)$_{ab}$
S_3	3.00 (1.85)$_{ab}$	2.34 (1.67)$_{b}$	1.71 (1.45)$_{a}$	4.72 (2.25)$_{a}$	4.56 (2.23)$_{a}$	2.23 (1.63)$_{b}$	7.73 (2.84)$_{a}$	7.96 (2.89)$_{a}$	6.68 (2.43)$_{a}$	2.05 (1.58)$_{b}$

The values followed by same letters do not differ significantly in DMRT P=(0.05)

DMRT is given in superscript italics- Main plot; Subscript - Subplot

Transformed values are given in parenthesis.

DAS – Days after spraying DAT – Days after transplanting

4.1.2.1.3 Interaction effect of organic manures and sprays

The interaction effect of organic manures and sprays was also significant throughout the observations (Table 3b). Before the first spray, mean per cent of infestation ranged from 0.00 (T_4S_2) to 5.59 (T_2S_1). A slight decline of infestation was observed from the second day of spraying and declining trend continued up to the tenth day of spraying. At second and tenth day after spraying, T_4S_2 gave the best result, as there was no infestation recorded. At two DAS, T_2S_1 recorded the maximum infestation of 5.02 per cent. From the twelfth day there was a slight increase in the infestation of stem borer, which gradually increased up to 20 DAS. The treatment T_4S_2 retained the superiority by maintaining the minimum infestation of 2.30 per cent. The maximum infestation was recorded in T_7S_1 (6.90%). Then, a decline in infestation noticed consequent to the second spray. Two days after the second spray, the lowest infestation was noticed in T_4S_1 (2.14%), which was on par with T_4S_2 (2.18%). At 10 DAS, also T_4S_2 and T_4S_1 were the best treatments (0.67% and 1.00% respectively). T_7S_1 recorded the maximum infestation of 6.81 and 4.79 per cent respectively at two and 10 DAS. All the treatments showed high infestation at 20 DAS. However, T_4S_2 recorded the minimum infestation of 2.88 per cent and T_5S_2 had the maximum infestation of 12.44 per cent. After the third spray the infestation of stem borer decreased up to harvest. The mean per cent of infestation was low in T_4S_2 and T_4S_1 throughout the crop period.

4.1.2.1.4 Comparison of treatment combinations with control

The treatment combinations were compared with control to know the superior treatments (Table 3b). At two days after the first spray, a slight decline in infestation was observed in control (3.24%). At 10 DAS, the per cent reduction in infestation in control was as high as compared to the botanicals. T_1S_3 (0.77%), T_4S_2 and T_4S_1 (0.00%) were superior to control (1.00%). At 20 DAS, the infestation, in control was higher than all other treatment combinations (7.00%). At ten days after the second spray a steep decline in infestation was observed

Table 3b. Interaction effect of organic manures and sprays on stem borer (*S. incertulus*) infestation (%)

Treatments	Organic manure (20 DAT)	First spray			Second spray			Third spray		
		2DAS (24 DAT)	10 DAS (32 DAT)	20 DAS (42 DAT)	2DAS (46 DAT)	10 DAS (54 DAT)	20 DAS (64 DAT)	2DAS (68 DAT)	10 DAS (76DAT)	20 DAS (86DAT)
T_1S_1	1.97 (1.57)^{bcd}	1.90 (1.53)^{h}	1.00 (1.22)^{g}	3.25 (1.93)^{h}	3.15 (1.91)^{h}	1.99 (1.57)^{fg}	3.36 (1.95)^{l}	3.32 (2.01)^{l}	6.93 (2.73)^{b}	2.30 (1.67)^{c}
T_1S_2	1.36 (1.35)^{cd}	1.20 (1.30)^{j}	0.00 (0.71)^{i}	2.50 (1.72)^{j}	2.35 (1.69)^{j}	0.93 (1.20)^{j}	3.32 (2.01)^{k}	3.56 (2.02)^{k}	3.13 (1.91)^{bc}	3.34 (1.96)^{ab}
T_1S_3	1.78 (1.51)^{bcd}	1.70 (1.51)^{i}	0.77 (1.13)^{h}	3.00 (1.92)^{i}	2.79 (1.81)^{i}	1.20 (1.30)^{i}	8.53 (2.95)^{g}	8.04 (2.92)^{g}	4.90 (2.32)^{bc}	2.13 (1.62)^{cd}
T_2S_1	5.59 (2.45)^{a}	5.02 (2.64)^{a}	1.41 (1.38)^{e}	4.58 (2.23)^{def}	I4.34 (2.20)^{def}	2.27 (1.66)^{ef}	4.48 (2.28)^{i}	4.62 (2.26)^{i}	4.56 (2.25)^{bc}	2.22 (1.65)^{c}
T_2S_2	3.11 (1.90)^{bc}	2.03 (1.59)^{gh}	1.20 (1.30)^{f}	5.00 (2.60)^{ef}	4.22 (2.17)^{ef}	2.40 (1.70)^{de}	4.32 (2.20)^{j}	4.27 (2.19)^{j}	4.80 (2.30)^{bc}	1.97 (1.57)^{de}
T_2S_3	5.15 (2.38)^{b}	4.28 (2.19)^{ab}	3.20 (1.92)^{b}	6.99 (2.75)^{a}	6.93 (2.73)^{a}	3.28 (1.95)^{bc}	8.29 (2.96)^{g}	8.11 (2.93)^{g}	5.16 (23.8)^{bc}	1.14 (1.28)^{g}
T_3S_1	4.95 (2.34)^{b}	4.01 (2.12)^{b}	3.47 (1.99)^{a}	4.80 (2.34)^{d}	4.69 (2.28)^{d}	3.57 (2.02)^{b}	7.47 (2.82)^{h}	7.38 (2.81)^{h}	2.14 (1.62)^{bc}	1.32 (1.35)^{f}
T_3S_2	3.30 (1.95)^{bc}	3.08 (1.89)^{c}	1.87 (1.54)^{d}	5.25 (2.39)^{c}	5.11 (2.37)^{c}	2.71 (1.79)^{d}	8.13 (2.95)^{g}	8.22 (2.95)^{g}	2.93 (1.85)^{bc}	2.14 (1.63)^{cd}
T_3S_3	2.13 (1.62)^{bc}	2.17 (1.63)^{fg}	1.20 (1.31)^{f}	3.95 (2.12)^{g}	3.82 (2.07)^{g}	1.21 (1.31)^{i}	8.32 (3.03)^{f}	8.61 (3.02)^{f}	2.49 (1.73)^{bc}	1.25 (1.32)^{fg}
T_4S_1	1.12 (1.27)^{cd}	0.97 (1.21)^{k}	0.00 (0.71)^{i}	2.50 (1.73)^{j}	2.14 (1.62)^{j}	1.00 (1.10)^{k}	3.36 (1.95)^{l}	3.22 (1.93)^{l}	1.27 (1.33)^{c}	1.14 (1.28)^{g}
T_4S_2	0.00 (0.71)^{d}	0.00 (0.71)^{l}	0.00 (0.71)^{i}	2.30 (1.71)^{j}	2.18 (1.64)^{j}	0.67 (1.00)^{k}	2.88 (1.89)^{m}	2.01 (1.59)^{m}	1.37 (1.37)^{c}	1.20 (1.31)^{fg}
T_4S_3	2.74 (1.80)^{bc}	2.05 (1.60)^{gh}	1.78 (1.51)^{d}	4.75 (2.31)^{d}	4.63 (2.27)^{d}	1.88 (1.54)^{g}	4.92 (2.37)^{j}	4.28 (2.19)^{j}	4.07 (2.14)^{bc}	2.25 (1.66)^{c}
T_5S_1	2.37 (1.70)^{bc}	2.12 (1.62)^{fgh}	1.71 (1.49)^{d}	4.24 (2.25)^{fg}	4.07 (2.14)^{fg}	2.63 (1.77)^{d}	11.25 (3.41)^{d}	10.48 (3.31)^{d}	4.41 (2.22)^{bc}	3.21 (1.93)^{b}
T_5S_2	2.11 (1.62) ^{bc}	1.12 (1.27)^{j}	1.03 (1.24)^{g}	3.60 (1.99)^{h}	3.11 (1.90)^{h}	1.27 (1.33)^{i}	12.44 (3.58)^{a}	12.28 (3.58)^{a}	4.36 (2.20)^{bc}	2.11 (1.62)^{cd}
T_5S_3	3.87 (2.09)^{bc}	2.62 (1.77)^{d}	2.12 (1.65)^{c}	5.95 (2.59)^{b}	5.84 (2.52)^{b}	2.68 (1.78)^{d}	8.15 (2.96)^{h}	7.61 (2.85)^{h}	4.29 (2.19)^{bc}	1.83 (1.53)^{e}
T_6S_1	3.36 (1.96)^{bc}	2.28 (1.67)^{ef}	1.47 (1.40)^{e}	4.50 (2.42)^{ef}	4.20 (2.17)^{ef}	2.08 (1.61)^{efg}	4.52 (2.31)^{j}	4.30 (2.19)^{j}	2.27 (1.66)^{bc}	1.28 (1.33)^{fg}
T_6S_2	2.10 (1.61)^{bc}	1.13 (1.28)^{j}	1.03 (1.24)^{g}	3.60 (2.00)^{h}	3.26 (1.94)^{h}	1.57 (1.43)^{h}	3.37 (1.91)^{l}	3.07 (1.89)^{l}	1.66 (1.47)^{c}	0.87 (1.17)^{g}
T_6S_3	3.15 (1.91)^{bc}	2.13 (1.62)^{fgh}	1.80 (1.52)^{d}	4.85 (2.39)^{de}	4.50 (2.24)^{de}	2.25 (1.66)^{cdef}	10.32 (3.21)^{e}	9.59 (3.18)^{e}	4.27 (2.19)^{bc}	2.17 (1.63)^{c}
T_7S_1	5.12 (2.37)^{b}	3.85 (2.09)^{b}	3.21 (1.93)^{b}	6.90 (2.75)^{a}	6.81 (2.70)^{a}	4.79 (2.30)^{a}	11.33 (3.45)^{b}	11.16 (3.41)^{c}	5.07 (2.36)^{bc}	3.55 (2.01)^{a}
T_7S_2	3.41 (1.98)^{bc}	2.58 (1.76)^{d}	1.80 (1.52)^{d}	5.50 (2.41)^{c}	5.15 (2.38)^{c}	3.11 (1.90)^{c}	11.16 (3.43)^{c}	11.14 (3.41)^{bc}	6.07 (2.56)^{bc}	3.25 (1.94)^{b}
T_7S_3	3.16 (1.91)^{bc}	2.35 (1.69)^{e}	1.76 (1.50)^{d}	4.80 (2.32)^{d}	4.65 (2.27)^{d}	3.11 (1.90)^{c}	9.60 (3.19)^{e}	9.50 (3.16)^{e}	5.50 (4.08)^{a}	3.55 (2.01)^{a}
Control +	3.73 (2.06)	3.24 (1.94)	1.00 (1.10)	7.00 (2.79)	5.20 (2.38)	1.23 (1.32)	12.45 (3.59)	11.40 (3.45)	3.10 (1.89)	3.55 (2.01)

The values followed by same letters do not differ significantly in DMRT P=(0.05). Transformed values are given in parenthesis.
+Abridged ANOVA is given in appendix

(1.23%). Here, also the per cent reduction in infestation was high as compared to the botanicals. At 20 DAS, the infestation of stem borer increased to its maximum in control (12.45%), which was on par with T_5S_2 (12.44%). The chemicals gave quick results in the control of stem borer. But the infestation was high after a lapse of 20 days

4.1.2.2 Leaf folder (Cnaphalocrocis medinalis)

4.1.2.2.1 Individual effect of organic manures

Organic manures showed significant influence on infestation of leaf folder (Table 4a). At 20 DAT, T_3 recorded the lowest infestation (2.29 %). The infestation of leaf folder in T_2 was high (6.05 %). At 24 DAT, T_3 recorded the minimum infestation (1.82 %), followed by T_1 (2.24 %) and T_4 (2.47 %). T_4 recorded the minimum leaf folder infestation at 32 and 42 DAT (1.08 and 2.46% respectively). At the same time, maximum infestation was recorded in T_2 (4.38 and 9.79% respectively). At 46 DAT, the lowest infestation of leaf folder was recorded in T_3 (2.10%), followed by T_4 (2.34 %). T_2 recorded the highest infestation of leaf folder (9.23%). At 54 DAT, the mean per cent of infestation varied from 1.66 (T_4) to 3.99 (T_7). T_4 was the best treatment at 64 DAT, (0.96%) which was on par with T_3 (0.97%). Maximum infestation of leaf folder was noticed in T_7 (3.01%).

4.1.2.2.2 Individual effect of organic sprays

The individual effect of organic manures on infestation of leaf folder has been depicted as Table 4a. Before the first spray, the mean per cent of infestation ranged from 4.00 to 4.78. A slight decline in infestation of leaf folder was recorded at two DAS in all the treatments. S_2 recorded the lowest infestation (3.78%). At 10 DAS, the infestation of leaf folder was on par. Then, the infestation increased to its maximum at 20 DAS. S_2 recorded the minimum infestation (5.84%) and the maximum infestation noticed in S_1 (7.68 %). After the

Table 4a. Effect of organic manures and sprays on leaf folder (*C. medinalis*) infestation (%)

Treatments	Organic manures	First Spray			Second Spray		
	20 DAT	2 DAS (24 DAT)	10 DAS (32 DAT)	20 DAS (42 DAT)	2 DAS (46 DAT)	10 DAS (54 DAT)	20 DAS (64 DAT)
Main plot T_1	3.27 (1.94)^{d}	2.24 (1.66)^{f}	2.30 (1.66)^{c}	7.82 (2.88)^{c}	6.26 (2.57)^{c}	3.76 (2.04)^{c}	2.08 (1.59)^{c}
T_2	6.05 (2.56)^{a}	5.83 (2.52)^{a}	4.38 (2.20)^{a}	9.79 (3.19)^{a}	9.23 (3.09)^{a}	3.75 (2.03)^{c}	2.22 (1.63)^{c}
T_3	2.29 (1.65)^{f}	1.82 (1.51)^{g}	1.55 (1.42)^{d}	2.56 (1.75)^{e}	2.10 (1.61)^{d}	1.79 (1.51)^{e}	0.97 (1.21)^{d}
T_4	2.58 (1.75)^{e}	2.47 (1.72)^{e}	1.08 (1.25)^{e}	2.46 (1.71)^{f}	2.34 (1.68)^{d}	1.66 (1.46)^{f}	0.96 (1.20)^{d}
T_5	5.60 (2.47)^{b}	5.50 (2.45)^{b}	1.69 (1.47)^{d}	7.10 (2.75)^{d}	6.71 (2.68)^{c}	3.98 (2.11)^{a}	2.03 (1.59)^{c}
T_6	4.93 (2.33)^{c}	4.65 (2.27)^{d}	2.96 (1.84)^{b}	6.97 (2.73)^{d}	6.33 (2.61)^{c}	3.52 (2.00)^{d}	2.62 (1.77)^{b}
T_7	5.94 (2.53)^{ab}	5.22 (2.39)^{c}	4.11 (2.16)^{a}	9.28 (3.10)^{b}	8.23 (2.92)^{b}	3.99 (2.22)^{a}	3.01 (1.86)^{a}
Sub plot S_1	4.78 (2.27)$_{a}$	4.24 (2.14)$_{a}$	2.60 (1.78)$_{a}$	7.68 (2.78)$_{a}$	6.96 (2.65)$_{a}$	3.66 (2.00)$_{a}$	2.35 (1.66)$_{a}$
S_2	4.36 (2.17)$_{b}$	3.78 (2.02)$_{c}$	2.60 (1.78)$_{a}$	5.84 (3.47)$_{c}$	5.22 (2.32)$_{c}$	2.64 (1.76)$_{c}$	1.80 (1.48)$_{c}$
S_3	4.00 (2.08)$_{c}$	3.86 (2.05)$_{b}$	2.56 (1.75)$_{a}$	6.18 (2.51)$_{b}$	5.48 (2.39)$_{b}$	3.25 (1.91)$_{b}$	1.85 (1.52)$_{b}$

The values followed by same letters do not differ significantly in DMRT P=(0.05)

DMRT is given in superscript italics- Main plot; Subscript - Subplot

Transformed values are given in parenthesis

DAS – Days after spraying DAT – Days after transplanting

second spray, infestation decreased up to 20 DAS. However, at all days of observations S_2 recorded the lowest infestation of leaf folder (5.22, 2.64 and 1.80% respectively). At the same time, the highest infestation was recorded in S_1 (6.96, 3.66 and 2.35% respectively).

4.1.2.2.3 Interaction effect of organic manures and sprays

The result of interaction effect of organic manures and sprays is given as Table 4b. Before the first spray, the mean per cent of infestation ranged from 1.39 (T_3S_3) to 7.07 (T_7S_1) per cent. A slight decline in infestation was observed consequent to the spray. T_3S_3 recorded the lowest infestation (1.13%) and the highest infestation was observed in T_5S_3 (6.13%). The infestation reached its minimum at 10 DAS and the lowest infestation noticed in T_4S_2 (0.77%). Then, the infestation increased up to 20 DAS. T_4S_2 was the best treatment (1.80%), followed by T_3S_3 (2.11%). After the second spray, again a decline in infestation of leaf folder was noticed. At two, 10 and 20 DAS also T_4S_2 recorded the lowest infestation of leaf folder (1.72, 1.17 and 0.66 % respectively).

4.1.2.2.4 Comparison of treatment combinations with control

At two days after the first spray, a slight decline in infestation was noticed in control (6.30 to 5.23%). At 10 DAS the infestation reduced considerably in control (1.38%). The per cent reduction in infestation was high in control as compared to the botanicals. But, the infestation again increased to its maximum (11.77%). After the second spray, also the same trend was observed. The infestation reduced from 11.77 to 1.13 per cent at 10 DAS. Then the infestation of leaf folder increased to 4.22 per cent at 20 DAS (Table 4b).

Table 4b. Interaction effect of organic manures and sprays on leaf folder (*C. medinalis*) infestation (%)

Treatments	Organic manure (20 DAT)	First spray			Second spray		
		2DAS (24 DAT)	10 DAS (32 DAT)	20 DAS (42 DAT)	2DAS (46 DAT)	10 DAS (54 DAT)	20 DAS (64 DAT)
T_1S_1	3.17 (1.92)^{g}	2.23 (1.65)^{gh}	2.63 (1.77)^{ef}	8.86 (3.06)^{d}	7.29 (2.79)^{c}	4.17 (2.16)^{d}	2.92 (1.85)^{c}
T_1S_2	3.27 (1.94)^{g}	2.20 (1.64)^{gh}	1.50 (1.41)^{h}	6.57 (2.66)^{hi}	3.69 (2.05)^{fg}	2.17 (1.63)^{i}	1.13 (1.28)^{hi}
T_1S_3	3.38 (1.97)^{g}	2.30 (1.67) ^{g}	2.79 (1.81)^{e}	8.02 (2.92)^{e}	7.80 (2.88)^{c}	4.93 (2.33)^{b}	2.20 (1.64)^{ef}
T_2S_1	6.34 (2.62)^{b}	6.18 (2.59)^{a}	5.72 (2.50)^{a}	12.16 (3.56)^{a}	12.00 (3.54)^{a}	5.76 (2.50)^{a}	3.28 (1.94)^{b}
T_2S_2	6.29 (2.61)^{bc}	6.11 (2.57)^{a}	3.31 (1.95)^{d}	10.40 (3.30)^{b}	9.85 (3.22)^{bc}	2.99 (1.87)^{g}	2.13 (1.62)^{ef}
T_2S_3	5.53 (2.46)^{d}	5.21 (2.39)^{c}	4.11 (2.15)^{c}	6.82 (2.71)^{gh}	5.84 (2.52)^{e}	2.51 (1.74)^{h}	1.23 (1.31)^{hi}
T_3S_1	3.20 (1.91)^{g}	2.20 (1.64) ^{gh}	0.91 (1.19)^{j}	2.97 (1.86)^{k}	2.30 (1.67)^{g}	1.23 (1.32)^{l}	0.99 (1.22)^{i}
T_3S_2	2.27 (1.66)^{h}	2.13 (1.62) ^{gh}	2.34 (1.69)^{fg}	2.06 (1.76)^{l}	2.00 (1.58)^{g}	2.20 (1.64))^{i}	0.62 (1.05)^{j}
T_3S_3	1.39 (1.37)^{i}	1.13 (1.28)^{i}	1.41 (1.38)^{hi}	2.11 (1.62)^{m}	2.00 (1.58)^{g}	1.94 (1.56)^{j}	1.31 (1.34)^{h}
T_4S_1	3.31 (1.95)^{g}	3.12 (1.90)^{f}	1.30 (1.34)^{hi}	2.99 (1.87)^{k}	3.00 (1.87)^{fg}	2.10 (1.61)^{i}	1.35 (1.36)^{h}
T_4S_2	2.17 (1.63)^{h}	2.20 (1.64)) ^{gh}	0.77 (1.12)^{j}	1.80 (1.52)^{n}	1.72 (1.49)^{h}	1.17 (1.29)^{l}	0.66 (1.07)^{j}
T_4S_3	2.27 (1.66)^{h}	2.09 (1.61) ^{h}	1.17 (1.29)^{i}	2.58 (1.76)^{l}	2.31 (1.68)^{g}	1.71 (1.49))^{k}	1.17 (1.29)^{hi}
T_5S_1	5.57 (2.46)^{d}	5.65 (2.48)^{b}	1.30 (1.34)^{hi}	7.44 (2.82)^{f}	6.89 (2.72)^{de}	4.48 (2.23)^{c}	1.78 (1.51)^{g}
T_5S_2	5.60 (2.47)^{cd}	4.73 (2.29)^{d}	1.33 (1.35)^{hi}	5.88 (2.53)^{j}	5.23 (2.39)^{e}	3.23 (1.93)^{f}	2.07 (1.60)^{fg}
T_5S_3	5.63 (2.48)^{bcd}	6.13 (2.58)^{a}	2.43 (1.71)^{fg}	7.98 (2.91)^{e}	8.00 (2.92)^{c}	4.23 (2.18)^{cd}	2.23 (1.65)^{ef}
T_6S_1	4.81 (2.30)^{ef}	4.21 (2.17)^{e}	2.18 (1.63)^{g}	6.99 (2.74)^{g}	5.85 (2.52)^{e}	3.17 (1.92)^{fg}	2.47 (1.72)^{de}
T_6S_2	4.61 (2.26)^{f}	4.26 (2.18)^{e}	4.27 (2.18)^{c}	6.51 (2.65)^{i}	6.00 (2.55)^{de}	3.07 (1.89)^{fg}	2.06 (1.76)^{cd}
T_6S_3	5.36 (2.42)^{de}	5.47 (2.44)^{bc}	2.44 (1.71)^{fg}	7.40 (2.81)^{f}	7.15 (2.77)^{c}	4.33 (2.20)^{cd}	2.80 (1.82)^{cd}
T_7S_1	7.07 (2.75)^{a}	6.09 (2.57)^{a}	4.19 (2.17)^{c}	12.37 (3.59)^{a}	11.40 (3.45)^{b}	4.73 (2.29)^{b}	3.67 (2.04)^{a}
T_7S_2	6.34 (2.62)^{b}	5.42 (2.43)^{bc}	4.69 (2.28)^{b}	9.52 (3.17)^{c}	8.05 (2.92)^{c}	3.65 (2.04)^{e}	3.39 (1.97)^{ab}
T_7S_3	4.41 (2.22)	4.14 (2.16)^{e}	3.59 (2.02)^{d}	5.94 (2.54)^{j}	5.23 (2.39)^{e}	3.11 (1.90)^{fg}	1.97 (1.57)^{fg}
Control +	6.30 (2.61)	5.23 (2.39)	1.38 (1.37)	11.77 (3.50)	9.43 (3.15)	1.13 (1.28)	4.22 (2.17)

The values followed by same letters do not differ significantly in DMRT P=(0.05). Transformed values are given in parenthesis.

