

**INFLUENCE OF ORGANIC AND INORGANIC SOURCES OF HOST PLANT  
NUTRITION ON THE INCIDENCE OF MAJOR INSECT PESTS OF  
GROUNDNUT (*Arachis hypogaea* Linn.)**

BY  
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THESIS SUBMITTED TO THE  
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**DOCTOR OF PHILOSOPHY**  
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BAPATLA

MARCH, 1997

## CERTIFICATE

Mr. KORADA RAJASEKHARA RAO has satisfactorily prosecuted the course of research and that the thesis entitled "**Influence of organic and inorganic sources of host plant nutrition on the incidence of major insect pests of groundnut (*Arachis hypogaea* Linn.)**" submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any University.

Date: 29.3.1977

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This is to certify that the thesis entitled "**Influence of organic and inorganic sources of host plant nutrition on the incidence of major insect pests of groundnut (*Arachis hypogaea* Linn.)**" submitted in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Agriculture** of the Acharya N.G. Ranga Agricultural University, Hyderabad, is a record of the bonafide research work carried out by **Mr K Rajasekhara Rao** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis

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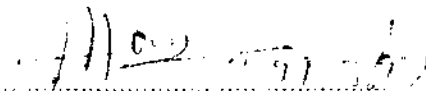
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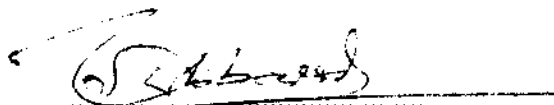
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Bapatla

Date : 20/05/2008

  
(K. Rajasekhara Rao)

## DECLARATION

I, **K Rajasekhara Rao** declare that the thesis entitled "**Influence of organic and inorganic sources of host plant nutrition on the incidence of major insect pests of groundnut (*Arachis hypogaea* Linn.)**" submitted to Acharya N G Ranga Agricultural University for the degree of **Doctor of Philosophy in Agriculture** majoring in Entomology is the result of original research work done by me. I also declare that any material contained in the thesis has not been published earlier.

Date: 29/05/2019

  
(K RAJASEKHARA RAO)

## ABSTRACT

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Title of the thesis	: Influence of organic and inorganic sources of host plant nutrition on the incidence of major insect pests of groundnut ( <i>Arachis hypogaea</i> Linn.).
Degree	: Doctor of Philosophy
Department	: Entomology
Faculty	: Agriculture
Major Adviser	: Dr K Tirumala Rao
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A field experiment was conducted for three seasons from 1994 to 1996 to study the influence of organic manures and inorganic fertilizers (NPK) on the incidence of major insect pests and predators on groundnut in sandy loam soils of Bapatla and Kavur, Guntur district of Andhra Pradesh. The treatments included farm yard manure (FYM), vermicompost, FYM + vermicompost, neem cake, NPK + neem cake, NPK with nuclear polyhedrosis virus (NPV) of *S. litura* at 50 and 75 days after sowing (DAS), NPK with sunflower as a trap crop and NPK with carbofuran seed treatment.

The results showed that the organic manures recorded lower incidence of sucking pests than the straight fertilized. The sucking insects *E. kerri* and *A. craccivora* were lowest in neem cake. The treatments that received organic manures recorded lower incidence of *A. modicella* compared to straight fertilized treatments. NPK with NPV application reduced the incidence of *S. litura* than all other treatments. NPK with carbofuran seed treatment showed its superiority in recording low incidence of *H. armigera* followed by other organically manured treatments.

The population of natural enemies was low in organically manured treatments compared to the straight fertilized treatments. The higher pest incidence in straight fertilized treatments contributed to higher predator population. NPK with seed treatment affected coccinellid and spider population.

Pertaining to the levels of biochemical constituents of groundnut leaves, the organically manured treatments recorded lower amounts of nitrogen (N), crude protein (CP), total free amino acids (TFAA) and carbohydrates and significantly higher levels of carbon based antiherbivore compounds like phenols and tannins, and the opposite was true in case of straight fertilized treatments.

All the pests and predators (except chrysopids) showed positive correlation with N, CP, TFAA, carbohydrates and negative association with phenols and tannins. Higher N, CP, TFAA, carbohydrates and lower levels of phenols and tannins in leaves of straight fertilized treatments contributed to higher pest incidence and vice versa in organically manured treatments.

Due to non-usage of insecticides as foliar sprays, the natural enemies increased. *Rabi* seasons recorded higher coccinellid beetles and spider population than *kharif* season. Sunflower plants attracted *S. litura* and also served as perches for predatory birds and contributed to lower incidence of caterpillar pests.

The studies provide insight into the manipulation of host plant ecosystem and tritrophic relationships through nutrition to bring induced / ecological resistance in plants. The organic manures induce the production of antiherbivore compounds, a protective system developed in the plants. The slight alterations in chemistry of the plant may bring desirable effects without sacrificing the growth and yield of groundnut crop. The results also provide insight into insect resistance through organic manures. The present studies without the use of insecticides as sprays and organic manures as nutrient sources focus on the search for alternatives to straight fertilizers. The studies reduce the cost of inputs towards fertilizers and insecticides through organic farming and promote the ecological balance and stress the need for ecological / organic farming to attain sustainable plant protection.

# *Introduction*

## INTRODUCTION

Groundnut (*Arachis hypogaea* Linn) is an important oilseed crop in India and ranks first in world in area (8.35 m ha) and production (8.85 mt). Among the states, Andhra Pradesh occupies first place in area (28.4%) and production (22.2%) (DES, 1993) with an average yield of 1054 kg ha<sup>-1</sup>. During *rabi*, groundnut is grown in large areas in coastal sands of Andhra Pradesh as a major crop or in rice fallows.

Insect pests are recognized as yield reducers. Of more than a hundred species of insect pests that live in groundnut crop, a few are economically important in India. Sucking pests such as aphids, jassids and thrips are occasionally important as direct pests, but their importance is increasing as vectors of viral diseases. Defoliators such as *Spodoptera litura* Fab, leaf miner *Protaetia modicella* Dev and gram pod borer *Helicoverpa armigera* Hub are gaining importance in South India. *S. litura* is attacking the crop every year and in some instances there was total failure of the crop (ICRISAT, 1994). The annual loss caused by these insect pests in groundnut was estimated to be US \$150 millions (Ghewande *et al.*, 1987).

Groundnut farmers till recently, were dependent on insecticides to overcome the pests. Despite heavy application of insecticides the farmers are not getting satisfactory control of *S. litura* which has become a serious menace in coastal districts and now spread to Rayalaseema. More over the indiscriminate use of insecticides has led to serious outbreak of *S. litura* and many farmers suffered serious losses. The usage of insecticides is becoming counter productive in that they cause resurgence of pest population by arousing insecticide resistance and upset the ecological balance, through elimination of beneficial species of insects. The indiscriminate use of nitrogenous fertilizers is also one of the reason for build up of pests. The pesticide induced health concern has further helped to popularize organic farming. The consumer in many

developed countries willingly pays a premium price for such authentic products. The export of agricultural commodities to developed countries has also suffered a set back due to pesticide contamination.

As we enter an era of potential food and energy shortage, the challenge to the scientists is to develop a technology that will permit higher yielding cropping patterns or maintenance of current production levels without creating conditions that will favour increased pest population pressure. Furthermore, management programmes should be economically feasible and should strive for minimal depletion of the resources. Such technology is the Integrated Pest Management (IPM) - the planned manipulation of the processes that relate to potential economic loss due to pests. How an IPM become a reality? Progress will be very slow if we rely on empirical (trial and error) approaches. Instead, we need a better theoretical base that can be addressed by priority experimentation. The IPM tactics then could move from a mode of trial and error to one of analytical optimization based on sound theory.

Organic manures supply both macro and micro nutrients and buildup resistance of the plant to insect attack (Tirumala Rao, 1994). The experience of the last three years by the scientists of Acharya N G Ranga Agricultural University (ANGRAU) and International Crops Research Institute for the Semi Arid Tropics (ICRISAT) give credence for relying more on control measures other than chemicals to achieve better control of the pests paving the way for sustainable plant protection and inturn sustainable agriculture

Keeping the above problems and avenues available in view, the present studies were designed for development of pest management strategies by manipulation of the plant through nutrition, encouraging the biological agents without using insecticides as a spray and other cultural practices which reduce the cost of inputs, with the following objectives

1. To study the influence of organic and inorganic sources of best plant nutrition on the incidence of major insect pests of groundnut.
2. To study the influence of organic and inorganic sources of best plant nutrition on the occurrence of predators of groundnut pests.
3. To study the biochemical constituents of leaves like nitrogen, crude protein, total free amino acids, carbohydrates, phenols and tannins in groundnut leaves in different treatments and their influence on pest and predator population.

*Review*  
*of*  
*Literature*

## REVIEW OF LITERATURE

Host plant, the key component in the insect ecosystem, determines the dimensions of insect-plant-predator interactions called the tritrophic relationships. Fertilizer application, which influences host plant growth, also exerts considerable influence on plant feeding insects and their natural enemies. Several earlier workers have reported the influence of varying levels of soil fertility on insects feeding on the evolutionary primitive plants (McKey *et al.*, 1978) and the present herbaceous advanced cultivated species (Fletcher, 1929; Thomas and Dunham, 1931; McGarr, 1943; Isley, 1946; Butt *et al.*, 1946. Kennedy, 1953 & 1958; Adkisson, 1957; Mittler, 1958; Muller, 1958). Since it is the first attempt to study the effect of organic manures on groundnut pest complex, the dearth of literature on groundnut necessitated to review the work pertaining to organic farming, soil fertility influence on plant resistance and the interconnected tritrophic arena of relations in other crops as well.

Every attempt has been made to collect and review the literature pertaining to the related studies and presented under three sections, namely fertilizer and manurial influences on insect pests and natural enemies; interrelationship between soil fertility and biochemical constituents of plants and insect herbivory and natural enemies in relation to plant biochemical constituents.

### 2.1. INFLUENCE OF MANURES AND FERTILIZERS ON THE INSECT PESTS AND NATURAL ENEMIES

Host plant nutrition through fertilizers or manures influence the injury to a crop from arthropod pests, primarily through alterations in crop growth or nutritional level.

### 2.1.1. Influence of Organic Manures on Pests and Natural Enemies

Although the organic manures do not have direct influence on pests, they influence the plant growth which in turn influences the pest on the crops (Painter, 1951). The natural enemies are at the third trophic level.

Plants grown on rich organic soil, without use of chemical fertilizers, will not be attacked by insects because such plants are not palatable to insects, says Robert Rodale in his "Organic Gardening and Farming Magazine" (Roger, 1976). This claim does sound less than credible at first, but seeing is believing, he suggests "down through decades organic gardeners and farmers have made that claim because they saw with their own eyes that such plants often enjoyed an almost mysterious immunity to insect attack. Neighbouring growers would have to spray several times a season, while organic gardeners and farmers could keep insects well under control by using few agents of biological control plus some old fashioned hand-picking of beetles and insect egg clusters (Roger, 1976). He claims that organic soil grows healthy plants and healthy plants resist insects, in his classic work "Organic Plant Protection". He also claims that healthy plants in healthy environment attract natural enemies.

Organic manures add nutrients to the soil, reduce the total dependency on fertilizers and energy (Tirumala Rao, 1994) and protect the crops from pests and diseases (Jackson, 1988). Pests on organic farms were controlled by crop rotation, tillage, crop spacing, intercropping, mulching and biological agents (USDA, 1980). Fonesca *et al.* (1988) found significantly less larval growth and development of *Spodoptera frugiperda* Smith on Italian millet that received poultry droppings than on those received straight fertilizers. Treatments which received NPK as chemical fertilizer resulted in an increase in the number of chrysomelid larvae (10.40 larvae per 10 seeds) on maize *Diabrotica speciosa* Germar compared to the treatments that received cow manure (4.40 larvae per 10 seeds) (Vardasca *et al.*, 1989). Similarly, Fratello *et al.* (1989) observed significant difference in population densities of different arthropod groups between plots treated with organic and mineral fertilizers. However,

no significant difference in the damage caused by *Heliothis zea* Boddie was observed on maize that received straight and organic fertilizers (Osuna *et al.*, 1989). Tele and Salunkhe (1994) reported the efficacy of organic materials on the control of sweet potato weevil. Higher yields of healthy tubers were obtained in the plots treated with cakes of mohuva and karanj and leaves of nirjundi and clerodendron.

#### 2.1.1.1. Farm yard manure (FYM)

Rossi *et al.* (1988) reported that larval weight, larval development, pupal length and pupal width of *S. frugiperda* were the lowest when it was fed on the plants that received FYM than the inorganic fertilizers.

Farm yard manure releases nutrients slowly into the soil and continuously throughout the crop period. Thus plants which are devoid of succulency in earlier stages of crop growth deter the pest attack (Tirumala Rao, 1994). Minimum populations of aphids, mites, thrips, whiteflies and fruit borer, *Helicoverpa armigera* Hub were observed in the plots applied with FYM than in the straight fertilized control plots in chillies (Varma, 1994).

Recent studies on influence of FYM on the incidence of pests of pigeonpea and rice at the Agricultural college farm, Bapatla indicated that the pest populations were significantly less in the plots applied with FYM than with fertilizers. Among the different NPK sources, FYM was the most effective in reducing the incidence of gram caterpillar, *H. armigera*; spotted pod borer, *Maruca testulalis* Geyer; plume moth, *Exelastis atomosa* Meyr; blister beetle, *Mylabris pustulata* Thunberg and pod bug, *Clavigralla gibbosa* Spin (Dayakar *et al.*, 1995). The incidence of rice pest complex was significantly less in the plots received FYM than in the straight fertilized control plots (Bhagyanakshatram, 1995).

Application of cow manure to corn fields increases predatory efficiency of a mesostigmatid mite on corn root worm larvae, *Diabrotica longicornis* Say and *D. virgifera* Leconte (Chiang, 1970).

The beneficial effects of FYM on the pod yield of groundnut have been reported by several workers (Survase *et al.*, 1986; Dhane *et al.*, 1996).

#### 2.1.1.2. Vermicompost

Vermicompost has recently emerged as a plant nutrient supplier, and literature pertaining to its suitability as manure and its influence on pests is meagre.

On application of vermicompost to the agricultural lands, the native earthworm population in the soil make the soil fertile by improving the soil structure (Madan *et al.*, 1987). The key role of earthworms like *Eisenia foetida* Sav in improving the soil fauna, and fertility is well known since long (Chandana, 1981; Kale and Krishna Moorthy, 1981). Earthworms have also been instrumental in transporting minerals and subsoil compounds from deeper layers to surface layers of soil (Jain, 1993). Vermicastings are a rich source of macro and micronutrients, vitamins, enzymes, antibiotics and growth hormones (Kale *et al.*, 1987; Bhawalkar, 1991; Kale, 1994).

The role of vermicompost in the control of nematodes and in mitigating toxic effect of pesticides have been adequately documented (Gaur and Prasad, 1970; Gaur *et al.*, 1975; Bhatnagar and Palta, 1996). Bhawalkar and Bhawalkar (1991) claimed that plants develop pest resistance by balanced nutrition provided by vermicompost and soil microorganisms including earthworms. Similarly, Bhide (1993) also mentioned that vermicompost provides resistance to pest buildup. Varma (1994) reported minimum populations of aphids, mites and fruit borer from the plots received vermicompost than from those applied with straight fertilizers. Similarly, Bhagyanakshatram (1995) and Kishore Kumar (1996) reported that the incidence of major

insect pests of rice like green leaf hopper (GLH), *Nephotettix virescens* Dist. brown plant hopper (BPH), *Nilaparvata lugens* Stal; leaf folder, *Cnaphalocrocis medinalis* Guenee and stem borer, *Scirpophaga incertulas* Wlk was significantly less in the plots received vermicompost than the straight inorganically fertilized plots.

The biotic interactions between soil nematodes and live and dead earthworm tissues were studied by Senapati (1992). The dead worm tissues were reported to enhance microbivore nematode activity and inhibition of plant parasitic nematodes. The plots applied with vermi-compost showed superiority over untreated control in suppressing the root-knot nematode, *Meloidogyne incognita* (K & W) Chitwood populations in tobacco nurseries (Swathi, 1995).

The vermicompost application increased the root and shoot length in rye grass (Springett and Syers, 1979), height of the plant, number of branches, thickness of leaves and number of leaves per plant of grapevine (Bhide, 1988). Higher yields were recorded in vermicompost applied plots than in the straight fertilized plots as reported by Dhane *et al.* (1996) in groundnut, Kale and Bano (1986) in rice, Jambhekar and Bhide (1991) in grape, Bhawalkar (1992) in coconut and Bhide (1993) in banana.

Vermicompost, in addition to recording the lowest pest population compared to straight fertilized control, has recorded higher population of beneficial insects in rice (Bhagyanakshatram, 1995 and Kishore Kumar, 1996).

#### 2.1.1.3. Neem cake

Recognizing the fact that the wild plants derive adequate protection against insect herbivores from a chemical 'umbrella', and that plant compounds are exploited to protect

susceptible crop plants, a search was made to identify effective and environmentally safe plant chemicals. Chemicals isolated from some tree species belonging to the genus *Melia* (Kraus *et al.*, 1993) have in the recent past received particular attention from applied entomologists, because several of them showed an almost ideal combination of properties suggesting that they might be excellent insect control agents (Schmutterer, 1990; Ascher, 1993). Thus they are among the strongest feeding deterrents known (Mordue (Luntz) and Blackwell, 1993), act after ingestion as growth disruptants in many insect species (Schmutterer, 1987), reduce food conversion efficiency by interfering with digestive processes (Timmins and Reynolds, 1992), and affect other physiological processes as well (Mordue (Luntz) *et al.*, 1985; Azambuja *et al.*, 1991).

Neem cake contains high per cent of nitrogen (N) (5.2%), sulphur (1.36%), triterpenoids, amino acids, sterols, flavanoids, sugars and an active repellent principle azadirachtin which was found highly effective against gypsy moth, Japanese beetles, aphids, tobacco budworm and boll weevils (Ketkar and Ketkar, 1985).

Residual toxicity of neem cake lasts for four weeks after its application (Dutta, 1974) and it is good antifeedant against *S. litura* and *H. armigera* (Rajasekharan and Jayaraj, 1990). Azadirachtin is known to have systemic action, being translocated through xylem and is available to plant system for a reasonable period (Kareem *et al.*, 1988).

Neem cake is having nitrification inhibition properties and thus it will release or permit in solution only small quantities of N at a time which can be utilized by plants and this reduces the chances for loss of N in nitrate form (Ketkar, 1976).

Application of neem cake as a fertilizer and repellent proved its effectiveness against many pests. As early as 1929, Hussain recommended soil treatment of wheat plots with neem and arsenic @ 165 lbs/acre. The attack of termites was reduced to 0.4% as against 7.5% in the untreated check. Tirumala Rao (1952) tested the efficacy of neem cake along with

kerosene and crude oil emulsion in controlling the larval population of paddy root weevil, *Echinocnemus oryzae* Marshall. It was observed that neem cake with tobacco refuse and 8:5 mixture of superphosphate and ammonium sulphate checked the larval population when applied to the soil. Many such investigations were carried out since then and neem cake as basal dose proved fatal to many insects which include termites (Dutta, 1974), soil insects of potato (Khound, 1975), crop pests - like singhara aphid, *Rhopalosiphum nymphaeae* (Goyal *et al.*, 1971), *Pieris brassicae* Linn (Atwal and Pajni, 1964; Ruscoe, 1972; Hans and Ferenzkoln, 1972), *Heliothis virescens* Fab. and *Dysdercus fasciatus* Sign (Ruscoe, 1972; Hans and Ferenzkoln, 1972), *Plutella xylostella* L. (Mong Ting Tan and Sudderuddin, 1978), *Argyroploce leucapsis* Meyr (Malik and Vaidya, 1979) and *Phyllocnistis citrella* Staint (Batra and Sandhu, 1981).

However, it was reported that when neem cake and other cakes like mohuva and karanj were used to control whitegrub, there was no insecticidal or repellency effect (Sachan and Pal, 1974) and neem cake @ 200 kg ha<sup>-1</sup> proved least effective in reducing the damage of leaves due to rice leaf folder (Ambethgar, 1996).

#### 2.1.1.4. Neem cake mixed with fertilizer

Mallik and Lal (1989) found that the plots received a mixture of fertilizer and neem cake had the lowest infestation (20.18%) of okra fruit borer, *Earias vittella* Fab. as against 26.83% with neem cake alone and 44.97% with fertilizer alone. Many reports are available stating that neem cake mixed with urea or neem cake coated urea at different rates according to the situation have paved the way for better pest control in rice (Tab. 1).

It is reported that although there was initial reduction in population of spiders and mirids in neem treated plots, there was better recolonization of predators (Mohan *et al.*, 1991). Many reports conclude that neem cake application to plants is relatively safe to the natural enemies like spiders and mirids (Krishnaiah and Kalode, 1985; Wu, 1986; Saxena *et al.*, 1989;

Mohan *et al.*, 1991; Jayaraj, 1992) and coccinellid, *Coccinella septempunctata* L. (Singh *et al.*, 1985). However, it was reported that maximum number of spiders was recorded in untreated control (5.7) than in neem treated plots (Muthukrishnan *et al.*, 1994).

**Tab. 1: Effect of neem cake mixed with straight fertilizers on pest complex of rice.**

Pest	Effect	Reference
1. Brown plant hopper	Less food consumption by females, reduction in growth and development of hoppers. Reduction in population	IRRI, 1982. Saxena <i>et al.</i> , 1984. Sasmal, 1986 Viswanathan and Kandianan, 1990
2. White backed plant hopper	Reduction in population	Sasmal, 1986
3. Green leaf hopper	Reduction in population	Sexena, 1986; Velusamy <i>et al.</i> , 1987. David, 1986; Viswanathan and Kandinnan, 1990
4. Pink borer	Reduction in population	Ho and Kibuka, 1983
5. Whorl maggot	Reduction in population	David, 1986
6. Earhead bug	Reduction in population	Velusamy <i>et al.</i> , 1987
7. Leaf folder	Reduction in population	David, 1986
8. Pest complex	Reduction in population	Ravindrababu, 1995 Kishore Kumar, 1996

## 2.1.2. Influence of Inorganic Straight Fertilizers on Pests and Natural Enemies

### 2.1.2.1. Pests

The plants respond to different fertilizer treatments by providing varying degrees of growth and as a result some plants were more attractive to the female moths than others. Enhancement of succulent cotton growth through fertilization renders the crop more attractive to population of the cotton aphid, *Aphis gossypii* Glover (McGarr, 1943; Isley, 1946), cotton bollworm moth, *Heliothis obsoleta* Fab. (Gaines, 1933; Fletcher, 1941), cotton leaf hopper (Butt *et al.*, 1946), cotton fleahopper, *Pseudatomoscelis seriatus* Reuter (Adkisson, 1957) and cotton bollworm *H. zea* (Adkisson, 1958). Hence higher rates of inorganic fertilizer by encouraging

rapid plant growth, produce a more attractive environment for oviposition than the slower growing checks (Adkisson, 1958). The increase in incidence of bollworm on cotton plants was found to be associated with the rate of inorganic N application (Bishara, 1969). The stem borer, *Chilo zonellus* Swinhoe and *Sesamia inferens* Walker on corn are influenced by fertilization practices. Populations have been shown to increase significantly with rate of N application. Similar effect has not been observed with variable rates of phosphorus (P) (Singh and Shekhawat, 1964). Different types of fertilizers exerted little influence on stem borer of rice, *Tryporyza incertulas* Wik while significant increase in the incidence of stem borer was noticed with increase in level of fertilization on rice (Michael Raj and Morachan, 1973).