+Abridged ANOVA is given in appendix

4.1.2.3 Rice bug (Leptocorisa acuta)

4.1.2.3.1 Individual effect of organic manures

The effect of organic manures on count of rice bug was recorded from 54 DAT onwards (Table 5a). At 54 DAT, the population of rice bug was minimum in T_1 (0.22 insects hill^{-10}), whereas T_6 recorded the maximum (1.56 insects hill^{-10}). After a lapse of 10 days, the population was increased. At 64 DAT, T_1 retained the superiority, where the lowest population of rice bug was recorded (2.78 insects hill^{-10}). T_2 recorded the highest count (4.89 insects hill^{-10}). Then, a decline in population was noticed at 68 DAT. At 68 and 76 DAT, also T_1 recorded the lowest population of 2.00 and 2.44 per cent. At 68 DAT, T_7 recorded the maximum population (3.22 insects hill^{-10}). Then the maximum count was noticed in T_2 at 76 DAT (4.11 insects hill^{-10}).

4.1.2.3.2 Individual effect of organic sprays

The individual effect of organic sprays on the population of rice bug is presented in Table 5a. The different organic sprays exhibited significant influence on count of rice bug at two and 10 DAS. Before the spray, the count of rice bug in all plots was statistically on par. Then, a declining phase was noticed up to the harvest. At two and 10 DAS, the lowest population of rice bug was recorded in S_3 (1.41 and 2.00 insects hill^{-10} respectively), whereas S_1 recorded the highest value (2.62 and 3.38 insects hill^{-10}). At 20 DAS the population of rice bug did not vary among the treatments.

4.1.2.3.3 Interaction effect of organic manures and sprays

The interaction effect of organic manures and sprays was found to be significant on the population of rice bug at 10 and 20 days after the spray (Table 5b). Before the spray, the mean values ranged from 2.67 (T_1S_1 and T_1S_3) to 6.00

Table 5a . Effect of organic manures and sprays on rice bug *(L. acuta*)
(mean number hill $^{-10}$)

Treatments	Pre treatment count		Third spray		
	10 days before the treatment (54 DAT)	2 days before the treatment (64 DAT)	2 DAS (68 DAT)	10 DAS (76 DAT)	20 DAS (86 DAT)
Main plot T_1	0.22 $(0.82)^{b}$	2.78 $(1.77)^{b}$	2.00 $(1.51)^{b}$	2.44 $(1.70)^{b}$	1.00 $(1.19)^{a}$
T_2	1.00 $(1.19)^{ab}$	4.89 $(2.29)^{a}$	3.00 $(1.84)^{a}$	4.11 $(2.12)^{a}$	1.22 $(1.27)^{a}$
T_3	1.00 $(1.19)^{ab}$	4.33 $(2.16)^{ab}$	3.00 $(1.84)^{a}$	3.78 $(2.04)^{a}$	1.00 $(1.19)^{a}$
T_4	0.44 $(0.92)^{b}$	3.78 $(2.05)^{ab}$	2.00 $(1.51)^{b}$	2.89 $(1.83)^{ab}$	1.00 $(1.19)^{a}$
T_5	1.00 $(1.19)^{ab}$	4.78 $(2.29)^{a}$	1.89 $(1.45)^{ab}$	3.00 $(1.83)^{ab}$	1.22 $(1.27)^{a}$
T_6	1.56 $(1.34)^{a}$	4.22 $(2.12)^{ab}$	2.67 $(1.65)^{ab}$	3.78 $(2.03)^{a}$	1.56 $(1.40)^{a}$
T_7	1.44 $(1.33)^{a}$	3.67 $(2.03)^{ab}$	3.22 $(1.81)^{a}$	3.11 $(1.88)^{ab}$	1.44 $(1.34)^{a}$
Sub plot S_1	1.29 $(1.26)_{a}$	3.86 $(2.05)_{a}$	2.62 $(1.67)_{a}$	3.38 $(1.93)_{a}$	1.14 $(1.23)_{a}$
S_2	0.86 $(1.11)_{a}$	4.57 $(2.21)_{a}$	2.00 $(1.51)_{a}$	3.19 $(1.88)_{a}$	1.24 $(1.26)_{a}$
S_3	0.71 $(1.73)_{a}$	2.16 $(1.52)_{a}$	1.41 $(1.34)_{b}$	2.00 $(1.48)_{b}$	1.22 $(1.27)_{a}$

The values followed by same letters do not differ significantly in DMRT P=(0.05)

Transformed values are given in parenthesis

DMRT is given in superscript italics- Main plot; Subscript - Subplot

DAS – Days after spraying DAT – Days after transplanting

Table 5b . Interaction effect of organic manures and sprays on rice bug (*L. acuta*)

(mean number hill $^{-10}$)

Treatments	Pre treatment count		Third spray		
	12 days before the spray (54 DAT)	2 days before the spray (64 DAT)	2DAS (68 DAT)	10DAS (76 DAT)	20 DAS (86 DAT)
T_1S_1	0.33 (0.88)^{b}	2.67 (1.74)^{b}	2.00 (1.52)^{ab}	2.33 (1.66)^{d}	1.00 (1.17)^{a}
T_1S_2	0.33 (0.88)^{b}	3.00 (1.82)^{ab}	2.00 (1.48)^{ab}	2.00 (1.48)^{d}	1.67 (1.35)^{a}
T_1S_3	0.00 (0.71)^{b}	2.67 (1.74)^{b}	1.67 (1.46)^{ab}	2.00 (1.48)^{d}	1.00 (1.17)^{a}
T_2S_1	1.00 (1.17)^{ab}	5.00 (2.35)^{a}b	2.33 (1.66)^{ab}	4.67 (2.27)^{a}	1.00 (1.17)^{a}
T_2S_2	1.33 (1.34)^{ab}	6.00 (2.53)^{a}	2.00 (1.48)^{ab}	4.33 (2.16)^{a}	1.33 (1.29)^{a}
T_2S_3	0.67 (0.98)^{b}	3.67 (2.00)^{ab}	3.00 (1.86)^{ab}	3.33 (1.94)^{bc}	1.33 (1.29)^{a}
T_3S_1	1.33 (1.34)^{ab}	5.00 (2.30)^{ab}	3.00 (1.86)^{ab}	4.33 (2.18)^{a}	1.33 (1.29)^{a}
T_3S_2	1.00 (1.17)^{ab}	3.67 (1.97)^{ab}	2.33 (1.66)^{ab}	3.33 (1.94)^{bc}	1.33 (1.29)^{a}
T_3S_3	0.67 (1.05)^{b}	4.33 (2.20)^{ab}	3.67 (2.00)^{ab}	3.67 (2.03)^{abc}	1.33 (1.29)^{a}
T_4S_1	0.67 (1.00)^{b}	4.00 (2.12)^{ab}	2.67 (1.72)^{ab}	3.33 (1.94)^{abc}	1.00 (1.17)^{a}
T_4S_2	0.67 (1.05)^{b}	4.00 (2.08)^{ab}	1.00 (1.17)^{b}	2.33 (1.68)^{d}	1.00 (1.17)^{a}
T_4S_3	0.00 (0.71)^{b}	3.33 (1.94)^{ab}	2.33 (1.64)^{ab}	3.00 (1.87)^{bc}	1.00 (1.17)^{a}
T_5S_1	1.33 (1.29)^{ab}	4.00 (2.12)^{ab}	2.00 (1.56)^{ab}	2.67 (1.77)^{cd}	0.67 (1.05)^{a}
T_5S_2	0.00 (0.71)^{b}	6.00 (2.53)^{a}	1.67 (1.46)^{ab}	3.33 (1.94)^{bc}	1.67 (1.46)^{a}
T_5S_3	1.67 (1.46)^{ab}	4.33 (2.20)^{ab}	2.00 (1.32)^{ab}	3.00 (1.80)^{bc}	1.33 (1.29)^{a}
T_6S_1	3.00 (1.86)^{a}	5.33 (2.39)^{ab}	2.33 (1.49)^{ab}	2.67 (1.72)^{cd}	1.00 (1.17)^{a}
T_6S_2	1.33 (1.29)^{ab}	5.33 (2.39)^{ab}	2.00 (1.56)^{ab}	4.33 (2.19)^{a}	1.33 (1.29)^{a}
T_6S_3	0.33 (0.88)^{b}	4.33 (2.19)^{ab}	3.67 (1.91)^{ab}	4.33 (2.19)$_{a}$	2.33 (1.68)^{a}
T_7S_1	1.33 (1.34)^{ab}	3.33 (1.94)^{ab}	4.67 (2.16)^{a}	3.67 (2.00)^{abc}	2.00 (1.56)^{a}
T_7S_2	1.33 (1.34)^{ab}	4.00 (2.11)^{ab}	3.00 (1.79)^{ab}	2.67 (1.77)^{cd}	1.33 (1.29)^{a}
T_7S_3	1.67 (1.39)^{ab}	3.67 (2.03)^{ab}	2.00 (1.48)^{ab}	3.00 (1.87)^{bc}	1.00 (1.17)^{a}
Control +	1.67 (1.39)	5.00 (2.30)	1.00 (1.10)	1.67 (1.46)	1.00 (1.17)

The values followed by same letters do not differ significantly in DMRT P=(0.05)

Transformed values are given in parenthesis.

+Abridged ANOVA for RBD is given in appendix

(T_5S_2 and T_2S_2). There was a gradual reduction in the population consequent to the spray. At two DAS, the lowest population of rice bug was recorded in T_4S_2 (1.33 insects hill^{-10}), followed by T_1S_3 and T_5S_2 (1.67 insects hill^{-10}). Maximum population of rice bug was noticed in T_7S_1 (4.67 insects hill^{-10}). At 10 DAS The lowest rice bug population was observed in T_1S_2 and T_1S_3 (2.00 insects hill^{-10}). T_2S_1 recorded the maximum population of rice bug (4.67 insects hill^{-10}). Then an increase in population was observed in all the treatments. Interaction effect had no significant influence on count of rice bug at 20 DAS.

4.1.2.3.4 Comparison of treatment combinations with control

Before the third spray, the population of rice bug was taken at 64 DAT and control recorded a population of 5.00 insects hill^{-10}. At two DAS, there was a rapid decline in the count of rice bug (1.00 insect hill^{-10}), which was superior to other treatment combinations. At 10 DAS, also control recorded the lowest population of rice bug (1.67 insects hill^{-10}). Chemical treatment (Methyl parathion 0.2%) was superior in the control of population of rice bug (Table 5b).

4.2 EFFECT OF ORGANIC MATERIALS ON NATURAL ENEMIES OF RICE ECOSYSTEM

The following natural enemies were recorded during period under study.

i) Coccinellid beetles
ii) Mirid bug
iii) Spiders
iv) Carabid beetle
v) Damsel flies
vi) Hymenopteran parasitoids

The observations on natural enemy population before the first spray were taken at 20 DAT. After that, the observations were taken at regular intervals to compare various treatment combinations with control (chemical treated plot). At this stage, the separate effect of organic manures and sprays were also studied.

4.2.1 Effect of organic materials on coccinellid beetles

Micraspis sp., *Brumoides* sp. and *Coccinella transversalis* were the major coccinellids observed during the study. During the initial stage of crop growth (active tillering stage), population of *Brumoides* sp. was high. *Micraspis* sp. was the predominant species at later stages (maximum tillering and milky stages).

4.2.1.1 Individual effect of organic manures

The effect of organic manures was found to be significant on population of coccinellids at 20, 32 and 46 DAT (Table 6a). At 20 DAT, maximum population of coccinellids was recorded in T_6 (1.22 insects hill^{-10}). T_2 recorded the minimum population of coccinellids (0.22 insects hill^{-10}). A gradual build up of population was recorded up to 42 DAT. At 32 DAT, the highest population of coccinellids was noticed in T_6 (2.44 insects hill^{-10}). T_1 registered the lowest population of coccinellids (0.33 insects hill^{-10}). After the second spray, a slight decline in population was observed. At 46 DAT, T_4 and T_6 recorded significantly higher number of predatory coccinellids (1.67 insects hill^{-10}), which was on par with T_1 (1.11 insects hill^{-10}). Minimum population was registered in T_7 (0.22 insects hill^{-10}). At 54 DAT, the mean count of coccinellids ranged from 0.22 (T_7) to 2.00 insects hill^{-10} (T_6). At 64 DAT, T_4 recorded comparatively higher number of coccinellids (2.11 insects hill^{-10}), which was followed by T_6 and T_7 (2.00 insects hill^{-10}). Then the population decreased gradually up to the harvest. The mean population of coccinellids during the crop period was maximum in $T_{6.}$

4.2.1.2 Individual effect of organic sprays

The effect of organic sprays did not differ significantly on population of predatory coccinellids (Table 6a). However, comparatively higher number of coccinellids was observed in $S_{2.}$

Table 6a. Effect of organic manures and sprays on coccinellids, mean number hill $^{-10}$

Treatments	Organic manures	First Spray			Second Spray			Third Spray		
	20DAT	2DAS (24DAT)	10DAS (32DAT)	20DAS (42DAT)	2DAS (46DAT)	10DAS (54DAT)	20DAS (64DAT)	2DAS (68DAT)	10DAS (76DAT)	20DAS (86DAT)
Main plot T_1	0.44 (0.92)^{b}	0.89 (1.09)^{a}	0.33 (0.88)^{b}	0.67 (1.00)^{a}	1.11 (1.19)^{ab}	2.00 (1.58)^{a}	1.67 (1.35)^{a}	1.56 (1.32)^{a}	0.22 (0.80)^{a}	0.33 (0.86)^{a}
T_2	0.22 (0.82)^{c}	1.22 (1.21)^{a}	2.22 (1.54)^{ab}	2.33 (168)^{a}	0.44 (0.92)^{bc}	1.22 (1.24)^{ab}	1.67 (1.39)^{a}	1.89 (1.46)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_3	0.67 (1.00)^{ab}	2.00 (1.52)^{a}	1.89 (1.41)^{ab}	2.00 (1.58)^{a}	0.67 (0.99)^{bc}	1.33 (1.29)^{ab}	1.44 (1.29)^{a}	1.44 (1.30)^{a}	0.44 (0.90)^{a}	0.33 (0.88)^{a}
T_4	0.56 (0.96)^{ab}	0.89 (1.09)^{a}	1.11 (1.17)^{ab}	1.33 (1.29)^{a}	1.67 (1.38)^{a}	0.78 (1.03)^{b}	2.11 (1.54)^{a}	1.67 (1.42)^{a}	0.56 (0.93)^{a}	0.22 (0.80)^{a}
T_5	0.78 (1.05)^{ab}	0.78 (1.06)^{a}	1.22 (1.21)^{ab}	1.33 (1.29)^{a}	0.67 (1.00)^{bc}	0.67 (1.00)^{b}	1.00 (1.10)^{a}	1.33 (1.29)^{a}	0.67 (1.00)^{a}	0.11 (0.76)^{a}
T_6	1.22 (1.22)^{a}	1.33 (1.25)^{a}	2.44 (1.61)^{a}	3.00 (1.86)^{a}	1.67 (1.38)^{a}	2.00 (1.58)^{a}	2.00 (1.35)^{a}	1.11 (1.16)^{a}	0.56 (0.93)^{a}	0.00 (0.71)^{a}
T_7	0.44 (0.94)^{b}	1.33 (1.25)^{a}	1.00 (1.10)^{ab}	1.33 (1.29)^{a}	0.22 (0.82)^{c}	0.22 (0.80)^{c}	2.00 (1.47)^{a}	1.78 (1.42)^{a}	0.33 (0.84)^{a}	0.33 (0.88)^{a}
Sub plot S_1	0.33 (0.88)$_{a}$	1.14 (1.20)$_{a}$	1.10 (1.15)$_{a}$	1.33 (1.29)$_{a}$	0.76 (1.04)$_{a}$	1.14 (1.20)$_{a}$	1.67 (1.38)$_{a}$	1.33 (1.29)$_{a}$	0.29 (0.83)$_{a}$	0.14 (0.77)$_{a}$
S_2	0.81 (1.08)$_{a}$	1.33 (1.29)$_{a}$	1.67 (1.32)$_{a}$	2.00 (1.58)$_{a}$	0.76 (1.01)$_{a}$	1.14 (1.17)$_{a}$	1.44 (1.30)$_{a}$	1.22 (1.21)$_{a}$	0.43 (0.89)^{a}	0.24 (0.82)$_{a}$
S_3	0.71 (1.02)$_{a}$	1.33 (1.29)$_{a}$	1.62 (1.36)$_{a}$	1.67 (1.36)$_{a}$	1.00 (1.15)$_{a}$	1.50 (1.12)$_{a}$	1.14 (1.16)$_{a}$	1.00 (1.10)$_{a}$	0.48 (0.90)$_{a}$	0.19 (0.79)$_{a}$

The values followed by same letters do not differ significantly in DMRT P=(0.05)

DMRT is given in superscript italics- Main plot; Subscript - Subplot

Transformed values are given in parenthesis.

DAS – Days after spraying DAT – Days after transplanting

Table 6b. Interaction effect of organic manures and sprays on coccinellids, mean number hill $^{-10}$

Treatments	Organic manures	First spray			Second spray			Third spray		
	20 DAT	2DAS (24DAT)	10 DAS (32 DAT)	20 DAS (42 DAT)	2DAS (46 DAT)	10 DAS (54 DAT)	20 DAS (64 DAT)	2DAS (68 DAT)	10 DAS (76 DAT)	20 DAS (86 DAT)
T_1S_1	0.00 (0.71)^{b}	0.67 (1.00)^{ab}	0.00 (0.71)^{c}	0.67 (1.00)^{c}	0.67 (1.00)^{cde}	1.33 (1.29)^{ab}	0.67 (1.00)^{ab}	1.67 (1.46)^{a}	0.67 (1.00)^{a}	1.00 (1.10)^{a}
T_1S_2	0.33 (0.88)^{b}	0.00 (0.71)^{b}	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.33 (0.88)^{de}	1.33 (1.29)^{ab}	2.33 (1.58)^{ab}	2.00 (1.58)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_1S_3	1.00 (1.17)^{ab}	2.00 (1.58)^{ab}	1.00 (1.10)^{abc}	1.33 (1.29)^{abc}	2.33 (1.68)^{ab}	3.33 (1.93)^{a}	2.00 (1.58)^{ab}	1.00 (1.10)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_2S_1	0.33 (0.88)^{b}	1.67 (1.46)^{ab}	1.67 (1.46)^{abc}	2.00 (1.58)^{abc}	0.00 (0.71)^{e}	1.00 (1.10)^{ab}	1.67 (1.46)^{ab}	2.00 (1.58)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_2S_2	0.33 (0.88)^{b}	0.67 (1.00)^{ab}	3.33 (1.88)^{a}	3.33 (1.88)^{a}	0.00 (0.71)^{e}	1.67 (1.46)^{ab}	1.33 (1.29)^{ab}	1.33 (1.29)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_2S_3	0.00 (0.71)^{b}	1.33 (1.29)^{ab}	1.67 (1.46$^{)abc}$	2.00 (1.58)^{abc}	1.33 (1.29)^{abcde}	1.00 (1.10)^{ab}	2.00 (1.58)^{ab}	2.33 (1.68)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_3S_1	0.33 (0.88)^{b}	1.67 (1.46)^{ab}	2.33 (1.57)^{abc}	2.67 (1.77)^{abc}	1.33 (1.29)^{abcde}	2.00 (1.58)^{ab}	1.67 (1.46)^{ab}	2.67 (1.78)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_3S_2	1.33 (1.39)^{ab}	1.67 (1..35)^{ab}	1.33 (1.18)^{abc}	1.44 (1.38)^{abc}	0.00 (0.71)^{e}	1.33 (1.29)^{ab}	1.67 (1.46)^{ab}	1.67 (1.46)^{a}	1.33 (1.29)^{a}	0.33 (0.88)^{a}
T_3S_3	0.33 (0.88)^{b}	2.67 (1.78)^{a}	2.00 (1.48)^{abc}	2.22 (1.59)^{abc}	0.67 (1.00)^{cde}	0.67 (1.00)^{b}	1.00 (1.10)^{ab}	3.00 (1.86)^{a}	0.00 (0.71)^{a}	0.67 (1.00)^{a}
T_4S_1	0.33 (0.88)^{b}	1.33 (1.29)^{ab}	1.00 (1.17)^{abc}	1.22 (1.15)^{abc}	0.00 (0.71)^{e}	0.67 (1.00)^{b}	2.33 (1.68)^{ab}	2.33 (1.68)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_4S_2	1.33 (1.29)^{ab}	1.33 (1.29)^{ab}	1.33 (1.18)^{abc}	1.44 (1.38)^{abc}	3.00 (1.86)^{a}	1.00 (1.10)^{ab}	3.33 (1.93)^{a}	1.33 (1.29)^{a}	1.00 (1.10)^{a}	0.67 (1.00)a
T_4S_3	0.00 (0.71)^{b}	0.00 (0.71)^{b}	1.00 (1.17)^{abc}	1.33 (1.29)^{abc}	2.00 (1.58)^{abc}	0.67 (1.00)^{b}	0.67 (1.00)^{ab}	1.33 (1.29)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}
T_5S_1	0.33 (0.88)^{b}	0.00 (0.71)^{b}	0.33 (0.88)^{bc}	1.33 (1.29)^{bc}	2.00 (1.58)^{abc}	1.33 (1.29)^{ab}	3.00 (1.86)^{a}	1.33 (1.29)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}
T_5S_2	0.67 (1.00)^{ab}	0.67 (1.00)^{ab}	1.67 (1.46)^{abc}	2.00 (1.58)^{abc}	0.00 (0.71)^{e}	0.67 (1.00)^{b}	0.00 (0.71)^{b}	0.67 (1.00)^{a}	0.67 (1.00)^{a}	0.33 (0.88)^{a}
T_5S_3	1.33 (1.29)^{ab}	1.67 (1.46)^{ab}	1.67 (1.46)^{abc}	2.00 (1.58)^{abc}	0.00 (0.71)^{e}	0.00 (0.71)^{b}	0.00 (0.71)^{b}	2.00 (1.58)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}
T_6S_1	0.67 (1.00)^{ab}	1.67 (1.46)^{ab}	1.67 (1.46)^{abc}	2.00 (1.58)^{abc}	1.33 (1.29)^{abcde}	1.67 (1.46)^{ab}	1.00 (1.10)^{ab}	1.00 (1.10)^{a}	0.67 (1.00)a	0.00 (0.71)^{a}
T_6S_2	2.00 (1.48)^{a}	2.00 (1.58)^{ab}	3.33 (1.88)^{a}	3.33 (1.88)^{a}	2.00 (1.48)^{abcd}	3.33 (1.93)^{a}	3.33 (1.93)^{a}	1.33 (1.29)^{a}	1.33 (1.29)^{a}	0.00 (0.71)^{a}
T_6S_3	1.00 (1.10)^{ab}	1.00 (1.10)^{ab}	2.67 (1.64)^{abc}	3.00 (1.86)^{abc}	0.00 (0.71)^{e}	1.00 (1.10)^{ab}	1.33 (1.29)^{ab}	1.00 (1.10)^{a}	1.00 (1.10)^{a}	0.00 (0.71)^{a}
T_7S_1	0.33 (0.88)^{b}	1.00 (1.10)^{ab}	0.67 (1.00)^{abc}	1.33 (1.29)^{abc}	0.00 (0.71)^{e}	0.00 (0.71)^{b}	3.33 (1.93)^{a}	2.33 (1.68)a	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_7S_2	0.67 (1.00)^{ab}	2.33 (1.57)^{ab}	1.00 (1.10)^{abc}	1.33 (1.29)^{abc}	0.00 (0.71)^{e}	0.00 (0.71)^{b}	1.67 (1.46)^{ab}	2.00 (1.58)^{a}	0.00 (0.71)^{a}	0.33 (0.88)^{a}
T_7S_3	0.33 (0.88)^{b}	0.67 (1.00)^{ab}	1.33 (1.29)^{abc}	1.44 (1.38)^{abc}	0.67 (1.00)^{bcde}	0.67 (1.00)^{b}	1.00 (1.10)^{ab}	1.00 (1.10)^{a}	1.00 (1.10)^{a}	0.67 (1.00)^{a}
Control +	0.67 (1.00)	0.00 (0.71)	0.00 (0.71)	1.33 (1.29)	0.00 (0.71)	0.00 (0.71)	0.67 (1.00)	0.33 (0.88)	0.00 (0.71)^{a}	0.33 (0.88)

The values followed by same letters do not differ significantly in DMRT P=(0.05). Transformed values are given in parenthesis.