In short duration crops, increasing levels of soil fertility delay the fruiting period of the crop, thereby reducing the potential to escape from boll weevil injury (Walker *et al.*, 1976 & 1977). Increase of soil fertility of both winter and spring wheat resulted in increased wheat stem saw fly injury, due to the presence of ovipositing female on large and succulent wheat plants.

According to Chaudhary and Kashyap (1987) there was significant difference in cicadellid numbers and incidence of *Leucinodes orbonalis* Guenee between the fertilized and unfertilized plots. An increase in the dose of N and P resulted in heavier infestation of both the species. There was more larval growth of *S. frugiperda* on Italian millet in NPK, NP and NK applied plots (Fonesca *et al.*, 1988) and more population densities of different arthropod groups of insects in plots treated with mineral fertilizers (Fratello *et al.*, 1989). Chillie pod borer incidence increased with the application of higher doses of nitrogen (Venkateswara Rao *et al.*, 1989 and Varma, 1994).

Modification of soil fertility through fertilizer, influenced the arthropod pests of soybean (Rhoads and Barnett, 1990). Funderburk *et al.* (1991) evaluated influence of phosphorus (P),

potassium (K) and magnesium (Mg) levels on population dynamics of velvet bean caterpillar, *Anticarsia gemmatalis* Hub and southern green stinkbug, *Nezara viridula* in soybean crop following winter wheat. The populations were affected by P and K levels and over-fertilization increased the pest outbreak. Such modifications of soil fertility levels can alter survival and development of insects (Herzog and Funderburk, 1986). Purohit and Despande (1991) stated that the incidence of whitefly on cotton was lower in the unfertilized plots than in the plots applied with inorganic fertilizers. Rote and Puri (1992) also got similar results. Purohit and Despande (1994) reported that the inorganic sources of NPK application increased the bollworm complex of cotton. Inorganic form of NPK application was less effective than organic form of NPK application in maintaining the population of gram caterpillar spotted pod borer, plume moth, blister beetle and pod bug of pigeonpea. Pod damage by pod borer complex and seed damage by pod fly were reported to be high in plots applied with inorganic straight fertilizers in pigeonpea (Dayakar *et al.*, 1995).

#### 2.1.2.2. Natural enemies

Soil fertilization modify foliage habits where many pests and natural enemies reside during atleast a part of their life cycle (Rhoads and Barnett, 1990)

Populations of some predators of bollworms in cotton increased by the application of N,P and K (Adkisson, 1958). It was reported that lady bird beetle populations of *Hippodamia convergens* G.M. and *Orius insidiosus* Say were influenced by fertilizer treatments and showed no influence on *Nabis* and *Chrysopa* species. The population of *A. gemmatalis* and *N. viridula* were either directly affected by P and K influence on soybean nutrition and growth or indirectly by natural enemy populations (Funderburk *et al.* 1991). Funderburk and his associates (1994) reported that spider density estimates were greater at higher P levels but not at K or Mg levels. Fluctuation in the number of cicadellids were accompanied by a corresponding increase or decrease in the number of spiders (Araneae) on groundnut (Singh *et al.*, 1991).

### 2.1.3. Seed Treatment

#### 2.1.3.1. Pests

Many researchers have shown that seed treatment with systemic insecticides had given satisfactory control of sucking insects like greenbug on sorghum and corn (Dahms and Wood, 1957; Daniels, 1960), aphids and hessian fly on wheat (Wilson *et al.*, 1960) and aphids on barley and oats (Hard Wood and Bruehl, 1961; Depew, 1964)

Groundnut seed treated with carbofuran gave good results against early sucking pests like jassids upto 30 days after sowing (NARP, 1982). Venkata Reddy (1988) reported that under field conditions, groundnut plots treated with carbofuran protected the crop against early sucking pests like jassids (24.33/20 plants) leaf miner (4.27%) upto 30 days when compared to control (59.33 jassids/20 plants: 11.51% of leaf miner, respectively).

The seed treatment with carbofuran was also having phytotonic effect (Reynolds *et al.*, 1957; Apple, 1971; Pless *et al.*, 1972; Ramamoorthy, 1986; Subramanyam *et al.*, 1988).

Carbofuran 300 ST (@ 0.9 kg a.i ha<sup>-1</sup>) as seed treatment was effective in reducing green bug, *Schizaphis graminum* Rondani and corn leaf aphid, *Rhopalosiphum maidis* Fitch infestations on wheat (Guerra-Sobrevilla, 1988)

Granular insecticides like isofenphos 5 G @ 2 or 5 kg a.i. ha<sup>-1</sup>, carbosulfan 10 G @ 4 kg a.i. ha<sup>-1</sup> were found to be significantly more effective in suppressing *Aproaerema modicella* Dev infestation (Rajagopal and Gowda, 1992). The granular insecticides have striking effects on populations of noctuids, *H. zea* and *S. frugiperda* (Mack, 1992).

#### 2.1.3.2. Natural enemies

The activity of natural enemies such as insect parasites and pathogens of *A. modicella* was not affected by the granular insecticide treatment (Rajagopal and Gowda, 1992). However, Panda and Khush (1995) reported that carbofuran reduced major predators of plant hoppers, such as spiders, mirid bugs and rove beetles.

#### 2.1.4. Sunflower as a trap crop

Many farmers use plants that are highly attractive to pests to lure them away from valued crops, since long. The traps can be set either around plantings or between rows (Batra, 1982). Trap crops can also serve as breeding grounds for parasitoids and predators. The survival and composition of natural enemies of crop pests are enhanced by manipulating the composition and abundance of other plants growing near or among the crop plants (Roger, 1976; USDA, 1980; DeBach, 1974; Southwood and Way, 1980). Adjacent trap crops can be managed to supplement pest or alternate prey populations, thus providing food sources for natural enemies during periods of prey parasite asynchrony or low population density (Stary, 1970).

Wightman *et al.* (1990) reported that farmers in India grow castor plants in groundnut fields to attract ovipositing *Spodoptera* moths. The moths preferentially lay eggs on the leaves of castor where the eggs or larvae are easier to find out and destroy. Observations on farmers' fields with sunflower as intercrop/mixed crop in post-rainy season groundnut of 1993 demonstrated its advantage as trap crop (Ranga Rao *et al.*, 1995; ICRISAT, 1994; Wightman *et al.*, 1994). Sunflower or castor as trap crop around the boundaries in the field at 3 to 5 metres distance in groundnut was reported to be useful for trapping *Spodoptera* egg masses and aid in easy destruction of the pest. Ranga Rao *et al.* (1995) reported that soybean can successfully be used as border or intercrop with groundnut to reduce leaf miner incidence.

Unrelated plants, when grown among crops, provide physical or chemical barriers that interfere with host location by phytophagous insects and their predators (Root and Tahvanainen, 1969).

Sivasubramanian and Palanisamy (1983) reported less incidence of jassids and leaf miners in groundnut plus cowpea intercropping system. Leaf miner and leaf hopper incidence was low when groundnut was intercropped with pearl millet (Kennedy *et al.*, 1990; Kennedy and Raveendran, 1989) or blackgram (Muthiah *et al.*, 1991). *Spodoptera* incidence was less when groundnut was intercropped with blackgram (Muthiah *et al.*, 1991). Groundnut intercropped with pearl millet significantly increased coccinellids like *Coccinella* sp. and *Menochilus sexmaculatus* Fb. per plant compared to groundnut monocultures (Kennedy *et al.*, 1990).

## 2.2. INTERRELATIONSHIP BETWEEN SOIL FERTILITY AND BIOCHEMICAL CONSTITUENTS OF PLANTS

Insects present their greatest threat to plants in nutrient rich, productive environments and their attack is focussed upon tissues of high nutritional value. Plants growing in rich productive environments are usually fast growing and have relatively short lived, soft leaves with high concentration of N and other nutrients (Grime, 1979). For any given life form-herb, shrub, tree etc. species that are adaptively stress tolerant tend to have lowest N levels and slowest growth rates. Evergreenness is a clue that a species is nutrient stress tolerant (Janzen, 1974).

The effect of nitrogen stress on plant secondary compounds have a great importance to the herbivores, since optimal growth conditions and high soil N levels are known to favour maximal alkaloid synthesis (Robinson, 1974, Williams, 1972). Most N-based secondary

compounds are in a state of continuous recycling in plants (Seigler, 1977; Seigler and Price, 1976) whereas most phenolic compounds appear to be rather soluble end products (Walker, 1975).

Fertilization seems to have the greatest effect on the levels of soluble N compounds. Fertilizers increase amino acid and amide levels (Catlin and Priestley, 1976; Hoff *et al.*, 1974; Weissman, 1964) and inorganic N levels sometimes increase (McDole and McMaster, 1978; Nielsen and MacDonald, 1978; Smith 1978; Stark, 1965). Build up of proteins and soluble N compounds, however, depend greatly on the amount and form of N used for fertilization as well as the normal uptake mechanism of the plants.

The association of toxic allelochemicals (TA) with N-rich plants and tissues is interesting because many of the toxins are N-based, eg. alkaloids, various proteins and non-protein amino acids. The digestibility reducing allelochemicals (DRAs), on the other hand, are basically not N-based, eg. phenolics, tannins and the various terpenoid compounds (Harborne, 1977)

N-rich plants and plant tissues employ mainly N-based allelochemicals, whereas the N-poor plants and plant tissues employ mainly non-N-based allelochemicals (McKey, 1979). The legumes have N-fixing symbionts, and therefore, have a vast battery of N-based allelochemicals. In contrast, the N-poor plants, which occupy impoverished substrate contain an amazing variety of non-nitrogenous allelochemicals such as of phenolic and terpenoid derivatives (Janzen, 1974).

The "availability" hypothesis suggests that N based allelochemicals ought to occur where N supplies are large relative to the amount needed for growth. In contrast, the non-N-based allelochemicals ought to occur where carbon supplies are large relative to their demands, presumably because, N availability is low (Mattson, 1980)

Plant species exhibiting single, more or less synchronised growth flushes often contain some N-based allelochemicals in expanding tissues, while levels of non-N-based allelochemicals, like phenols are usually nominal until tissue growth is nearly complete. After this point, such compounds begin to accumulate markedly. As individual leaves complete growth there is little change in their phenolic levels. (Dement and Mooney, 1974; Feeny, 1970; Haukioja *et al.*, 1978; Rhoades and Cates, 1976).

Several authors have mentioned the effect of nutrition on the amount of polyphenols in plants (Davies *et al.*, 1964). Stitt *et al.* (1946) showed that *Lespedeza cuneata* produced significantly greater quantities of tannins when grown on 'poor' soils. Vogel (1931) states that the tannin content of trees is affected by the soil, though he makes no reference to the effect produced. The relationship of specific deficiencies in nutrition to a high polyphenol content has been recorded, e.g. N deficiency appears to increase polyphenol biosynthesis in the plant. Heller (1948), using tissue culture, found that N-deficient medium gave a high level of anthocyanin in Virginia Creeper; Swaby (1958) found that N deficiency, induced in subterranean clover by lack of symbiotic organisms, was responsible for anthocyanin formation. Peach (1950) noted the accumulation of a red pigment in the leaves, stems, and roots of N-deficient Graminae seedlings. Bonner (1950) states that many nutrient deficiencies particularly N and P, are associated with increase in anthocyanin content. Davies *et al.* (1964) opined that growing a number of plants in sand produced high content of polyphenolic substances, which was attributed to lack of N or P. The study of McKey *et al.* (1978) provides support for the hypothesis that vegetation on low-nutrient soils contains relatively high concentration of polyphenolic compounds deterrent to herbivores and pathogens.

Increasing plant N through fertilization has lowered levels of phenolics and lignins (Jones, 1976; Kiraly, 1976; Troilidenier and Zehler, 1976), whereas reducing plant N through

culturing soils that are N and P-poor has raised levels of phenolics (Davies *et al.* 1964; Forrest, 1975; McKey *et al.*, 1978; Reader, 1979; Szweykowska, 1959).

The best known DRAs are those (tannins and phenols) that directly interfere with N availability by complexing with proteins, enzymes and carbohydrates (Cates and Rhoades, 1977; Harborne, 1977; Mayer and Harel, 1979; Rhoades and cates, 1976; Swain, 1977). It has also been hypothesized that tannins are rather broad-spectrum anti-herbivore compounds that block protein availability by affecting digestive enzymes and/or the plant proteins themselves (Feeny, 1975 & 1976).

It has been suggested that the high concentration of carbon based secondary substances found in plants of nutrient poor habitats are not primarily defensive, but rather a metabolic consequence of nutrient deficiency. According to the "nutrient stress hypothesis" (Tuomi *et al.*, 1984 & 1988), carbon is allocated to new growth when the supply of mineral nutrients is adequate for new cells, but surplus carbon may be converted into allelochemicals.

Levels of damage or performance of herbivores on different plants or plant parts can be correlated with tannin levels. It was also suggested that correlation between insect performance and dietary tannin levels in their food plants may be positive or absent (Faeth, 1985; Fox and Macauley, 1977; Lawson *et al.*, 1984)

Availability of soil nutrients had a profound influence on the production of phenolics including tannin in many plant species (Waterman and Mole, 1989). Nitrogen fertilization of *Populus tremuloides* led to a reduction in tannins to less than one-fifth of the levels found in unfertilized control trees (Bryant *et al.*, 1987). Higher levels of phenolics including tannins are associated with nutrient poor soils (Bryant *et al.*, 1983; Coley *et al.*, 1985) and showed

slow growth rates when plants are grown in poor soil, suggested as a cause of higher levels of tannin (Bryant *et al.*, 1985). Also, nitrogen fertilization of particular plant species has been shown to cause a decrease in their production of tannins (Bryant *et al.*, 1987). Haslam (1988) has indicated that in tannin producing species, tannin involvement in lignification could be very important.

### 2.3. INSECT HERBIVORY AND NATURAL ENEMIES IN RELATION TO PLANT BIOCHEMICAL CONSTITUENTS

#### 2.3.1. Insect Pests

Phytophagous insects are very sensitive to nutritional changes in host plants. These changes are accomplished by regulating the cultural practices like fertilization, irrigation, etc., which is called induced resistance or pseudoresistance (Kogan, 1982). The potential effect of fertilization upon pseudoresistance in plants to insects was documented earlier. Fertilizers applied to enhance the growth and yield of crop plants is a cultural method of modifying the environment of the pest (Kogan and Paxton, 1983). The fertilizers induce changes in concentrations of the primary and secondary metabolites of the plant and ultimately result in growth and dynamics of the insect pests that harbour such plants. In general, all the phytophagous insects have similar qualitative nutritional requirements but it is the quantitative factor that play a decisive role in insect host plant interactions (House, 1969). Changes induced in the concentrations of plant metabolites affect the insects at the nutritional level and may alter behavioural response towards plants (Bernays and Chapman, 1977; Rhoades, 1979).

Van Emden and Wearing (1965) had suggested that reduced rate of multiplication of insects such as aphids on particularly resistant varieties should result in a magnification of plant resistance in the presence of natural enemies.

### 2.3.1.1. Nitrogen (N)

Nitrogen is the primary constituent of plant metabolic systems and every system of the plant depends on nitrogen. There are different studies which correlated the susceptibility of the pests to plant N content.

Differences in N content of varieties was correlated to growth rate in pale western cutworm, *Agrotis orthogonia* Morrison on wheat (Kasting and McGinnis, 1959). Fecundity and reproductive rate of green peach aphid, *Myzus persicae* Sulzer are depressed in brussels sprouts by reductions in soluble N levels in the crop's phloem (Van Emden and Wearing, 1965). Low N or high K levels in the soil induce this modification in physiology of brussels sprouts. Rodriguez and Campbell (1961) while working with mites on apple, *Tetranychus telarius* Linn and *Panonychus ulmi* Koch. Honeyborne (1969) with aphids, *Aphis fabae* Scop on broadbean and *Brevicoryne brassicae* on brussels sprouts and Chadha and Arora (1982) with mustard aphid, *Lipaphis erysimi* Kall. recorded changes in pest populations following changes in the concentrations of total N content in the plants. Sorghum varieties or lines less susceptible to delphacid, *Peregrinus maidis* Ashmead and aphid, *Melanaphis sacchari* Zehnter recorded lower amounts of nitrogen (Mote and Shahane, 1994). Groundnut lines susceptible to groundnut leaf miner, *A. modicella* recorded lower amounts of amino nitrogen (Ranga Rao, 1991) and vice versa (Visalakshi, 1994). However, Kasting *et al* (1958) and McGinnis and Kasting (1961) observed that comparisons of N concentrations in pith and stem walls of wheat varieties disclosed varietal and plant developmental differences but no correlation with resistance against insects.

### 2.3.1.2. Protein

Non-preference of *Jasminum auriculatum* Vahl by *Dialeurodes vulgaris* Singh was attributed to low leaf protein content (Sundararaj and David, 1990). The requirements of

European corn borer larvae for proteins was found to change during growth, but no evidence could be accounted for such nutritional basis (Beck, 1956).

### 2.3.1.3 Amino acids

Cutworm (*Agrotis ipsilon* Hfn) larvae were more sensitive to amino acid imbalance in wheat (McGinnis and Kasting, 1961). The work of Auclair and his associates on the importance of amino acids in the resistance of peas to the aphid, *Acyrtosiphon pisum* Harris is well known (Auclair and Cartier, 1960; Mallais and Auclair, 1952 & 1962). It was found that resistant pea varieties were deficient in amino acids, and aphids on resistant varieties grow more slowly than normal and secrete less honeydew and produce fewer progeny. Not only structural amino acids, but also essential amino acids proved to be deleterious if they are ingested in excessive quantities or if they are not in balance with other amino acids (Janzen, 1977). Higher amounts of amino acids make the plant either attractive or dettractive to pest attack. High amounts of amino acids in castor made it more preferred by the whitefly, *Trialeurodes rara* Singh (David and Paul, 1973) and *Jasminum multiflorum* Andr by *D. vulgaris* (Sundararaj and David, 1990).

### 2.3.1.4. Carbohydrates

The earlier reports suggested that carbohydrates in plant had no influence on pest population. Larval requirements of European corn borer for sugar change during growth but no evidence was obtained that plant resistance could be accounted for such a nutritional change (Beck, 1956). Lopatecki *et al.* (1962) and Kasting and McGinnis (1961) reported that there was no correlation between varietal growth differences due to soluble carbohydrates to insect resistance.

The literature of the past twenty years, however, showed that pest population changes could be correlated to carbohydrate levels in the plants. Ehatia (1975) claimed that low

carbohydrate content seems to be responsible for resistance to anguinois grain moth. Khurana and Verma (1983) reported that total sugars in 30 day old plants were found to be negatively correlated with sorghum stem borer susceptibility. The concentration of sugars in the plants affected the population of mites on apple (Rodriguez and Campbell, 1961), aphids on broadbeans and brussels sprouts (Honeyborne, 1969) and on mustard (Chadha and Arora, 1982). Ranga Rao (1991) estimated biochemical constituents of different groundnut lines and found that the resistant groundnut lines had higher amounts of total soluble sugars. Excessive accumulation of sugars in host plants makes them less attractive for *D. vulgaris* (Sundararaj and David, 1990). Low levels of sugars have been correlated with groundnut leaf miner resistance in the resistant cultivars (Visalakshi, 1994) and *P. maidis* and *M. sacchari* resistance on sorghum (Mole and Shahane, 1994).

#### 2.3.1.5. Phenols

Higher plants possess a wide variety of phenolic compounds, which are aromatic in nature, and possess one or more phenolic hydroxy groups. The phenyl propanoids are the most widely distributed and are found in all higher plants. The phenyl propanoids form a biosynthetically homogeneous group formed atleast in part via the shikimate pathway. The phenyl propanes are generally denoted as C<sub>6</sub>-C<sub>3</sub> compounds (Panda and Khush, 1995).

The phenolic constituents of cotton leaf, which show antibiotic activity against insect pests, are biosynthetically produced through either acetate or shikimic acid pathway (Chan *et al.*, 1978). Phenolic levels increase following the damage by lygus bug to chinese cabbage and sugarbeet (Hori and Allay, 1980) and cotton (Gueira, 1981). Even abrasions on the cotton cotyledons transported secondary compounds into the leaves systemically (Kashan and Carey, 1984). The application of *Azospirillum* (biofertilizer) to sorghum seeds and soil imparted resistance to sorghum against sorghum shootfly which was due to higher level of phenolics in

the treated crops (Mohan *et al.*, 1987). Phenolic substances of cotton plant reduce the consumption and digestibility of *S. litura* and *H. armigera* (Ananthakrishnan *et al.*, 1990)

Sundararaj and David (1990) reported that high amount of phenol (21 238 mg g<sup>-1</sup> leaf) make the *Jasminum pubescens* Willd plants less attractive to *D. vulgaris*. Mote and Shahane (1994) reported that varieties less susceptible to delphacids and aphids showed high amounts of polyphenols. High amounts of polyphenols also induce resistance in groundnut to leaf miner (Visalakshi, 1994).

#### 2.3.1.6. Tannins

Tannins are compounds with an astringent taste, and are protein binding agents. Tannins are present in all plant materials. These are polyphenolic compounds, divided into two main groups - hydrolysable and condensed tannins. Hydrolysable tannins contain a polyhydric alcohol, glucose esterified with hexahydroxydiphenic acid. Condensed tannins are mostly flavonols and are polymers of flavan 3-ol (catechin) and these cannot be hydrolysed to simple components. Among the cereals, sorghum has been found to contain higher amounts of polyphenols (Watterson and Butler, 1983). The plant parts having tannins in higher quantities display impaired nutritional quality, lower digestibility and reduction of food consumption (Sadasivam and Manickam, 1992).

Tannins play an important role in plant defense against herbivory. Insects tend to avoid astringent food, which affects their digestion because of the coagulation of mucoproteins in their oral cavity (Bernays *et al.*, 1989). Recent evidence suggests that post-absorptive inhibition, rather than inhibition of digestion, is the primary factor responsible for poor insect growth caused by dietary tannins (Butler, 1989). Herbivory can be reduced by increasing leaf toughness by

accumulation of palatability reducing compounds (Coley, 1983; Grubb, 1986; Waterman and McKey, 1989).