+Abridged ANOVA is given in appendix

4.2.1.3 Interaction effect of organic manures and sprays

The interaction effect of organic manure and sprays was found to be significant at first and second spray observations (Table 6b). Before the first spray, the population of coccinellids was maximum in T_6S_2 (2.00 insects hill^{-10}). At 20 DAS, also T_6S_2 and T2S2 recorded the highest population (3.33 insects hill^{-10}). After the second spray, a decline in population was observed in all the treatments. At two DAS, T_4S_2 recorded the highest population of coccinellids (3.00 insects hill^{-10}). A gradual increase in population was observed up to 20 DAS. At 20 DAS, also T_6S_2 recorded the highest population of predatory beetles (3.33 insects hill^{-10}) with T_4S_2 and T_7S_1. After the third spray, the population decreased. Throughout the observation period, the population of coccinellids was significantly high in T_6S_2.

4.2.1.4 Comparison of treatment combinations with control

The different treatment combinations were compared with control and the data is furnished in Table 6b. Before the first spray, control recorded 0.67insects hill^{-10}. At two and 10 DAS, coccinellid beetles were absent in control. Then, the population build up was observed upto 20 DAS (1.33 insects hill^{-10}). After the second spray, coccinellids were absent at 2 and 10 DAS. At 20 DAS, a slight build up population of coccinellids was observed (0.67 insects hill^{-10}). A gradual decline in population was observed in all the treatments including control upto 10 DAS. At 20 DAS, control recorded 0.33 insects hill^{-10}. The mean population of coccinellids was high in botanical treatments as compared to control.

4.2.2 **Effect of organaic materials on mirid bug *(Cyrtorhinus lividipennis)***

4.2.2.1 Individual effect of organic manures

Organic manures had significant influence on count of mirid bugs at 32, 42 and 46 DAT (Table 7a). At 20 DAT, the count of mirid bug was statistically on par in all the treatments. However, T_6 recorded the maximum count (2.67

Table 7a. Effect of organic manures and sprays on mirid bug (*C. lividipennis*), mean number hill $^{-10}$

Treatments	Organic manures	First Spray			Second Spray		
	20DAT	2DAS (24DAT)	10DAS (32DAT)	20DAS (42DAT)	2DAS (46DAT)	10DAS (54DAT)	20DAS (64DAT)
Main plot T_1	1.78 (1.41)^{a}	3.78 (1.99)^{a}	2.56 (1.60)^{ab}	1.78 (1.45)^{a}	0.44 (0.92)^{abc}	0.33 (0.86)^{a}	0.00 (0.71)^{a}
T_2	2.11 (1.48)^{a}	2.11 (1.54)^{a}	1.44 (1.32)^{ab}	0.22 (0.80)^{b}	0.00 (0.71)^{c}	0.44 (0.90)^{a}	0.44 (0.90)^{a}
T_3	2.33 (1.63)^{a}	3.78 (1.99)^{a}	2.89 (1.67)^{ab}	1.22 (1.15)^{a}	0.56 (0.99)^{ab}	0.44 (0.89)^{a}	0.00 (0.71)^{a}
T_4	1.44 (1.29)^{a}	3.33 (1.84)^{a}	2.00 (1.51)^{ab}	0.78 (1.06)^{ab}	0.11 (0.77)^{bc}	0.33 (0.86)^{a}	0.22 (0.80)^{a}
T_5	2.22 (1.59)^{a}	2.67 (1.71)^{a}	1.22 (1.15)^{c}	0.22 (0.80)^{b}	0.33 (0.88)^{abc}	0.11 (0.77)^{a}	0.22 (0.80)^{a}
T_6	2.67 (1.71)^{a}	3.78 (1.99)^{a}	3.22 (1.91)^{a}	2.00 (1.49)^{a}	0.56 (0.99)^{ab}	0.56 (0.96)^{a}	0.52 (0.94)^{a}
T_7	2.33 (1.64)^{a}	3.11 (1.84)^{a}	2.78 (1.66)^{ab}	1.11 (1.19)^{ab}	0.89 (1.09)^{a}	0.56 (0.96)^{a}	0.22 (0.80)^{a}
Sub plot S_1	2.19 (1.57)$_{a}$	3.52 (1.95)$_{a}$	2.86 (1.74)$_{a}$	1.43 (1.32)$_{a}$	0.52 (0.94)$_{a}$	0.33 (0.87)$_{a}$	0.19 (0.79)$_{a}$
S_2	2.05 (1.49)$_{a}$	3.10 (1.80)$_{a}$	1.62 (1.34)$_{a}$	1.11 (1.19)$_{a}$	0.33 (0.87)$_{a}$	0.38 (0.88)$_{a}$	0.19 (0.79)$_{a}$
S_3	1.71 (1.40)$_{a}$	2.86 (1.76)$_{a}$	2.43 (1.56)$_{a}$	1.19 (1.19)$_{a}$	0.33 (0.87)$_{a}$	0.52 (0.94)$_{a}$	0.10 (0.75)$_{a}$

The values followed by same letters do not differ significantly in DMRT P=(0.05)

DMRT is given in superscript italics- Main plot; Subscript - Subplot

Transformed values are given in parenthesis.

DAS – Days after spraying   DAT – Days after transplanting

insects $hill^{-10}$). A gradual increase in population was observed up to 24 DAT. Then a decline in population was recorded at 32 DAT. However, T_6 recorded comparatively higher population of mirid bug (3.22 insects $hill^{-10}$). T_5 recorded the lowest population of mirid bug (1.22 insects $hill^{-10}$). Thereafter, a gradual decline in population was noticed upto harvest. At 42 DAT, also T_6 recorded higher population of mirid bug of 2.00 insects $hill^{-10}$. But at 46 DAT, T_7 recorded the maximum population (0.89 insects $hill^{-10}$), followed by T_3 and T_6 (0.54 insects $hill^{-10}$). After 64 days of transplanting, the count of mirid bug was negligible. The mean population of mirid bug was maximum in T_6 during the crop period.

4.2.2.2 Individual effect of organic sprays

Organic sprays did not exhibit significant effect on count of mirid bugs (Table 7a). The population of mirid bugs reached its maximum at two DAS. Then a decline in population was observed up to the harvest. From the results, it was clear that S_1 recorded comparatively higher population of mirid bugs.

4.2.2.3 Interaction effect of organic manures and sprays

The interaction effect of different organic manures and sprays is presented in Table 7b. At 20 DAT (*i.e.*, before the first spray), the population of mirid bug was statistically on par in all the treatments. At two DAS, comparatively higher population was recorded in T_6S_1 and T_3S_2 (5.00 insects $hill^{-10}$). Then, the population was declined up to the harvest. At 10 DAS, T_6S_1 was the best treatment (5.33 insects $hill^{-10}$), whereas mirid bugs were not observed in T_5S_2. At 20 DAS, T_6S_1 recorded the highest population of mirid bugs (2.33 insects $hill^{-10}$) with T_6S_2 and the population was nil in T_2S_1. After the second spray, maximum population of mirid bugs was observed in T_6S_1 (1.67 insects $hill^{-10}$). Population of mirid bug was not observed in T_1S_1, T_2S_1, T_2S_2, T_2S_3, T_4S_1, T_4S_2 and T_5S_2. The mean population of mirid bug during the crop period was maximum in T_6S_1.

Table 7b. Interaction effect of treatments on count of mirid bug, *C. lividipennis*, mean number hill $^{-10}$

Treatments	Organic manures	First spray			Second spray		
	(20DAT)	2 DAS (24 DAT)	10 DAS (32 DAT)	20 DAS (42 DAT)	2DAS (46 DAT)	10 DAS (54 DAT)	20 DAS (64 DAT)
T_1S_1	2.00 (1.47)^{a}	4.00 (2.11)^{a}	2.00 (1.48)^{ab}	2.00 (1.56)^{a}	0.00 (0.71)^{b}	0.67 (1.00)^{a}	0.00 (0.71)^{a}
T_1S_2	0.17 (1.00)^{a}	3.67 (2.04)^{a}	3.33 (1.93)^{ab}	2.00 (1.58)^{a}	1.00 (1.17)^{ab}	0.67 (1.00)^{a}	0.00 (0.71)^{a}
T_1S_3	2.67 (1.77)^{a}	4.00 (2.11)^{a}	2.33 (1.38)^{ab}	1.33 (1.27)^{ab}	0.33 (0.88)^{ab}	0.33 (0.88)^{a}	0.00 (0.71)^{a}
T_2S_1	2.00 (1.58)^{a}	1.33 (1.29)^{a}	1.33 (1.29)^{ab}	0.00 (0.71)^{b}	0.00 (0.71)^{b}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_2S_2	3.00 (1.86)^{a}	2.33 (1.68)^{a}	1.33 (1.29)^{ab}	0.67 (1.00)^{ab}	0.00 (0.71)^{b}	0.00 (0.71)^{a}	0.67 (1.00)^{a}
T_2S_3	1.33 (1.29)^{a}	2.67 (1.65)^{a}	1.67 (1.39)^{ab}	0.00 (0.71)^{b}	0.00 (0.71)^{b}	0.33 (0.88)a	0.67 (1.00)^{a}
T_3S_1	3.00 (1.86)^{a}	4.67 (2.27)^{a}	3.33 (1.95)^{ab}	1.00 (1.10)^{ab}	1.43 (1.32)^{a}	0.33 (0.29)^{a}	0.00 (0.71)^{a}
T_3S_2	2.00 (1.58)^{a}	5.00 (2.30)^{a}	1.33 (1.18)^{ab}	1.33 (1.29)^{ab}	0.67 (1.00)^{ab}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_3S_3	2.00 (1.47)^{a}	1.67 (1.39)^{a}	1.33 (1.29)^{ab}	1.33 (1.29)^{ab}	0.33 (0.88)^{ab}	1.00 (1.10)^{a}	0.00 (0.71)^{a}
T_4S_1	2.67 (1.76)^{a}	3.67 (2.02)^{a}	2.00 (1.47)^{ab}	0.33 (0.88)^{ab}	0.00 (0.71)^{b}	0.33 (0.88)^{a}	0.67 (1.00)^{a}
T_4S_2	0.67 (1.00)^{a}	2.00 (1.32)^{a}	1.33 (1.29)^{ab}	1.33 (1.29)^{ab}	0.00 (0.71)^{b}	0.67 (1.00)^{a}	0.00 (0.71)^{a}
T_4S_3	1.00 (1.10)^{a}	4.33 (2.20)^{a}	2.67 (1.76)^{ab}	0.67 (1.00)^{ab}	0.33 (0.88)^{ab}	0.00 0.71)^{a}	0.00 (0.71)^{a}
T_5S_1	2.33 (1.68)^{a}	4.00 (2.06)^{a}	2.33 (1.57)^{ab}	1.67 (1.46)^{ab}	0.67 (1.00)^{ab}	0.00 0.71)^{a}	0.00 (0.71)^{a}
T_5S_2	2.00 (1.48)^{a}	1.67 (1.39)^{a}	0.00 (0.71)^{ab}	1.33 (1.29)^{ab}	0.00 (0.71)^{b}	0.00 0.71)^{a}	0.67 (1.00)^{a}
T_5S_3	2.33 (1.57)^{a}	2.33 (1.68)^{a}	1.33 (1.18)^{ab}	1.33 (1.29)^{ab}	0.33 (0.88)^{ab}	0.33 (0.88)^{a}	0.00 (0.71)^{a}
T_6S_1	2.33 (1.68)^{a}	5.00 (2.30)^{a}	5.33 (2.41)^{a}	2.33 (1.59)^{a}	1.67 (1.39)^{a}	1.33 (1.29)^{a}	0.00 (0.71)^{a}
T_6S_2	3.00 (1.84)^{a}	2.67 (1.65)^{a}	2.67 (1.77)^{ab}	2.33 (1.59)^{a}	0.33 (0.88)^{ab}	0.00 (0.71)^{a}	0.67 (1.00)^{a}
T_6S_3	1..33 (1.29)^{a}	3.00 (1.86)^{a}	2.67 (1.77)^{ab}	1.33 (1.29)^{ab}	0.33 (0.88)^{ab}	0.67 (1.00)^{a}	0.00 (0.71)^{a}
T_7S_1	1.33 (1.29)^{a}	3.00 (1.86)^{a}	4.67 (2.27)^{a}	1.33 (1.29)^{ab}	1.67 (1.39)^{a}	1.33 (1.29)^{a}	0.67 (1.00)^{a}
T_7S_2	3.11 (1.84)^{a}	4.33 (2.19)^{a}	1.33 (1.18)^{ab}	1.33 (1.29)^{ab}	0.33 0.88)^{ab}	1.33 (1.29)^{a}	0.00 (0.71)^{a}
T_7S_3	1.33 (1.29)^{a}	2.00 (1.47)^{a}	1.67 (1.39)^{ab}	0.67 (1.00)^{ab}	0.67 (1.00)^{ab}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
Control +	3.00 (1.86)	0.00 (0.71)	0.33 (0.88)	0.67 (1.00)	0.00 (0.71)	0.00 (0.71)	0.33 (0.88)

The values followed by same letters do not differ significantly in DMRT P=(0.05). Transformed values are given in parenthesis.
+Abridged ANOVA is given in appendix

4.2.2.4 Comparison of treatment combinations with control

The different treatment combinations were compared with control and the data is furnished in Table 7b. Before the first spray, population of mirid bug in control plot was comparatively high (3.00 insects $hill^{-10}$). After the spray, mirid bugs were absent. A slight increase in population was observed in control at 10 DAS (0.33 insect $hill^{-10}$). The population did not develop in the control after the second spray.

4.2.3 Effect of organic materials on spiders

Tetragnatha sp., *Lycosa pseudoannulata* and *Oxyopes* sp. were the predominant spiders observed during the study.

4.2.3.1 Individual effect of organic manures

The individual effect of organic manures on population of spiders is given in Table 8a. At 20 DAT, count of spiders was ranged from 0.22 (T_2) to 1.22 (T_6). A gradual build up of spiders was observed up to 20 DAS. At two DAS, the effect of organic manures did not differ significantly. At 10 DAS, the count of spiders was significantly higher in T_6 (2.44), whereas T_1 recorded the minimum count (0.33 spiders $hill^{-10}$). After the second spray a sudden decrease in population was noticed in all the plots. Count of spiders was significantly higher in T_6 and T_4 (1.67 spiders $hill^{-10}$), which was on par with T_1 (1.11 spiders $hill^{-10}$). T_7 recorded the minimum count (0.22 spiders $hill^{-10}$). Thereafter, a gradual build up of population was noticed up to 20 DAS. After the third spray, organic manures did not show significant influence.

4.2.3.2 Individual effect of organic sprays

Effect of organic sprays on spider population was not significantly different at all days of observations (Table 8a).

Table 8a. Effect of organic manures and sprays on spiders, mean number hill $^{-10}$

Treatments	Organic manure	First Spray			Second Spray			Third Spray		
	20 DAT	2 DAS (24DAT)	10 DAS (32DAT)	20 DAS (42DAT)	2 DAS (46DAT)	10 DAS (54DAT)	20 DAS (64DAT)	2 DAS (68DAT)	10 DAS (76DAT)	20 DAS (86DAT)
Main plot T_1	0.44 (0.92)^{ab}	0.39 (1.09)^{a}	0.33 (0.88)^{b}	1.22 (1.21)^{a}	1.11 (1.19)^{ab}	1.33 (125)^{a}	1.67 (1.35)^{a}	1.56 (1.32)^{a}	0.22 (0.80)^{a}	0.33 (0.86)^{a}
T_2	0.22 (0.82)^{b}	1.22 (1.21)^{a}	2.22 (1.54)^{ab}	2.22 (1.54)^{a}	0.44 (0.92)^{c}	1.22 (1.24)^{a}	1.67 (1.39)^{a}	1.33 (1.25)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_3	0.67 (1.03)^{ab}	2.00 (1.52)^{a}	1.89 (1.41)^{ab}	2.00 (1.58)^{a}	1.00 (1.10)^{b}	1.33 (1.25)^{a}	1.44 (1.29)^{a}	1.00 (1.10)^{a}	0.44 (0.90)^{a}	0.33 (0.86)^{a}
T_4	0.56 (0.96)^{ab}	0.89 (1.09)^{a}	1.11 (1.17)^{ab}	1.22 (1.21)^{a}	0.67 (1.00)^{b}	0.78 (1.03)^{a}	1.00 (1.10)^{a}	1.67 (1.42)^{a}	0.56 (0.93)^{a}	0.22 (0.80)^{a}
T_5	0.78 (1.05)^{ab}	0.78 (1.06)^{a}	1.22 (1.21)^{ab}	2.67 (1.77)^{a}	0.67 (1.00)^{bc}	0.67 (1.00)^{a}	1.00 (1.10)^{a}	0.78 (1.03)^{a}	0.67 (1.00)^{a}	0.33 (0.86)^{a}
T_6	1.22 (1.21)^{a}	1.33 (1.25)^{a}	2.44 (1.61)^{a}	2.67 (1.77)^{a}	1.67 (1.38)^{a}	1.56 (1.35)^{a}	2.00 (1.47)^{a}	1.67 (1.38)^{a}	0.56 (0.93)^{a}	0.44 (0.92)^{a}
T_7	0.44 (0.95)^{ab}	1.33 (1.25)^{a}	1.00 (1.10)^{ab}	2.09 (1.58)^{a}	0.22 (0.82)^{c}	1.22 (1.24)^{a}	2.00 (1.47)^{a}	1.78 (1.42)^{a}	0.33 (0.84)^{a}	0.33 (0.86)^{a}
Sub plot S_1	0.33 (0.87)$_{a}$	1.14 (1.20)$_{a}$	1.10 (1.15)$_{a}$	1.22 (1.21)$_{a}$	0.76 (1.04)$_{a}$	1.14 (1.20)$_{a}$	1.95 (1.48)$_{a}$	1.91 (1.49)$_{a}$	0.29 (0.83)$_{a}$	0.14 (0.77)$_{a}$
S_2	0.81 (1.08)$_{a}$	1.44 (1.29)$_{a}$	1.67 (1.32)$_{a}$	1.91 (1.49)$_{a}$	0.76 (1.01)$_{a}$	1.14 (1.17)$_{a}$	1.81 (1.42)$_{a}$	1.48 (1.31)$_{a}$	0.48 (0.90)$_{a}$	0.24 (0.82)$_{a}$
S_3	0.71 (1.03)$_{a}$	1.33 (1.20)$_{a}$	1.62 (1.20)$_{a}$	0.24 (0.80)$_{a}$	1.00 (1.15)$_{a}$	1.05 (1.12)$_{a}$	1.14 (1.46)$_{a}$	1.67 (1.36)$_{a}$	0.48 (0.90)$_{a}$	0.19 (0.79)$_{a}$

The values followed by same letters do not differ significantly in DMRT P=(0.05)

Transformed values are given in parenthesis.

DMRT is given in superscript italics- Main plot; Subscript - Subplot

DAS – Days after spraying DAT – Days after transplanting

4.2.3.3 Interaction effect of organic manures and sprays

The interaction effect of treatments on spider population is presented in (Table 8b). Before the first spray, the spider population was maximum in T_6S_3 (2.00 spiders hill^{-10}). In majority of plots, population of spider was not well established. At two DAS, the mean population was maximum in T_3S_3 (2.67 spiders hill^{-10}), which was immediately followed by T_7S_2 (2.33 spiders hill^{-10}). Population of spiders was gradually increased up to 20 DAS. At 20 DAS, the mean values ranged from 0.67 (T_1S_1 and T_1S_2) to 3.33 spiders hill^{-10} (T_6S_2). After the second spray, count of predatory spiders was reduced in all the plots. The mean population was maximum in T_6S_2 (3.00 spiders hill^{-10}). In T_2S_1, T_2S_2, T_3S_2, T_4S_1, T_5S_2, T_5S_3, T_6S_3, T_7S_1 and T_7S_2, population of spiders was not observed. At 10 DAS, T_1S_3 recorded the highest count (3.33 spiders hill^{-10}), immediately followed by T_6S_2 (2.00 spiders hill^{-10}). At 20 DAS, T_4S_2 and T_7S_1 had the maximum population of spiders (3.33 spiders hill^{-10}), followed by T_6S_2 and T_5S_1 (3.00 spiders hill^{-10}). Population of spiders was not observed in T_5S_2 and T_5S_3. After the third spray, count of spiders decreased gradually. The maximum population of spiders was observed in T_6S_2.

4.2.3.4 Comparison of treatment combinations with control

Different treatment combinations were compared with control (Table 8b). The count of spiders in control plot was 0.67 spiders hill^{-10}. After the first spray, the count of spiders was decreased in the control plot from 0.67 to 0.33 spiders hill^{-10}. After that, the population increased up to 20 DAS. At 10 DAS, T_1S_1 and T_1S_2 were inferior to control, where the population was not observed. At 20 DAS, also the same trend was noticed. Control (1.00 insects hill^{-10}) was superior to T_1S_1 and T_1S_2 (0.67 spiders hill^{-10}). After the second spray, the population of predatory spiders decreased in majority of the plots including control. At two DAS, spider population was nil in the control along with T_2S_1, T_2S_2, T_3S_2, T_4S_1, T_5S_2, T_5S_3, T_6S_3, T_7S_1 and T_7S_2. At 10 DAS, T_7S_1 and T_7S_2 were inferior to

Table 8b. Interaction effect of organic manures and sprays on count of spiders, mean number hill $^{-10}$

Treatments	Organic manures (20 DAT)	First spray			Second spray			Third spray		
		2DAS (24 DAT)	10 DAS (32 DAT)	20 DAS (42 DAT)	2DAS (46 DAT)	10 DAS (54 DAT)	20 DAS (64 DAT)	2 DAS (68 DAT)	10 DAS (76 DAT)	20 DAS (86 DAT)
T_1S_1	0.00 (0.71)^{b}	0.67 (1.00)^{ab}	0.00 (0.71)^{c}	0.67 (1.00)^{b}	0.67 (1.00)^{cde}	1.33 (1.29)^{ab}	0.67 (1.00)^{ab}	1.67 (1.39)^{a}	0.67 (1.00)^{a}	1.00 (1.10)^{a}
T_1S_2	0.33 (0.88)^{b}	0.00 (0.71)^{b}	0.00 (0.71)^{c}	0.67 (1.00)^{b}	0.33 (0.88)^{de}	1.33 (1.29)^{ab}	2.33 (1.59)^{ab}	2.00 (1.58)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_1S_3	1.00 (1.17)^{ab}	2.00 (1.58)^{ab}	1.00 (1.10)^{abc}	1.00 (1.10)^{b}	2.33 (1.59)^{ab}	3.33 (1.93)^{a}	2.00 (1.58)^{ab}	1.00 (1.10)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_2S_1	0.33 (0.88)^{b}	1.67 (1.39)^{ab}	1.67 (1.39)^{abc}	2.00 (1.58)^{ab}	0.00 (0.71)^{e}	1.00 (1.10)^{ab}	1.67 (1.39)^{ab}	2.00 (1.58)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_2S_2	0.33 (0.88)^{b}	0.67 (1.00)^{ab}	3.33 (1.93)^{a}	3.33 (1.93)^{a}	0.00 (0.71) ^{e}	1.67 (1.39)^{ab}	1.33 (1.29)^{ab}	1.33 (1.29)^{ab}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_2S_3	0.00 (0.71)^{b}	1.33 (1.29)^{ab}	1.67 (1.39)^{abc}	2.00 (1.58)^{ab}	1.33 (1.29)^{abcde}	1.00 (1.10)^{ab}	2.00 (1.58)^{ab}	2.33 (1.59)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_3S_1	0.33 (0.88)^{b}	1.67 (1.39)^{ab}	2.33 (1.59)^{abc}	3.00 (1.81)^{a}	1.33 (1.29)^{abcde}	2.00 (1.58)^{ab}	1.67 (1.39)^{ab}	2.67 (1.77)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_3S_2	1.33 (1.34)^{ab}	1.67 (1.39)^{ab}	1.33 (1.29)^{abc}	1.33 (1.29)^{ab}	0.00 (0.71)^{e}	1.33 (1.29)^{ab}	1.67 (1.39)^{ab}	1.67 (1.39)^{a}	1.33 (1.29)^{a}	0.33 (0.88)^{a}
T_3S_3	0.33 (0.88)^{b}	2.67 (1.77)^{a}	2.00 (1.58)^{abc}	2.33 (1.59)^{ab}	0.67 (1.00)^{cde}	0.67 (1.00)^{b}	1.00 (1.10)^{ab}	3.00 (1.81)^{a}	0.00 (0.71)^{a}	0.67 (1.00)^{a}
T_4S_1	0.33 (0.88)^{b}	1.33 (1.29)^{ab}	1.00 (1.10)^{abc}	1.00 (1.10)^{b}	0.00 (0.71)^{e}	0.67 (1.00)^{b}	2.33 (1.59)^{ab}	2.33 (1.59)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_4S_2	1.33 (1.29)^{ab}	1.33 (1.29)^{ab}	1.33 (1.29)^{abc}	1.67 (1.39)^{ab}	1.00 (1.10)^{abcde}	1.00 (1.10)^{ab}	3.33 (1.93)^{a}	1.33 (1.29)^{a}	1.00 (1.10)^{a}	0.67 (1.00)^{a}
T_4S_3	0.00 (0.71)^{ab}	0.00 (0.71)^{b}	1.00 (1.10)^{abc}	1.33 (1.29)^{ab}	2.00 (1.58)^{abc}	0.67 (1.00)^{b}	0.67 (1.00)^{ab}	1.33 (1.29)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}
T_5S_1	0.33 (0.88)^{b}	0.00 (0.71)^{b}	0.33 (0.88)^{bc}	1.33 (1.29)^{ab}	2.00 (1.58)^{c}	1.33 (1.29)^{ab}	3.00 (1.87)^{a}	1.33 (1.29)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}
T_5S_2	0.67 (1.00)^{ab}	0.67 (1.00)^{ab}	1.67 (1.39)^{abc}	2.33 (1.59)^{ab}	0.00 (0.71)^{e}	0.67 (1.00)^{b}	0.00 (0.71)^{b}	0.67 (1.00)^{a}	0.67 (1.00)^{a}	0.33 (0.88)^{a}
T_5S_3	1.33 (1.29)^{ab}	1.67 (1.39)^{ab}	1.67 (1.39)^{abc}	2.33 (1.59)^{ab}	0.00 (0.71)^{e}	0.00 (0.71)^{b}	0.00 (0.71)^{b}	2.00 (1.58)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}
T_6S_1	0.67 (1.00)^{ab}	1.67 (1.39)^{ab}	1.67 (1.39)^{abc}	2.00 (1.58)^{ab}	1.33 (1.29)^{abcde}	1.67 (1.39)^{ab}	1.00 (1.10)^{ab}	1.00 (1.10)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}
T_6S_2	1.00 (1.10)^{ab}	1.00 (1.10)^{ab}	3.00 (1.81)^{ab}	3.33 (1.93)^{a}	3.00 (1.81)^{a}	2.00 (1.58)^{ab}	3.00 (1.87)^{a}	2.33 (1.59)^{a}	1.00 (1.10)^{a}	0.67 (1.00)^{a}
T_6S_3	2.00 (1.56)^{a}	1.00 (1.10)^{ab}	2.67 (1.77)^{abc}	3.00 (1.81)^{a}	0.00 (0.71)^{e}	1.00 (1.10)^{ab}	1.33 (1.29)^{ab}	1.00 (1.10)^{a}	1.00 (1.10)^{a}	0.00 (0.71)^{a}
T_7S_1	0.33 (0.88)^{b}	1.00 (1.10)^{ab}	0.67 (1.00)^{abc}	1.33 (1.29)^{ab}	0.00 (0.71)^{e}	0.00 (0.71)^{b}	3.33 (1.93)^{a}	2.33 (1.59)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_7S_2	0.67 (1.00)^{ab}	2.33 (1.59)^{ab}	1.00 (1.10)^{abc}	1.33 (1.29)^{ab}	0.00 (0.71)^{e}	0.00 (0.71)^{b}	1.67 (1.39)^{ab}	2.00 (1.58)^{a}	0.00 (0.71)^{a}	0.33 (0.88)^{a}
T_7S_3	0.33 (0.88)^{b}	0.67 (1.00)^{ab}	1.33 (1.29)^{abc}	1.67 (1.39)^{ab}	0.67 (1.00)^{bcde}	0.67 (1.00)^{b}	1.00 (110)^{ab}	1.00 (1.10)^{a}	1.00 (1.10)^{a}	0.67 (1.00)^{a}
Control +	0.67 (1.00)	0.33 (0.88)	0.67 (1.00)	1.00 (1.10)	0.00 (0.71)	0.33 (0.88)	0.67 (1.00)	0.33 (0.88)	0.00 (0.71)	0.00 (0.71)

The values followed by same letters do not differ significantly in DMRT P=(0.05). Transformed values are given in parenthesis.
+Abridged ANOVA is given in appendix

control. The population was found to increase till 20 DAS. After the third spray, there was a decline in population up to harvest.

4.2.4 Effect of organic materials on carabid beetle *(Ophionea nigrofasciata)*

4.2.4.1 Individual effect of organic manures

The result of effect of organic manures on count of carabid beetle is given in Table 9a. At 20 DAT, the count of predatory carabids was the highest in T_7 (1.27 insects hill^{-10}), followed by T_6 (0.65 insects hill^{-10}). The lowest count of insects was recorded in T_1 (0.09 insects hill^{-10}), which was on par with T_4 (0.31 insects hill^{-10}). A slight decline in population was observed at 24 DAT. Here, also the same trend was noticed. Maximum population of carabids was noticed in T_7 (1.16 insects hill^{-10}). T_1 recorded the lowest population of carabids (0.09 insects hill^{-10}), which was on par with T_4 (0.10 insects hill $^{-10}$). A gradual increase in population of predatory beetles was observed up to 42 DAT. At 32 DAT, also T_7 was superior to other treatments in the count of beetles (1.43 insects hill^{-10}). Minimum population was registered in T_4 (0.24 insects hill^{-10}). At 42 DAT, T_2 recorded the highest population of beetles (3.26), followed by T_7 (3.08 insects hill^{-10}). Minimum count was observed in T_4 (0.62). Then a gradual decline in population was observed in all the treatments upto harvest. At 46 DAT, T_2 (2.66 insects hill^{-10}) recorded the maximum population of carabid beetles, followed by T_7 (2.61). In all other days of observation the highest count of predatory beetles was observed in T_2.

4.2.4.2 Individual effect of organic sprays

The different organic sprays did not exhibit significant influence on count of carabid beetles. However, S_1 was comparatively safer to the predatory carabids (Table 9a).

Table 9a. Effect of organic manures and sprays on carabid (*O. nigrofasciata*), mean number hill $^{-10}$

Treatments	Organic manures	First Spray			Second Spray		
	20DAT	2DAS (24DAT)	10DAS (32DAT)	20DAS (42DAT)	2DAS (46DAT)	10DAS (54DAT)	20DAS (64DAT)
Main plot T_1	0.09 $(0.76)^{b}$	0.09 $(0.75)^{b}$	0.78 $(1.10)^{abc}$	2.59 $(1.67)^{a}$	2.15 $(1.55)^{a}$	1.62 $(.44)^{a}$	0.25 $(0.83)^{b}$
T_2	0.52 $(0.97)^{ab}$	0.30 $(0.86)^{ab}$	1.36 $(1.35)^{ab}$	3.26 $(1.88)^{a}$	2.66 $(1.73)^{a}$	1.72 $(1.46)^{a}$	0.98 $(1.18)^{a}$
T_3	0.46 $(0.94)^{ab}$	0.37 $(0.91)^{ab}$	0.52 $(0.98)^{bc}$	1.53 $(1.31)^{ab}$	1.69 $(1.44)^{ab}$	1.26 $(1.29)^{a}$	0.14 $(0.79)^{b}$
T_4	0.31 $(0.88)^{b}$	0.10 $(0.76)^{b}$	0.24 $(0.83)^{c}$	0.62 $(0.95)^{b}$	1.02 $(1.16)^{b}$	1.27 $(1.32)^{a}$	0.39 $(0.90)^{b}$
T_5	0.41 $(0.91)^{b}$	0.37 $(0.89)^{ab}$	0.53 $(0.96)^{bc}$	2.32 $(1.64)^{a}$	1.88 $(1.51)^{a}$	1.47 $(1.40)^{a}$	0.20 $(0.81)^{b}$
T_6	0.65 $(1.04)^{ab}$	0.58 $(1.01)^{ab}$	1.00 $(1.10)^{abc}$	2.74 $(1.75)^{a}$	2.31 $(1.65)^{a}$	1.64 $(1.45)^{a}$	0.21 $(0.82)^{b}$
T_7	1.27 $(1.26)^{a}$	1.16 $(1.23)^{a}$	1.43 $(1.38)^{a}$	3.08 $(1.84)^{a}$	2.61 $(1.76)^{a}$	1.65 $(1.46)^{a}$	0.44 $(0.95)^{b}$
Sub plot S_1	0.62 $(0.99)_{a}$	0.58 $(0.97)_{a}$	1.00 $(1.10)_{a}$	2.53 $(1.65)_{a}$	2.30 $(1.65)_{a}$	1.64 $(1.45)_{a}$	0.58 $(0.97)_{a}$
S_2	0.48 $(0.94)_{a}$	0.45 $(0.93)_{a}$	0.91 $(1.14)_{a}$	2.45 $(1.63)_{a}$	1.98 $(1.49)_{a}$	1.62 $(1.43)_{a}$	0.27 $(0.85)_{a}$
S_3	0.22 $(0.83)_{a}$	0.11 $(0.77)_{a}$	0.80 $(1.09)_{a}$	1.93 $(1.45)_{a}$	1.86 $(1.48)_{a}$	1.40 $(1.37)_{a}$	0.49 $(0.96)_{a}$

The values followed by same letters do not differ significantly in DMRT P=(0.05)

DMRT is given in superscript italics- Main plot; Subscript - Subplot

Transformed values are given in parenthesis

DAS – Days after spraying DAT – Days after transplanting

Table 9b. Interaction effect of organic manures and sprays on carabid (*O. nigrofasciata*), mean number hill^{-10}

Treatments	Organic manures (20 DAT)	First spray			Second spray		
		2DAS (24 DAT)	10 DAS (32 DAT)	20 DAS (42 DAT)	2DAS (46 DAT)	10DAS (54 DAT)	20 DAS (64 DAT)
T_1S_1	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.87 (1.17)^{abcd}	2.91 (1.84)^{a}	2.43 (1.71)^{abcd}	1.70 (1.47)^{a}	0.00 (0.71)^{a}
T_1S_2	0.00 (0.71)^{c}	0.00 (0.71)^{c}	0.53 (0.99)^{bcde}	2.18 (1.53)^{abc}	1.23 (1.15)^{ef}	1.60 (1.43)^{a}	0.00 (0.71)^{a}
T_1S_3	0.27 (0.85)^{bc}	0.26 (0.85)^{bc}	0.93 (1.14)^{bcd}	2.67 (1.64)^{abc}	2.79 (1.79)^{abc}	1.56 (1.42)^{a}	0.23 (0.84)^{a}
T_2S_1	0.00 (0.71)^{c}	2.41 (1.69)^{a}	1.96 (1.54)^{a}	4.02 (2.10)^{a}	3.17 (1.91)^{a}	1.28 (1.30)^{a}	0.44 (0.95)^{a}
T_2S_2	0.86 (1.12)^{bc}	0.69 (1.06)^{bc}	1.06 (1.24)^{abcd}	3.48 (1.99)^{a}	3.05 (1.87)^{ab}	2.21 (1.63)^{a}	0.00 (0.71)^{a}
T_2S_3	0.70 (1.06)^{bc}	0.22 (0.83)^{bc}	1.37 (1.28)^{abc}	2.27 (1.55)^{abc}	1.76 (1.41)^{abcde}	1.67 (1.44)^{a}	0.22 (0.83)^{a}
T_3S_1	0.89 (1.14)^{bc}	0.73 (1.08)^{bc}	0.00 (0.71)^{e}	0.97 (1.09)^{bcd}	1.38 (1.36)^{bcde}	1.16 (1.28)^{a}	0.00 (0.71)^{a}
T_3S_2	0.26 (0.85)^{bc}	0.22 (0.83)^{bc}	1.12 (1.27)^{abc}	2.94 (1.85)^{a}	2.61 (1.76)^{abc}	1.48 (1.32)^{a}	0.33 (0.88)^{a}
T_3S_3	0.22 (0.83)^{bc}	0.17 (0.81)^{c}	0.45 (0.96)^{bcde}	0.86 (1.06)^{bcd}	1.08 (1.20)^{de}	1.13 (1.28)^{a}	0.00 (0.71)^{a}
T_4S_1	0.22 (0.83)^{bc}	0.23 (0.84)^{bc}	0.43 (0.92)^{cde}	0.99 (1.09)^{bcd}	1.65 (1.46)^{abcde}	1.52 (1.42)^{a}	0.00 (0.71)^{a}
T_4S_2	0.30 (0.87)^{bc}	0.52 (0.99)^{bc}	0.00 (0.71)^{e}	0.00 (0.71)^{d}	0.00 (0.71)^{f}	1.11 (1.25)^{a}	0.11 (0.77)^{a}
T_4S_3	0.40 (0.93)^{bc}	1.89 (1.38)^{ab}	0.30 (0.86)^{de}	0.86 (1.06)^{bcd}	1.41 (1.31)^{cde}	1.17 (1.28)^{a}	0.00 (0.71)^{a}
T_5S_1	0.25 (0.84)^{bc}	0.22 (0.83)^{bc}	0.43 (0.95)^{cde}	2.39 (1.70)^{abc}	2.01 (1.58)^{abcde}	1.55 (1.43)^{a}	0.00 (0.71)^{a}
T_5S_2	0.70 (1.01)^{bc}	0.67 (1.00)^{bc}	0.40 (0.91)^{cde}	1.92 (1.46)^{abc}	1.38 (1.29)^{cde}	1.44 (1.39)^{a}	0.00 (0.71)^{a}
T_5S_3	0.29 (0.86)^{bc}	0.22 (0.83)^{bc}	0.77 (1.03)^{bcde}	2.65 (1.75)^{abc}	2.25 (1.64)^{abcde}	1.42 (1.38)^{a}	0.00 (0.71)^{a}
T_6S_1	0.37 (0.92)^{bc}	0.45 (0.96)^{bc}	0.83 (1.05)^{bcde}	2.32 (1.56)^{abc}	2.58 (1.73)^{abcd}	1.81 (1.51)^{a}	0.00 (0.71)^{a}
T_6S_2	0.93 (1.14)^{bc}	0.67 (1.05)^{bc}	1.42 (1.36)^{ab}	3.51 (1.99)^{a}	2.92 (1.84)^{abc}	1.89 (1.52)^{a}	0.00 (0.71)^{a}
T_6S_3	0.67 (1.05)^{bc}	0.64 (1.03)^{bc}	0.73 (1.11)^{bcd}	2.40 (1.70)^{abc}	1.45 (1.39)^{abcde}	1.22 (1.31)^{a}	0.00 (0.71)^{a}
T_7S_1	2.64 (1.77)^{a}	2.41 (1.69)^{a}	1.96 (1.54)^{a}	4.12 (2.15)^{a}	3.02 (1.87)^{ab}	1.73 (1.49)^{a}	0.00 (0.71)^{a}
T_7S_2	0.30 (0.86)^{bc}	0.40 (0.91)^{bc}	1.87 (1.54)^{a}	3.14 (1.90)^{a}	2.54 (1.74)^{abcd}	1.58 (1.44)^{a}	0.22 (0.83)^{a}
T_7S_3	0.87 (1.17)^{b}	0.67 (1.08)^{bc}	1.07 (1.25)^{abcd}	1.98 (1.48)^{abc}	2.26 (1.66)^{abcde}	1.64 (1.46)^{a}	0.44 (0.95)^{a}
Control +	1.65 (1.46)	0.00 (0.71)	0.00 (0.71)	0.86 (1.06)	0.33 (0.88)	1.00 (1.10)	0.00 (0.71)

The values followed by same letters do not differ significantly in DMRT P=(0.05). Transformed values are given in parenthesis.

+Abridged ANOVA is given in appendix

4.2.4.3 Interaction effect of organic manures and sprays

The interaction effect of organic manures and sprays was significantly different throughout the observations except 10 days after the second spray(Table 9b). Before the first spray, the mean values varied from 0.00 (T_1S_1, T_1S_2 and T_2S_1) to 2.64 (T_7S_1). At two DAS T_2S_1 and T_7S_1 recorded the maximum population (2.41 insects hill^{-10}), which was on par with T_4S_3 (1.89 insects hill^{-10}). Then a gradual increase in population was noticed upto 20 DAS. At 10 DAS, the highest count of predatory beetles was noticed in T_7S_1 and T_2S_1 (1.96 insects hill^{-10}). Carabid population was not observed in T_3S_1 and T_4S_2. At 20 DAS, T_7S_1 showed the maximum population (4.12 insects hill^{-10}). Population was nil in T_4S_2. After the second spray, population was found to decline. At two DAS, T_2S_1 recorded the highest count of predatory beetles (3.17 insects hill^{-10}). No carabid beetles were found in T_4S_2. At 10 and 20 DAS the count of carabids was similar in all the treatments.

4.2.4.4 Comparison of treatment combinations with control

Different treatment combinations were compared with control (Table 9b). Before the first spray, the count of carabid beetles in control plot was 1.65 insects hill^{-10}. At two and 10 DAS, carabid beetles were not recorded in control. After that, a slight build up of population was observed. At 20 DAS, control (0.86 insects hill^{-10}) was superior to T_4S_2 where carabid beetles were not observed. After the second spray in control, population was decreased from 0.86 to 0.33 insects hill^{-10}. At two DAS, control was superior to T_4S_2, where carabid beetles were not observed. At 10 DAS, count was increased to 1.00.

4.2.5 Effect of organic materials on damsel flies

The predominant species observed in this group is *Agriocnemis* sp.