Tannins have striking effects on insect herbivory. There were many studies which reported that increase in tannins reduce herbivory of *E. vitifella* (Sharma and Agarwal, 1982 a,b; Sharma *et al.*, 1982; Sharma and Agarwal, 1983), *H. virescens*, *H. zea*, *Pectinophora gossypiella* Saunders (Chan *et al.*, 1978; Shaver and Parrot, 1979) and *H. armigera* and *S. litura* (Ananthakrishnan *et al.*, 1990).

### 2.3.2. Natural Enemies

Painter (1951) feels two general ways in which plant resistance can influence the performance of natural enemies. First, reduction in prey populations may affect the success of some predators and parasites. If prey density falls below the optimum searching capacity of the natural enemy. Secondly, host plant-induced changes in prey physiology and behaviour may modify the success of natural enemies. Allomonal or toxic resistance factors and morphological defense mechanisms also limit populations of beneficial arthropods that come into physical contact with the host plant or that use the plant for incidental feeding (Bergman and Tingey, 1979).

Plants provide nutrition to the natural enemies in the form of pollen, nectar and extrafloral nectar directly or indirectly through their insect hosts (Smiley, 1978). Three hemipteran predators of *H. zea* viz *O. insidiosus* Say, *Geocoris pallens* Stal and *Nabis americanoferus* Carayon consume juices and pollen of corn and cotton (Dick and Jarvis, 1962; Ridgway and Jones, 1968).

Numerous studies, however, indicate that predator and parasite performance may be altered by the host plant of the prey (Flanders 1939 & 1942; Smith, 1957; Gerling, 1966; Kuo, 1977). Biological control and plant resistance are considered compatible pest management strategies (Casagrande and Haynes, 1976; Pimental and Wheeler, 1973; Starks *et al.*, 1972; Kennedy *et al.*, 1975; Schuster and Starks, 1975; Shuster *et al.*, 1976 a,b). There are also a number of instances where the chemicals (of plant) imparting resistance to host plant have affected natural enemies adversely (Thurston and Fox, 1972; Barbosa *et al.*, 1982; Obryckiel *et al.*, 1983; Smith, 1988).

Nutritionally inadequate diet impairs the ability of prey to encapsulate developing endo-parasites (El-Shazly, 1972), and adversely influence the development, fecundity and longevity of parasites (House and Barlow, 1961; Zohdy, 1976). A major impact of plant resistance in predator and parasite density is resulting from reduced prey populations (Pimental and Wheeler, 1973; Kennedy *et al.*, 1975; Casagrande and Haynes, 1976). Kousalya (1994) reported that the level of parasitization of sorghum midge did not follow a definite pattern with susceptibility or resistance of the host plant to midge.

*Materials*  
*and*  
*Methods*

## MATERIALS AND METHODS

The investigation on the "Influence of organic and inorganic sources of host plant nutrition on the incidence of major insect pests of groundnut (*Arachis hypogaea* Linn)" were carried out for three seasons in the sandy soils of the Agricultural college farm, Bapatla and Prof N G Ranga Krishi Vigyan Kendra, Kavur, Guntur district of Andhra Pradesh, from 1994 to 1996

### 3.0.1. Seasons of Study

The experiment (Plate 1) was carried out for three seasons viz. *rabi* 1994-95, *kharif*, 1995 and *rabi* 1995-96 (Tab. 2) The two *rabi* crops were irrigated at regular intervals and the *kharif* crop was rainfed but irrigated whenever the soil moisture was found wanting.

Tab. 2: Seasons of study

Sl. No.	Season	Year	Date of sowing	Date of harvesting
1.	<i>Rabi</i>	1994-95	08.12.1994	05.04.1995
2.	<i>Kharif</i>	1995	04.08.1995	01.12.1995
3.	<i>Rabi</i>	1995-96	08.12.1995	06.04.1996

### 3.0.2. Variety of the Crop

ICGS-44 was selected for the study. It is a semi-dwarf variety with spreading branches. The duration of the variety is 120 days and the variety is not known for its resistance against the pests of groundnut. The seed was procured from Prof. N G Ranga Krishi Vigyan Kendra, Vinayashram, Guntur district.

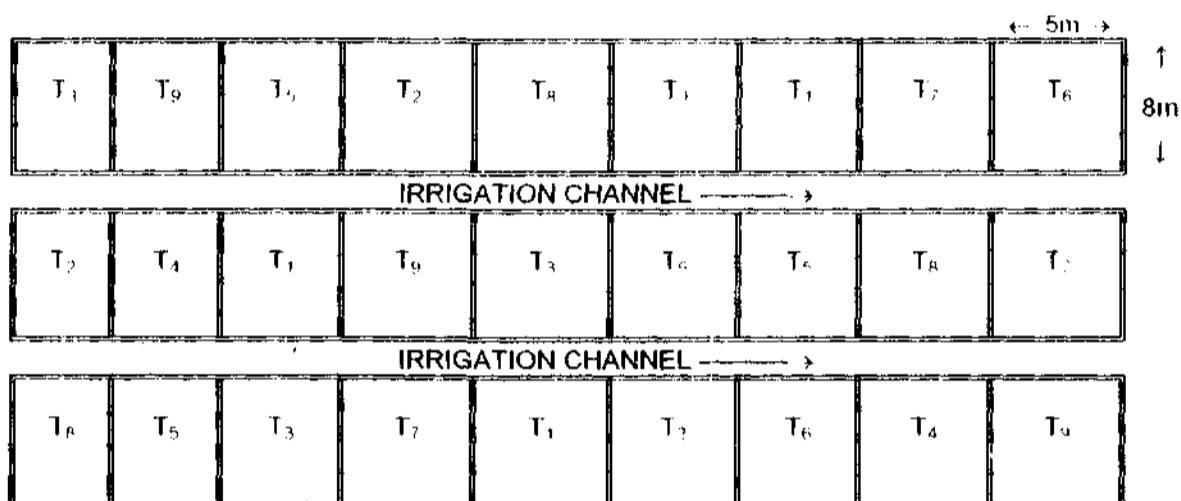


Plate 1: Experimental plot.

### 3.0.3. Layout of the Experiment

The experiment was laid in a randomised block design (R B D) with nine treatments and three replications (Fig 1). The plot size was 5 x 8 metres

Fig. 1 Lay-out of the experiment ( R B D)



### 3.0.4. Cultural Practices

The groundnut kernels in all the treatments were treated with Indofil M-45 @ 3 g kg<sup>-1</sup> seed three days before sowing as a seed protectant against soil borne pathogen infections. The groundnut kernels were sown @ 2 per hill with a spacing of 30 x 10 cm and irrigated. Subsequent irrigations were given at 10 day interval during *rabi*. The irrigations during *kharif* were, however, given when the soil moisture was found deficient. Timely weeding operations were taken up and the crop was kept free from weeds. The crop was irrigated one day before harvest to facilitate easy pulling of pods from the soil and harvested plot wise. The yield was recorded plot wise and expressed in kg ha<sup>-1</sup>.

### 3.0.5. Application of the treatments

All the treatments (Tab. 3) were applied as a basal dose. The treatments having organic manures (T<sub>2</sub> to T<sub>4</sub>) were applied a week prior to sowing and thoroughly incorporated into the soil to facilitate decomposition of farm yard manure (FYM), vermicompost and neem cake. The straight fertilizers (NPK), in the form of urea, single super phosphate and muriate of potash, in different treatments (T<sub>1</sub>, T<sub>5</sub>, T<sub>7</sub>, T<sub>8</sub> and T<sub>9</sub>) were applied in furrows on the day of sowing.

**Tab. 3: Treatments.**

Treatment No.	Treatment
T <sub>1</sub>	NPK (straight fertilizer) alone @40-60-40 kg ha <sup>-1</sup>
T <sub>2</sub>	Farm Yard Manure (FYM) alone @ 8 t ha <sup>-1</sup>
T <sub>3</sub>	Vermicompost alone @ 3.75 t ha <sup>-1</sup>
T <sub>4</sub>	FYM @ 4t ha <sup>-1</sup> + vermicompost @ 1.875 t ha <sup>-1</sup>
T <sub>5</sub>	Neem cake alone @ 770 kg ha <sup>-1</sup>
T <sub>6</sub>	NPK (Straight fertilizer) @ 20-30-20 kg ha <sup>-1</sup> + Neem cake @ 385 kg ha <sup>-1</sup>
T <sub>7</sub>	NPK (Straight fertilizer) @ 40-60-40 kg ha <sup>-1</sup> and Nuclear Polyhedrosis virus (NPV) application @ 250 LE ha <sup>-1</sup> at 50 & 75 DAS
T <sub>8</sub>	NPK (Straight fertilizer) @ 40-60-40 kg ha <sup>-1</sup> and planting sunflower plants at a distance of 2-3 m in the plot as a trap crop to <i>S. litura</i>
T <sub>9</sub>	NPK (Straight fertilizer) @ 40-60-40 kg ha <sup>-1</sup> and seed treatment with 250 g carbofuran 3G kg <sup>-1</sup> seed.

Treatments : 9  
Replications : 3  
Design : Randomized Block Design (RBD)

Crop : Groundnut  
Variety : ICGS-44  
Plot size : 5 x 8 m

The nuclear polyhedrosis virus (NPV) in the T<sub>7</sub> was applied at 50 and 75 days after sowing (DAS) @ 250 LE ha<sup>-1</sup>. The NPV solution (250 LE) was mixed in 12 L of water and sprayed uniformly on the foliage of the crop during the evening hours.

In the  $T_{10}$ , sunflower seeds were sown at a distance of 2 to 3m within and between the crop rows synchronizing with the sowing of groundnut such that a minimum of 6 plants were available in the respective plots as a trap crop (Plate 2) for oviposition of *Spodoptera litura* Fab. The egg masses were collected whenever noticed on the sunflower leaves and were destroyed. The birds attracted to the heads of sunflower alighted on the plants and picked up the caterpillars during the later stages of the crop

In the  $T_9$ , the groundnut seed was treated with carbofuran 3G. First, 375 g of carbofuran 3G was added to 1.5 L water in a vessel to which 1.5 kg Indofil M-45 treated groundnut seed was mixed and the seed was soaked for one hour. Later the seed was sown in the respective plots

In all the treatments no insecticide was applied but two sprays of a mixture of fungicides dithane M-45 @ 2 g L<sup>-1</sup> and carbendazim @ 1 g L<sup>-1</sup> were applied at 75 and 90 DAS against tikka leaf spot.

### 3.1. RECORDING OF DATA

The data pertaining to insect pests and natural enemy populations were recorded at weekly intervals from 21 DAS, till the harvest of the crop

#### 3.1.1. Insect Pests

Data pertaining to five important insect pests of groundnut (Tab. 4) were recorded according to the procedures described below



Plate 2: Sunflower as trap crop in groundnut.

**Tab. 4: Groundnut insect pests under study**

<b>Pest</b>	<b>Scientific Name</b>	<b>Family</b>	<b>Order</b>
Jassids	<i>Empoasca kerri</i> Pruthi	Cicadellide	Homoptera
Aphids	<i>Aphis craccivora</i> Koch	Aphididae	Homoptera
Leaf miner	<i>Aproaerema modicella</i> Dev	Gelichiidae	Lepidoptera
Tobacco caterpillar	<i>Spodoptera litura</i> Fab	Noctuidae	Lepidoptera
Gram pod borer	<i>Helicoverpa armigera</i> Hub	Noctuidae	Lepidoptera

**3.1.1.1. Jassids**

The nymphs of jassids on the three terminal leaves of ten randomly selected and tagged plants from each plot were counted at weekly intervals (Amin and Mohammad, 1980).

**3.1.1.2. Aphids**

The population counts of aphids per plant on ten randomly selected and tagged plants were recorded per plot at each count (AICORPO, 1978).

**3.1.1.3. Leaf miner**

The leaf miner larvae (Plate 3) on ten leaflets per plant on ten randomly selected and tagged plants were recorded per plot at each count (AICORPO, 1978).

**3.1.1.4. Tobacco caterpillar**

The number of larvae (Plate 4) per plant were recorded on ten randomly selected and tagged plants per plot at each count (Amin and Mohammad, 1980).



Plate 3: Damage caused by *A. modicella* larva.



Plate 4: *S. litura* early instar (upper) and late instar (lower) larvae feeding on groundnut leaflet.

### 3.1.1.5. Gram pod borer

The number of larvae (Plate 5) per plant on ten randomly selected and tagged plants were recorded per plot at each count (Amin and Mohammad, 1980).

### 3.1.2. Natural enemies

The data pertaining to the following natural enemies of pest complex of groundnut viz. coccinellid beetles, spiders and chrysopids (Tab. 5) were recorded on whole plant basis. The population of these natural enemies per plant on 10 randomly selected and tagged plants were recorded.

**Tab. 5: Natural enemies.**

Sl. No.	Natural enemies	Scientific Name	Family	Order
1.	Coccinellid beetles	a. <i>Coccinella transversalis</i> Fab	Coccinellidae	Coleoptera
		b. <i>Verania vincta</i> Gorhm	Coccinellidae	Coleoptera
		c. <i>Menochilus sexmaculatus</i> Fab	Coccinellidae	Coleoptera
2.	Spiders	a. <i>Oxyopes salticus</i> Hentz	Oxyopidae	Araneae
		b. <i>Pardosa pauxilla</i>	Lycosidae	Araneae
		c. <i>Lycosa pseudoannulata</i>	Lycosidae	Araneae
3.	Chrysopids	a. <i>Chrysopa carnea</i> Stefans	Chrysopidae	Neuroptera
		b. <i>Chrysoperla sinica</i>	Chrysopidae	Neuroptera

### 3.2. BIOCHEMICAL ANALYSIS OF GROUNDNUT LEAVES

Groundnut leaves were analysed for their biochemical constituents at three growth stages of the crop viz. 21, 49 and 77 DAS coinciding with the flowering (Plate 6), peg penetration (Plate 7) and pod formation stage (Plate 8) respectively. The fourth leaf from tip downwards was plucked from 50 groundnut plants per plot (Bhargava and Raghupathi, 1993) for the analysis. The leaves thus collected were made into two sets of 25 each, and one set was taken in a polythene cover and kept in a deep freezer for the estimation of phenols and total free amino acids. The other set of leaves was collected in a paper bag and dried in an



oven at 40<sup>o</sup> C for 24 hours. The dried samples were powdered to estimate nitrogen (N), crude protein (CP), carbohydrates and tannins.

### 3.2.1. Analysis of Fresh Leaves for Total Free Amino Acids (TFAA) and Phenols

One day after plucking, 500 mg of deep freezeed leaf material was taken out and homogenised in a mortar and pestle with 10 mL of 80% ethanol. The homogenate was centrifuged at 10,000 rpm for 20 minutes and the supernatant was collected. The residue was reextracted with 5 mL of 80% ethanol, centrifuged and the supernatants were pooled up and made upto a known volume. The supernatant was used for estimation of phenols and total free aminoacids (Plate 9) (Sadasivam and Manickam, 1992)

#### 3.2.1.1. Total free amino acids (TFAA)

The alcohol extract, 0.1 mL was taken in a test tube and 1.0 mL of freshly prepared ninhydrin solution (prepared by dissolving 100 mg ninhydrin in 100 mL acetone and 4 mL glacial acetic acid) was added. The volume was made upto 2.0 mL with distilled water and the contents were heated in a boiling water bath for 20 minutes. The test tubes were then taken out from water bath and 5.0 mL of diluent solvent prepared by mixing equal volumes of water and n-propanol, was added and kept for 15 minutes for colour development. The intensity of the purple colour developed in the sample was read at 570 nm against a reagent blank in a Spectronic 20. Reagent blank was prepared by taking 0.1 mL of 80% ethanol instead of the sample extract.

The standards were prepared by dissolving 100 mg leucine in 100 mL distilled water in a volumetric flask. The stock solution was further diluted by taking 10 mL and making it upto 100 mL with distilled water for preparation of working standard solution. A series of concentrations of working standards 10 µg, 20 µg, 30 µg, ... 100 µg mL<sup>-1</sup> were prepared by taking

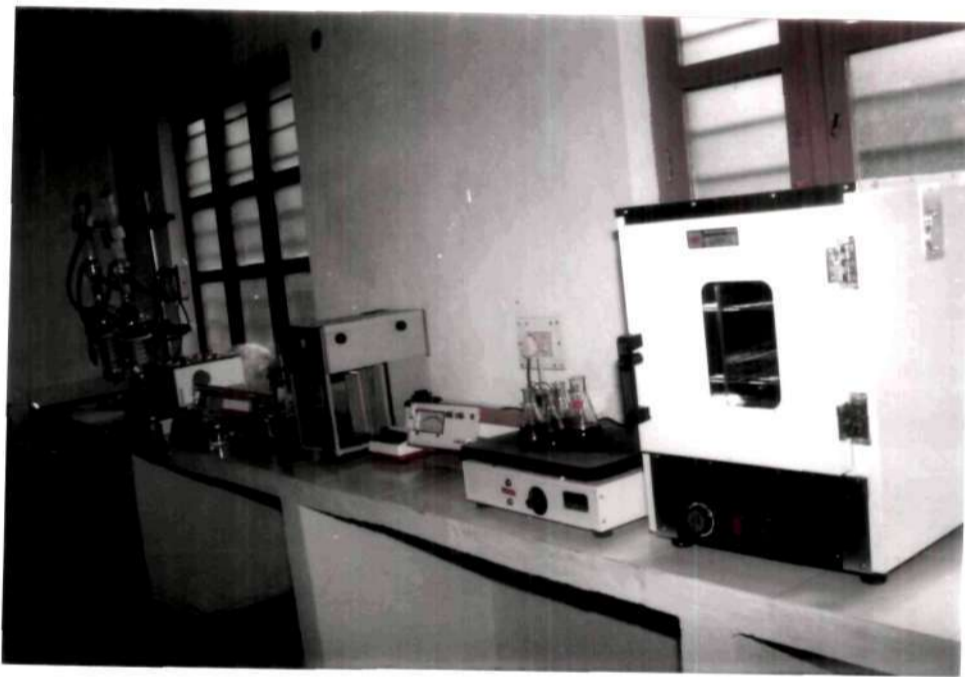


Plate 9: Alcohol extract of fresh leaf samples for estimation of phenols and amino acids.

0.1 mL, 0.2 mL, 0.3 mL ..... 1.0 mL of the working standard solution and making up the volume to 1.0 mL with distilled water in all the test tubes. The reagents were added to these standards as that of the sample and proceeded for colour development. The standard graph was drawn by plotting concentration of leucine on x-axis and absorbance on y-axis. By using the standard graph, the concentration of the total free aminoacids in the samples were calculated and expressed in  $\text{mg g}^{-1}$  fresh leaf (Moore and Stein, 1948)

#### 3.2.1.2. Phenols

The alcohol extract, 0.5 mL was pipetted out into a test tube and the volume was made upto 3.0 mL with distilled water to which 0.5 mL of Folin-ciocalleau reagent was added and kept for 3 minutes. Then 2.0 mL of 20%  $\text{Na}_2\text{CO}_3$  was added to the contents of the test tube and the contents were mixed thoroughly and the test tubes were kept in a boiling water bath for one minute and cooled for colour development. The absorbance was measured at 650  $\text{nm}$  against a reagent blank prepared by taking 0.5 mL of 80% ethanol instead of the sample extract

The standards were prepared by dissolving 100 mg catechol in 100 mL distilled water. It was further diluted by taking 10 mL of the stock solution and making the volume upto 100 mL. A series of concentrations of working standards 10  $\mu\text{g}$ , 20  $\mu\text{g}$ , 30  $\mu\text{g}$ ....100  $\mu\text{g mL}^{-1}$  were prepared by taking 0.1, 0.2, 0.3....1.0 mL of the working standard solution and making the volume in all the test tubes to 1.0 mL with distilled water. The reagents were added to the test tubes as that of the sample and proceeded for colour development. The standard graph was prepared and the phenols in the leaf sample were estimated using standard graph and expressed in  $\text{mg g}^{-1}$  fresh leaf (Malick and Singh, 1980)

### 3.2.2. Assay of Dry Leaf Samples for Estimation of Nitrogen (and Crude Protein), Carbohydrates and Tannins

#### 3.2.2.1. Nitrogen

The nitrogen content of leaf samples was analysed by microkjeldhal method by taking 100 mg of powdered leaf sample in a small test tube to which 3.0 mL of conc.  $H_2SO_4$  was added. The mixture was left overnight for digestion. To the digested sample, hydrogen peroxide was added drop by drop by keeping the test tube on a flame until it was converted from black to colourless solution. The colourless solution was then transferred to the microkjeldhal flask for distillation (Plate 10). 25 mL of 4% boric acid (40g in 1.0 L of water) was taken in 150 mL beaker to which 1 to 2 drops of mixed indicator (3 parts of bromocresol green plus 2 parts of methyl red) was added. The tip of the condenser was dipped into the solution. 15 mL of 40% NaOH (400 gm in 1.0 L) was added into the distillation flask and the reaction was continued till all the ammonia was released.

The contents in the beaker were titrated against 0.1 N  $H_2SO_4$ . The N content (%) in the sample was obtained by using the formula.

$$N\% = \frac{\text{Titre value} \times 0.0014}{\text{weight of the sample}} \times 100$$

#### 3.2.2.2. Crude protein (CP)

In general, the nitrogen content is multiplied by the factor 6.25 to arrive at the percentage of crude protein which is based on the assumption that nitrogen constitutes 16% of a protein. However, the nitrogen per cent varies with the aminoacid composition of the proteins. For more refined expression of protein percentage in the sample, different factors were used. These factors were arrived at by the aminoacid composition. Such factor for

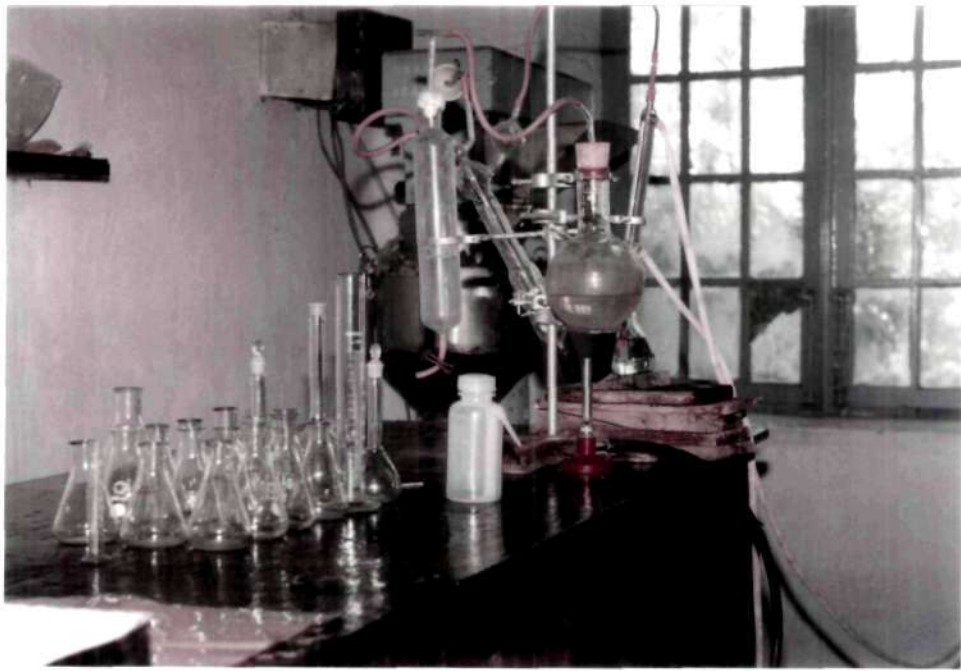


Plate 10: Microkjeldahl apparatus for estimation of leaf nitrogen.

groundnut was 5.46. Nitrogen content was multiplied by the factor 5.46 to get the crude protein content of groundnut leaves (Sadasivam and Manickam, 1992).