Table 10a. Effect of organic manures and sprays on count of damsel flies, mean number sweep^{-1}

Treatment	Organic manures	First Spray			Second Spray			Third Spray		
	20 DAT	2 DAS 24 DAT	10 DAS 32 DAT	20 DAS 42 DAT	2 DAS 46 DAT	10 DAS 54 DAT	20 DAS 64 DAT	2 DAS 68 DAT	10 DAS 76 DAT	20 DAS 86 DAT
Main plot T_1	0.56 (0.97)^{a}	0.67 (1.00)^{a}	0.33 (0.88)^{b}	0.33 (0.88)^{a}	0.33 (0.88)^{a}	0.22 (0.82)^{a}	0.33 (0.88)^{b}	0.44 (0.94)^{a}	0.22 (0.82)^{b}	0.00 (0.71)^{b}
T_2	0.33 (0.88)^{a}	0.78 (1.09)^{a}	0.67 (1.00)^{b}	0.22 (0.82)^{a}	0.78 (1.11)^{a}	0.33 (0.88)^{a}	1.00 (1.10)^{a}	0.67 (1.00)^{a}	0.11 (0.77)^{b}	0.00 (0.71)^{b}
T_3	0.89 (1.05)^{a}	1.00 (1.10)^{a}	0.33 (0.88)^{b}	0.22 (0.82)^{a}	0.33 (0.88)^{a}	0.22 (0.82)^{a}	0.44 (0.92)^{b}	0.44 (0.94)^{a}	0.11 (0.77)^{b}	0.00 (0.71)^{b}
T_4	0.44 (0.92)^{a}	0.56 (0.97)^{a}	0.44 (0.92)^{b}	0.11 (0.77)^{a}	0.11 (0.77)^{a}	0.00 (0.71)^{a}	0.33 (0.88)^{b}	0.44 (0.94)^{a}	0.11 (0.77)^{b}	0.00 (0.71)^{b}
T_5	0.33 (0.88)^{a}	0.44 (0.94)^{a}	0.33 (0.88)^{b}	0.22 (0.82)^{a}	0.33 (0.88)^{a}	0.22 (0.82)^{a}	0.33 (0.88)^{b}	0.56 (0.97)^{a}	0.44 (0.94)^{a}	0.11 (0.77)^{ab}
T_6	0.89 (1.05)^{a}	1.00 (1.10)^{a}	0.67 (1.00)^{b}	0.33 (0.88)^{a}	0.22 (0.82)^{a}	0.11 (0.77)^{a}	0.11 (0.77)^{b}	0.56 (0.97)^{a}	0.11 (0.77)^{b}	0.00 (0.71)^{b}
T_7	0.56 (0.99)^{a}	1.67 (1.40)^{a}	1.33 (1.29)^{a}	0.33 (0.88)^{a}	0.56 (0.97)^{a}	0.44 (0.94)^{a}	1.00 (1.10)^{a}	0.89 (1.05)^{a}	0.67 (1.00)^{a}	0.44 (0.94)^{a}
Sub plot S_1	0.89 (1.05)$_{a}$	1.05 (1.17)$_{a}$	0.71 (1.07)$_{a}$	0.33 (0.88)$_{a}$	1.00 (1.10)$_{a}$	0.33 (0.88)$_{a}$	0.33 (0.88)$_{a}$	0.52 (0.93)$_{a}$	0.05 (0.73)$_{a}$	0.29 (0.86)$_{a}$
S_2	0.52 (0.97)$_{a}$	0.57 (0.98)$_{b}$	0.48 (0.95)$_{a}$	0.29 (0.86)$_{a}$	0.71 (1.01)$_{ab}$	0.29 (0.86)$_{a}$	0.29 (0.86)$_{a}$	0.52 (0.93)$_{a}$	0.05 (0.73)$_{a}$	0.10 (0.76)$_{a}$
S_3	0.62 (1.01)$_{a}$	0.57 (0.98)$_{b}$	0.44 (0.92)$_{a}$	0.33 (0.88)$_{a}$	0.14 (0.78)$_{b}$	0.43 (0.93)$_{a}$	0.29 (0.86)$_{a}$	0.29 (0.86)$_{a}$	0.10 (0.76)$_{a}$	0.05 (0.73)$_{a}$

The values followed by same letters do not differ significantly in DMRT P=(0.05)

DMRT is given in superscript italics- Main plot; Subscript - Subplot

Transformed values are given in parenthesis.

DAS – Days after spraying DAT – Days after transplanting

4.2.5.1 Individual effect of organic manures

The effect of organic manures on count of damsel flies was studied and it was observed that the count of insects was not statistically different at 20 DAT (Table 10a). However, maximum population was recorded in T_3 and T_6(0.89 insect sweep^{-1}). An increasing trend was following in all the plots. At 32 DAT, T_7 recorded significantly higher population of damsel flies (1.33 insects sweep^{-1}), whereas T_4 recorded the lowest value (0.11 insect sweep^{-1}). After 32 DAT, a decline and then an increase in population was recorded in all the plots except T_4. The population of damsel flies stepped to its maximum at 64 DAT. At 64 DAT, T_2 and T_7 recorded the maximum count (1.00 insect sweep^{-1}). Thereafter, a gradual decline in population was observed up to 86 DAT. At 76 DAT, T_7 recorded the maximum count (0.67 insect sweep^{-1}).

4.2.5.2 Individual effect of organic sprays

The count of damsel flies was statistically on par before the first spray (Table 10a). At two DAS, the highest count of damsel flies was noticed in S_1 (1.05 insects sweep^{-1}), whereas S_2 and S_3 recorded the lowest value (0.57 insect sweep^{-1}). Then, a decline in population was observed up to 20 DAS. At two days after the second spray S_1 recorded the highest count (1.00 insect sweep^{-1}). At the same time, S_3 recorded the lowest count (0.14 insect sweep^{-1}). Then a decline in population was noticed up to 20 DAS. Population reached its maximum at two DAS. Then, a declining trend was noticed in all the plots.

4.2.5.3 Interaction effect of organic manures and sprays

Before the first spray, the count of damsel flies was statistically on par in all the plots (Table 10b). At two DAS, the highest count of damsel flies was recorded in T_7S_1 (3.00 insects sweep $^{-1}$), whereas the population was not recorded in T_1S_3 and T_5S_2. At 10 and 20 DAS, the count was not statistically different. However, T_7S_1 recorded the maximum population (1.33 and 1.00 insects sweep $^{-1}$).

Table 10b. Interaction effect of organic manures and sprays on count of damsel flies, mean number sweep^{-1}

Treatments	Organic manures (20 DAT)	First spray			Second spray			Third spray		
		2DAS (24 DAT)	10 DAS (32 DAT)	20 DAS (42 DAT)	2DAS (46 DAT)	10 DAS (54 DAT)	20 DAS (64 DAT)	2DAS (68 DAT)	10 DAS (76 DAT)	20 DAS (86 DAT)
T_1S_1	0.33 (0.88)^{a}	0.67 (1.00)^{b}	0.67 (1.00)^{a}	0.33 (0.88)^{a}	0.33 (0.88)^{ab}	0.67 (1.00)^{ab}	0.00 (0.71)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}	0.67 (1.00)^{a}
T_1S_2	0.67 (1.00)^{a}	0.67 (1.00)^{b}	0.67 (1.00)^{a}	0.29 (0.86)^{a}	0.67 (1.00)^{ab}	0.67 (1.00)^{ab}	0.67 (1.00)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.33 (0.88)^{a}
T_1S_3	0.67 (1.00)^{a}	0.00 (0.71)^{c}	0.67 (1.00)^{a}	0.33 (0.88)^{a}	0.00 (0.71)^{b}	0.67 (1.00)^{ab}	0.33 (0.88)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_2S_1	0.33 (0.88)^{a}	0.67 (1.00)^{b}	1.00 (1.10)^{a}	0.00 (0.71)^{a}	0.33 (0.88)^{ab}	0.00 (0.71)^{b}	0.67 (1.00)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_2S_2	0.00 (0.71)^{a}	1.00 (1.10)^{b}	1.00 (1.10)^{a}	0.33 (0.88)^{a}	1.00 (1.10)^{a}	0.33 (0.88)^{ab}	0.67 (1.00)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_2S_3	0.67 (1.00)^{a}	0.67 (1.00)^{b}	0.67 (1.00)^{a}	0.67 (1.00)^{a}	1.00 (1.10)^{a}	0.67 (1.00)^{ab}	0.33 (0.88)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_3S_1	1.00 (1.10)^{a}	0.33 (0.88)^{b}	0.67 (1.00)^{a}	0.33 (0.88)^{a}	0.33 (0.88)^{ab}	0.00 (0.71)^{b}	0.67 (1.00)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}	0.33 (0.88)^{a}
T_3S_2	0.67 (1.00)^{a}	0.33 (0.88)^{b}	0.33 (0.88)^{a}	0.00 (0.71)^{a}	0.67 (1.00)^{ab}	0.33 (0.88)^{a}	0.00 (0.71)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_3S_3	1.00 (1.10)^{a}	0.67 (1.00)^{b}	0.67 (1.00)^{a}	0.33 (0.88)^{a}	0.00 (0.71)^{b}	0.33 (0.88)^{ab}	0.67 (1.00)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_4S_1	0.67 (1.00)^{a}	0.67 (1.00)^{b}	0.33 (0.88)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{b}	0.00 (0.71)^{b}	0.67 (1.00)^{a}	0.33 (0.88)^{a}	0.00 (0.71)^{a}	0.33 (0.88)^{a}
T_4S_2	0.33 (0.88)^{a}	0.67 (1.00)^{b}	0.33 (0.88)^{a}	0.00 (0.71)^{a}	0.33 (0.88)^{a}	0.00 (0.71)^{b}	0.00 (0.71)^{a}	0.33 (0.88)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_4S_3	0.33 (0.88)^{a}	0.33 (0.88)^{b}	1.00 (1.10)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{b}	0.67 (1.00)^{ab}	0.33 (0.88)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_5S_1	0.00 (0.71)^{a}	1.00 (1.10)^{b}	1.00 (1.10)^{a}	0.00 (0.71)^{a}	0.33 (0.88)^{ab}	0.33 (0.88)^{ab}	0.33 (0.88)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}	0.33 (0.88)^{a}
T_5S_2	0.00 (0.71)^{a}	0.00 (0.71)^{c}	0.67 (1.00)^{a}	0.00 (0.71)^{a}	1.00 (1.10)^{a}	0.67 (1.00)^{ab}	0.67 (1.00)^{ab}	1.00 (1.10)^{a}	0.33 (0.88)^{a}	0.33 (0.88)^{a}
T_5S_3	0.00 (0.71)^{a}	0.33 (0.88)^{b}	0.33 (0.88)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{b}	0.33 (0.88)^{ab}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}
T_6S_1	1.33 (1.29)^{a}	1.00 (1.10)^{b}	0.33 (0.88)^{a}	0.33 (0.88)^{a}	0.33 (0.88)^{ab}	0.33 (0.88)^{ab}	0.00 (0.71)^{a}	0.33 (0.88)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_6S_2	0.67 (1.00)^{a}	0.33 (0.88)^{b}	0.33 (0.88)^{a}	1.00 (1.10)^{a}	0.33 (0.88)^{ab}	0.33 (0.88)^{ab}	0.00 (0.71)^{a}	0.67 (1.00)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_6S_3	0.67 (1.00)^{a}	1.00 (1.10)^{b}	0.67 (1.00)^{a}	0.33 (0.88)^{a}	0.00 (0.71)^{b}	0.33 (0.88)^{ab}	0.33 (0.88)	0.67 (1.00)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_7S_1	0.33 (0.88)^{a}	3.00 (1.71)^{a}	1.33 (1.29)^{a}	1.00 (1.10)^{a}	1.00 (1.10)^{a}	1.00 (1.10)^{a}	0.00 (0.71)^{a}	0.33 (0.88)^{a}	0.33 (0.88)^{a}	0.33 (0.88)^{a}
T_7S_2	0.33 (0.88)^{a}	1.00 (1.10)^{b}	0.00 (0.71)^{a}	0.33 (0.88)^{a}	1.00 (1.10)^{a}	0.33 (0.88)^{ab}	0.00 (0.71)^{a}	1.00 (1.10)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
T_7S_3	1.00 (1.10)^{a}	0.00 (0.71)^{b}	0.67 (1.00)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{b}	0.33 (0.88)^{ab}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.33 (0.88)^{a}
Control +	0.67 (1.00)^{a}	0.00 (0.71)	0.33 (0.88)	0.33 (0.88)	0.00 (0.71)	0.00 (0.71)	0.33 (0.88)	0.00 (0.71)	0.00 (0.71)	0.33 (0.88)

The values followed by same letters do not differ significantly in DMRT P=(0.05). Transformed values are given in parenthesis. +Abridged ANOVA is given in appendix

At two and 10 days after the second spray, also T_7S_1 retained the superiority (1.00 insect sweep^{-1}). The mean population of damsel flies was maximum in T_7S_1 during the crop period.

4.2.5.4 Comparison of treatment combinations with control

Before the first spray, the count of damsel flies in all the treatments was more or less similar. At two DAS, control was inferior to all treatments except T_1S_3 and T_5S_2, where the population was nil. After that, a build up of population was noticed in control and it retained the same number at 20 DAS. At two days after the second spray, control was statistically on par with T_1S_3, T_3S_3, T_4S_3, T_5S_3, T_6S_3 and T_7S_3, where the population was nil. At 10 DAS, also the population was nil and slight increase in count was observed at 20 DAS. Thereafter the population of damsel flies was negligible in all the treatments (Table 10b).

4.2.6 Effect of organic materials on count of Hymenopteran parasitoids

The important Hymenopteran parasitoids predominant during the study were *Xanthopimpla flavolineata*, *Charops* sp., *Macrocentrus* sp., *Brachymeria* sp., *Stenobracon* sp. *etc*.

4.2.6.1 Individual effect of organic manures

The population of Hymenopteran members was similar at 20, 24 and 32 DAT (Table 11a). Population of Hymenopterns reached its maximum at 42 DAT. Among different treatments, the highest count of Hymenoptera was observed in T_3 and T_4 (2.89 insects sweep^{-1}). Then a decline in population was observed in all the treatments. The highest count of Hymenopterans was observed in T_4 (2.44 insects sweep^{-1}) at 46 DAT. At 54 DAT, T_5 recorded the minimum population (0.33 insects sweep^{-1}), whereas T_6 recorded the maximum population (2.00 insects sweep^{-1}). An increase in population was observed in all the treatments upto 68 DAT. At 76 DAT, T_5 was the superior treatment (2.44 insects

Table 11a. Effect of organic manures and sprays on count of Hymenopterans, mean number sweep $^{-1}$

Treatments	Organic manures	First Spray			Second Spray			Third Spray		
	20DAT	2 DAS (24DAT)	10 DAS (32DAT)	20 DAS (42DAT)	2 DAS (46DAT)	10 DAS (54DAT)	20 DAS (64DAT)	2 DAS (68DAT)	10 DAS (76DAT)	20 DAS (86DAT)
Main plot T_1	0.33 (0.88)^{a}	0.33 (0.88)^{a}	0.33 (0.88)^{a}	1.00 (1.10)^{ab}	0.33 (0.88)^{c}	1.00 (1.10)^{ab}	1.00 (1.10)^{cd}	3.56 (1.90)^{a}	0.33 (0.88)^{b}	0.22 (0.80)^{c}
T_2	0.89 (1.08)^{a}	1.00 (1.10)^{a}	0.00 (0.71)^{a}	1.78 (1.38)^{ab}	1.22 (1.19)^{b}	0.56 (0.93)^{b}	0.33 (0.88)^{d}	2.11 (1.59)^{ab}	1.00 (1.10)^{ab}	0.44 (0.90)^{bc}
T_3	0.78 (1.03)^{a}	0.67 (0.91)^{a}	1.00 (1.10)^{a}	2.89 (1.74)^{a}	1.33 (1.29)^{b}	1.00 (1.10)^{ab}	1.67 (1.35)^{bc}	2.89 (1.74)^{ab}	1.67 (1.35)^{ab}	0.78 (1.03)^{abc}
T_4	1.22 (1.19)^{a}	1.44 (1.20)^{a}	0.89 (0.05)^{a}	2.89 (1.74)^{a}	2.44 (1.64)^{a}	0.33 (0.88)^{b}	2.00 (1.58)^{ab}	2.89 (1.74)^{ab}	2.00 (1.58)^{ab}	1.00 (1.10)^{ab}
T_5	0.89 (1.08)^{a}	1.00 (1.10)^{a}	0.00 (0.71)^{a}	1.00 (1.10)^{ab}	1.67 (1.35)^{b}	0.89 (1.02)^{ab}	2.44 (1.64)^{a}	1.67 (1.35)^{b}	2.33 (1.61)^{a}	1.33 (1.29)^{a}
T_6	0.44 (0.90)^{a}	0.67 (1.00)^{a}	0.11 (0.17)^{a}	2.00 (1.58)^{ab}	1.00 (1.10)^{b}	2.00 (1.58)^{a}	1.33 (1.29)^{bc}	1.67 (1.35)^{b}	1.33 (1.29)^{ab}	0.78 (1.03)^{abc}
T_7	0.89 (1.08)^{a}	1.22 (1.19)^{a}	1.11 (1.17)^{a}	1.11 (1.17)^{ab}	1.00 (1.10)^{b}	1.00 (1.10)^{ab}	0.89 (1.05)^{cd}	2.00 (1.58)^{ab}	1.33 (1.29)^{ab}	0.67 (1.00)^{abc}
Sub plot S_1	0.71 (1.01)$_{a}$	0.95 (0.07)$_{a}$	0.24 (0.79)$_{a}$	1.38 (1.23)$_{a}$	0.71 (1.04)$_{b}$	0.81 (1.03)$_{a}$	1.24 (1.19)$_{a}$	2.38 (1.57)$_{b}$	1.43 (1.26)$_{a}$	0.81 (1.05)$_{a}$
S_2	0.95 (1.07)$_{a}$	0.95 (1.07)$_{a}$	0.52 (0.90)$_{a}$	1.95 (1.43)$_{a}$	1.76 (1.36)$_{a}$	0.95 (1.07)$_{a}$	1.48 (1.27)$_{a}$	3.08 (1.84)$_{a}$	1.57 (1.32)$_{a}$	0.57 (0.96)$_{a}$
S_3	0.52 (0.90)$_{a}$	0.71 (1.01)$_{a}$	0.24 (0.79)$_{a}$	1.91 (1.39)$_{a}$	0.86 (1.04)$_{a}$	1.38 (1.30)$_{a}$	1.43 (1.26)$_{a}$	2.71 (1.65)$_{b}$	1.29 (1.21)$_{a}$	1.00 (1.10)$_{a}$

The values followed by same letters do not differ significantly in DMRT P=(0.05)

Transformed values are given in parenthesis.

DMRT is given in superscript italics- Main plot; Subscript - Subplot

DAS – Days after spraying DAT – Days after transplanting

Table 11b. Interaction of organic manures and sprays on count of Hymenopterans, mean number sweep $^{-1}$

Treatments	Organic manures (20 DAT)	First spray			Second spray			Third spray		
		2 DAS (24 DAT)	10 DAS (32 DAT)	20 DAS (42 DAT)	2 DAS (46 DAT)	10 DAS (54 DAT)	20 DAS (64 DAT)	2 DAS (68 DAT)	10 DAS (76 DAT)	20 DAS (86 DAT)
T_1S_1	0.33 (0.88)^{a}	0.33 (0.88)^{b}	0.33 (0.88)^{b}	1.00 (1.10)^{ab}	0.33 (0.88)^{c}	0.33 (0.88)^{a}	1.00 (1.10)^{ab}	3.67 (2.03)^{a}	0.33 (0.88)^{a}	0.33 (0.88)^{a}
T_1S_2	0.33 (0.88)^{a}	1.00 (1.10)^{ab}	1.00 (1.10)^{ab}	1.00 (1.10)^{ab}	0.33 (0.88)^{c}	2.00 (1.58)^{e}	1.00 (1.10)^{ab}	4.00 2.10)^{a}	1.00 (1.10)^{a}	0.67 (1.00)^{a}
T_1S_3	0.33 (0.88)^{a}	0.00 (0.71)^{b}	0.33 (0.88)^{b}	1.00 (1.10)^{ab}	0.33 (0.88)^{c}	1.00 (1.10)^{a}	1.00 (1.10)^{ab}	3.00 (1.71)^{a}	0.33 (0.88)^{a}	0.33 (0.88)^{a}
T_2S_1	1.00 (1.10)^{a}	1.00 (1.10)^{ab}	0.33 (0.88)^{b}	1.00 (1.10)^{ab}	3.67 (2.03)^{a}	0.67 (1.00)^{a}	0.33 (0.88)^{b}	2.00 (1.58)^{a}	2.00 (1.58)^{a}	0.67 (1.00)^{a}
T_2S_2	0.67 (1.00)^{a}	0.33 (0.88)^{b}	0.33 (0.88)^{b}	1.00 (1.10)^{ab}	0.33 (0.88)^{c}	0.33 (0.88)^{a}	0.33 (0.88)^{b}	1.00 (1.10)^{a}	0.00 (0.71)^{a}	0.67 (1.00)^{a}
T_2S_3	1.00 (1.10)^{a}	2.00 (1.58)^{ab}	0.33 (0.88)^{b}	3.33 (1.95)^{a}	0.33 (0.88)^{c}	1.00 (1.10)^{a}	1.00 (1.10)^{ab}	3.33 (1.79)^{a}	1.00 (1.10)^{a}	0.00 (0.71)^{a}
T_3S_1	0.67 (1.00)^{a}	1.00 (1.10)^{ab}	0.33 (0.88)^{b}	3.67 (2.03)^{a}	1.00 (1.10)^{bc}	2.00 (1.58)^{a}	2.00 (1.58)^{ab}	3.00 (1.71)^{a}	2.00 (1.58)^{a}	1.33 (1.29)^{a}
T_3S_2	0.67 (1.00)^{a}	0.33 (0.88)^{b}	0.33 (0.88)^{b}	2.00 (1.58)^{ab}	0.33 (0.88)^{c}	2.67 (1.64)^{a}	3.00 (1.71)^{a}	2.67 (1.64)^{a}	3.00 (1.71)^{a}	1.33 (1.29)^{a}
T_3S_3	1.00 (1.10)^{a}	1.00 (1.10)^{ab}	3.00 (1.73)^{a}	3.00 (1.71)^{ab}	0.33 (0.88)^{c}	2.00 (1.58)^{a}	0.33 (0.88)^{b}	3.00 (1.71)^{a}	2.00 (1.58)^{a}	1.33 (1.29)^{a}
T_4S_1	0.67 (1.00)^{a}	0.33 (0.88)^{b}	0.67 (1.00)^{ab}	2.00 (1.58)^{ab}	1.67 (1.25)^{abc}	0.33 (0.88)^{a}	1.00 (1.10)^{ab}	1.00 (1.10)^{a}	2.00 (1.58)^{a}	0.67 (1.00)^{a}
T_4S_2	2.00 (1.58)^{a}	2.67 (1.64)^{a}	1.00 (1.10)^{ab}	3.67 (2.03)^{a}	3.00 (1.71)^{ab}	2.00 (1.58)^{a}	2.00 (1.58)^{ab}	3.00 (1.71)^{a}	2.00 (1.58)^{a}	0.00 (0.71)^{a}
T_4S_3	1.00 (1.10)^{a}	2.67 (1.64)^{a}	1.67 (1.25)^{ab}	3.00 (1.71)^{ab}	1.00 (1.10)^{bc}	1.33 (1.29)^{a}	3.00 (1.71)^{a}	3.00 (1.71)^{a}	2.00 (1.58)^{a}	2.33 (1.68)^{a}
T_5S_1	1.33 (1.29)^{a}	2.00 (1.58)^{ab}	0.33 (0.88)^{b}	0.00 (0.71)^{b}	3.00 (1.71)^{ab}	1.00 (1.10)^{a}	3.00 (1.71)^{a}	3.00 (1.71)^{a}	2.00 (1.58)^{a}	1.33 (1.29)^{a}
T_5S_2	0.67 (1.00)^{a}	1.00 (1.10)^{ab}	0.33 (0.88)^{b}	3.00 (1.71)^{ab}	0.33 (0.88)^{c}	0.33 (0.88)^{a}	1.00 (1.10)^{ab}	3.00 (1.71)^{a}	1.00 (1.10)^{a}	0.67 (1.00)^{a}
T_5S_3	0.67 (1.00)^{a}	0.33 (0.88)^{b}	0.33 (0.88)^{b}	0.00 (0.71)^{b}	2.00 (1.58)^{abc}	2.67 (1.64)^{a}	3.33 (1.95)^{a}	2.67 (1.64)^{a}	2.00 (1.58)^{a}	1.33 (1.29)^{a}
T_6S_1	0.00 (0.71)^{a}	0.33 (0.88)^{b}	0.33 (0.88)^{b}	2.00 (1.58)^{ab}	0.00 (0.71)^{c}	1.00 (1.10)^{a}	1.00 (1.10)^{ab}	2.33 (1.57)^{a}	1.00 (1.10)^{a}	1.00 (1.10)^{a}
T_6S_2	1.33 (1.29)^{a}	2.00 (1.58)^{ab}	1.67 (1.25)^{ab}	2.00 (1.58)^{ab}	3.00 (1.71)^{ab}	1.00 (1.10)^{a}	1.00 (1.10)^{ab}	1.67 (1.64)^{a}	2.00 (1.58)^{a}	0.00 (1.10)^{a}
T_6S_3	0.00 (0.71)^{a}	0.00 (0.71)^{b}	1.67 (1.25)^{ab}	2.00 (1.58)^{ab}	0.33 (0.88)^{c}	2.00 (1.58)^{a}	2.00 (1.58)^{ab}	1.00 (1.10)^{a}	1.00 (1.10)^{a}	1.33 (1.29)^{a}
T_7S_1	1.33 (1.29)^{a}	2.67 (1.64)^{a}	1.67 (1.25)^{ab}	0.00 (0.71)^{b}	3.00 (1.71)^{ab}	1.00 (1.10)^{a}	0.67 (1.00)^{ab}	1.00 (1.10)^{a}	1.00 (1.10)^{a}	0.67 (1.00)^{a}
T_7S_2	1.33 (1.29)^{a}	1.00 (1.10)^{ab}	0.33 (0.88)^{b}	1.00 (1.10)^{ab}	1.00 (1.10)^{bc}	1.00 (1.10)^{a}	2.00 (1.58)^{ab}	2.00 (1.58)^{a}	2.00 (1.58)^{a}	0.67 (1.00)^{a}
T_7S_3	0.33 (0.88)^{a}	0.33 (0.88)^{b}	1.67 (1.25)^{ab}	1.00 (1.10)^{ab}	3.00 (1.71)^{ab}	1.00 (1.10)^{a}	0.33 (0.88)^{b}	3.00 (1.71)^{a}	1.00 (1.10)^{a}	0.67 (1.00)^{a}
Control +	2.00 (1.58)	0.00 (0.71)	0.33 (0.88)	0.67 (1.00)	0.00 (0.71)	0.67 (1.00)	1.33 (1.29)	1.00 (1.10)	0.00 (0.71)	0.00 (0.71)

The values followed by same letters do not differ significantly in DMRT P=(0.05). Transformed values are given in parenthesis.
+Abridged ANOVA is given in appendix

sweep^{-1}), which was on par with T_4 (2.00 insects sweep^{-1}). The population showed declining phase from 76 DAT to harvest. The mean population of Hymenopterans was maximum in T_4 during the crop period.

4.2.6.2 Individual effect of organic sprays

From the Table 11a it is clear that Hymenopteran population was maximum in S_2 during the crop period.

4.2.6.3 Interaction effect of organic manures and sprays

The interaction effect of treatments on population of Hymenopteran members is presented in Table 11b. At two DAS, T_4S_2 and T_4S_3 recorded the highest count of Hymenoptera (2.67 insects sweep^{-1}). T_4S_2 registered the maximum population of Hymenopterans at 20 DAS (3.67 insects sweep^{-1}). The population of parasitoids reduced consequent to the second spray. However, the maximum population was noticed in T_2S_1 (3.67 insects sweep^{-1}), followed by T_4S_2, T_6S_2, T_7S_1 and T_7S_3 (3.00 insects sweep^{-1}). At 20 days after the second spray, the highest population was noticed in T_5S_3 (3.33 insects hill^{-1}). After the third spray, the population of Hymenopterans was similar in all the treatments.

4.2.6.4 Comparison of treatment combinations with control

Compared to the control plot, all the botanical treated plots recorded significantly higher mean population of Hymenoptera (Table 11b).

4.3 EFFECT OF ORGANIC MATERIALS ON DISEASE MANAGEMENT

4.3.1 Brown spot

Disease incidence and its severity were recorded at 46 DAT. Based on per cent disease incidence and disease severity, coefficient of disease index (CODEX) was also worked out and the data are furnished in Table 12a and 12b.

4.3.1.1 Individual effect of organic manures

The effects of various organic manures on brown spot disease were found to be significant. Among the treatments, the lowest disease incidence of 1.00 per cent was recorded in T_6. Thus the highest disease control was obtained with T_6 (CODEX=0.01). Next best alternative on suppression of disease was T_5 (CODEX=0.02).

4.3.1.2 Individual effect of organic sprays

Different organic sprays did not exert significant influence on brown spot disease of rice. However, S_3 was comparatively better than other treatments in suppression of disease (CODEX=0.04).

4.3.1.3 Interaction effect of organic manures and sprays

The combination effect of organic manures and sprays had significant effect on brown spot of rice. Complete disease control was noticed in T_6S_3 and T_3S_3 (CODEX=0.00).

4.3.1.4 Comparison of treatment combinations with control

The various treatment combinations were compared with control to evaluate its superiority. T_1S_1 (CODEX=0.52) and T_1S_2 (CODEX=0.33) were inferior to control (CODEX=0.20).

4.3.2 Sheath rot

The observation on the effect of organic materials on sheath rot was recorded at 64 DAT. The effect of organic materials and sprays alone and combination is presented in Table 12a and 12b.

4.3.2.1 Individual effect of organic manures

The different organic manures did not exhibit significant influence on per cent disease incidence and severity. However, the organic manures had significant effect on CODEX value. The highest disease control was observed in T_3 (CODEX=0.05), which was followed by T_5 and T_6 (CODEX=0.11). T_7 recorded the highest value (CODEX=0.53).

4.3.2.2 Individual effect of organic sprays

The effect of organic sprays was statistically on par in the case of sheath rot of rice. However, the treatment S_1 gave comparatively lower disease incidence (CODEX=1.02).

4.3.2.3 Interaction effect of organic manures and sprays

T_2S_3, T_3S_1 and T_6S_2 recorded the lowest disease incidence and severity (1.67 and 0.46% respectively), whereas T_7S_2 was the inferior treatment (CODEX=4.81).

4.3.2.4 Comparison of treatment combinations with control

The observations on sheath rot disease at 64 DAT revealed that T_7S_2 (CODEX=1.08) was inferior as compared to control (CODEX=0.54). T_6S_2, T_3S_1, T_2S3 (CODEX=0.02), T_6S_1 (0.05), T_2S_2 (0.07), T_3S_3 (0.08), T_5S_1, T_5S_2 (0.09) and T_1S_3 (0.12) were the superior treatments over control.

4.4 EFFECT OF ORGANIC MATERIALS ON WEED POPULATION

Before hand weeding and organic spraying, the first observation on weed population was taken at 20 DAT. After hand weeding and organic spray application, observations were taken at 45 and 70 DAT and at harvest to compare the effect of treatment combinations with control. At this instance, the separate effects of organic manures and sprays also were studied. In all the plots, the population of weeds was found to be increasing from 45 DAT up to harvest.

4.4.1 Individual effect of organic manures

The effect of organic manures on weed count varied significantly at all days of observations (Table 13a). At 20 DAT, the least weed infestation was recorded in T_4 (40.00 no. m^{-2}) followed by T_1 (66.22 no. m^{-2}). The highest weed population was observed in T_7 (116.67 no. m^{-2}). At 45 DAT, the best treatments were T_4 and T_5, where the weed population was not found. These were on par with T_3 (0.44 no. m^{-2}) and T_1 (0.89 no. m^{-2}). T_7 was found to be inferior to all other treatments, where the weed population was high (5.78 no. m^{-2}). At 70 DAT, minimum weed count was noticed in T_4 (26.67 no. m^{-2}), which was followed by T_2 (43.56 no. m^{-2}) and T_3 (45.33 no. m^{-2}). Weed infestation was maximum in T_7 (74.22 no. m^{-2}). At harvest, weed population was lower in T_1 (50.22 no. m^{-2}), which was on par with T_3 (52.22 no. m^{-2}) and T_4 (52.67 no. m^{-2}). Maximum count was registered in T_7 (96.00 no. m^{-2}). Throughout the crop growth, application of snake wood leaves (T_4) recorded its superiority in the suppression of weed population.

4.4.2 Individual effect of organic sprays

At 20 DAT, S_2 was the superior treatment in the suppression of weed population (76.10 no. m^{-2}). The highest infestation was registered in S_1 (103.33 no. m^{-2}). At 45 DAT and harvest, S_2 retained the superiority (0.76 and 67.91 no. m^{-2} respectively), and S_3 was the inferior treatment (2.86 and 77.81 no. m^{-2}) respectively (Table 13a). Spraying of hydnocarpus oil (S_2) recorded the lowest population of weeds during the crop growth.

Table 13a. Effect of organic manures and sprays on weed count (No. m^{-2})

Treatments	Days after transplanting			
	20	45	70	Harvest
Main plot				
T_1	66.22 (8.16)^{d}	0.89 (1.02)^{c}	46.67 (6.86)^{bc}	50.22 (7.10)^{c}
T_2	108.89 (10.38)^{b}	3.56 (1.74)^{b}	43.56 (6.60)^{c}	81.11 (9.02)^{b}
T_3	114.22 (10.66)^{ab}	0.44 (0.86)^{c}	45.33 (6.74)^{c}	52.22 (7.20)^{c}
T_4	40.00 (6.36)^{e}	0.00 (0.71)^{c}	26.67 (5.15)^{d}	52.67 (7.24)^{c}
T_5	81.78 (9.02)^{c}	0.00 (0.71)^{c}	51.11 (7.17)^{b}	75.11 (8.69)^{b}
T_6	104.67 (10.23)^{ab}	4.00 (2.05)^{ab}	71.11 (8.46)^{a}	81.11 (9.02)^{b}
T_7	116.67 (10.78)^{a}	5.78 (2.20)^{a}	74.22 (8.64)^{a}	96.00 (9.82)^{a}
Sub plot				
S_1	103.33 (10.04)$_{a}$	2.67 (1.52)$_{a}$	50.86 (7.03)$_{a}$	73.71 (8.48)$_{ab}$
S_2	76.10 (8.63)$_{c}$	0.76 (0.98)$_{b}$	49.71 (6.98)$_{a}$	67.91 (8.17)$_{b}$
S_3	95.71 (9.63)$_{b}$	2.86 (1.48)$_{a}$	53.14 (7.25)$_{a}$	77.81 (8.76)$_{a}$

The values followed by same letters do not differ significantly in DMRT P=(0.05)

DMRT is given in superscript italics- Main plot; Subscript - Subplot

Transformed values are given in parenthesis

DAS – Days after spraying DAT – Days after transplanting

4.4.3 Interaction effect of organic manures and sprays

The interaction effect of organic manures and sprays on weed count was found to be significant at all days of observations (Table 13b). At 20 DAT, T_4S_2 (36.00 no. m^{-2}) was superior in the suppression of weed population, which was on par with T_4S_3 (40.00 no. m^{-2}) and T_4S_1 (44.00 no. m^{-2}). T_7S_1 recorded the highest weed population (133.33 no. m^{-2}). At 45 DAT, the best treatments were T_1S_2, T_1S_3, T_3S_1, T_3S_2, T_4S_1, T_4S_2, T_4S_3, T_5S_1, T_5S_2, T_5S_3 and T_6S_2, where weed population was not found. T_4S_1 recorded the lowest weed population at 70 DAT (18.67 no. m^{-2}), and the next best treatment was T_4S_2 (28.00 no. m^{-2}). The highest population of weeds was recorded in T_7S_1 (76.00 no. m^{-2}). At harvest, weed infestation was minimum in T_3S_2 (43.33 no. m^{-2}), which was on par with T_4S_1, T_1S_3, T_4S_2 (46.00 no. m^{-2}), T_3S_1 (48.00 no. m^{-2}), and T_1S_2 (48.67 no. m^{-2}). T_7S_1 and T_7S_3 were the inferior treatments, where the weed population was very high (98.67 no. m^{-2}). Thus the treatment combination T_4S_2 maintained its superiority in the control of weeds throughout the crop period.

4.4.4 Comparison of treatment combinations with control

The different treatment combinations were compared with control to find out the superior treatments in the suppression of weeds. At 20 DAT, control recorded the weed population of 124 no. m^{-2}, while T_7S_1 recorded the highest weed population of 133.33 no. m^{-2}. At 45 DAT, T_7S_1 (12.00 no. m^{-2}), T_6S_1 and T_2S_1 (6.67 no. m^{-2}) recorded higher weed population than control. At 70 DAT, T_7S_1 (76.00 no. m^{-2}), T_7S_2, T_7S_3 (73.33 no. m^{-2}) and T_6S_3 (72.00 no. m^{-2}) were the inferior treatments as compared to control, and T_6S_2 recorded the same count (70.67 no. m^{-2}). At harvest, T_7S_1, T_7S_3 (98.67 no. m^{-2}) and T_7S_2 (90.67 no. m^{-2}) recorded higher weed population than control (89.33 no. m^{-2}) (Table 13b).

Table 13b. Interaction effect of treatments on weed count (No. m^{-2})

Treatments	Days after transplanting			
	20	45	70	Harvest
T_1S_1	68.00 (8.27)^{e}	2.67 (1.65)^{bcd}	52.00 (7.24)^{b}	56.00 (7.51)^{fg}
T_1S_2	62.67 (7.94)^{e}	0.00 (0.71)^{d}	42.67 (6.57)^{bcd}	48.67 (7.00)^{g}
T_1S_3	68.00 (8.27) ^{e}	0.00 (0.71)^{d}	45.33 (6.76)^{bcd}	46.00 (6.79)^{g}
T_2S_1	126.67 (11.28)^{a}	6.67 (2.39)^{b}	41.33 (6.46)^{bcd}	83.33 (9.15)^{cde}
T_2S_2	73.33 (8.59)^{de}	1.33 (1.18)^{cd}	46.67 (6.82)^{bc}	81.33 (9.04)^{cde}
T_2S_3	126.67 (11.28)^{a}	2.67 (1.65)^{bcd}	42.67 (6.51) ^{bcd}	78.67 (8.87)^{cde}
T_3S_1	121.33 (11.04)^{a}	0.00 (0.71)^{d}	45.53 (6.75) ^{bcd}	48.00 (6.91)^{g}
T_3S_2	88.00 (9.38)^{c}	0.00 (0.71)^{d}	36.00 (6.04)^{cde}	43.33 (6.59)^{g}
T_3S_3	133.33 (11.56)^{a}	1.33 (1.18)^{cd}	54.67 (7.43)^{b}	65.33 (8.11)^{ef}
T_4S_1	44.00 (6.67)^{f}	0.00 (0.71)^{d}	18.67 (4.37)^{f}	46.00 (6.77)^{g}
T_4S_2	36.00 (6.04)^{f}	0.00 (0.71)^{d}	28.00 (5.27)^{e}	46.00 (6.81)^{g}
T_4S_3	40.00 (6.36)^{f}	0.00 (0.71)^{d}	33.33 (5.81)^{de}	66.00 (8.14)^{ef}
T_5S_1	106.67 (10.35)^{b}	0.00 (0.71)^{d}	52.00 (7.24)^{b}	70.67 (8.43)^{def}
T_5S_2	65.33 (8.11)^{e}	0.00 (0.71)^{d}	50.67 (7.11)^{b}	76.00 (8.74)^{de}
T_5S_3	73.33 (8.59)^{de}	0.00 (0.71)^{d}	50.67 (7.11)^{b}	78.67 (8.89)^{cde}
T_6S_1	94.62 (9.54)^{c}	6.67 (2.39)^{b}	70.67 (8.43)^{a}	88.00 (9.25)^{cd}
T_6S_2	83.33 (9.15)^{cd}	0.00 (0.71)^{d}	70.67 (8.43)^{a}	79.33 (8.79)^{cde}
T_6S_3	92.67 (9.64)^{a}	4.00 (2.12)^{bc}	72.00 (8.51)^{a}	88.00 (9.25)^{cd}
T_7S_1	133.33 (11.57)^{a}	12.00 (3.50)^{a}	76.00 (8.74)^{a}	98.67 (9.96)^{a}
T_7S_2	124.00 (11.16)^{a}	4.00 (2.12)^{bc}	73.33 (8.59)^{a}	90.67 (9.53)^{bcd}
T_7S_3	92.67 (9.64)^{c}	4.00 (2.12)^{bc}	73.33 (8.59)^{a}	98.67 (9.96)^{a}
Control +	124.00 (11.68)	4.00 (2.12)	70.67 (8.43)	89.33 (9.47)

+Abridged ANOVA of RBD is given in appendix

Transformed values are given in parenthesis

The values followed by same letters do not differ significantly in DMRT P=(0.05)

4.5 EFFECT OF ORGANIC MATERIALS ON CROP GROWTH PARAMETERS

4.5.1 Height of the plant

4.5.1.1 Individual effect of organic manures

The different organic manures did not exhibit significant influence on height of the plant at active tillering stage (ATS), panicle initiation stage (PIS) and harvest stages of crop growth (Table 14a). Numerically, the highest values at ATS, PIS and harvest stages were recorded in T_6 (31.08 cm, 49.35 cm and 66.02 cm respectively). The lowest values of 30.09, 47.16 and 63.82 at ATS, PIS and harvest respectively were observed in T_7, T_1 and T_2.

4.5.1.2 Individual effect of organic sprays

The different organic sprays had no significant influence on height of the plant except at PIS (Table 14a). The mean values ranged from 30.35 (S_1) to 30.66 (S_2) at ATS. S_2 recorded the highest value of 49.11 at PIS. At harvest, height ranged between 63.51 and 65.29.

4.5.1.3 Interaction effect of organic manures and sprays

The interaction effect was also significant only at PIS, wherein T_6S_2 produced the tallest plants (51.55cm). T_1S_1 recorded the lowest value (46. 23 cm) (Table 14b).

4.5.1.4 Comparison of treatment combinations with control

Control crop had a mean height of 31.1, 49.22 and 60.57 cm at ATS, PIS and harvest respectively. Control plot was significantly superior to treatment combinations T_1S_1 (46.23 cm) and T_6S_3 (45.89 cm) at PIS.

Table 14a . Effect of organic manures and sprays on growth parameters

Treatments	Height of the plant (cm)			No. of tillers per plant			Days to 50% flowering
	ATS	PIS	Harvest	ATS	PIS	Harvest	
Main plot							
T_1	30.23^{a}	47.16^{a}	64.41^{a}	5.33^{a}	7.98^{a}	7.39^{a}	87.11^{a}
T_2	30.26^{a}	48.76^{a}	63.82^{a}	5.58^{a}	8.31^{a}	8.02^{a}	87.44^{a}
T_3	30.78^{a}	48.43^{a}	64.63^{a}	5.37^{a}	7.80^{a}	7.52^{a}	86.33^{a}
T_4	30.87^{a}	48.28^{a}	64.26^{a}	5.74^{a}	8.37^{a}	8.26^{a}	87.78^{a}
T_5	30.36^{a}	47.29^{a}	64.17^{a}	5.30^{a}	8.26^{a}	8.21^{a}	87.56^{a}
T_6	31.08^{a}	49.35^{a}	66.02^{a}	5.75^{a}	8.45^{a}	8.25^{a}	86.67^{a}
T_7	30.09^{a}	48.88^{a}	64.14^{a}	5.72^{a}	8.22^{a}	8.22^{a}	87.33^{a}
Sub plot							
S_1	30.35_{a}	48.91_{a}	64.69_{a}	5.51_{a}	8.30_{a}	8.13_{a}	87.14_{a}
S_2	30.66_{a}	49.11_{a}	65.29_{a}	5.49_{a}	7.90_{a}	7.82_{a}	87.29_{a}
S_3	30.60_{a}	47.12_{b}	63.51_{a}	5.57_{a}	8.13_{a}	7.84_{a}	88.00_{a}

The values followed by same letters do not differ significantly in DMRT P=(0.05)

DMRT is given in superscript italics- Main plot; Subscript - Subplot

Transformed values are given in parenthesis

DAS – Days after spraying DAT – Days after transplanting

ATS- Active tillering stage PIS- Panicle initiation stage

Table 14b. Interaction effect of treatments on growth parameters

Treatments	Height of the plant (cm)			No.of tillers per plant			Days to 50% flowering
	ATS	PIS	Harvest	ATS	PIS	Harvest	
T_1S_1	29.14[a]	46.23[c]	65.52[a]	4.20[b]	8.14[a]	7.25[a]	87.00[a]
T_1S_2	31.5[a]	48.38[abc]	65.41[a]	5.59[ab]	8.03 [a]	8.00[a]	87.33[a]
T_1S_3	30.26[a]	46.86[abc]	62.31[a]	6.19[a]	7.78[a]	6.92[a]	87.00[a]
T_2S_1	29.90[a]	48.57[abc]	63.98[a]	5.58[ab]	8.16[a]	7.50[a]	88.00[a]
T_2S_2	31.60[a]	49.32[abc]	62.27[a]	5.78[ab]	7.94[a]	8.44[a]	87.67[a]
T_2S_3	29.24[a]	48.39[abc]	65.22[a]	5.39[ab]	8.83[a]	8.11[a]	86.67[a]
T_3S_1	31.14[a]	48.98[abc]	61.97[a]	5.86[ab]	8.00[a]	7.86[a]	86.33[a]
T_3S_2	30.27[a]	48.03[abc]	65.95[a]	4.61[ab]	7.44[a]	7.17[a]	86.33[a]
T_3S_3	30.93[a]	48.27[abc]	65.97[a]	5.64[ab]	7.97[a]	7.53[a]	86.33[a]
T_4S_1	30.23[a]	49.27[ab]	68.36[a]	4.97[ab]	8.97[a]	8.70[a]	87.67[a]
T_4S_2	29.94[a]	50.01[ab]	67.00[a]	5.00[ab]	8.02[a]	8.17[a]	88.00[a]
T_4S_3	32.45[a]	49.00[ab]	61.54[a]	5.92[ab]	8.70[a]	7.91[a]	87.67[a]
T_5S_1	30.57[a]	48.78[abc]	64.80[a]	5.64[ab]	8.33[a]	8.60[a]	87.00[a]
T_5S_2	29.61[a]	47.98[abc]	64.50[a]	5.83[ab]	8.25[a]	7.75[a]	88.00[a]
T_5S_3	30.90[a]	46.61[bc]	63.22[a]	5.75[ab]	8.21[a]	8.08[a]	87.67[a]
T_6S_1	31.87[a]	50.60[ab]	65.87[a]	6.39[a]	9.00[a]	8.67[a]	86.67[a]
T_6S_2	31.11[a]	51.55 [a]	67.04[a]	6.45[a]	8.85[a]	8.90[a]	87.00[a]
T_6S_3	30.27[a]	45.89[bc]	65.15[a]	4.61[ab]	7.95[a]	8.22[a]	86.33[a]
T_7S_1	29.55[a]	49.20[ab]	66.53[a]	5.92[ab]	7.47[a]	8.61[a]	87.33[a]
T_7S_2	30.13[a]	49.22[ab]	64.74[a]	5.75[ab]	8.47[a]	7.97[a]	86.67[a]
T_7S_3	30.58[a]	48.23[abc]	61.14[a]	5.50[ab]	7.89[a]	8.08[a]	88.00[a]
Control +	31.10	49.22	60.57	5.83	8.03	8.09	87.67

The values followed by same letters do not differ significantly in DMRT P=(0.05)

+Abridged ANOVA of RBD is given in appendix

Transformed values are given in parenthesis

ATS- Active tillering stage PIS- Panicle initiation stage

4.5.2 Number of tillers per plant

4.5.2.1 Individual effect of organic manures

Main plot treatments had no significant effect on number of tillers per plant throughout the crop growth (Table 14a). Number of tillers per plant ranged from 5.30 (T_5) to 5.75 (T_6), 7.80 (T_3) to 8.45 (T_6) and 7.39 (T_1) to 8.26 (T_4) at ATS, PIS and harvest respectively.