#### 3.2.2.3. Carbohydrates

The carbohydrates present in the leaf samples were estimated by anthrone method (Hedge and Hofreiter, 1962). 100 mg of the dried leaf sample was placed in a test tube. The sample was hydrolysed by keeping it in boiling water bath for 3 hours with 5.0 mL of 2.5 N HCl and cooled to room temperature. Solid sodium carbonate was added to it to neutralize until the effervescence ceases and the volume was made upto 100 mL and centrifuged. From the supernatant 1.0 mL of aliquot was taken for analysis. Simultaneously the standards were prepared by taking 0.2, 0.4, 0.8 and 1.0 mL of the working standard (Stock solution-100 mg glucose was dissolved in 100 mL distilled water; working standard-10 mL of the stock diluted to 100 mL with distilled water). The volume in each tube was made up to 1.0 mL including the sample tubes by adding distilled water. After adding 4.0 mL of anthrone reagent (dissolving 200 mg anthrone in 100 mL of ice cold conc.  $H_2SO_4$ ), the tubes were heated for eight minutes in a boiling water bath. The tubes were cooled rapidly for development of green to dark green colour and the intensity of colour was read at 630 nm. The standard graph was prepared using analar glucose. From the graph the amount of carbohydrate present in the sample was calculated and expressed in  $mg\ g^{-1}$  dry leaf.

#### 3.2.2.4. Tannins

The tannins in the leaf samples were estimated by Folin-Denis method (Schranderl, 1970). 500 mg of the dried leaf sample was transferred into a 250 mL conical flask (Plate 11). After adding 75 mL distilled water to it, the flask was heated up for 30 minutes. The contents were then centrifuged at 2000 rpm for 20 minutes and the supernatant was made upto 100 mL. The sample extract, 1.0 mL each, was transferred to 100 mL volumetric flask containing 75 mL

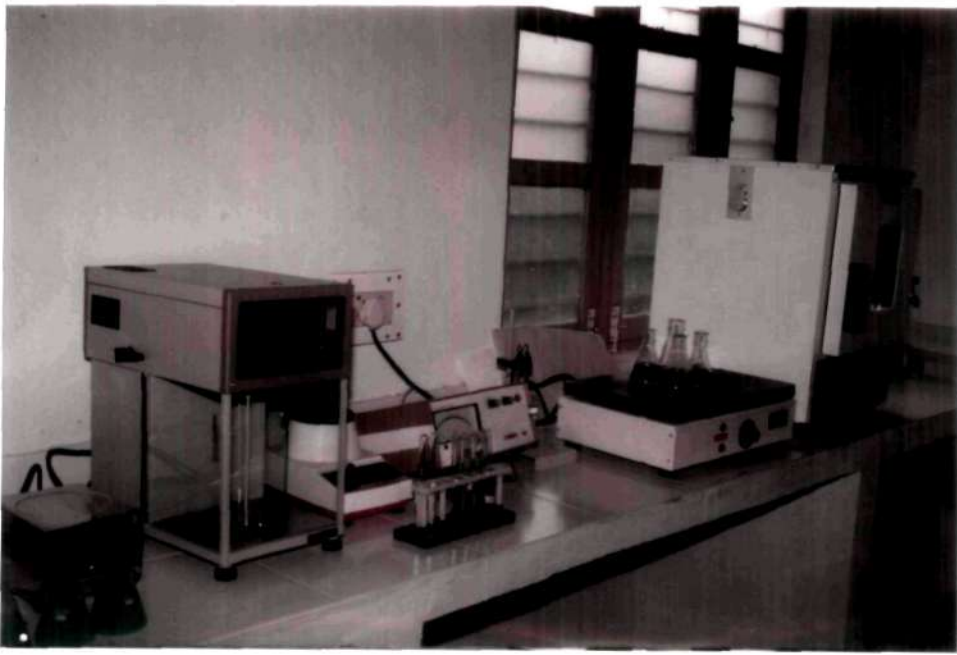


Plate 11: Extraction of dry leaf samples for tannins in groundnut leaf.

distilled water. Folin-Denis reagent, 5.0 mL, was added to the contents in the volumetric flask. Folin-Denis reagent was prepared by dissolving 100 g of sodium tungstate and 20 g phosphomolybdic acid in 750 mL distilled water in a suitable flask and 50 mL of phosphoric acid was added. The mixture was refluxed for 2 hours and the volume was made upto 1.0 L with distilled water and the reagent was protected from exposure to light. Then 10 mL of  $\text{Na}_2\text{CO}_3$  solution was added and diluted to 100 mL with distilled water. The  $\text{Na}_2\text{CO}_3$  solution was prepared by dissolving 350 g of  $\text{Na}_2\text{CO}_3$  in 1.0 L distilled water at 70-80°C and filtered and used after allowing it to stand overnight. The absorbance was read at 700 nm after 30 minutes. The blank was prepared by using water instead of the sample.

The standards were prepared by dissolving 100 mg tannic acid in 100 mL water. It was further diluted by taking 10 mL and making the volume upto 100 mL to prepare working standard solution. A series of concentrations i.e., 10 µg, 20 µg, 30 µg... 100 µg tannic acid  $\text{mL}^{-1}$  were prepared by taking 0.1, 0.2, 0.3, 1.0 mL of the working standard solution and the volume in all the test tubes was made up to 1.0 mL with distilled water. The colour was developed in all the test tubes as that of the sample and standard graph was prepared. From the standard graph, the amount of tannin in the samples was calculated and expressed in  $\text{mg g}^{-1}$  dry leaf.

### 3.3. STATISTICAL ANALYSIS

The data pertaining to insect pests and predators collected at weekly intervals in all the three seasons from 21 DAS to harvest of the crop was evaluated at three stages. The I stage evaluation was based on the single observation made at 21 DAS (3rd week). The II stage evaluation was done with the data recorded at weekly intervals from 28 DAS to 49 DAS (4, 5, 6 and 7 weeks). Similarly, III stage evaluation was done with the data recorded from 56 DAS to 77 DAS (8, 9, 10 and 11 weeks). The overall evaluation included all the weekly observations taken during the crop period. To reduce the variation, the data pertaining to pest and predator population was subjected to square root transformation  $(X+1)^{0.5}$ . Transformations were not done

for the data pertaining to biochemical constituents of leaves. The data thus obtained was analysed statistically duly consulting the statistical procedures of Snedecor and Cochran (1967). The data pertaining to biochemical constituents of leaves analysed at 21, 49 and 77 DAS synchronising with the three stages of pest and predator evaluation was also analysed

Simple correlations were calculated between biochemical constituents of leaves collected at three stages and the pests and predators collected during all the three seasons. The data of the three seasons was analysed statistically to know the influence of season on pests and natural enemies.

# *Results*

## RESULTS

The present studies pertaining to the influence of plant nutrition on the incidence of major insect pests of groundnut, *Arachis hypogaea* L. were carried out for three successive seasons from *rabi* 1994. The results showed that there was no significant influence of season on the two *rabi* crops studied i.e. *rabi* 1994-95 and *rabi* 1995-96. The results are presented in three sections. First section deals with the influence of treatments on the five insect pests viz. jassids, *Empoasca kerri* Pruthi; aphids, *Aphis craccivora* Koch; leaf miner, *Aproaerema modicella* Dev; tobacco caterpillar, *Spodoptera litura* Fab; and gram pod borer, *Helicoverpa armigera* Hub and three predators viz. coccinellid beetles, spiders and chrysopids. The second section highlights the influence of treatments on biochemical constituents of leaves and the last section deals with the relationship between the biochemical constituents of the plant and the population of pests and predators.

### 4.1. INFLUENCE OF TREATMENTS ON THE INCIDENCE OF INSECT PESTS AND THEIR PREDATORS ON GROUNDNUT

#### 4.1.1. Insect Pests

The data pertaining to five different insect pests under study were recorded from third week after sowing (WAS) of the crop till the incidence became insignificant. The results are presented at three stages of the crop growth in each season synchronizing with the biochemical analysis of leaves done at flowering (21 DAS) peg penetration (49 DAS) and the pod formation (77 DAS) stages of groundnut, seasonwise for the three seasons under study.

##### 4.1.1.1. Jassids, *E. kerri*

###### *Kharif, 1995*

The incidence of jassids was noticed from 3rd WAS and increased gradually upto 10th WAS (Appendix 1). The incidence started to decline from 11th WAS and by 14th WAS the

jassid population was negligible. However, during 4th week the jassid population disappeared due to heavy rain.

The results presented in Tab 6 pertaining to the average jassid population at the end of 3rd WAS indicated that NPK with seed treatment and FYM recorded the lowest jassid population (8.0/10 Plants) among all the treatments and were also on par with neem cake (9.33), NPK + neem cake (10.66), vermicompost (12.0) and FYM + vermicompost (13.33). The treatments, control (16), NPK with sunflower as a trap crop (18.66) and NPK with NPV (20.0), were on par and recorded comparatively higher jassid population among all the treatments

The treatments influenced significantly the jassid population during stage II (Tab 6; Fig. 2). Among all the treatments, neem cake recorded the lowest jassid population of 17.33 per 10 plants and was closely followed by FYM (17.66), NPK with seed treatment (19.99), NPK + neem cake (21.77), FYM + vermicompost (22.66), and vermicompost (23.55) all being on par with neem cake. Significantly higher population of jassids was recorded in NPK with sunflower (33.33), control (35.33) and NPK with NPV (36.88), being on par.

During the III stage (Tab. 6; Fig. 2), neem cake (82.66) and FYM + vermicompost (83.75) recorded lower jassid population per 10 plants among the treatments followed by FYM (90.75). The treatments, NPK + neem cake (96.66), vermicompost (104.08), NPK with seed treatment (106.33), NPK with sunflower (107.16) and NPK with NPV (115.75) recorded higher jassid population. Among the treatments, control (134.75) recorded the highest population

The overall influence of treatments (Tab 7 Fig. 2) on the incidence of jassids showed distinct variation. Neem cake and FYM recorded less than 40 jassids per 10 plants (35.66 and 39.0) and were on par, compared to other treatments. Among the other treatments FYM +

Tab. 6: Influence of treatments on jassid, *E. kerrii* population (nymphs / 10 plants) on groundnut at three stages of evaluation.

Treatments	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
T <sub>1</sub> NPK(Control) @40-60-40 Kg ha <sup>-1</sup>	16.00 <sup>abcd</sup> (4.10)	35.33 <sup>c</sup> (6.019)	134.75 <sup>c</sup> (11.643)	9.33 <sup>a</sup> (3.201)	21.16 <sup>c</sup> (4.696)	47.58 <sup>c</sup> (6.966)	7.00 <sup>d</sup> (2.817)	23.21 <sup>c</sup> (4.894)	58.08 <sup>d</sup> (7.681)
T <sub>2</sub> FYM @8t ha <sup>-1</sup>	8.0 <sup>a</sup> (2.947)	17.66 <sup>ab</sup> (4.316)	90.75 <sup>ab</sup> (9.578)	2.66 <sup>bc</sup> (1.824)	9.916 <sup>c</sup> (3.297)	21.37 <sup>c</sup> (4.698)	1.00 <sup>e</sup> (1.414)	11.16 <sup>c</sup> (3.481)	25.25 <sup>d</sup> (5.103)
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	12.00 <sup>abc</sup> (3.57)	23.55 <sup>b</sup> (4.938)	104.08 <sup>cd</sup> (10.239)	4.00 <sup>cd</sup> (2.236)	10.66 <sup>b</sup> (3.412)	21.73 <sup>c</sup> (4.748)	1.30 <sup>ab</sup> (1.52)	12.33 <sup>b</sup> (3.648)	27.16 <sup>d</sup> (5.298)
T <sub>4</sub> FYM @4t ha <sup>-1</sup> + Vermicompost @1.875t ha <sup>-1</sup>	13.33 <sup>abcd</sup> (3.77)	22.66 <sup>bc</sup> (4.860)	83.75 <sup>a</sup> (9.194)	4.0 <sup>cd</sup> (2.236)	11.33 <sup>b</sup> (3.50)	24.24 <sup>c</sup> (5.00)	2.00 <sup>abc</sup> (1.715)	12.83 <sup>b</sup> (3.705)	28.91 <sup>ab</sup> (5.441)
T <sub>5</sub> Neem cake @770 kg ha <sup>-1</sup>	9.33 <sup>ab</sup> (3.12)	17.33 <sup>a</sup> (4.231)	82.66 <sup>c</sup> (9.138)	0.00 <sup>a</sup> (1.0)	5.33 <sup>a</sup> (2.495)	22.11 <sup>c</sup> (4.801)	2.30 <sup>b</sup> (1.794)	6.916 <sup>c</sup> (2.795)	22.5 <sup>a</sup> (4.833)
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + Neem Cake @385 Kg ha <sup>-1</sup>	10.66 <sup>ab</sup> (3.77)	21.77 <sup>ab</sup> (4.77)	96.66 <sup>bc</sup> (9.868)	2.66 <sup>bc</sup> (1.824)	13.08 <sup>b</sup> (3.746)	30.63 <sup>c</sup> (5.622)	2.60 <sup>b</sup> (1.910)	15.08 <sup>b</sup> (3.996)	35.41 <sup>c</sup> (6.028)
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> NPV @250LE ha <sup>-1</sup>	20.00 <sup>b</sup> (4.56)	36.88 <sup>b</sup> (6.138)	115.75 <sup>b</sup> (10.803)	8.00 <sup>bc</sup> (3.0)	20.83 <sup>c</sup> (4.659)	45.23 <sup>c</sup> (6.79)	7.00 <sup>d</sup> (2.824)	23.08 <sup>c</sup> (4.899)	54.08 <sup>d</sup> (7.413)
T <sub>8</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with sunflower	18.66 <sup>cd</sup> (4.287)	33.33 <sup>b</sup> (5.849)	107.16 <sup>cd</sup> (10.388)	9.33 <sup>c</sup> (3.201)	17.33 <sup>c</sup> (4.28)	32.22 <sup>c</sup> (5.342)	7.60 <sup>d</sup> (2.935)	25.75 <sup>c</sup> (4.970)	57.66 <sup>d</sup> (7.652)
T <sub>9</sub> NPK @40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g kg <sup>-1</sup> seed	8.00 <sup>a</sup> (3.0)	19.99 <sup>ab</sup> (4.532)	106.33 <sup>cd</sup> (10.356)	1.33 <sup>ab</sup> (1.412)	5.33 <sup>a</sup> (2.513)	32.26 <sup>c</sup> (5.738)	3.00 <sup>e</sup> (1.989)	7.166 <sup>c</sup> (2.852)	37.16 <sup>c</sup> (6.173)
F test (P=0.05)	*	*	*	*	*	NS	*	*	*
SEM	0.496	0.328	0.301	0.384	0.2486	0.821	0.159	0.256	0.328
CD	1.052	0.696	0.639	0.814	0.52711	---	0.337	0.543	0.696

Means followed by same letters are not significantly different (P=0.05) by DMRT  
Values in parentheses are (X+1)<sup>0.5</sup> transformed values

\* - Significant at 5% level  
NS - Non-significant

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**Tab. 7: Overall influence of treatments on jassid, *E. kerri* population (nymphs / 10 plants) on groundnut.**

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	61.84 <sup>f</sup>	24.85 <sup>f</sup>	29.87 <sup>f</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	39.90 <sup>d</sup>	11.70 <sup>ab</sup>	14.27 <sup>f</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	46.45 <sup>e</sup>	12.18 <sup>ab</sup>	15.22 <sup>bc</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	41.87 <sup>e</sup>	13.30 <sup>abc</sup>	16.13 <sup>f</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	35.66 <sup>d</sup>	10.34 <sup>a</sup>	11.66 <sup>d</sup>
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	42.84 <sup>bc</sup>	16.07	18.99 <sup>e</sup>
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> NPV @ 250 LE ha <sup>-1</sup>	56.11 <sup>c</sup>	23.96 <sup>d</sup>	28.69 <sup>f</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	50.84 <sup>c</sup>	24.03 <sup>d</sup>	30.27 <sup>f</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	45.72	14.72 <sup>b</sup>	16.80 <sup>b</sup>
F Test (P=0.05)	*	*	*
SEm	2.379	1.472	1.926
CD	5.045	3.122	4.085

Means followed by same letters are not significantly different (P=0.05) by DMRT.

NS - Non-significant

\* - Significant at 5% level

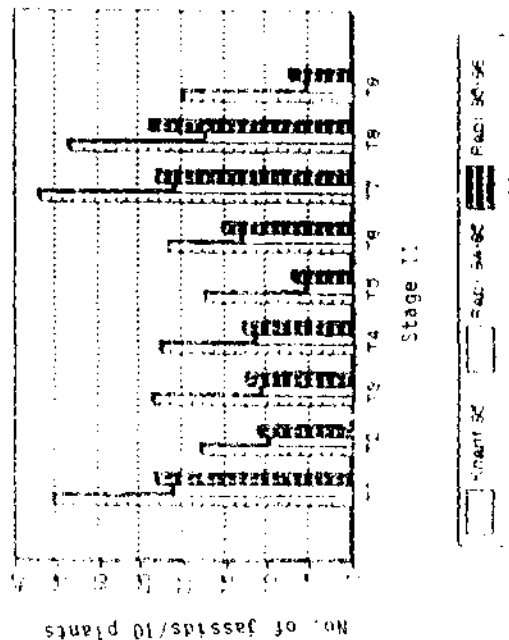
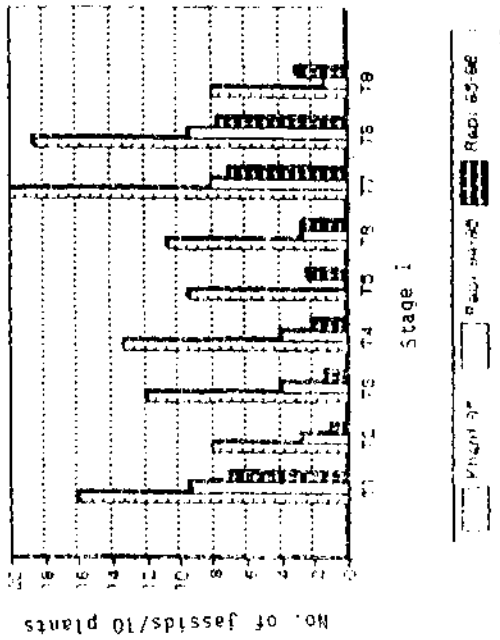
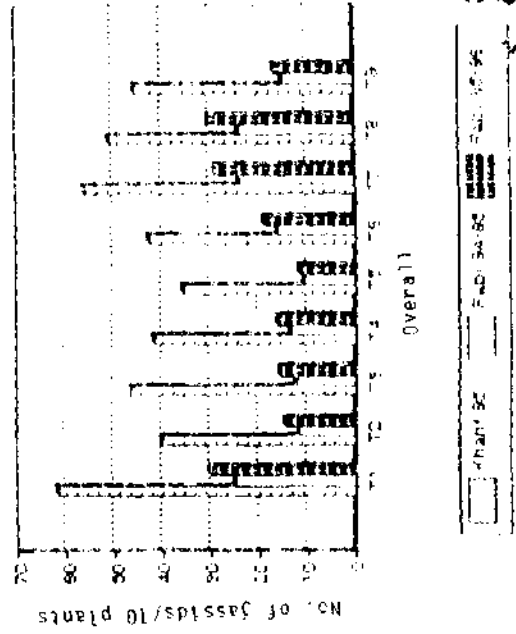
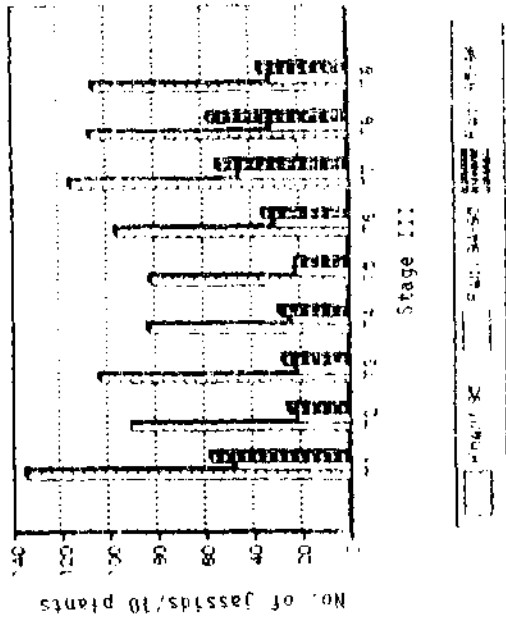


Figure 2. Influence of treatments on the incidence of jassid, E. kerri on groundnut.

vermicompost (41.87), NPK and neem cake (42.84), NPK with sunflower (50.84) recorded moderate levels of jassid population, ranging between 41.87 and 50.84 and were significantly superior to NPK with NPV (56.11). Among the treatments control (61.84) recorded the highest jassid population and was found to be significantly inferior to all the treatments, in checking the build up of jassids.

#### **Rabi, 1994-95**

During *rabi* 94-95 the incidence of jassids started from 3rd WAS and increased upto 9th WAS and declined gradually later (Appendix 1). The data furnished in Tab. 6 revealed that neem cake recorded no population during stage I. However, the next treatment NPK with seed treatment recorded 1.33 jassids/10 plants which was also on par with neem cake. The treatments that followed were FYM and NPK + neem cake (2.66/10 plants each), vermicompost and FYM + vermicompost (4.0/10 plants, each) with low population of jassids. The other treatments viz. NPK with NPV (8.0), NPK with sunflower (9.0) and control (9.0) also recorded low jassid population of less than 10 per 10 plants.