4.5.2.2 Individual effect of organic sprays

Organic sprays did not influence on number of tillers per plant during different growth stages (Table 14a). The mean values on number of tillers ranged from 7.82 to 8.13 at harvest.

4.5.2.3 Interaction effect of organic manures and sprays

The interaction effect was found to be significant only at ATS (Table 14b). At ATS, T_6S_2 recorded the highest tiller number (6.45) but similar to all other treatment combinations except $T_1S_{1.}$

4.5.2.4 Comparison of treatment combinations with control

A significant difference was observed between treatment combinations and control at ATS and harvest (Table 14b). At ATS T_6S_2 (6.45), T_6S_1 (6.39), T_1S_3 (6.19), T_4S_3 (5.92), T_3S_1 (5.86) and T_5S_2 (5.84) were comparatively superior to the control (5.83). At harvest, T_6S_2 (8.90), T_4S_1 (8.70), T_7S_1 (8.61), T_2S_2 (8.44), T_6S_3 (8.22), T_4S_2, T_6S_1 (8.17) and T_2S_3 (8.11) were superior to control (8.09) on count of tillers per plant. Control plot on an average produced 5.83, 8.03 and 8.09 tillers per plant at ATS, PIS and harvest.

4.5.3 Days to 50% flowering

The individual effects of organic manures, sprays and interaction effect was found to be insignificant on days to 50 per cent flowering. There was no significant difference between treatment combinations and control (Table 14a & 14b).

4.6 EFFECT OF ORGANIC MATERIALS ON YIELD PARAMETERS

4.6.1 Number of panicles per hill

4.6.1.1 Individual effect of organic manures

The organic manures had significant influence on number of panicles per hill. Highest number of panicles per hill (7.80) was produced by $T_{6,}$ which was superior to T3 (6.77), but was on par with other treatments (Table 15a).

4.6.1.2 Individual effect of organic sprays

Organic sprays showed significant effect on number of panicles per hill. S_2 recorded the highest value (7.59), significant over S_3 (7.06), but similar to S_1 (7.23) (Table 15a).

4.6.1.3 Interaction effect of organic manures and sprays

The interaction effects of organic manures and sprays on number of panicles per hill were found to be significant. T_6S_2 recorded the maximum number of panicles (8.92), and the least value recorded for T_3S_1 (6.25) (Table 15b).

Table 15a . Effect of organic manures and sprays on yield parameters

Treatments	No.of panicles hill $^{-1}$	Per cent of filled grains	1000 grain weight	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Grain: Straw ratio
Main plot T_1	7.00^{ab}	82.00^{a}	26.61^{a}	2790^{a}	3946^{a}	0.72^{a}
T_2	7.49^{ab}	76.67^{abc}	26.54^{a}	2734^{a}	3958^{a}	0.69^{ab}
T_3	6.77^{b}	73.98^{c}	26.94^{a}	2600^{a}	3832^{a}	0.68^{ab}
T_4	7.67^{ab}	76.67^{abc}	26.34^{a}	2805^{a}	4010^{a}	0.70^{ab}
T_5	7.48^{ab}	76.66^{abc}	26.27^{a}	2469^{a}	4331^{a}	0.57^{b}
T_6	7.80^{a}	80.00^{ab}	27.17^{a}	2825^{a}	3948^{a}	0.70^{ab}
T_7	6.84^{ab}	72.24^{c}	26.09^{a}	2508^{a}	4055^{a}	0.68^{b}
Sub plot S_1	7.23_{a}	74.42_{b}	26.55_{a}	2671_{a}	4150_{a}	0.66_{a}
S_2	7.59_{a}	79.17_{a}	26.60_{a}	2674_{a}	3987_{a}	0.68_{a}
S_3	7.06_{b}	76.25_{ab}	26.55_{a}	2660_{a}	4085_{a}	0.67_{a}

The values followed by same letters do not differ significantly in DMRT P=(0.05)

DMRT is given in superscript italics- Main plot; Subscript - Subplot

Transformed values are given in parenthesis

DAS – Days after spraying DAT – Days after transplanting

Table 15b. Interaction effect of organic manures and sprays on yield parameters

Treatments	No.of panicles hill $^{-1}$	Per cent of filled grains	1000 grain weight	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Grain Straw ratio
T_1S_1	6.72^{cd}	78.31^{abc}	26.03^{a}	2607^{abcde}	3804^{ab}	0.70^{ab}
T_1S_2	8.03^{abc}	82.00^{a}	27.00^{a}	3000 ^{ab}	4198^{ab}	0.68^{bc}
T_1S_3	6.80^{cd}	80.44^{ab}	26.80^{a}	2620^{abcde}	3834^{ab}	0.68^{bc}
T_2S_1	7.00^{cd}	70.34^{c}	26.00^{a}	2471^{cde}	3965^{ab}	0.62^{ab}
T_2S_2	7.72^{abcd}	73.00^{abc}	26.07^{a}	2399 ^{de}	3584^{ab}	0.68^{bc}
T_2S_3	7.75^{abcd}	78.28^{abc}	27.57^{a}	2849^{abcde}	4326^{ab}	0.70^{ab}
T_3S_1	6.25^{d}	75.18^{abc}	27.00^{a}	2923^{abcd}	3535^{b}	0.85^{a}
T_3S_2	6.83^{cd}	74.13^{abc}	27.10^{a}	2477^{cde}	3668^{ab}	0.68^{bc}
T_3S_3	6.67^{cd}	72.64^{abc}	26.73^{a}	3001^{ab}	4293^{ab}	0.59^{c}
T_4S_1	7.31^{bcd}	73.00^{bc}	27.77^{a}	2479^{cde}	4200^{ab}	0.59^{c}
T_4S_2	8.47^{ab}	80.00^{ab}	26.00^{a}	3025^{ab}	3927^{ab}	0.77^{a}
T_4S_3	7.22^{bcd}	72.25^{abc}	25.27^{a}	2574^{bcde}	4573^{ab}	0.57^{c}
T_5S_1	8.00^{abc}	74.20^{abc}	26.90^{a}	2409^{cde}	4287^{ab}	0.56^{c}
T_5S_2	7.00^{cd}	79.00^{abc}	25.97^{a}	2635^{abcde}	4047^{ab}	0.73^{ab}
T_5S_3	7.44^{bcd}	72.90^{abc}	25.93^{a}	2368^{e}	4659^{a}	0.54^{c}
T_6S_1	7.20^{cd}	71.89^{abc}	26.73^{a}	2788^{abcde}	4320^{ab}	0.64^{bc}
T_6S_2	8.92^{a}	80.00^{ab}	27.13^{a}	3152^{a}	4200^{ab}	0.64^{bc}
T_6S_3	6.78^{cd}	75.07^{abc}	27.63^{a}	2523^{cde}	3676^{ab}	0.68^{bc}
T_7S_1	7.2^{bcd}	70.34^{abc}	25.43^{a}	2538^{bcde}	4497^{ab}	0.56^{c}
T_7S_2	7.17^{bcd}	70.00^{abc}	26.93^{a}	2367^{e}	3990^{ab}	0.60^{bc}
T_7S_3	7.33^{bcd}	77.20^{abc}	25.90^{a}	2618^{abcde}	3800^{ab}	0.69^{bc}
Control^{+}	7.75	80.00	27.43	2997	4458	0.65

The values followed by same letters do not differ significantly in DMRT P=(0.05)

+Abridged ANOVA for RBD is given in appendix

Transformed values are given in parenthesis

4.6.1.4 Comparison of treatment combinations with control

Treatment combinations T_6S_2 (8.92), T_1S_2 (8.03) and T_4S_2 (8.00) were superior in comparison to control (7.75) (Table 15b).

4.6.2 Per cent of filled grains

4.6.2.1 Individual effect of organic manures

The different organic manures had significant influence on per cent of filled grains. T_1 (79.87 %) recorded the highest value, which was significantly superior to T_7 (72.24%) and T_3 (73.98%)(Table 15a).

4.6.2.2 Individual effect of organic sprays

A significant influence for different organic sprays on per cent of filled gains was noticed. S_2 (82.00%) recorded the highest value and superior to S_1 (74.42%) (Table 15a).

4.6.2.3 Interaction effect of organic manures and sprays

The interaction effect on per cent of filled grains were also found to be significant. T_1S_2 (82.00%) registered the highest per cent of filled grains, and the lowest value was recorded for T_2S_1 (70.34%) (Table 15b).

4.6.2.4 Comparison of treatment combinations with control

Control crop had 80.00 per cent of filled grains. It was on par with T_1S_2, which recorded the highest per cent of filled grains (82.00%) (Table 15b).

4.6.3 1000 Grain weight

The effect of organic manures, sprays and interaction effect did not differ significantly on 1000 grain weight. (Table 15a and 15 b).

4.6.4 Grain yield

4.6.4.1 Individual effect of organic manures

The different organic manures did not influence the grain yield. The mean quantity of grain due to the application of organic manures ranged from 2469 to 2825 kg ha^{-1}(Table 15a).

4.6.4.2 Individual effect of organic sprays

Similarly organic sprays did not affect the grain yield. The yield ranged from 2660 to 2674 kg ha^{-1} due to organic sprays (Table 15a).

4.6.4.3 Interaction effect of organic manures and sprays

The interaction effect was found to be significant on the grain yield. T_6S_2 (3152 kg ha^{-1}) recorded the highest yield and the lowest value was observed in T_7S_2 (2367 kg ha^{-1}) (Table 15b).

4.6.4.4 Comparison of treatment combinations with control

Control was significantly different from treatment combinations and T_6S_2 (3152 kg ha^{-1}) was superior to control (2997 kg ha^{-1}) (Table 15b).

4.6.5 Straw yield

4.6.5.1 Individual effect of organic manures

The organic manures had no significant influence on straw yield. Mean straw yield varying from 3832 to 4331 kg ha^{-1} (Table 15a).

4.6.5.2 Individual effect of organic sprays

Organic sprays had no significant effect on straw and the mean values ranged from 3987 to 4150 kg ha^{-1} (Table 15a).

4.6.5.3 Interaction effect of organic manures and sprays

The interaction effects had significant influence on the straw yield. T5S3 recorded the maximum yield (4654 kg ha^{-1}) but it was superior only to T_3S_1 (3535 kg ha^{-1}) (Table 15b).

4.6.5.4 Comparison of treatment combinations with control

Control crop recorded straw yield of 4458 kg ha^{-1}. It showed the similar effect as all other treatment combinations except T_3S_1, which recorded the lowest straw yield (3535 kg ha^{-1}) (Table 15b).

4.6.6 Grain : Straw ratio

4.6.6.1 Individual effect of organic manures

Organic manures had significant influence on grain : straw ratio. Maximum grain : straw ratio was noticed in T_1 (0.72), but it was superior only to T_5 having grain : straw ratio of 0.57 (Table 15a).

4.6.6.2 Individual effect of organic sprays

Organic sprays did not exhibit significant influence on grain : straw ratio and the mean grain : straw ratio was 0.67 (Table 15a).

4.6.6.3 Interaction effect of organic manures and sprays

The interaction effect of organic manures and sprays had significant influence on grain : straw ratio. T_3S_1 recorded maximum grain : straw ratio of 0.85, followed by T_4S_2 (0.77).

4.6.6.4 Comparison of treatment combinations with control

T_5S_3 (0.54), T_5S_1, T_7S_1 (0.56), T_4S_3 (0.57), T_3S_3 and T_4S_1 (0.59) were inferior to control (0.65) in respect to grain : straw ratio (Table 15b).

Discussion

5. DISCUSSION

Rice being our staple food, its importance in our daily diet cannot be ignored. For the past several years, rice cultivation is facing major problems include pest and disease management. As we all know farmers are using chemicals including pesticides, which are hazardous to the living things in the earth. Frequent and indiscriminate use of chemical pesticides has created higher magnitude of environmental pollution leading to imbalance in natural ecosystem.

In view of the above reasons, many alternative methods have been formulated for the management of pests. Among the several methods available, management of pests with botanicals has been gaining recognition and importance in recent years for several reasons.

Naturally available plant materials or products or derivatives are least harmful to the environment due to their quick biodegradable nature, specifically to target organisms and less harmful to beneficial organisms. Therefore, a field experiment was conducted to study the effect of some natural organic materials at Agricultural Research station, Mannuthy. A popular variety 'Jyothi' released by RARS, Pattambi was used for the study. The detailed discussion on the result is presented under the following headings.

a) Efficacy of natural organic materials against insect pests of rice.
b) Safety to natural enemies of insect pests.
c) Effect of organic materials on disease management.
d) Influence of organic materials on weed population.
e) Influence of organic materials on crop growth parameters.
f) Effect of organic materials on yield parameters.

5.1 EFFICACY OF NATURAL ORGANIC MATERIALS AGAINST INSECT PESTS OF RICE

In the present study, combined effect of organic materials is compared with chemicals. At this instance, the separate effect of organic manures and sprays were also studied at three critical stages of crop growth (*i.e*., active tillering stage, maximum tillering stage and milky stage).

5.1.1 Stem borer

The infestation of stem borer was low in snake wood leaves incorporated plots. It might be due to the development of induced resistance in plants by snake wood leaves. Rao *et al*. (2001) reported that organic manures supply both macro and micronutrients and build up resistance of plants to insect attack. According to House (1969), phytophagous insects are very sensitive to nutritional changes in host plant, which can be regulated by cultural practices like fertilization. This induced resistance or pseudoresistance might have induced changes in concentrations of primary and secondary metabolites of the plant, ultimately resulted in changes in growth and dynamics of the insect pests that harbour such plants. The study of Mc Key *et al*. (1978) provides support to the hypothesis that crop plants on organic manure treated plots might contain relatively higher concentrations of polyphenolic compounds, which deterred the herbivores.

The effect of treatments varied significantly on insect pests, which is evident from the data (Table 3a, 3b, 4a, 4b, 5a and 5b). This differential effect might be due to the variation in nutrient levels and active components in the manures. Plants are rich source of phytochemicals (active components) and various bioactivities of plant extracts on insect pests were well documented by different authors (Grainage and Ahmed, 1988; Isman *et al*., 1995). Incorporation of leaves of these insecticidal plants might have resulted in translocation of these active principles to the aerial part through the root system of the crop. The active principles may be converted to compounds that are more toxic by the action of physical, chemical and biological factors present in the soil.

Snake wood is renowned for its poisonous alkaloid, ‘strychnine’ and ‘brucin’ (CSIR, 1976) and the insecticidal and antifeedant property of leaf extract against different pests have been documented by several authors (Desai and Desai, 2000; Suresh, 2002; Jayasinghe *et al.*, 2003). The infestation of stem borer in mango leaves incorporated plots was less. This might be due to the translocation of active principles ‘mangiferine’ and ‘caryophyllene’ to the aerial parts, which deterred the insects. The effect of partial resistance or pseudoresistance is already discussed.

Among different organic sprays, hydnocarpus oil treated plots showed lesser infestation of stem borer. The present findings uphold the view of Kumar and Thakur (1988) with regard to the antifeedant activity of seed extract of *H. laurifolia* against *S. litura*.

The effect of snake wood leaves was enhanced by the application of hydnocarpus oil. Treatment combination of snake wood and hydnocarpus oil was effective in controlling the stem borer throughout the crop period.

Chemical treatment (carbofuran @ 0.75 kg ai ha^{-1}) resulted in drastic control of stem borer. The per cent reduction in infestation of stem borer at 10 DAS was high as compared to botanicals. However, the rebuild up of population after a lapse of 20 days was high. Botanicals showed dual role of conserving natural enemies and non-resurgence. The development of resistance and resurgence of pests might be low when plant products are used due to several complex substances. The resurgence of stem borer in the field might be due to the decimation of natural enemies, which received the pests from biotic suppression, resulted in the resurgence of pests. This result corroborates the findings of Dhawan *et al*. (2000). Another reason could be the changes in the nutritive quality of the plant in favour of insect pests. The application of chemical insecticides resulted in higher content of sugars, amino acids, proteins and chlorophyll content, and decreased phenol content (Tamilselvan *et al*., 1990).

Among treatment combinations, snake wood + karanj oil was the next best treatment. The efficacy of karanj oil against variety of pests was well documented by several authors (Meshram, 2000; Singh, 2002; Singh, 2003).

5.1.2 Leaf folder

Among different organic manures snake wood leaves showed prolonged influence on leaf folder infestation. But, garadi leaves was superior to snake wood leaves at initial stages. Then the effect was reduced, whereas snake wood maintained the superiority. Incorporation of garadi leaves into farmers' field was a common practice to reduce the pests (Kumar, 1999). The active principle 'oduvin' might be responsible for this. The superior effect of snake wood is discussed in the case of leaf folder. The translocation of these active principles might have resulted in physiological changes, which deterred the insects.

Hydnocarpus oil was the best treatment in controlling the leaf folder. The next best treatment was cow's urine + asafoetida. The repellent activity of cow-urine + asafoetida resulted in lower infestation of leaf folder. This was in corroboration with the study of Lingaiah *et al.* (1998), who opined the strong repellent activity of cowdung - urine extract against insect pests of cotton. At the same time Swapna (2003) reported the efficacy of asafoetida against rice bug. The repellent activity of asafoetida was due to the strong alliaceous odour (CSIR, 1956).

In the case of leaf folder also, combination of snake wood + hydnocarpus oil showed the superiority. The next best treatment was garadi + karanj oil. The activity of garadi leaves was enhanced by the application of karanj oil. The effect of these two treatment combinations was almost similar to chemical, carbaryl (0.3%).

5.1.3 Rice bug

Observations recorded from the preliminary infestation stage of gundhi bug showed the signs of infestation as usual. Like any epidemic process, the rice bug with its migratory tendency and explosive reproductivity showed infestation at the milky stage of crop. But the timely application of chemicals and organic sprays gradually brought down the infestation to minimum and the epidemic process was curtailed from its usual process cycle.

Among different organic manures, mango leaves was the best treatment in controlling the population of rice bug. It was in confirmity with the report of Swapna (2003). The next best treatment was snake wood.

Cow's urine + asafoetida gave the highest control of rice bug population. It might be due to the repellent activity of cow's urine + asafoetida. The repellent activity of cow's urine and asafoetida was reported by Lingaiah *et al*. (1998) and Mishra *et al*. (1999). The effect of karanj oil and hydnocarpus oil was invariable.

The treatment combinations, mango + karanj oil, mango + hydnocarpus oil, mango + cow's urine - asafoetida and snake wood + hydnocarpus oil exhibited similar effect on the population of rice bug at milky stage of the crop. This result confirmed the superiority of mango leaves in the suppression of rice bug population.

The chemical insecticide, methyl parathion (0.2%) was the best treatment in controlling the rice bug population as compared to other treatment combinations. The efficacy of methyl parathion in the control of rice bug is well documented (KAU, 2004). Eventhough the effectiveness of botanicals is not superior to chemicals, they are not far behind in its efficacy. It is evident from Table 5b.

5.2 SAFETY OF ORGANIC MATERIALS TO NATURAL ENEMIES OF INSECT PESTS

As compared to synthetic pesticides, the safety of different treatment combinations to various groups of natural enemies is quite evident from the data (Table 5b, 6b,7b, 8b, 9b, 10b and 11b).

5.2.1 Coccinellids

The coccinellids were found predating on leaf and planthoppers. Similar reports about coccinellids as effective predators on jassids were given by Jagadish *et al*. (1996). Their population fluctuation in different organic manure treated plots were noticed synchronizing with pest population since they are density dependent. It was in corroboration with the findings of Rao *et. al*. (2001), who reported the density dependent activity of coccinellids. Significantly higher predator population was noticed in glyricidia treated plots. High pest incidence in glyricidia incorporated plot might have led to high predator population. In contrast, mango treated plot recorded low predator population. It may be due to lower pest population.

The population of coccinellid beetles was not influenced by different organic sprays. It shows the safety of these organic sprays to coccinellid beetles. The safety of cow's urine and karanj oil to coccinellid beetles was reported by Kasyap *et al.* (1998) and Puri (1998) respectively.

Among different treatment combinations, glyricidia + hydnocarpus oil applied plots recorded the maximum population of coccinellids.

5.2.2 Cyrtorhinus lividipennis

The mirid bug, *C. lividipennis* was found predaceous on eggs of leaf and planthoppers. They were searching the leaf sheaths and stems for the eggs of hoppers. Glyricidia incorporated plots recorded the maximum population of mirid bugs. Heong *et al.* (1991) reported positive correlation between the population of mirid bugs and hoppers. At the same time, Bharadwaj and Pawar (1986) have reported that mirid bugs had a negative correlation with hoppers. The present result is in conformity with the first report. The mean population of *C. lividipennis* was low in mango treated plots. The organic manures provide the plant a type of partial resistance called induced resistance through intrinsic production of secondary metabolites like phenol and tannins. The prey confined to resistant hosts, commonly experience reduced growth rate, greater developmental time, mortality and decreased fecundity. Such alterations of fundamental physiological processes affect the nutritional quality of the prey, which in turn affect the predators.

The organic sprays did not influence the population of mirid bugs, which confirmed the safety of botanicals to natural enemies. There are no research findings on the safety of these materials to mirid bug. However, less toxic nature of custard-apple (*Annona squamosa*) oil on mirid bug predator was documented by Saxena *et al*. (1984). Glyricidia and karanj oil treated plots recorded the maximum population of mirid bug, *C. lividipennis*.

5.2.3 Spiders

The spiders are major predators on leafhoppers, leaf feeding caterpillars and adult stem borer. As the spiders were also density dependent, the pest population fluctuations affected the spiders. The mean population of spiders was high in glyricidia treated plots. Different organic sprays did not influence the population of spiders. This result again confirmed the safety of organic materials to natural enemies. The safety of karanj oil to spiders was evident in studies of Puri (1998). Saxena *et al.* (1984) reported the less toxic nature of *A. squamosa* oil to the predatory spider, *Lycosa pseudoannulata*. The population of spiders was high in treatment combination, glyricidia + hydnocarpus oil during the study.

5.2.4 Carabid beetle

The carabid beetle, *O. nigrofasciata* is a potential predator of leaf folder, *C. medinalis.* The population of carabids was high in cashew incorporated plots and showed a positive correlation with leaf folder. It was in corroboration with the study of Bhaskar (1999), who reported the positive correlation of carabid beetles with the population of *Nilaparvata lugens.*

The different organic sprays did not exhibit influence on population of carabid beetles. This result shows the safety of karanj oil, hydnocarpus oil and cow's urine + asafoetida to carabid beetles. Cashew + karanj oil treated plots had higher population of carabid beetles.

5.2.5 Damsel flies

Damsel fly adults are voracious feeders of flying insects and hoppers. The population of damsel flies was very much fluctuating in the field. However, cowdung treated plots recorded higher population. It might be due to the high population of pests in cowdung incorporated plots. The different organic sprays did not affect the population of damsel flies. The safety of karanj oil to damsel flies was in conformity with the findings of Puri (1998). At the same time, Kasyap (1998) reported the safety of cow's urine to damsel flies. The population of damsel flies was high in cowdung + karanj oil applied plots.

5.2.6 Hymenopteran parasitoids

The population of Hymenopterans was high in snake wood incorporated plots, where the population of major insect pests (stem borer and leaf folder) was low. It showed a negative correlation of Hymenopteran parasitoids with pest population. This result was in conformity with the findings of Bhaskar (1999), who reported the negative correlation between the population of *O. nigrofasciata* and *N. lugens*. Another reason for high population of Hymenopterans could be the emission of volatiles from the plant. Influence of plant volatiles on natural enemies was already reported (Whitman and Nordlund, 1994). Plants provide nutrition to the natural enemies in the form of extra floral nectar directly or indirectly through their hosts (Ridgway and Jones 1968). Hydnocarpus oil recorded significantly higher population of Hymenopterans at two days after the second and third spray. Then the population was similar in all the plots. Among treatment combinations, snake wood + hydnocarpus oil recorded higher population of Hymenopterans.

The mean population of natural enemies in chemical treated plots was low due to highly toxic nature of chemicals. The negative effect of chemical insecticides on the population of natural enemies was reported by many authors (Dhaliwal and Arora, 2001; Nadarajan and Kumar, 2000). Nearly, 60 per cent of the natural control of pests is due to entomophages occurring in nature, when they are not destroyed by the use of synthetic chemicals (Jayaraj, 1996). The higher rate of build up of infestation of insects in chemical treated plots caused by the reduced population of natural enemies.

5.3 EFFECT OF ORGANIC MATERIALS ON DISEASE MANAGEMENT

The present study has also attempted to evaluate the efficacy of different combinations of organic materials on disease management. As evidenced by Table 12a, among different organic manures, glyricidia incorporated plots recorded maximum control on brown spot. Hence the present study establishes that glyricidia leaves could effectively control the brown spot. It is contended that when organic matter is present in sufficient quantities in the soil, the development of mycorrhiza is encouraged. Howard (1950) is of the firm opinion that if proper mycorrhizal connections are established, the growth of the plants would be very vigorous and plant diseases would disappear. Among different organic sprays, cow urine + asafoetida gave the highest disease control. The suppressive effect of cow urine on fungal pathogens has been noticed by Verma and Pathak (1998). The efficacy of asafoetida observed in the present study is in confirmity with the findings of Das *et al*. (1998). The best treatment combinations were cowdung + cow's urine –asafoetida and garadi + cow's urine –asafoetida. The activity of cowdung and garadi was enhanced by the application of cow's urine –asafoetida.

Among different organic manures, garadi leaves showed maximum control on sheath rot. Amin *et al*. (1974) and Rajan (1980) reported that the intensity of sheath rot disease of rice could be considerably reduced by soil amendment with various organic materials. Application of garadi leaves might have been resulted in the gradual stimulation of bacteria and actinomycetes in the soil due to green manuring. The decomposition of freshly added green manure might have led to the increased availability of substrate for the multiplication of bacteria and actinomycetes. Foliar application of karanj oil in the present study have stimulated the growth of fungi, bacteria and actinomycetes in the soil. This phenomenon was already reported by Saifuneesa (2001). This can be explained in the light of phenomenon, wherein the active principles absorbed by plants might have led to the induction of root exudates, which in turn could stimulate the microflora present in the soil. The antifungal activity of oil of *P. pinnata* have been noticed by Banerjee *et al*. (1989) and Narasimhan *et al*. (1998). Among different treatment combinations, cashew + cow's urine – asafoetida, garadi + karanj oil and glyricedia + hydnocarpus oil showed the superior effect.

5.4 INFLUENCE OF ORGANIC MATERIALS ON WEED POPULATION

The important weeds noticed in the experimental field included broad leaved weeds like *Ludwigia perennis, Limnocharis flava, Monochoria vaginalis, Sphenoclea zeylanica,* grasses like *Echinochloa colona, Sacciolepis interrupta, Isachne miliacea,* sedges like *Cyperus* spp., *Fimbristylis* sp. etc. Thomas and Abraham (1998) reported the superiority of these weeds in rice ecosystem in Kerala.

Weeds in general compete with crop for nutrients, moisture and light, and thereby affect the crop health, growth and development and finally the yield.

In the present experiment, the count of weeds was taken to compare the differential effect of different organic manures, sprays and its interaction effect on weed suppression.

The overwhelming influence of different organic manures on weed suppression is evident from the data on weed population. The preliminary observation showed that the weed infestation was prevalent at 20 DAT (*i.e.*, before hand weeding) in all the treatments and there was a marked difference between treatments. From this, it could be inferred that organic manures exhibited a differential suppressing phenomenon. A progressive increase was observed from 45 DAT (*i.e.,* after hand weeding) to harvest, irrespective of the treatments. At different stages of crop-weed competition, the suppresive action of the organics is very much evident as seen in snake wood amended plots, where the weed population was invariably lower and weed count was higher in cow dung incorporated plots.

Fuji (1989) reported that allelopathins, alkaloids and isoflavanoids found in plants have allelopathic action on the growth and development of other plants and could be made use of in weed control. Pawlowski and Bachthaler (1989) also reported the successful use of allelopathic effect of plant residues in inhibiting the germination of weed seeds.

The organic sprays were given specifically to booster the activity of organics applied to the soil. All the organic sprays were found to supplement the activity of organics applied to the soil in influencing the crop-weed competition. It could be seen that the weed count was invariably low in hydnocarpus oil applied plots.

Even the organic manures contributed much in lowering the crop-weed competition at critical stages of crop growth. Organic sprays helped to booster the activity of such organic manure. Snake wood leaves + hydnocarpus oil applied plots showed effective suppression of weeds. Suppressive ability of green leaf manures and sprays more was more justified with a fact that weeds had luxurious growth in cowdung + chemical insecticide treated plots.

5.5 INFLUENCE OF ORGANIC MATERIALS ON CROP GROWTH PARAMETERS

All the organic manures and sprays had same effect on height of the plant. However, comparatively better plants in terms of height of the plant was observed in glyricidia + hydnocarpus oil applied plots. The growth enhancing effect of this treatment was more as compared to control (cowdung + chemical insecticides). It might be due to the faster decomposition of glyricidia leaves and its subsequent nutrient release. The faster decomposition of glyricidia leaves was reported to be due to low C:N ratio (13:1) (Bal *et al*., 1993). The application of hydnocarpus oil enhanced the activity of glyricidia leaves.

The organic manures and sprays alone did not contribute much to the increase in number of tillers throughout the crop growth. At ATS, the number of tillers was maximum in glyricidia + karanj oil applied plots. Effect of glyricidia leaves on number of tillers was in consonance with the study of Talashilkar and Chavan (1997). The activity of glyricidia leaves compounded by the application of hydnocarpus oil.

Differential effect was not observed with respect to organic manures, sprays and combination on growth parameter, days to 50 per cent flowering.

5.6 INFLUENCE OF ORGANIC MATERIALS ON YIELD PARAMETERS

Rice grain yield is a product of *viz*., number of panicles per hill, per cent of filled grains and test weight of seeds. Each of these parameters can be influenced by the variations in input sources consequently in yield variation.

The glyricidia amended plots recorded higher number of panicles, which might be due to the enhancement of productive tillers. Among the organic sprays, the maximum number of panicles was observed in hydnocarpus oil treated plots. Hydnocarpus oil compounded the effect of glyricidia and increased the number of panicles. Increase in number of panicles due to the application of glyricidia has been reported by Samad and Sahadevan (1952). The higher number of panicles in hydnocarpus oil applied plots might be due to the reduced stem borer infestation.

The highest per cent of filled grains was recorded in mango amended plots. It might be due to the reduced rice bug attack, which ultimately reduced the chaffy grains. Kumar (1999) and Swapna (2003) reported the repellent activity of mango leaves, consequently in yield increase. Due to the high manurial value (*i.e.*, 2.75 to 3.0% N, 0.51% P_2O_5 and 1.55% K_2O on oven dry weight basis), glyricidia amended plots recorded higher per cent of filled grains. Patil (1989) and Bal *et al.* (1993) reported high organic carbon content, faster rate of decomposition and subsequent nutrient release of glyricidia, which ultimately resulted in higher per cent of filled grains and yield. Among the oils, hydnocarpus oil treated plots recorded higher per cent of filled grains. The effect of mango was enhanced by the application of hydnocarpus oil, which resulted in higher per cent of filled grains.

With respect to test weight, different organic manures, sprays and combination showed the same effect.

The different organic manures and sprays did not show individual effect on grain yield. Higher grain yield in glyricidia + hydnocarpus oil applied plot was mainly due to the enhancement in number of panicles. In mango + hydnocarpus oil applied plot, higher grain yield was achieved. It might be due to lower population of rice bug, which resulted in higher per cent of filled grains. Balanced manuring with green manures with fast decomposition result in well nourished, robust plants. As a result plants were able to withstand the attack of pests. Organic sources with slow decomposition failed to provide nutrients at critical stages and to resist the attack of pests. The grain yield from glyricidia + hydnocarpus oil applied plot was on par with control.

Grain:straw ratio of rice was significantly influenced by organic manures and treatment combinations. The non-proportionate increase in quantity of straw, which is undesirable and may even be responsible for reducing grain yield. Such a tendency can result in lodging and higher pest and disease incidence and enhance chaff percentage. Mango treated plots showed higher grain:straw ratio, which might have resulted in higher per cent of filled grains. Garadi + karanj oil applied plot recorded higher grain:straw ratio, followed by snake wood + hydnocarpus oil applied plot.

Summary

6. Summary

At present, highly hazardous chemical pesticides are applied by farmers to manage the pests of rice. In order to reduce the harmful effects of chemical insecticides, an attempt was made to evaluate the bio efficacy of natural organic materials against the pests of rice during 2003-04 at Agricultural Research Station, Mannuthy. The experiment was laid out in split plot design with seven main plots, three sub plots and three replications. Main plot treatments include incorporation of mango (*Mangifera indica*), cashew (*Anacardium occidentale*), garadi (*Cleistanthus collinus*), snake wood (*Strychnos nux-vomica*), glycosmis (*Glycosmis pentaphylla*), glyricidia (*Glyricidia maculata*) leaves and cowdung @ 5 t ha^{-1}. Sub plot treatments include karanj (*Pongamia pinnata*) oil (2%), hydnocarpus oil (*Hydnocarpus laurifolia*) oil (2%) and cow's urine + asafoetida (*Ferula foetida*) (20ml + 20g L^{-1}). Organic manuring was done two weeks before transplanting and organic spraying was done at three critical stages of crop growth (*ie.,* active tillering, maximum tillering and milky stages). A control plot was laid out in trial and cultural practices and plant protection methods were followed as per the POP Recommendations of KAU.

Different treatment combinations were compared with chemical insecticides. At the same time the individual effects of organic manures and sprays on insect pests were also studied. In addition to this, the influence of these natural organic materials on natural enemies, diseases, weed population, crop growth and yield parameters were also studied. The salient findings of the investigation are summarized below:

- Snake wood leaves and mango leaves were found effective in controlling the infestation of stem borer, *S. incertulus*. Hydnocarpus oil recorded the lowest infestation of stem borer. Snake wood + hydnocarpus oil and snake wood + karanj oil were the best treatment

combinations in reducing the infestation. It was found as effective as chemical treatment (Carbofuran @ 0.75 kg ai ha^{-1}).

- Snake wood leaves was the best treatment against leaf folder (*C. medinalis*, followed by garadi leaves. Among organic sprays, hydnocarpus oil was the superior treatment. The effect of snake wood + hydnocarpus oil and garadi + karanj oil was similar to that of Carbaryl (0.3%).

- Methyl parathion (0.2%) was the best treatment against rice bug (*L. acuta*). Among organic manures, mango leaves was the best treatment against rice bug. Cow's urine + asafoetida showed the maximum control on rice bug. Among treatment combinations, mango + karanj oil, mango + hydnocarpus oil, mango + cow's urine-asafoetida and snake wood + hydnocarpus oil exhibited superior effect on the rice bug population.

- The population of natural enemies was high in organic material applied plots as compared to chemical treated plots. Predators showed a density dependent activity and parasitoids exhibited a negative correlation with the pest population.

- The effect of glyricidia leaves on brown spot disease was enhanced by the application of cow's urine-asafoetida. Among organic manures garadi leaves showed the maximum effect on sheath rot disease. Karanj oil showed the maximum individual effect on sheath rot Maximum control of sheath rot was observed in treatment combinations of garadi + karanj oil, cashew + cow's urine – asafoetida and glyricidia + hydnocarpus oil.

- The suppressing effect of snake wood on weed population was enhanced by the application of hydnocarpus oil.

- Better plant height and maximum number of tillers were observed in glyricidia and hydnocarpus oil treated plots.

- Glyricidia and hydnocarpus oil treated plots gave higher number of panicles per hill, whereas mango and hydnocarpus oil applied plots recorded highest per cent of filled grains. Combination of glyricidia and hydnocarpus oil gave higher grain yield. Highest grain:straw ratio was noticed in garadi + karanj oil treated plots.

Based on the result obtained it can be concluded that organic materials are effective in reducing the population of pests. They were conserving the natural enemies and insect population in a level. So it is proposed that the best treatment combinations can be included in sustainable agriculture to manage different pests in rice ecosystem.

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*Originals not seen

Appendices

APPENDIX I

Abridged ANOVA of RBD for stem borer infestation

All treat-ments inclu-ding contr-ol	df	Mean sum of squares									
	21	20DAT	2DAS (24DAT)	10DAS (32DAT)	20DAS (42DAT)	2DAS (46DAT)	10DAS (54DAT)	20DAS (64DAT)	2DAS (68DAT)	10DAS (76DAT)	20DAS (86DAT)
		15.157*	9.517*	7.964*	39.413*	6.130*	7.946*	26.886*	24.863*	21.125*	4.232*

APPENDIX II

Abridged ANOVA of RBD for leaf folder infestation

All treatments including control	df	Mean sum of squares						
	21	20DAT	2DAS (24DAT)	10DAS (32DAT)	20DAS (42DAT)	2DAS (46DAT)	10DAS (54DAT)	20DAS (64DAT)
		9.764*	11.047*	9.719*	26.079*	24.915*	7.988*	6.214*

APPENDIX III

Abridged ANOVA of RBD for population of rice bug

All treatments including control	df	Mean sum of squares				
	21	10DAS (54DAT)	20DAS (64DAT)	2DAS (68DAT)	10DAS (76DAT)	20DAS (86DAT)
		2.111*	3.344*	2.863*	3.892*	1.790*

Note: *: Significant at 5% level

APPENDIX IV

Abridged ANOVA of RBD for population of coccinellids

All treatments including control	df	Mean sum of squares									
	21	20DAT	2DAS (24DAT)	10DAS (32DAT)	20DAS (42DAT)	2DAS (46DAT)	10DAS (54DAT)	20DAS (64DAT)	2DAS (68DAT)	10DAS (76DAT)	20DAS (86DAT)
		3.075*	5.324*	5.844*	3.621*	9.329*	6.258*	8.842*	3.924*	2.236*	1.208*

APPENDIX V

Abridged ANOVA of RBD for population of mirid bug

All treatments including control	df	Mean sum of squares						
	21	20DAT	2DAS (24DAT)	10DAS (32DAT)	20DAS (42DAT)	2DAS (46DAT)	10DAS (54DAT)	20DAS (64DAT)
		5.481*	9.259*	9.800*	4.492*	2.086*	2.297*	0.984*

APPENDIX VI

Abridged ANOVA of RBD for spider population

All treatments including control	df	Mean sum of squares									
	21	20DAT	2DAS (24DAT)	10DAS (32DAT)	20DAS (42DAT)	2DAS (46DAT)	10DAS (54DAT)	20DAS (64DAT)	2DAS (68DAT)	10DAS (76DAT)	20DAS (86DAT)
		3.075*	5.324*	5.844*	3.621*	9.329*	6.258*	8.842*	3.924*	2.236*	1.208*

Note: *: Significant at 5% level

APPENDIX VII

Abridged ANOVA of RBD for population of carabid beetle

All treatments including control	df	Mean sum of squares						
	21	20DAT	2DAS (24DAT)	10DAS (32DAT)	20DAS (42DAT)	2DAS (46DAT)	10DAS (54DAT)	20DAS (64DAT)
		4.01**	4.313**	3.973*	9.855*	5.841*	0.819*	2.017*

APPENDIX VIII

Abridged ANOVA of RBD for population of damsel flies

All treat-ments inclu-ding contr-ol	df	Mean sum of squares									
	21	20DAT	2DAS (24DAT)	10DAS (32DAT)	20DAS (42DAT)	2DAS (46DAT)	10DAS (54DAT)	20DAS (64DAT)	2DAS (68DAT)	10DAS (76DAT)	20DAS (86DAT)
		1.732	3.341*	1.417	1.382*	2.436*	1.615*	1.482*	1.653	0.471*	0.470

APPENDIX IX

Abridged ANOVA of RBD for population of Hymenopteran parasitoids

All treat-ments inclu-ding contr-ol	df	Mean sum of squares									
	21	20DAT	2DAS (24DAT)	10DAS (32DAT)	20DAS (42DAT)	2DAS (46DAT)	10DAS (54DAT)	20DAS (64DAT)	2DAS (68DAT)	10DAS (76DAT)	20DAS (86DAT)
		3.075*	5.213*	5.985*	3.123*	8.329*	6.305*	8.312*	3.921*	2.236*	1.100

Note: * : Significant at 5% level

APPENDIX X

Abridged ANOVA of RBD for disease incidence

	df	Mean sum of squares					
		Brown spot			Sheath rot		
All treatments including control	21	Per cent disease incidence	Per cent disease severity	CODEX Value	Per cent disease incidence	Per cent disease severity	CODEX Value
		25.98*	12.73*	0.367*	26.917*	11.03*	0.88*

APPENDIX XI

Abridged ANOVA of RBD for weed count.

All treatments including control	df	Mean sum of squares			
		20 DAT	45 DAT	70 DAT	Harvest
	21	10.52*	1.95*	4.34*	5.15*

APPENDIX XII

Abridged ANOVA of RBD for crop growth and yield parameters

All treat-ments inclu-ding contr-ol	df	Mean sum of squares													
		Height of the plant			No.of tillers per plant			Days to 50% flowering	No.of panicles hill $^{-1}$	Percent of filled grains	1000 grain weight	Grain yield	Straw yield	Grain :Straw ratio
		ATS	PIS	Harvest	ATS	PIS	Harvest							
	21	2.20*	9.59*	12.85	0.88*	0.52	0.76*	1.10	1.29*	58.29*	1.64	167167.92*	521063.14*	0.023*

Note: * : Significant at 5% level.

INDIGENOUS NATURAL ORGANIC MATERIALS FOR THE MANAGEMENT OF MAJOR INSECT PESTS OF RICE

By

SMITHA REVI

ABSTRACT OF THE THESIS

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ABSTRACT

Bio efficacy of natural organic materials was evaluated by field experiment at Agricultural Research Station, Mannuthy, 2003-04 against major insect pests of rice. A popular variety 'Jyothi' released by RARS, Pattambi was used for the study. Leaves of different plant species like mango (*Mangifera indica*), cashew (*Anacardium occidentale*), garadi (*Cleistanthus collinus*), snake wood (*Strychnos nux-vomica*), glycosmis (*Glycosmis pentaphylla*), glyricidia (*Glyricidia maculata*) leaves and cowdung (5 t ha^{-1}) were incorporated into the field two weeks prior to transplanting. The organic sprays *viz.*, karanj (*Pongamia pinnata*) oil (2%), hydnocarpus (*Hydnocarpus laurifolia*) oil (2%) and cow's urine + asafoetida (*Ferula foetida*) (20ml + 20g L^{-1}) were sprayed at three critical stages of crop growth (*i.e*, active tillering stage, maximum tillering stage and milky stage). The effect of these treatment combinations was compared with chemical insecticides, which were recommended by Package of Practices Recommendations of KAU. The salient findings are abstracted below.

The present investigation revealed that the most effective treatment combinations against stem borer were snake wood + hydnocarpus oil and snake wood + karanj oil. It was found as effective as chemical treatment carbofuran (@0.75 kg ai ha^{-1}). The effect of snake wood + hydnocarpus oil and garadi + karanj oil was similar to that of carbaryl (0.3%) in the control of leaf folder. The chemical insecticide Methyl parathion (0.2%)gave the highest control over rice bug infestation. The treatment combinations mango + karanj oil, mango + hydnocarpus oil, mango + cow's urine-asafoetida, and snake wood + hydnocarpus oil exhibited effective control over the population of rice bug. Population of natural enemies was high in botanical treated plots as compared to chemical treated plots.

Treatment combination, garadi + karanj oil gave the highest control on sheath rot disease of rice. Glyricidia + cow's urine–asafoetida treated plots recorded the lowest incidence of brown spot. Studies on the effect of treatments

on weed population showed that combination of snake wood and hydnocarpus oil was the best treatment. Better plant height and maximum number of tillers was observed in glyricidia + hydnocarpus oil treated plots. Different treatment combinations showed similar effect on test weight of seeds. Glyricidia + hydnocarpus oil treated plots gave higher number of panicles per hill, whereas mango + hydnocarpus oil applied plots recorded the highest per cent of filled grains. The highest grain yield of rice crop was recorded in glyricidia + hydnocarpus oil treated plot (3152 kg ha^{-1}). Highest grain : straw ratio was noticed in garadi + karanj oil applied plots followed by snake wood + hydnocarpus oil.

The results show the importance of organic materials for the suppression of pests of rice and also their efficacy in preserving the natural ecosystem. In the present scenario of sustainable agriculture, use of natural organic materials requires special attention, as they are ecofriendly and farmer friendly.