During stage II (Tab. 6; Fig. 2) there was significant difference in jassid population among the treatments. Significantly lower population was observed in neem cake and NPK with seed treatment (5.33 / 10 plants each). The treatments that followed were FYM (9.91), vermicompost (10.66), FYM + vermicompost (11.33), NPK + neem cake (13.08) which also recorded lower populations of jassids and all were on par with each other. Among the treatments higher population was observed in NPK with sunflower (17.33), NPK with NPV (20.83) and control (21.16).

Third stage (Tab. 6; Fig. 2) evaluation of jassid population did not show significant difference among the treatments. However, the lowest population was recorded in FYM (21.37)

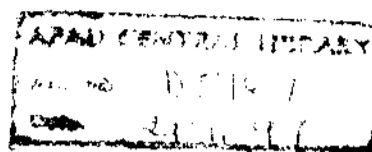
followed by vermicompost (21.73), neem cake (22.11), FYM + vermicompost (24.24), NPK with sunflower (32.22), NPK + neem cake (30.63), NPK with seed treatment (32.26) and NPK with NPV (45.23). The highest population being observed in control with an average jassid population of 47.58 per 10 plants.

The overall influence of treatments on jassid population during *rabi* 94-95 presented in Tab. 7 and Fig. 2 indicated that neem cake recorded the lowest mean jassid population (10.34) followed by FYM (11.7), vermicompost (12.18), and FYM + vermicompost (13.3) which were also on par with neem cake. NPK with seed treatment (14.72) and NPK + neem cake (16.07) recorded higher population but were also on par with FYM + vermicompost. Among the treatments significantly higher population of jassids was recorded in NPK with NPV (23.96), NPK with sunflower (24.03) and control (24.85).

#### **Rabi, 1995-96**

During *rabi* 95-96, the incidence of jassids started from 3rd WAS, increased gradually till 9th WAS and declined thereafter (Appendix 1). The results presented in Tab. 6 indicated that among all the treatments, during stage I, FYM recorded the lowest mean jassid population (1.0 jassid/10 plants) but it was on par with vermicompost (1.3) and FYM + vermicompost (2.0). The other treatments that followed were neem cake, NPK + neem cake, NPK with seed treatment, with a mean jassid population ranging between 2.3 and 3.0/10 plants. Significantly higher jassid population was noticed in control, NPK with NPV and NPK with sunflower (7.0, 7.0 and 7.6 per 10 plants, respectively).

During II stage evaluation (Tab. 6; Fig. 2) there was significant difference in jassid population among the treatments, with the mean population ranging between 6.91 to 23.75 per 10 plants. Among the treatments, neem cake (6.91) and NPK with seed treatment (7.16)



recorded significantly lower jassid population FYM(11.16), vermicompost (12.33), FYM + vermicompost (12.83), NPK + neem cake (15.08) recorded moderate population of jassids among the treatments and were on par with each other. Significantly higher population of jassids was noticed in control (23.21), NPK with NPV (23.08) and NPK with sunflower (23.75).

Third stage evaluation of jassid population (Tab 6; Fig. 2) indicated lowest population in neem cake (22.5 per 10 plants) followed by FYM (25.25), vermicompost (27.16), FYM + vermicompost (28.91) all being on par NPK + neem cake (35.41), NPK with seed treatment (37.16) recorded moderate jassid population. Among the treatments significantly higher jassid population was noticed in NPK with NPV (54.08), NPK with sunflower (57.66) and control (58.08).

The data furnished in Tab. 7 and Fig. 2 showing the overall influence of treatments on jassid population indicated that all the organically manured treatments, NPK with seed treatment and NPK + neem cake were superior in recording low levels of jassid population than the straight fertilized plots. Lower mean jassid population was recorded in neem cake (11.66/10 plants) which was closely followed by FYM (14.27) and vermicompost (15.22) being on par. However, moderate levels were observed in FYM + vermicompost (16.13), NPK with seed treatment(16.80) and NPK + neem cake (18.99) with mean jassid population ranging between 16.33 and 18.99 per 10 plants. NPK with NPV(28.69), control (29.87) and NPK with sunflower (30.27) were on par and recorded significantly higher jassid population among the treatments.

#### 4.1.1.2. Aphids, *A. craccivora*

The incidence of aphids was observed from 3rd WAS with gradual increase upto 8th WAS and declined from 9th WAS. From 15th WAS to harvest, aphid infestation was not observed during all the three seasons (Appendix 2).

**Kharif, 1995**

The data pertaining to mean aphid population during *kharif* 1995, at the three stages of crop growth are presented in Tab. 8 & Fig. 3. The results revealed that, there was significant difference among the treatments in affecting aphid population. During stage I, significantly lower population of aphids was observed in NPK with seed treatment (13.2 per 10 plants), FYM (14.0), neem cake (14.0), FYM + vermicompost (14.6) and vermicompost (16.0), all being on par. NPK + neem cake recorded moderate population with a mean of 33.2 aphids per 10 plants. NPK with sunflower (46.6), control (46.6) and NPK with NPV (48.0) were on par and recorded significantly higher population than the other treatments with a mean jassid population ranging from 46.6 to 48.0 per 10 plants.

The treatments showed significant differences in aphid population during II stage also. Significantly lower population of aphids was observed in NPK with seed treatment (26.88 per 10 plants), FYM (27.76), neem cake (29.32), FYM + vermicompost (29.98) and vermicompost (30.88) being on par. Moderate population of aphids was observed in NPK + neem cake (43.1). NPK with NPV (57.32), NPK with sunflower (60.20) and control (62.44) recorded significantly higher population of aphids among the treatments.

During III stage evaluation (Tab. 8; Fig. 3), neem cake recorded the lowest aphid population (47.0 per 10 plants) followed by FYM (48.32), FYM + vermicompost (49.0) and vermicompost (52.66) all being on par. NPK + neem cake came next with mean aphid population of 55.66 per 10 plants but was on par with the last three among the preceding treatments. Higher population of aphids was noticed in NPK with sunflower (67.5), NPK with seed treatment (69.82), control (76.0) and the highest in NPK with NPV (76.32).

Tab. 8: Influence of treatments on aphid, *A. craccivora* population (Adults / 10 plants) on groundnut.

Treatments	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
T <sub>1</sub> NPK(Control) @40-60-40Kg ha <sup>-1</sup>	46.60 <sup>a</sup> (6.899)	62.44 <sup>c</sup> (7.962)	76.00 <sup>cd</sup> (8.775)	71.32 <sup>b</sup> (8.504)	132.10 <sup>e</sup> (11.50)	120.30 <sup>d</sup> (11.01)	116.00 <sup>b</sup> (10.81)	141.50 <sup>e</sup> (11.93)	78.62 (8.923)
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	14.00 <sup>a</sup> (3.873)	27.66 <sup>b</sup> (5.353)	48.32 <sup>ab</sup> (6.95)	28.00 <sup>ab</sup> (5.385)	46.16 <sup>a</sup> (6.867)	97.56 <sup>bc</sup> (9.927)	28.00 <sup>a</sup> (5.385)	84.66 <sup>c</sup> (9.255)	58.68 (7.725)
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	16.00 <sup>a</sup> (4.123)	30.88 <sup>a</sup> (5.646)	52.66 <sup>ab</sup> (7.225)	32.66 <sup>b</sup> (5.801)	48.00 <sup>a</sup> (7.00)	84.74 <sup>ab</sup> (9.259)	32.60 <sup>ab</sup> (5.796)	83.66 <sup>c</sup> (9.201)	60.96 (7.814)
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @1.875t ha <sup>-1</sup>	14.60 <sup>a</sup> (3.949)	29.98 <sup>a</sup> (5.566)	49.00 <sup>ab</sup> (7.07)	31.32 <sup>b</sup> (5.685)	48.50 <sup>a</sup> (7.035)	88.40 <sup>ab</sup> (9.455)	26.60 <sup>a</sup> (5.253)	86.00 <sup>c</sup> (9.327)	58.56 (7.717)
T <sub>5</sub> Neem cake @770 Kg ha <sup>-1</sup>	14.00 <sup>a</sup> (3.873)	29.32 <sup>a</sup> (5.506)	47.00 <sup>a</sup> (6.928)	20.66 <sup>a</sup> (4.654)	59.66 <sup>b</sup> (6.376)	79.80 <sup>b</sup> (8.988)	52.00 <sup>a</sup> (7.28)	90.50 <sup>c</sup> (9.565)	65.74 (8.169)
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + Neem Cake @385 Kg ha <sup>-1</sup>	33.20 <sup>b</sup> (5.848)	43.10 <sup>b</sup> (6.640)	55.00 <sup>b</sup> (7.527)	34.66 <sup>b</sup> (5.971)	71.50 <sup>b</sup> (8.514)	100.82 <sup>c</sup> (10.09)	60.00 <sup>b</sup> (8.185)	94.66 <sup>c</sup> (9.78)	67.58 (8.287)
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> NPV @250LE ha <sup>-1</sup>	48.00 <sup>b</sup> (7.00)	57.32 <sup>b</sup> (7.636)	76.32 <sup>b</sup> (8.793)	66.00 <sup>b</sup> (8.185)	109.32 <sup>d</sup> (10.503)	134.36 <sup>e</sup> (11.63)	104.00 <sup>b</sup> (10.246)	152.66 <sup>e</sup> (11.561)	76.74 (8.817)
T <sub>8</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with sunflower	46.60 <sup>b</sup> (6.899)	60.20 <sup>b</sup> (7.823)	67.50 <sup>b</sup> (8.276)	72.66 <sup>b</sup> (8.582)	117.50 <sup>c</sup> (10.88)	140.80 <sup>d</sup> (11.889)	98.60 <sup>b</sup> (9.979)	130.82 <sup>d</sup> (11.48)	73.36 (8.623)
T <sub>9</sub> NPK @40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	13.20 <sup>a</sup> (3.768)	26.88 <sup>a</sup> (5.280)	69.82 <sup>cd</sup> (8.415)	22.00 <sup>a</sup> (4.795)	43.00 <sup>a</sup> (6.782)	98.58 <sup>b</sup> (9.978)	48.00 <sup>bc</sup> (7.00)	83.32 <sup>c</sup> (9.182)	72.58 (8.577)
F test (0.05)	*	*	*	*	*	*	*	*	*
SEM	0.34	0.3128	0.3396	0.488	0.564	0.576	0.822	0.502	0.602
CD	0.76	0.6634	0.72	1.036	1.196	1.224	1.746	1.066	0.602

Means followed by same letters are not significantly different (P=0.05) by DMR<sup>2</sup>. Values in parentheses are (X-1)<sup>1/2</sup> transformed values. NS - Non-significant. \* - Significant at 5% level.

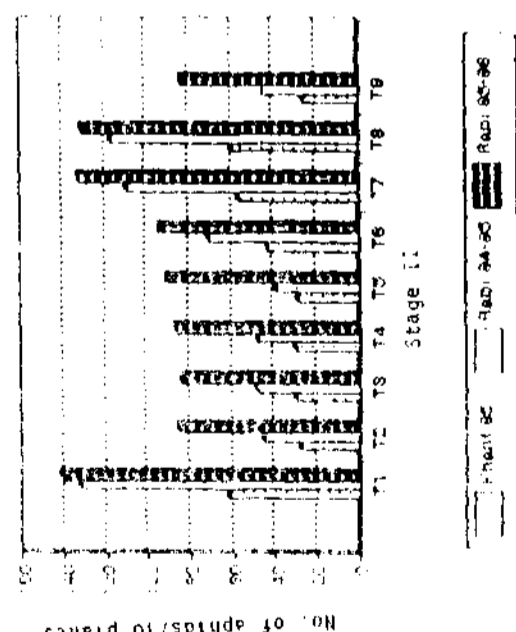
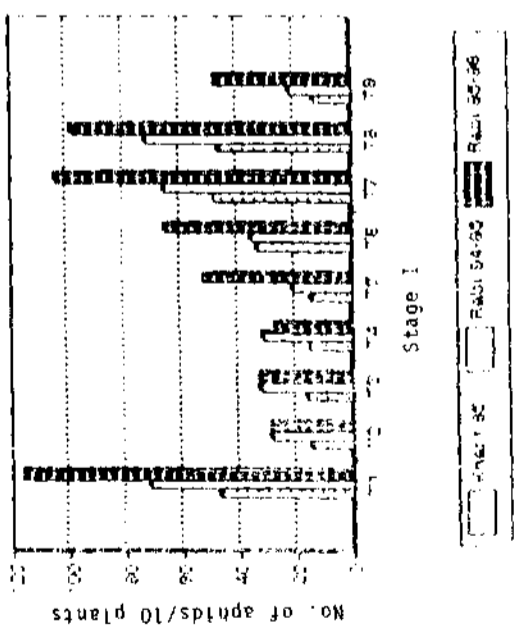
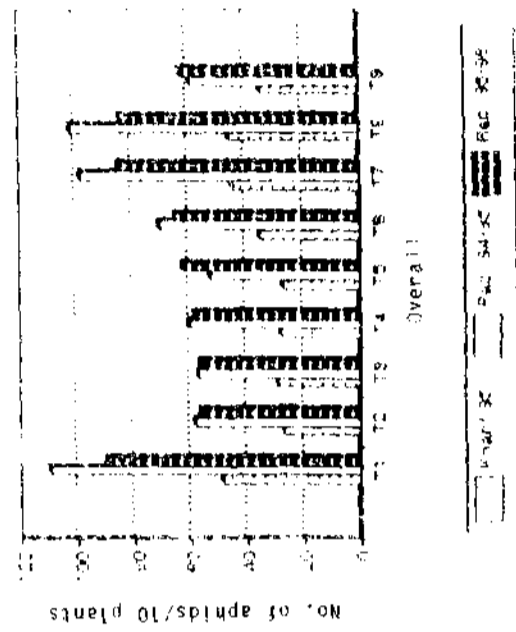
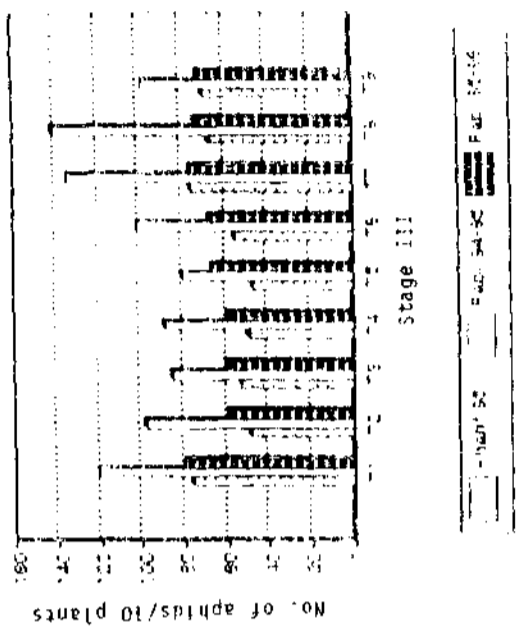


Figure 3. Influence of treatments on the incidence of aphid, A. craccivora on groundnut.

The overall influence of treatments on the mean population of aphids depicted in Tab. 9 & fig 3 revealed that once again all the treatments that received organic manures and the treatment NPK with seed treatment were effective in recording significantly lower population than the treatments which received NPK through straight fertilizers. The lowest population of aphids was recorded in neem cake (26.34) which was closely followed by FYM (26.40). FYM + vermicompost (27.16), vermicompost (29.02) all being on par and significantly superior to the other treatments. The treatments that recorded moderate levels of aphid incidence were NPK with seed treatment (33.92) and NPK + neem cake (35.02). Among the treatments NPK with NPV (45.14) and NPK with sunflower (45.5) recorded higher population but were superior to control which recorded the highest population (48.9 per 10 plants)

#### **Rabi, 1994-95**

The results pertaining to the influence of treatments on aphid population during stage I (Tab. 8; Fig. 3) indicated that neem cake (20.66), NPK with seed treatment (22.0) and FYM(28.0) were on par and recorded lower aphid population among the treatments. FYM + vermicompost (31.32), vermicompost (32.66) and NPK + neem cake (34.66) recorded moderate population of aphids ranging between 31.32 and 34.66 per 10 plants and were on par with FYM. Significantly higher population of aphids among the treatments was observed in NPK with NPV (66.0), control (71.32) and NPK with sunflower (72.66) being on par.

During II stage evaluation, significant difference among the treatments was observed (Tab. 8; Fig.3). The lowest aphid population was recorded in neem cake (39.66) and was followed by NPK with seed treatment (45.0), FYM (46.16), vermicompost (48.0), FYM + vermicompost (48.5) all being on par with each other. Moderate population of aphids was observed in NPK + neem cake (71.5). Significantly higher population of aphids was seen in NPK

Tab. 9: Overall influence of treatments on aphid, *A. craccivora* population (adults /10 plants) on groundnut.

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	48.90 <sup>d</sup>	109.54 <sup>d</sup>	89.92 <sup>d</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	26.40 <sup>a</sup>	58.22 <sup>a</sup>	55.98 <sup>a</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	29.02 <sup>a</sup>	56.96 <sup>ab</sup>	55.90 <sup>a</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	27.26 <sup>a</sup>	60.06 <sup>a</sup>	57.90 <sup>ab</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	26.34 <sup>a</sup>	52.98 <sup>a</sup>	61.80 <sup>ab</sup>
T <sub>6</sub> NPK @ 20-30-20 Kg ha <sup>-1</sup> + Neem cake @ 385 Kg ha <sup>-1</sup>	35.02 <sup>b</sup>	70.40 <sup>b</sup>	65.22 <sup>b</sup>
T <sub>7</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and NPV @ 250 LE ha <sup>-1</sup>	45.14 <sup>c</sup>	98.34 <sup>c</sup>	85.22 <sup>d</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	45.50 <sup>c</sup>	102.54 <sup>cd</sup>	83.50 <sup>d</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	33.92 <sup>b</sup>	59.08 <sup>a</sup>	63.14 <sup>b</sup>
F Test (P=0.05)	*	*	*
SEm	1.55	4.236	3.27
CD	3.278	8.984	6.936

Means followed by same letters are not significantly different (P=0.05) by DMRT.

NS - Non-significant

\* - Significant at 5% level

with NPV (109.32), NPK with sunflower (117.5) and control (132.1) which showed their inferiority over all the other treatments in checking the buildup of aphid population.

During III stage evaluation (Tab. 8; Fig. 3), the lowest aphid population was observed in neem cake treatment (79.8 per 10 plants). The treatments that followed were vermicompost (84.74), FYM + vermicompost (88.40) and FYM (89.56), all being on par with neem cake. Moderate level of population, however, was recorded in NPK with seed treatment (98.58) and NPK + neem cake (100.92) which were on par with the preceding three treatments. Higher population of aphids was noticed in control (120.30), NPK with NPV (134.36) and the highest in NPK with sunflower (140.80).

The overall influence of treatments (Tab. 9; Fig. 3) during *rabi* 1994-95 on aphid population indicated that, the treatments which received organic manures and NPK with seed treatment showed superiority in recording significantly lower population of aphids than the straight fertilized treatments. The lowest population of aphids was observed in neem cake (52.98) but it was on par with vermicompost (56.96), FYM (58.22), NPK with seed treatment (59.08) and FYM + vermicompost (60.06). The next treatment that recorded moderate population was NPK + neem cake with a mean population of 70.4 aphids / 10 plants. Significantly higher population of aphids was observed in NPK with NPV (98.34), NPK with sunflower (102.52) and the highest population was noticed in control (109.54).

#### **Rabi, 1995-96**

The data presented in Tab. 8 & Fig. 3 revealed that during I stage evaluation, FYM + vermicompost recorded the lowest aphid population (26.6 per 10 plants) among the treatments but was on par with FYM (28.0) and vermicompost (32.6). The treatments that followed were NPK with seed treatment (48.0), neem cake (52.0) and NPK + neem cake (66.0). Among the

treatments, significantly higher population of aphids was observed in NPK with sunflower (98.6), NPK with NPV (104.0) and control (116.0), all the three being on par with each other.

Second stage evaluation of aphid population (Tab. 8; Fig. 3) revealed that all the treatments which received organic manures and NPK with seed treatment showed their superiority in recording lower population of aphids with the mean ranging between 83.32 and 94.66, than the straight fertilized treatments, with the mean population ranging between 130.82 and 141.5 per 10 plants. Among the treatments, significantly lower population of aphids was observed in NPK with seed treatment (83.32), vermicompost (83.66), FYM (84.66), FYM + vermicompost (86), neem cake (90.50) and NPK + neem cake (94.66) all being on par with each other. NPK with sunflower (130.82), NPK with NPV (132.66) and control (141.5) recorded higher population of aphids, among the treatments.

The treatments did not influence much, the aphid population during III stage (Tab. 8; Fig. 3). However, among the treatments the lowest population of aphids was observed in FYM + vermicompost (58.56 per 10 plants) which was closely followed by FYM, vermicompost, neem cake, NPK + neem cake, NPK with seed treatment, NPK with sunflower and NPK with NPV with a mean population ranging between 58.68 and 76.74 per 10 plants. The highest population of aphids was observed in control (78.62).

The overall influence of treatments (Tab. 9, Fig. 3) on the aphid population during *rabi* 1995-96 indicated that the population of aphids was the lowest in vermicompost (55.84 per 10 plants) which, however, was on par with FYM (55.98), FYM + vermicompost (57.84) and neem cake (61.8). The treatments that showed moderate infestation were NPK with seed treatment (63.14) and NPK + neem cake (65.22). Among the treatments, significantly higher population of aphids was noticed in NPK with sunflower (83.5), NPK with NPV (85.22) and control (89.92) being on par with each other.

#### 4.1.1.3. Leaf miner, *A. modicella*

##### *Kharif, 1995*

The data pertaining to the leaf miner population (Appendix 3) indicated that the incidence was noticed from 3rd WAS and increased gradually upto 7th WAS and declined during the later weeks. No incidence was observed after 11th WAS.

The data regarding the leaf miner population during 1st stage presented in Tab 10 & Fig. 4 revealed that lowest population was recorded in NPK with seed treatment (8.6 per 10 plants) but was on par with FYM(9.2), neem cake (10.0), FYM + vermicompost (10.6), vermicompost (12.0) and NPK + neem cake (17.2). The treatments that followed were NPK with NPV (23.2), NPK with sunflower (23.2) and control (24.0) but were on par with preceding treatments.

During II stage evaluation (Tab. 10; Fig. 4), the organically manured treatments showed their superiority over straight fertilized treatments in recording lower leaf miner population. NPK with seed treatment recorded the lowest (12.44 per 10 plants) population followed by FYM (12.88), neem cake (14.66), FYM + vermicompost (15.32) and vermicompost (16.66), being on par. Significantly high population, however, was observed in NPK + neem cake (24.88), NPK with NPV (29.98), NPK with sunflower (34.22) and control (35.1).

During III stage (Tab 10; Fig. 4), lower levels of leaf miner population was observed in neem cake (15.32) followed by FYM (15.82), FYM + vermicompost (16.0), and vermicompost (17.0), being on par. NPK + neem cake (20.16) recorded moderate population. Significantly higher population was noticed in NPK with NPV (24.0), NPK with sunflower (24.16), control (25.5) and the highest being recorded in NPK with seed treatment(27.82).

Tab. 10: Influence of treatments on leaf miner, *A. modicella* population (larvae /10 plants) on groundnut.

Treatment	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
T <sub>1</sub> : NPK(Control) @40-60-40 Kg ha <sup>-1</sup>	24.00 <sup>a</sup> (5.00)	35.10 <sup>a</sup> (6.008)	25.50 <sup>ab</sup> (5.157)	12.00 <sup>a</sup> (3.605)	18.16 <sup>a</sup> (4.377)	37.50 <sup>a</sup> (6.204)	14.66 <sup>a</sup> (3.957)	41.50 <sup>a</sup> (6.519)	37.82 <sup>a</sup> (6.230)
T <sub>2</sub> : FYM @8t ha <sup>-1</sup>	9.20 <sup>b</sup> (3.193)	12.88 <sup>a</sup> (3.725)	15.83 <sup>a</sup> (4.102)	2.66 <sup>bc</sup> (1.913)	5.66 <sup>b</sup> (2.580)	17.46 <sup>a</sup> (4.296)	6.66 <sup>a</sup> (2.767)	17.00 <sup>a</sup> (4.242)	22.82 <sup>abc</sup> (4.88)
T <sub>3</sub> : Vermicompost @3.75t ha <sup>-1</sup>	12.00 <sup>b</sup> (3.605)	16.66 <sup>a</sup> (4.202)	17.00 <sup>ab</sup> (4.242)	2.66 <sup>bc</sup> (1.913)	6.50 <sup>b</sup> (2.738)	18.50 <sup>a</sup> (4.415)	6.00 <sup>a</sup> (2.645)	18.83 <sup>ab</sup> (4.464)	22.66 <sup>abc</sup> (4.864)
T <sub>4</sub> : FYM @4t ha <sup>-1</sup> + Vermicompost @1.875t ha <sup>-1</sup>	10.66 <sup>b</sup> (3.414)	15.32 <sup>a</sup> (4.059)	16.00 <sup>a</sup> (4.123)	4.00 <sup>bc</sup> (2.236)	7.16 <sup>b</sup> (2.856)	19.83 <sup>a</sup> (4.563)	7.20 <sup>a</sup> (2.865)	20.16 <sup>ab</sup> (4.60)	22.82 <sup>abc</sup> (4.88)
T <sub>5</sub> : Neem cake @770 Kg ha <sup>-1</sup>	10.00 <sup>b</sup> (3.316)	14.00 <sup>a</sup> (3.957)	15.32 <sup>a</sup> (4.039)	1.32 <sup>cd</sup> (1.523)	3.83 <sup>b</sup> (2.197)	20.50 <sup>ab</sup> (4.636)	6.40 <sup>a</sup> (2.72)	21.00 <sup>a</sup> (4.69)	19.31 <sup>a</sup> (4.506)
T <sub>6</sub> : NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @385 Kg ha <sup>-1</sup>	17.20 <sup>ab</sup> (4.266)	24.88 <sup>a</sup> (5.087)	20.16 <sup>a</sup> (4.60)	5.32 <sup>b</sup> (2.514)	9.50 <sup>a</sup> (3.240)	27.50 <sup>a</sup> (5.338)	8.00 <sup>a</sup> (3.00)	26.60 <sup>a</sup> (5.255)	27.24 <sup>a</sup> (5.314)
T <sub>7</sub> : NPK @40-60-40 Kg ha <sup>-1</sup> NPV @ 250LE ha <sup>-1</sup>	23.20 <sup>a</sup> (4.919)	29.98 <sup>bc</sup> (5.566)	24.00 <sup>a</sup> (5.00)	13.32 <sup>a</sup> (3.784)	16.50 <sup>a</sup> (4.183)	34.82 <sup>a</sup> (5.985)	14.60 <sup>a</sup> (3.949)	34.66 <sup>a</sup> (5.971)	36.10 <sup>a</sup> (6.093)
T <sub>8</sub> : NPK @40-60-40 Kg ha <sup>-1</sup> with sunflower	23.20 <sup>a</sup> (4.919)	34.22 <sup>a</sup> (5.934)	24.16 <sup>ab</sup> (5.016)	12.00 <sup>a</sup> (3.605)	18.83 <sup>a</sup> (4.646)	37.52 <sup>a</sup> (6.206)	14.00 <sup>a</sup> (3.873)	37.16 <sup>ab</sup> (6.177)	34.46 <sup>a</sup> (5.954)
T <sub>9</sub> : NPK @40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @250g Kg <sup>-1</sup> seed	8.6 <sup>b</sup> (3.098)	12.44 <sup>a</sup> (3.666)	27.83 <sup>a</sup> (5.369)	00.00 <sup>cd</sup> (1.00)	5.83 <sup>b</sup> (2.613)	24.80 <sup>bc</sup> (5.079)	4.60 <sup>a</sup> (2.366)	18.83 <sup>ab</sup> (4.453)	24.66 <sup>b</sup> (5.065)
F test (P=0.05)	*	*	*	*	*	*	*	*	*
SEM	0.554	0.4342	0.2424	0.490	0.192	0.302	0.476	0.264	0.358
CD	1.178	0.9206	0.514	1.038	0.408	0.642	1.008	0.558	0.760

Means followed by same letters are not significantly different (P=0.05) by DMRT.

NS - Non-significant

Values in parentheses are (X+1)<sup>0.5</sup> transformed values  
\* - Significant at 5% level

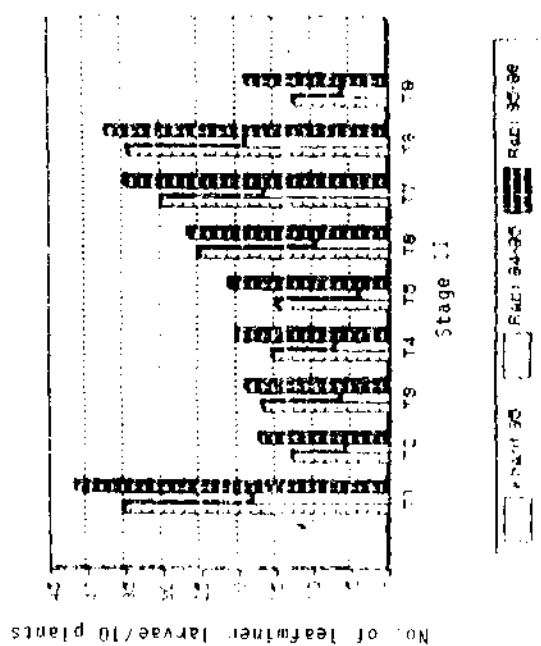
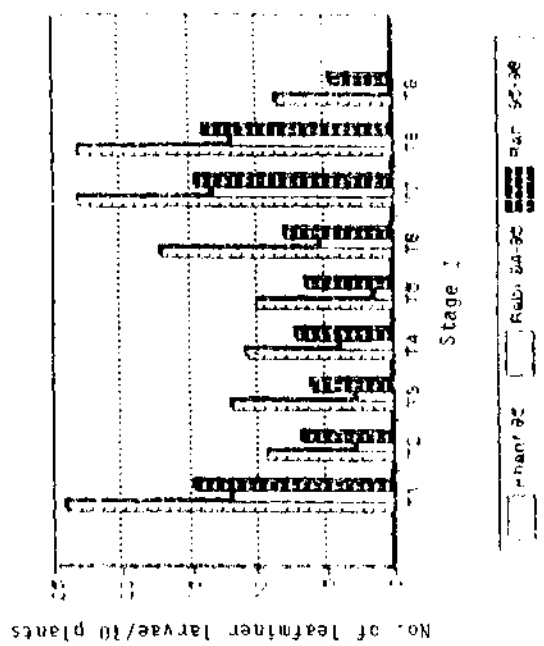
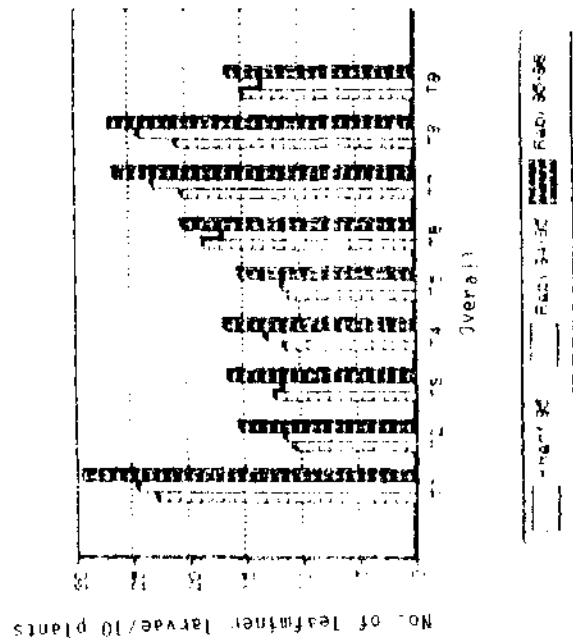
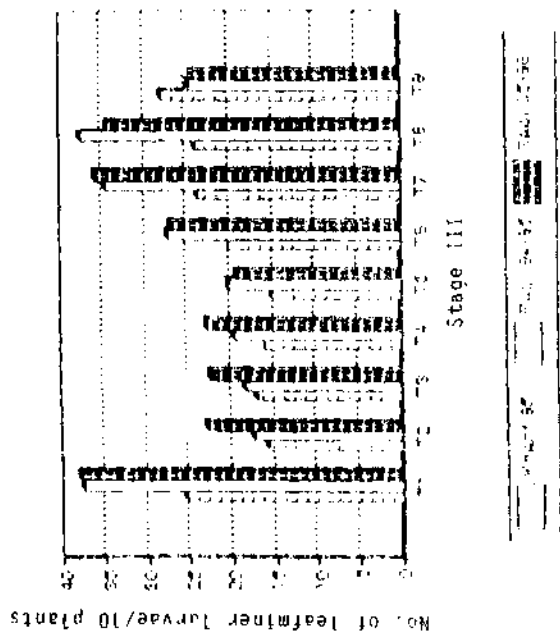


Figure 4. Influence of treatments on the incidence of leaf miner, *A. modicella* on groundnut.

The overall influence of treatments during *kharif*, 1995 (Tab. 11; Fig. 4) indicated that the treatments which received organic manures and NPK with seed treatment were superior over straight fertilized treatments by recording lower number of leaf miner larvae. The lowest leaf miner population was recorded in FYM (10.66) but it was on par with neem cake (11.02), FYM + vermicompost (11.38) and vermicompost (12.42). The next best treatment was NPK with seed treatment (14.96) and it was superior to the remaining treatments. The treatments NPK + neem cake (18.6), NPK with NPV (20.6), NPK with sunflower (21.02) were on par and recorded significantly higher population of leaf miners. Among the treatments control recorded the highest population (22.84) but it was on par with the last two of the preceding treatments.

#### **Rabi, 1994-95**

The data pertaining to leaf miner population trend during 1994-95 indicated that the pest incidence was noticed upto 14th WAS with peak population during 11th WAS (Appendix 3)

The population of leaf miners increased from stage I to stage III (Tab. 10; Fig. 4). NPK with seed treatment showed zero population during stage I. The treatments with very low level of population were neem cake (1.32 per 10 plants), FYM (2.66), vermicompost (2.66) and FYM + vermicompost (4.0) which were on par. The population of leaf miners was 5.32 per 10 plants in NPK + neem cake which was also on par with its preceding three treatments. All the treatments that received straight fertilizers (except NPK with seed treatment) viz. control (12.0), NPK with sunflower (12.0) and NPK with NPV (13.32) were on par and recorded significantly higher population of leaf miners among the treatments.

During second stage (Tab. 10; Fig. 4), neem cake recorded significantly lowest population of leaf miners (3.83 per 10 plants). The treatments that followed were FYM (5.66), NPK with seed treatment (5.83), vermicompost (6.5) and FYM + vermicompost (7.16) being on

**Tab. 11: Overall influence of treatments on leaf miner, *A. modicella* population (larvae /10 plants) on groundnut.**

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	21.84 <sup>1</sup>	24.60 <sup>c</sup>	29.48 <sup>f</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	10.66 <sup>f</sup>	11.48 <sup>f</sup>	15.48 <sup>f</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	12.42 <sup>g</sup>	11.76 <sup>f</sup>	16.10 <sup>f</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	11.18 <sup>h</sup>	13.22 <sup>f</sup>	16.72 <sup>f</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	11.92 <sup>g</sup>	11.76 <sup>f</sup>	15.54 <sup>f</sup>
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	18.60 <sup>d</sup>	16.88 <sup>h</sup>	20.52 <sup>h</sup>
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	20.60 <sup>d</sup>	23.10 <sup>f</sup>	26.42 <sup>f</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	21.02 <sup>d</sup>	24.34 <sup>e</sup>	26.82 <sup>f</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	14.96 <sup>i</sup>	13.26 <sup>g</sup>	16.54 <sup>g</sup>
F Test (P=0.05)	*	*	*
SEm	1.70	1.002	1.508
CD	3.614	3.208	3.20

Means followed by same letters are not significantly different (P=0.05) by DMRT.

NS - Non-significant

\* - Significant at 5% level

par and significantly superior to NPK + neem cake (9.5). Significantly higher population of leaf miners was observed in NPK with NPV(16.5), control (18.16) and NPK with sunflower (18.83), all the three being on par.

During III stage (Tab. 10; Fig. 4) FYM recorded the lowest pest population (17.46) followed by vermicompost (18.5), FYM + vermicompost (19.83), and neem cake (20.50) all being on par with each other. Moderate population was observed in NPK with seed treatment (24.80) which was on par with neem cake but superior to NPK + neem cake (27.5) NPK with NPV (34.82), control (37.5) and NPK with sunflower (37.52) which recorded significantly higher population of leaf miners among all the treatments.

The overall influence of treatments during *rabi* 94-95 on leaf miner population (Tab. 11, Fig. 4) indicated that all the organically manured treatments and NPK with seed treatment were significantly superior in recording lower population than the other treatments. The lowest population being recorded in FYM (11.48) followed by vermicompost (11.76), neem cake (11.76), FYM + vermicompost (13.22) and NPK with seed treatment (13.26), all being on par with each other. NPK + neem cake recorded a moderate population of 16.88 leaf miner larvae per 10 plants. Among the treatments, NPK with NPV (23.1), NPK with sunflower (24.34) and control (24.60) were on par and recorded significantly higher population of leaf miners.

#### **Rabi, 1995-96**

The data pertaining to the leaf miner population collected at weekly intervals indicated that the population during the earlier weeks of observation i.e. upto 8th WAS was higher when compared to the previous *rabi* crop and started to decline from 9th WAS and by 14th WAS the population disappeared (Appendix 3).

The data presented in Tab. 10 & fig 4 revealed significant difference in leaf miner population among the treatments. All the organically manured treatments and NPK with seed treatment in stage I recorded significantly lower population of leaf miners over the straight fertilized plots, with a mean population ranging between 4.6 and 8.0 per 10 plants. Among the treatments, NPK with seed treatment recorded the lowest leaf miner population (4.6) but was on par with vermicompost (6.0), neem cake (6.4), FYM (6.6), FYM + vermicompost (7.2) and NPK + neem cake (8.0). Significantly higher population, however, was noticed in NPK with sunflower (14.0), NPK with NPV (14.66) and control (14.66), which were on par with each other.

FYM recorded the lowest pest population (17.0) during stage II (Tab. 10; Fig. 4) followed by vermicompost (18.82), NPK with seed treatment (18.82), FYM + vermicompost (20.16), which were on par. Neem cake with 21.0 leaf miner larvae per 10 plants came closely behind and was also on par with the earlier treatments except FYM. NPK + neem cake recorded moderate population (26.66) but was significantly superior to NPK with NPV (34.66) and NPK with sunflower (37.16). The highest population of leaf miners was observed in control with 41.5 larvae per 10 plants but was on par with NPK with sunflower.

During stage III (Tab. 10; Fig. 4), the lowest population was recorded in neem cake (19.31) followed by vermicompost (22.66), FYM + vermicompost (22.82) and FYM (22.82) which were on par. The treatments that came closely behind were NPK with seed treatment (24.66) and NPK + neem cake (27.24) both being on par with the former treatments except neem cake. NPK with sunflower (34.46), NPK with NPV (36.1) and control (37.62) were found inferior and recorded significantly higher population of leaf miners, among all the treatments.

The overall influence of treatments (Tab. 11; Fig. 4) on leaf miner population during *rabi* 1995-96 revealed distinct variation among the treatments in affecting the population. Once

again all the organically manured treatments and NPK + seed treatment recorded significantly lower incidence of leaf miners than the straight fertilized treatments. Among the treatments FYM (15.48 leaf miners per 10 plants) recorded the lowest population and it was on par with neem cake (15.54), vermicompost (16.10), NPK with seed treatment (16.54) and FYM + vermicompost (16.72). Moderate leaf miner population was observed in NPK + neem cake with 20.52 larvae per 10 plants. Among the treatments NPK with NPV (26.42), NPK with sunflower (26.82) and control (29.48) were on par and recorded significantly higher population of leaf miners

#### 4.1.1.4. Tobacco caterpillar, *S. litura*

##### **Kharif, 1995**

During *kharif*, 1995 the incidence of *S. litura* was low and the population was moderate upto 9th WAS and declined during the latter weeks. From 11th WAS *S. litura* was not found damaging the crop. The incidence of *S. litura* was not observed upto 4th WAS in some treatments and even during 5th WAS the treatments received vermicompost and FYM + vermicompost even recorded zero population (Appendix-4).

The data presented in Tab. 12 & Fig. 5 clearly indicated the absence of the pest during stage I. During stage II the population of *S. litura* was very low. Among the treatments, FYM (0.88 larvae per 10 plants), vermicompost (0.88), FYM + vermicompost (0.99), NPK with seed treatment (1.10), and neem cake (1.21) recorded significantly lower population of *S. litura* and were on par with each other. Significantly higher population was noticed in NPK + neem cake (1.99), control (2.32), NPK with sunflower (2.55) and NPK with NPV (2.66) all being on par with each other.

Stage III evaluation of *S. litura* population (Tab. 12; Fig. 5) also revealed the same trend. The population of the pest was low in FYM (2.88), vermicompost (3.21), FYM + vermicompost

Tab. 12: Influence of treatments on tobacco caterpillar, *S. litura* population (larvae / 10 plants) on groundnut

Treatments	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	0.00 (0.00)	2.32 <sup>a</sup> (1.819)	4.99 <sup>a</sup> (2.438)	7.60 (2.877)	10.83 <sup>b</sup> (5.436)	16.41 <sup>b</sup> (4.172)	5.00 (2.443)	10.07 <sup>b</sup> (3.323)	13.09 <sup>b</sup> (3.754)
T <sub>2</sub> FYM @ 8 t ha <sup>-1</sup>	0.00	0.88 <sup>a</sup> (1.372)	2.88 <sup>a</sup> (1.965)	5.50 (2.483)	5.41 <sup>a</sup> (2.55)	13.67 <sup>a</sup> (3.828)	2.30 (1.821)	5.47 <sup>a</sup> (2.529)	10.36 <sup>ab</sup> (3.457)
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	0.00	0.88 <sup>a</sup> (1.372)	3.21 <sup>ab</sup> (2.046)	4.60 (2.372)	5.58 <sup>b</sup> (2.547)	13.35 <sup>ab</sup> (3.787)	2.60 (1.90)	6.16 <sup>a</sup> (2.671)	10.36 <sup>ab</sup> (3.37)
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	0.00	0.99 <sup>a</sup> (1.409)	3.21 <sup>ab</sup> (2.046)	5.30 (2.459)	5.91 <sup>a</sup> (2.623)	11.85 <sup>a</sup> (3.584)	3.00 (1.989)	6.47 <sup>a</sup> (2.718)	11.76 <sup>a</sup> (3.571)
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	0.00	1.216 <sup>a</sup> (1.481)	3.22 <sup>ab</sup> (2.049)	4.00 (2.328)	5.25 <sup>a</sup> (2.485)	10.17 <sup>a</sup> (3.336)	2.50 (1.821)	5.10 <sup>a</sup> (2.468)	9.40 <sup>ab</sup> (3.224)
T <sub>6</sub> NPK @ 20-30-20 Kg ha <sup>-1</sup> + Neem Cake @ 385 Kg ha <sup>-1</sup>	0.00	1.99 <sup>a</sup> (1.729)	4.44 <sup>ab</sup> (2.322)	5.30 (2.504)	6.66 (2.767)	10.41 <sup>a</sup> (3.377)	5.50 (2.078)	9.16 <sup>a</sup> (2.666)	10.58 <sup>abc</sup> (3.402)
T <sub>7</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	0.00	2.66 <sup>a</sup> (1.909)	5.32 <sup>a</sup> (2.513)	7.00 (2.824)	10.25 <sup>b</sup> (3.352)	3.06 <sup>a</sup> (2.612)	4.30 (2.265)	9.47 <sup>b</sup> (3.334)	3.33 <sup>a</sup> (2.076)
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with sunflower	0.00	2.55 <sup>a</sup> (1.883)	5.66 <sup>a</sup> (2.58)	8.00 (2.996)	9.91 <sup>b</sup> (3.274)	6.75 <sup>b</sup> (2.783)	5.00 (2.553)	10.83 <sup>b</sup> (3.435)	8.61 <sup>a</sup> (3.097)
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and Carbofuran 3G ST @250g Kg <sup>-1</sup> seed	0.00	1.10 <sup>a</sup> (1.446)	3.22 <sup>ab</sup> (2.052)	3.50 (2.078)	5.00 <sup>a</sup> (2.443)	12.91 <sup>bc</sup> (3.629)	2.00 (1.715)	4.27 <sup>a</sup> (2.29)	12.51 <sup>bc</sup> (3.673)
F test (P=0.05)	----	*	*	NS	*	*	NS	*	*
Sem	----	0.1037	0.1563	----	0.172	0.0908	----	0.2052	0.0845
CD	----	0.2199	0.3315	----	0.3655	0.1925	----	0.4351	0.1791

Means followed by same letters are not significantly different (P=0.05) by DMRT.  
NS - Non-significant  
\* - Significant at 5% level  
Values in parentheses are (X+1)<sup>0.5</sup> transformed values.

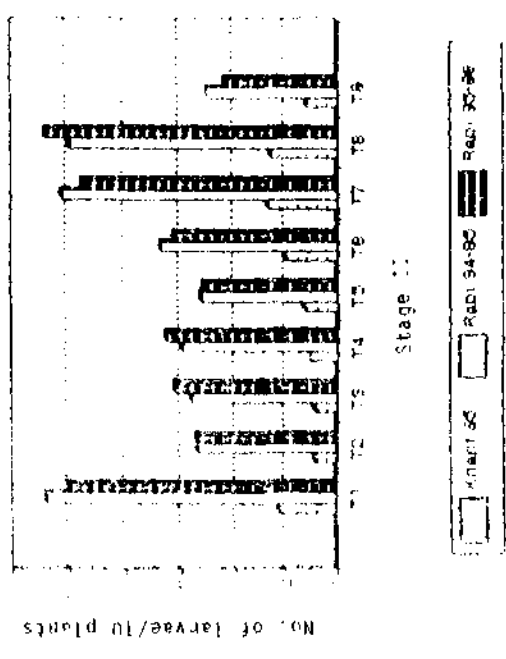
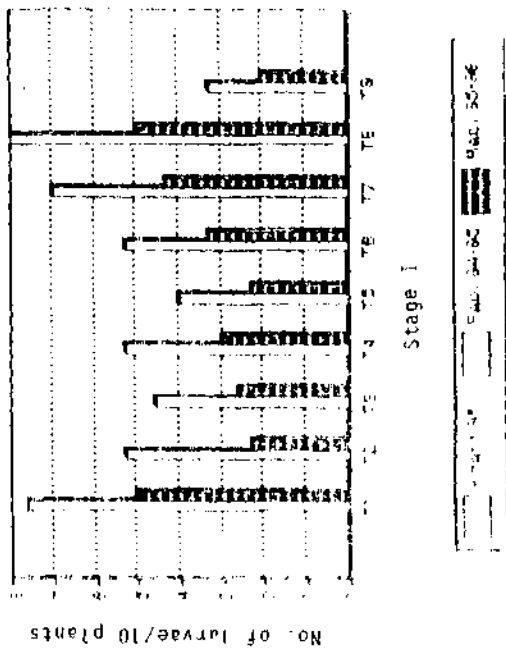
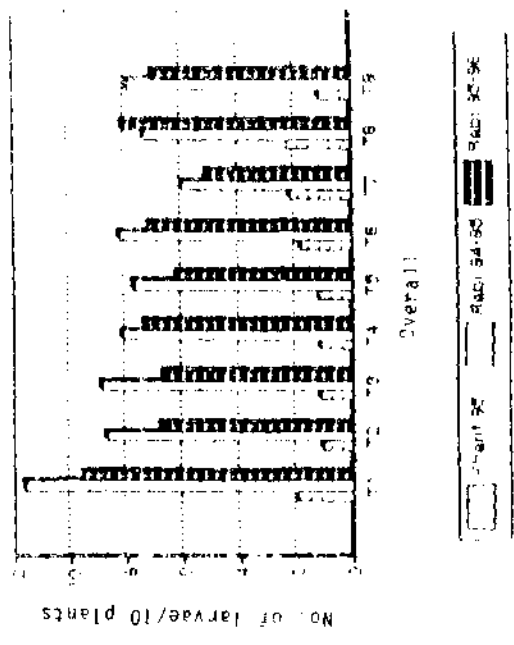
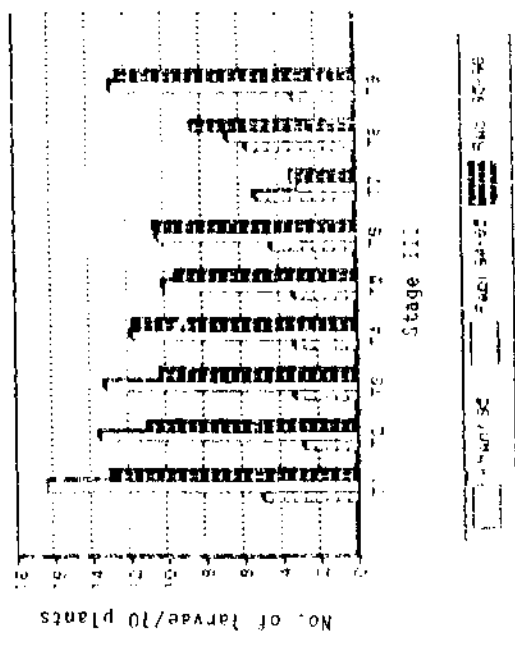


Figure 5. Influence of treatments on the incidence of tobacco caterpillar, *S. litura* on groundnut.

(3.21), neem cake (3.22) and NPK with seed treatment (3.22) all being on par. Higher population among the treatments was noticed in NPK + neem cake (4.44), control (4.99), NPK with NPV (5.32) and NPK with sunflower (5.66)

The overall influence of treatments on the incidence of *S. litura* (Tab. 13; Fig. 5) vividly showed that the treatments which received organic manures and NPK with seed treatment were on par and recorded significantly lower *S. litura* population ranging from 1.03 to 1.18 larvae per 10 plants, indicating their superiority over all other treatments. Higher population among the treatments of *S. litura* was observed in NPK + neem cake (1.75), control (1.99), NPK with NPV (2.18) and NPK with sunflower (2.24) which were on par with each other.

#### **Rabi, 1994-95**

The incidence of *S. litura* started from 3rd WAS and increased gradually, reaching maximum levels by 7th and 8th WAS and declined later (Appendix 4)

During I stage evaluation (Tab. 12; Fig. 5) no distinct variation was observed in the incidence of *S. litura*. However, among the treatments the lowest population was recorded in NPK with seed treatment (3.3 larvae per 10 plants) and the highest in NPK with sunflower (8.0). The remaining treatments recorded a mean population varying between 4.0 and 7.6 larvae per 10 plants.

During II stage, the lowest population of *S. litura* was noticed in NPK with seed treatment (5.0 larvae per 10 plants) but was on par with neem cake (5.25), FYM (5.41), vermicompost (5.58), FYM + vermicompost (5.91) and NPK + neem cake (6.66). Significantly higher population of *S. litura* was recorded in NPK with sunflower (9.91), NPK with NPV (10.25) and control (10.83), all being on par.

**Tab. 13: Overall influence of treatments on tobacco caterpillar, *S. litura* population (larvae / 10 plants) on groundnut.**

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	1999 <sup>bc</sup>	11693 <sup>c</sup>	951 <sup>c</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	1403 <sup>a</sup>	8688 <sup>cd</sup>	681 <sup>bc</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	1409 <sup>a</sup>	8857 <sup>d</sup>	667 <sup>bc</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	1151 <sup>ab</sup>	8144 <sup>bc</sup>	738 <sup>cd</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	1181 <sup>a</sup>	7752 <sup>bc</sup>	622 <sup>b</sup>
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	1757 <sup>b</sup>	8222 <sup>bcd</sup>	713
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	2181 <sup>c</sup>	604 <sup>a</sup>	513 <sup>a</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	2241 <sup>d</sup>	743 <sup>b</sup>	809 <sup>d</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	1151 <sup>a</sup>	791 <sup>bcd</sup>	703 <sup>b</sup>
F Test (P=0.05)	*	*	*
SEm	0.245	0.504	0.414
CD	0.521	1.069	0.878

Means followed by same letters are not significantly different (P=0.05) by DMRT.

\* - Significant at 5% level

Significant differences in pest population, among the treatments were observed during stage III. NPK with NPV recorded the lowest population of *S. litura* (3.05 per 10 plants) and was significantly superior to all the other treatments. The next best treatment was NPK with sunflower (6.75 per 10 plants). The treatments that followed were neem cake (10.17) and NPK + neem cake (10.41) being on par and significantly superior to FYM + vermicompost (11.85) and NPK with seed treatment (12.91). Higher population of *S. litura* was noticed in vermicompost (13.35) and FYM (13.67). Control (16.41) recorded the highest population among all the treatments.

The overall influence of treatments (Tab. 13, Fig. 5) on *S. litura* during *rabi* 1994-95 indicated that the treatment which received straight fertilizer plus NPV recorded the lowest population (6.04 larvae per 10 plants) among the treatments showing its superiority over all other treatments. The treatments that followed were NPK with sunflower (7.33), neem cake (7.75), NPK with seed treatment (7.91), FYM + vermicompost (8.14), NPK + neem cake (8.22), FYM (8.08) and vermicompost (8.85) which recorded a mean population ranging between 7.33 to 8.85 larvae per 10 plants. Control plot recorded the highest population (11.69 larvae per 10 plants) which showed its inferiority among all the treatments, in checking the build up of *S. litura* population.

#### **Rabi, 1995-96**

The incidence of *S. litura* was noticed from 3rd WAS till the end of the crop growth (Appendix 4). During stage I evaluation the treatments did not significantly affected the *S. litura* population. However, the lowest population was recorded in NPK with seed treatment (2.0) and the highest being observed in control and NPK with sunflower (5.0) (Tab. 12, Fig. 5)

During stage II evaluation (Tab. 12, Fig. 5), NPK with seed treatment recorded the lowest population of *S. litura* (4.27) followed by neem cake (5.1), FYM (5.47), NPK + neem cake (6.16),

vermicompost (6.16), and FYM + vermicompost (6.47) all being on par. Higher population of *S. litura* was however noticed in NPK with NPV (3.234), control (3.32) and NPK with sunflower (10.83).

During III stage, there were significant differences among the treatments. NPK with NPV recorded the lowest population of *S. litura* (3.33) among the treatments and once again was significantly superior to the treatments in checking the build up of pest population. The other treatments in the descending order of efficacy were NPK with sunflower (8.61) < neem cake (9.4) < vermicompost (10.36) < NPK + neem cake (10.58) < FYM (10.96) < FYM + vermicompost (11.76) < NPK with seed treatment (12.51). The highest population was, however, noticed in control (13.09) but was on par with NPK with seed treatment (Tab. 12; Fig. 5).

The overall influence of treatments on *S. litura* population (Tab. 13; Fig. 5) revealed that NPK with NPV application proved its effectiveness in recording the lowest *S. litura* population (5.13) than all the other treatments. The next best treatments with a moderate population are NPK with neem cake (6.22), vermicompost (6.67), FYM (6.81) and NPK with seed treatment (7.03) being on par. NPK + neem cake (7.13), FYM + vermicompost (7.38) and NPK with sunflower (8.09) came closely behind. Among all the treatments the highest population was observed in control (9.51).

#### 4.1.1.5. Gram pod borer, *H. armigera*

The incidence of *H. armigera* during *kharif*, was almost negligible, however a moderate population was observed during the two *rabi* seasons under study. During *kharif* 1995 the incidence of *H. armigera* was observed from 5th WAS and declined to a negligible population by 7th WAS (Appendix 5).

**Kharif, 1995**

There was negligible or no incidence of *H. armigera* during *kharif* crop during the I and III stages of observation (Tab. 14, Fig. 6). Though the pest incidence was noticed during stage II, it was not significant. However, among the treatments lowest population of *H. armigera* was observed in NPK with seed treatment (0.97 larvae per 10 plants) followed by neem cake, vermicompost, NPK + neem cake, FYM + vermicompost with an average population ranging between 1.25 and 1.52 larvae per 10 plants. Slightly higher population, among the treatments, was noticed in NPK with NPV, control and NPK with sunflower with the population ranging between 2.22 and 2.49 larvae per 10 plants.

**Rabi, 1994-95**

Insignificant levels of *H. armigera* population was noticed during *rabi*, 1994-95 in stage I in all the treatments (Tab. 14; Fig. 6). During stage II NPK with seed treatment and the treatments that received organic manures recorded significantly low levels of *H. armigera* with a mean population ranging from 1.41 to 2.16 larvae per 10 plants. Lowest population was observed in NPK with seed treatment (1.41) followed by neem cake (1.5), FYM (1.58), vermicompost (1.75), FYM + vermicompost (1.75) and NPK + neem cake (2.16) all being on par with each other. NPK with NPV, NPK with sunflower and control recorded higher population among the treatments with the mean ranging between 3.41 and 3.58 larvae per 10 plants.

Stage III evaluation indicated that, the lowest population of *H. armigera* was observed in neem cake (4.5 larvae per 10 plants) followed by vermicompost (4.91), FYM (4.92) and NPK + neem cake (5.15), being on par. However, NPK with NPV recorded 6.79 larvae per 10 plants and was on par with the preceding one treatment and the succeeding treatments viz. FYM + vermicompost (7.14), control (7.37), NPK with seed treatment (8.24) and NPK with sunflower (8.65) (Tab. 14; Fig. 6).

Tab. 14: Influence of treatments on gram pod borer, *H. armigera* population (larvae / 10 plants) on groundnut

Treatments	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	0.00 (1.829)	2.36 <sup>a</sup> (1.829)	0.00	0.66 (1.276)	3.58 <sup>b</sup> (2.134)	7.37 <sup>c</sup> (2.891)	0.66 (1.276)	4.25 <sup>b</sup> (2.289)	6.90 <sup>c</sup> (2.807)
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	0.00	1.52 <sup>abc</sup> (1.585)	0.00	0.35 (1.138)	1.58 <sup>a</sup> (1.605)	4.92 <sup>bc</sup> (2.426)	0.00 (1.00)	2.91 <sup>abc</sup> (1.964)	4.50 <sup>d</sup> (2.338)
T <sub>3</sub> Vermicompost @ 3.75 t ha <sup>-1</sup>	0.00	1.27 <sup>abc</sup> (1.489)	0.00	0.33 (1.138)	1.75 <sup>a</sup> (1.637)	4.91 <sup>a</sup> (2.424)	0.33 (1.138)	3.25 <sup>abcd</sup> (2.05)	4.56 <sup>d</sup> (2.35)
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	0.00	1.52 <sup>abc</sup> (1.587)	0.00	0.33 (1.138)	1.75 <sup>a</sup> (1.637)	7.14 <sup>c</sup> (2.847)	0.33 (1.138)	3.41 <sup>abc</sup> (2.099)	5.55 <sup>abc</sup> (2.552)
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	0.00	1.25 <sup>ab</sup> (1.487)	0.00	0.00 (1.00)	1.50 <sup>a</sup> (1.57)	4.50 <sup>b</sup> (2.343)	0.00 (1.00)	7.50 <sup>ab</sup> (1.869)	4.60 <sup>d</sup> (2.363)
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + Neem Cake @ 385 Kg ha <sup>-1</sup>	0.00	1.52 <sup>abc</sup> (1.574)	0.00	0.00 (1.00)	2.16 <sup>bc</sup> (1.744)	5.15 <sup>ab</sup> (2.48)	0.33 (1.138)	3.16 <sup>abcd</sup> (2.04)	5.25 <sup>abc</sup> (2.498)
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @250 LE ha	0.00	2.22 <sup>bc</sup> (1.793)	0.00	0.66 (1.276)	3.41 <sup>b</sup> (2.099)	6.70 <sup>bc</sup> (2.79)	0.66 (1.276)	3.91 <sup>cd</sup> (2.213)	6.35 <sup>bc</sup> (2.711)
T <sub>8</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with Sunflower	0.00	2.49 <sup>c</sup> (1.867)	0.00	1.00 (1.414)	3.41 <sup>b</sup> (2.101)	8.65 <sup>d</sup> (3.099)	0.66 (1.276)	4.08 <sup>cd</sup> (2.246)	5.47 <sup>abc</sup> (2.536)
T <sub>9</sub> NPK @40-60-40 Kg ha <sup>-1</sup> and Carbofuran 3G ST @250g Kg <sup>-1</sup> seed	0.00	0.97 <sup>a</sup> (1.402)	0.00	0.00 (1.00)	1.41 <sup>a</sup> (1.552)	8.24 <sup>d</sup> (3.035)	0.00 (1.00)	2.08 <sup>c</sup> (1.755)	4.23 <sup>d</sup> (2.268)
F Test (P=0.05)	---	*	---	NS	*	*	NS	*	*
SEM	---	0.147	---	---	0.107	0.151	---	0.141	0.145
CD	---	0.3116	---	---	0.227	0.334	---	0.300	0.318

Means followed by same letters are not significantly different (P=0.05) by DMRT Values in parentheses are (X+1)<sup>0.5</sup> transformed values.  
 NS - Non-significant \* - Significant at 5% level

Tab. 15: Overall influence of treatments on gram pod borer, *H. armigera* population (larvae / 10 plants) on groundnut.

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	---	4.18 <sup>c</sup>	4.27 <sup>c</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	---	2.61 <sup>ab</sup>	2.72 <sup>ab</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	---	2.70 <sup>ab</sup>	2.77 <sup>ab</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	---	3.45 <sup>c1</sup>	3.18 <sup>bc1</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	---	2.30 <sup>a</sup>	2.42 <sup>a</sup>
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	---	2.91 <sup>b</sup>	3.08 <sup>b</sup>
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	---	3.99 <sup>b</sup>	3.75 <sup>b</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	---	4.37 <sup>c</sup>	3.46 <sup>cd</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	---	3.41 <sup>b</sup>	2.35 <sup>a</sup>
F Test (P=0.05)	---	*	*
SEm	---	0.26	0.30
CD	---	0.56	0.64

Means followed by same letters are not significantly different (P=0.05) by DMRT.

\* - Significant at 5% level

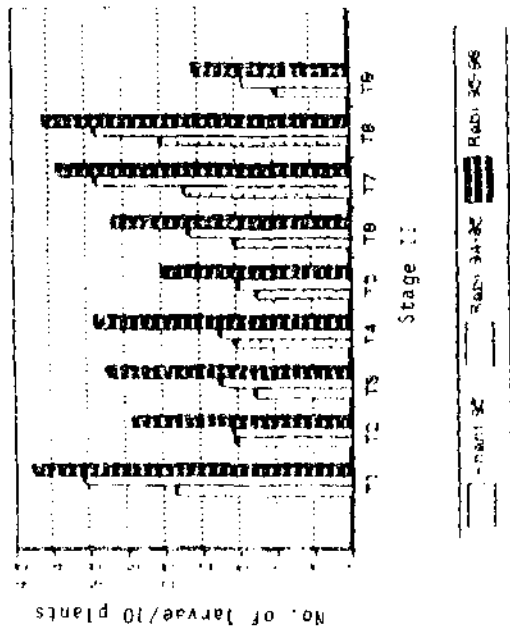
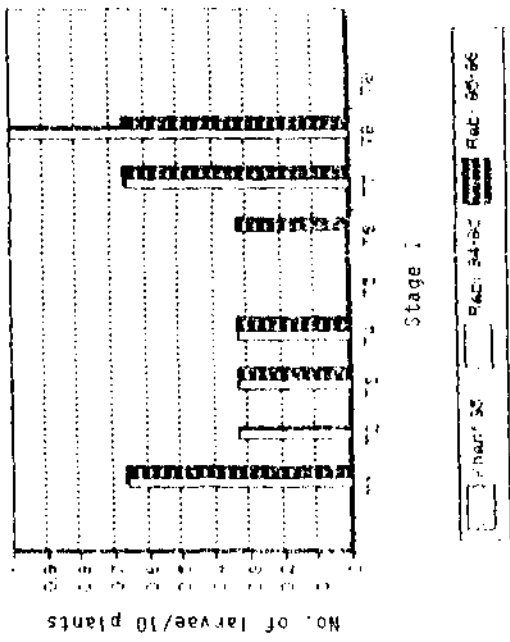
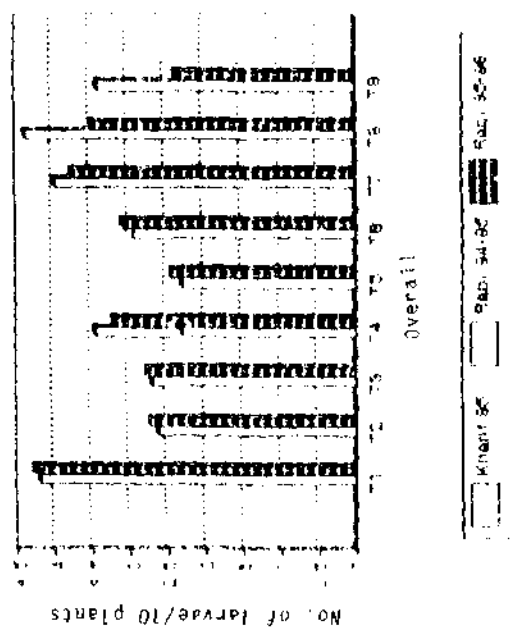
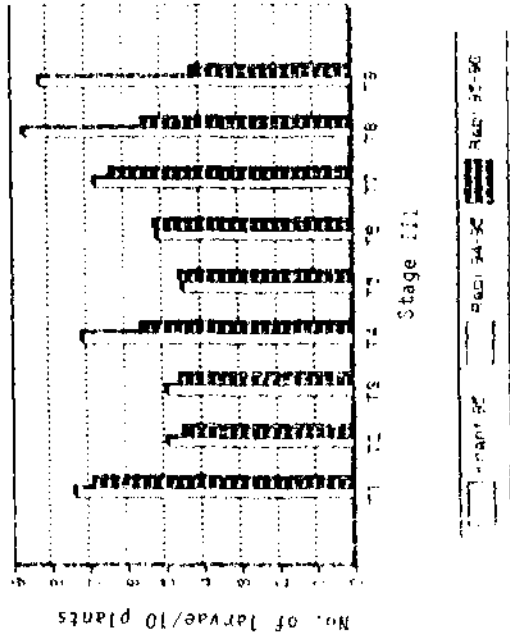


Figure 6. Influence of treatments on the incidence of gram pod borer, *H. armigera* on groundnut.

The overall efficacy of treatments on the *H. armigera* population during rabi, 1994-95 (Tab. 15; Fig. 6) indicated lowest population in neem cake (2.30) followed by FYM (2.61) and vermicompost (2.70) all being on par. The treatments that followed were NPK + neem cake (2.91), NPK with seed treatment (3.41) and FYM + vermicompost (3.45), being on par. The treatments NPK with NPV (3.99), control (4.18) and NPK with sunflower (4.37) were found inferior but non significant in their efficacy in reducing the *H. armigera* population when compared to the other treatments

#### **Rabi, 1995-96**

As observed during the previous *rabi* crop, the treatments did not showed any significant variation on the incidence of *H. armigera* population during stage I (Tab. 14; Fig. 6). Though the pest population was noticed in II and III stages, it was low.

During stage II (Tab. 14; Fig. 6), NPK with seed treatment recorded the lowest *H. armigera* population (2.08) followed by neem cake (2.5), FYM (2.91), NPK + neem cake (3.16) and vermicompost (3.25), and were on par. However the last two treatments were also on par with all the succeeding treatments viz. FYM + vermicompost (3.41), NPK with NPV (3.91), NPK with sunflower (4.08), control (4.25).

During III stage evaluation (Tab. 14; Fig. 6) NPK with seed treatment (4.23) recorded the lowest population and was followed by FYM (4.5), vermicompost (4.56), neem cake (4.6), NPK + neem cake (5.25), NPK with sunflower (5.47) and FYM + vermicompost (5.55) all being on par. Slightly higher population of *H. armigera* was recorded in NPK with NPV (6.35) and control (6.90) both being on par with preceding two treatments

During *rabi* 95-96, the overall influence of treatments (Tab 15) on *H. armigera* indicated that NPK with seed treatment recorded lower population (2.35) followed by neem cake (2.42), FYM (2.72), vermicompost (2.77), NPK + neem cake(3.08), FYM + vermicompost (3.18), NPK with sunflower and NPK with NPV (3.75) The control plot that received straight fertilizer recorded the highest population of *H. armigera* (4.27 per 10 plants) among all the treatments (Tab. 15; Fig 6).

#### **4.1.2. Natural Enemies**

The results pertaining to natural enemy population collected at weekly intervals are presented in Appendices 6 to 8 and the data pertaining to evaluation at the stages are presented in Tables 16 to 21 & Figures 7 to 9.

##### **4.1.2.1. Coccinellid beetles *V. vincta*, *C. transversalis*, *M. sexmaculatus***

###### ***Kharif, 1995***

The occurrence of coccinellid beetles during *Kharif* was low and their numbers hardly reached 2.5 per plant and from 12th WAS no coccinellid predator population was observed (Appendix 6).

It was found from the Tab. 16 & Fig. 7 that the treatments failed to influence the predator population in *kharif* crop. There was no significant difference among the treatments in affecting the coccinellid beetles at the three different stages of evaluation, as well.

All the treatments recorded negligible number of coccinellid beetles during stage I with an average population of 0.33 to 0.66 beetles per 10 plants. Insignificant levels of population were observed in stage II, with a mean population ranging between 2.11 to 3.77 per 10 plants in all the treatments. During the stage III also, there was no significant variation in the population of

Tab. 16: Influence of treatments on coccinellid beetle population (adults / 10 plants) on groundnut.

Treatments	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
T <sub>1</sub> NPK (Control) @ 40-60-40 kg ha <sup>-1</sup>	0.66 (1.27)	3.33 (2.078)	14.16 (3.895)	11.00 <sup>bc</sup> (3.365)	32.91 <sup>a</sup> (5.818)	90.16 <sup>c</sup> (9.547)	16.60 (4.182)	28.00 (5.581)	90.57 <sup>cd</sup> (9.565)
T <sub>2</sub> FYM @ 8 t ha <sup>-1</sup>	0.66 (1.27)	2.66 (1.904)	14.16 (3.89)	9.66 <sup>bc</sup> (3.247)	28.33 <sup>b</sup> (5.407)	71.58 <sup>ab</sup> (8.518)	16.00 (4.117)	21.60 (4.672)	83.85 <sup>bc</sup> (9.207)
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	0.66 (1.27)	2.44 (1.845)	15.08 (4.01)	9.66 <sup>bc</sup> (3.26)	31.66 <sup>a</sup> (5.666)	76.75 <sup>b</sup> (8.816)	14.00 (3.867)	25.16 (5.098)	82.15 <sup>b</sup> (9.113)
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	0.33 (1.33)	2.55 (1.877)	13.75 (3.84)	10.33 <sup>bc</sup> (3.36)	32.50 <sup>b</sup> (5.772)	73.08 <sup>ab</sup> (8.583)	12.60 (3.694)	26.25 (5.214)	86.82 <sup>bc</sup> (9.369)
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	0.33 (1.13)	3.22 (1.787)	13.75 (3.838)	9.00 <sup>b</sup> (3.159)	28.41 <sup>b</sup> (5.418)	78.25 <sup>b</sup> (8.897)	13.00 (3.736)	23.50 (4.93)	91.60 <sup>cd</sup> (9.443)
T <sub>6</sub> NPK @ 20-30-20 Kg ha <sup>-1</sup> + Neem Cake @ 385 Kg ha <sup>-1</sup>	0.66 (1.27)	3.55 (1.874)	11.75 (3.569)	11.66 <sup>c</sup> (3.55)	28.66 <sup>b</sup> (5.415)	73.41 <sup>ab</sup> (8.624)	14.60 (3.951)	26.08 (5.182)	86.00 <sup>cd</sup> (9.326)
T <sub>7</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with NPV @ 250LE ha <sup>-1</sup>	0.33 (1.13)	3.22 (2.002)	13.50 (3.806)	9.00 <sup>b</sup> (3.262)	33.50 <sup>a</sup> (5.85)	74.91 <sup>b</sup> (8.707)	18.00 (4.554)	26.91 (5.270)	84.50 <sup>cd</sup> (9.244)
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with sunflower	0.66 (1.27)	3.77 (2.157)	13.58 (3.818)	13.33 <sup>b</sup> (3.781)	31.08 <sup>a</sup> (5.689)	78.00 <sup>b</sup> (8.884)	16.00 (4.117)	28.91 (5.468)	96.98 <sup>b</sup> (9.863)
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg seed	0.66 (1.27)	2.11 (1.762)	13.58 (3.817)	5.66 (2.56)	14.41 <sup>b</sup> (3.921)	65.25 <sup>b</sup> (8.136)	11.30 (3.479)	14.66 (3.956)	69.30 (8.383)
F Test (p=0.05)	NS	NS	NS	*	*	*	NS	NS	*
Sem	---	---	---	0.172	0.342	0.2367	---	---	0.209
CD	---	---	---	0.364	0.7259	0.5019	---	---	0.444

Means followed by same letters are not significantly different (P=0.05) by DMRT.  
 NS - Non-significant  
 \* - Significant at 5% level  
 Values in parentheses are (X+1)<sup>0.5</sup> transformed values

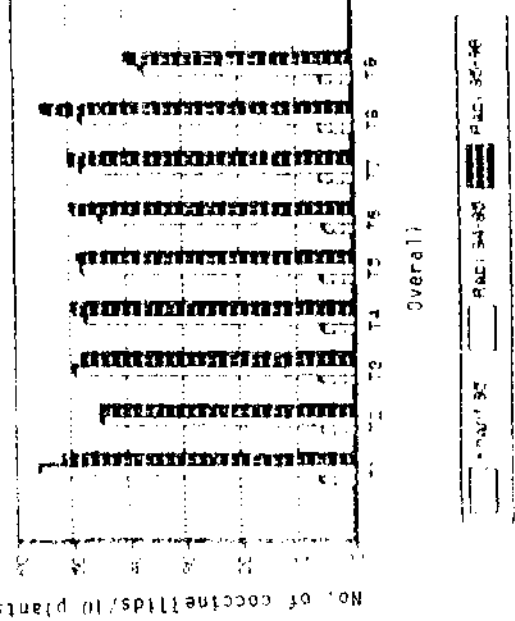
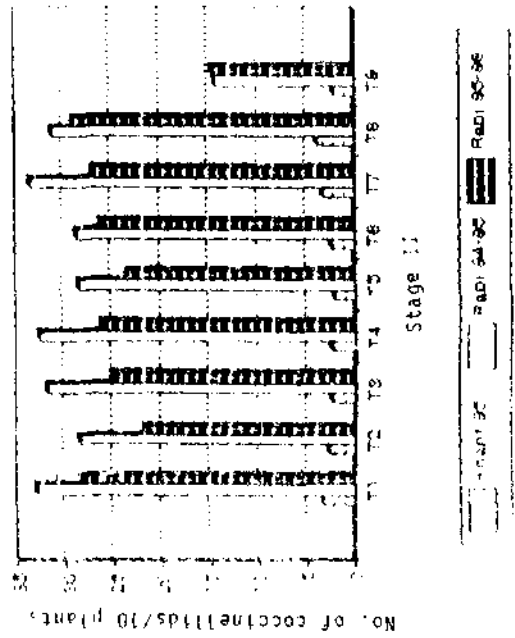
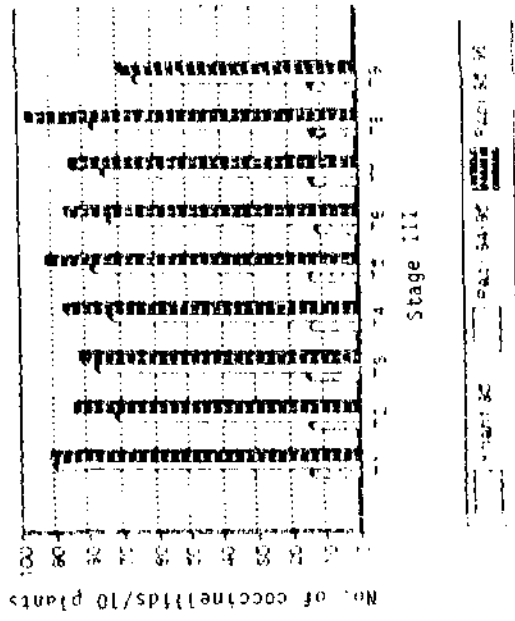
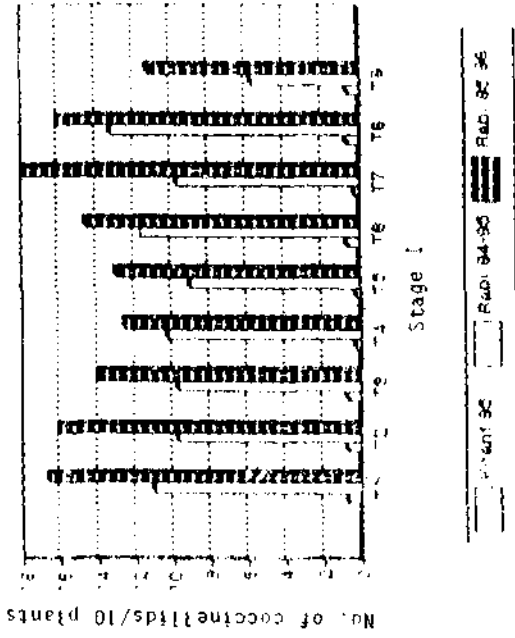


Figure 7. Influence of treatments on the coccinellid beetle population on groundnut.

coccinellid beetles among the treatments. However, the lowest population was observed in NPK + neem cake (11.75) and the highest in vermicompost (15.08) (Tab. 16; Fig. 7)

The overall influence of treatments (Tab. 17; Fig. 7) on coccinellid beetle population was also non significant. All the treatments recorded less than 7 beetles per 10 plants and the mean population ranged between 5.2 and 6.18 beetles per 10 plants.

#### **Rabi, 1994-95**

Higher number of coccinellid predators were observed during rabi 94-95 during 10th WAS and declined during the latter stages of the crop growth (Appendix 6).

Significant treatmental influence was observed on the coccinellid population during the three stages of evaluation (Tab. 16; Fig. 7). During stage I, the lowest number of beetles were observed in NPK with seed treatment (5.66 per 10 plants). The treatments that followed with higher number of coccinellid predators were neem cake (9.0), FYM (9.66), vermicompost (9.66), NPK with NPV (9.66), FYM + vermicompost (10.33) control (11.0) and NPK + neem cake (11.66) all being on par with each other. The highest member of beetles were recorded in NPK with sunflower (13.33 per 10 plants), showing its superiority over all other treatments in harbouring coccinellid population.

During stage II also the lowest population of beetles was observed in NPK with seed treatment (14.41 per 10 plants). The remaining treatments recorded higher population and all were on par with each other, with an average population ranging between 28.33 and 33.5. The ascending order of the predator population was FYM (28.33) < neem cake (28.41), NPK + neem cake (28.66) < vermicompost (31.66), < NPK with NPV (33.5) (Tab. 16; Fig. 7)

**Tab. 17: Overall influence of treatments on coccinellid beetle population (adults / 10 plants) on groundnut.**

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	6.121	55.91 <sup>c</sup>	51.46 <sup>d</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	5.939	44.66 <sup>b</sup>	44.94 <sup>b</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	6.181	49.49 <sup>b</sup>	48.38 <sup>b</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	5.727	47.94 <sup>b</sup>	49.52 <sup>c</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	5.636	48.11 <sup>b</sup>	48.61 <sup>b</sup>
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	5.211	44.66 <sup>b</sup>	49.52 <sup>c</sup>
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	5.908	48.33 <sup>b</sup>	49.94 <sup>c</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	5.848	48.30 <sup>b</sup>	44.97 <sup>d</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	5.518	37.19 <sup>a</sup>	39.49 <sup>a</sup>
F Test (P=0.05)	NS	*	*
SEm	---	2.434	1.857
CD	---	5.161	3.939

Means followed by same letters are not significantly different (P=0.05) by DMRT.

NS - Non-significant

\* - Significant at 5% level

Higher population of coccinellid beetles was observed during stage III (Tab. 16; Fig. 7) when compared to the other two stages of evaluation. Among the treatments the lowest number of beetles was seen in NPK with seed treatment (65.25 per 10 plants) and it was followed by FYM (71.58), FYM + vermicompost (73.08) and NPK + neem cake (73.41) all being on par. Higher population of beetles was seen in NPK with NPV (74.91), vermicompost (76.75), NPK with sunflower (78.0) and neem cake (78.25) all being on par with each other. The highest number of beetles, however, was noticed in control (90.16) among all the treatments.

The overall influence of treatments (Tab. 17; Fig. 7) on predator population indicated that the lowest population of beetles was observed in NPK with seed treatment (37.19). Higher number of beetles, however, were recorded in all the remaining treatments VIZ. NPK + neem cake (44.66), FYM (44.66), FYM + vermicompost (47.94), neem cake (48.11), NPK with sunflower (48.30), NPK with NPV (48.33), vermicompost (49.49), all being on par. Control (55.91) recorded the highest beetle population among the treatments.

#### **Rabi, 1995-96**

The coccinellid beetle population in *rabi* 95-96 was higher reaching more than 100 beetles per 10 plants in some treatments during the later stages of the crop growth when compared to previous *rabi* season (Appendix 6).

During the first stage evaluation the treatmental variation pertaining to the beetle population was non significant. However, the lowest population was observed in NPK with seed treatment (11.3 beetles per 10 plants) and the highest in NPK with NPV (18.0) (Tab. 16; Fig. 7).

NPK with seed treatment in stage II (Tab. 16) as well, recorded the lowest coccinellid beetle population (14.66) and the highest being observed in NPK with sunflower (28.91). The

remaining treatments recorded a mean population ranging between 14.66 and 28.91 per 10 plants.

During III stage evaluation (Tab. 16; Fig. 7) NPK with seed treatment once again recorded the lowest population (69.3) among the treatments. The treatments with higher number of beetles were vermicompost (82.15), FYM (83.85), NPK with NPV (84.5), NPK + neem cake (86), FYM + vermicompost (86.82), neem cake (91.6), and control (90.57) and all were on par. The highest population of beetles were recorded in NPK with sunflower (96.98) but it was on par with the preceding two treatments.

The overall influence of treatments (Tab. 17; Fig. 7) on coccinellid population indicated the lowest beetle population in NPK with seed treatment (39.49), while moderate number of beetles were observed in FYM (44.94), vermicompost (48.38) and neem cake (48.61) being on par. The treatments that followed were FYM + vermicompost, NPK + neem cake (49.52 each), NPK with NPV (49.94) and control (51.46) all being on par with preceding two treatments. NPK with sunflower recorded the highest population of beetles (54.97) among the treatments.

#### 4.1.2.2. Spiders

The spider population recorded during the three seasons indicated low population levels during *kharif*, 1995 (Appendix 7). The *kharif* crop recorded less than 25 spiders per 10 plants while it was around 50 per 10 plants during the two *rabi* seasons.

#### ***Kharif*, 1995**

Although spider population was low in *kharif* (Tab. 18; Fig. 8), the treatments showed differences in spider population. The lowest spider population was observed in neem cake (1.0 per 10 plants) and it was closely followed by NPK with seed treatment (1.3). The treatments that

remaining treatments recorded a mean population ranging between 14.66 and 28.91 per 10 plants.

During III stage evaluation (Tab. 16, Fig. 7) NPK with seed treatment once again recorded the lowest population (69.3) among the treatments. The treatments with higher number of beetles were vermicompost (82.15), FYM (83.85), NPK with NPV (84.5), NPK + neem cake (86), FYM + vermicompost (86.82), neem cake (91.6), and control (90.57) and all were on par. The highest population of beetles were recorded in NPK with sunflower (96.98) but it was on par with the preceding two treatments.

The overall influence of treatments (Tab. 17, Fig. 7) on coccinellid population indicated the lowest beetle population in NPK with seed treatment (39.49), while moderate number of beetles were observed in FYM (44.94), vermicompost (48.38) and neem cake (48.61) being on par. The treatments that followed were FYM + vermicompost, NPK + neem cake (49.52 each), NPK with NPV (49.94) and control (51.46) all being on par with preceding two treatments. NPK with sunflower recorded the highest population of beetles (54.97) among the treatments.

#### 4.1.2.2. Spiders

The spider population recorded during the three seasons indicated low population levels during *kharif*, 1995 (Appendix 7). The *kharif* crop recorded less than 25 spiders per 10 plants while it was around 50 per 10 plants during the two *rabi* seasons.

#### **Kharif, 1995**

Although spider population was low in *kharif* (Tab. 18, Fig. 8), the treatments showed differences in spider population. The lowest spider population was observed in neem cake (1.0 per 10 plants) and it was closely followed by NPK with seed treatment (1.3). The treatments that

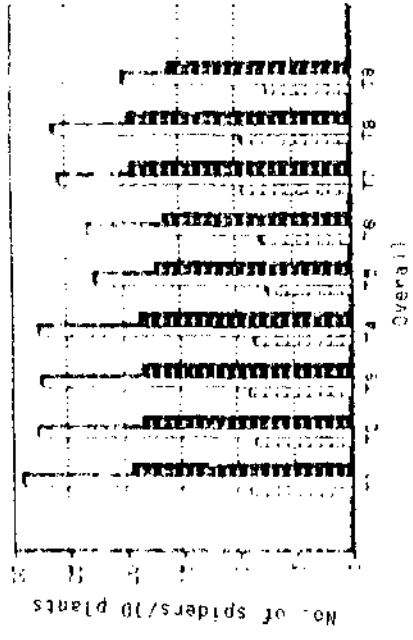
Tab. 18: Influence of treatments on spider population (adults / 10 plants) on groundnut.

Treatments	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
T <sub>1</sub> NPK (Control) @40-60-40 Kg ha <sup>-1</sup>	3.30 <sup>cd</sup> (2.08)	7.11C (2.85)	17.75 (4.53)	3.30 <sup>abc</sup> (2.06)	19.50 <sup>a</sup> (4.53)	42.50 (6.59)	3.30 (2.06)	12.83 <sup>a</sup> (3.79)	35.25 (6.01)
T <sub>2</sub> FYM @8t ha <sup>-1</sup>	3.30 <sup>cd</sup> (2.08)	7.44 <sup>cd</sup> (2.90)	16.83 (4.23)	2.00 <sup>abc</sup> (1.71)	19.08 <sup>c</sup> (4.48)	41.66 (6.53)	2.60 (1.88)	10.58 <sup>bc</sup> (3.39)	33.75 (5.89)
T <sub>3</sub> Vermicompost @3.75t ha <sup>-1</sup>	3.00 <sup>bc</sup> (1.98)	6.44 <sup>a</sup> (2.73)	17.83 (4.33)	3.00 <sup>abc</sup> (1.99)	17.83 <sup>a</sup> (4.34)	41.25 (6.50)	2.60 (1.90)	10.25 <sup>bc</sup> (3.34)	34.75 (6.00)
T <sub>4</sub> FYM @4t ha <sup>-1</sup> + Vermicompost @1.875t ha <sup>-1</sup>	2.30 <sup>bc</sup> (1.82)	6.77 <sup>a</sup> (2.79)	16.91 (4.23)	3.30 <sup>bc</sup> (2.08)	18.16 <sup>c</sup> (4.38)	40.00 (6.40)	3.66 (2.13)	11.33 <sup>bc</sup> (3.51)	36.58 (6.09)
T <sub>5</sub> Neem cake @770 Kg ha <sup>-1</sup>	1.00 <sup>a</sup> (1.41)	3.10 <sup>a</sup> (2.02)	16.41 (4.17)	1.00 <sup>a</sup> (1.41)	5.83 <sup>abc</sup> (2.58)	39.25 (6.34)	1.60 (1.55)	7.50 <sup>a</sup> (2.91)	33.25 (5.79)
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + Neem Cake @385 Kg ha <sup>-1</sup>	2.30 <sup>bc</sup> (1.82)	4.10 <sup>a</sup> (2.26)	16.75 (4.21)	1.30 <sup>bc</sup> (1.52)	6.50 <sup>a</sup> (2.74)	40.75 (6.46)	1.60 (1.55)	9.16 <sup>bc</sup> (3.19)	30.41 (5.57)
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @250LE ha <sup>-1</sup>	4.00 <sup>b</sup> (2.22)	8.44 <sup>b</sup> (3.01)	17.33 (4.28)	4.60 <sup>b</sup> (2.32)	17.33 <sup>a</sup> (4.28)	37.91 (6.24)	2.30 (1.82)	12.75 <sup>a</sup> (3.70)	34.56 (5.95)
T <sub>8</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with sunflower	3.30 (2.07)	7.33 <sup>cd</sup> (2.88)	18.08 (4.67)	4.60 <sup>b</sup> (2.30)	17.83 <sup>a</sup> (4.33)	36.75 (6.14)	4.20 (2.30)	12.50 <sup>b</sup> (3.67)	36.16 (6.10)
T <sub>9</sub> NPK @40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @250g Kg <sup>-1</sup> seed	1.30 <sup>ab</sup> (1.52)	2.66 <sup>a</sup> (1.91)	16.16 (4.14)	1.00 <sup>a</sup> (1.41)	4.91 <sup>a</sup> (2.42)	40.50 (6.43)	1.30 (1.52)	7.16 <sup>a</sup> (2.86)	31.75 (5.72)
F Test(P=0.05)	*	*	NS	*	*	NS	NS	*	NS
SEM	0.142	0.090	---	0.304	0.1466	---	---	0.201	---
CD	0.302	0.1912	---	0.646	0.310	---	---	0.4263	---

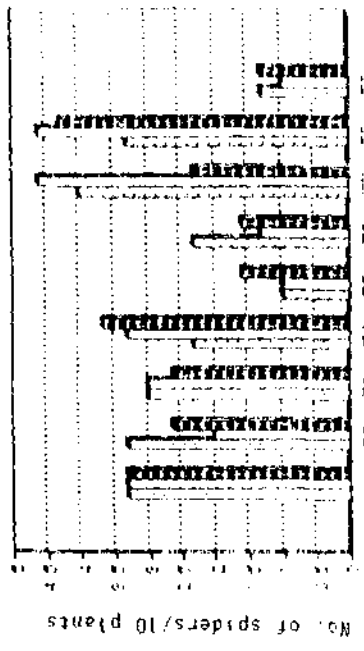
Means followed by same letters are not significantly different (P=0.05) by DMRT  
 Values in parentheses are (X+1)<sup>0.5</sup> transformed values.  
 NS - Non-significant  
 \* - Significant at 5% level



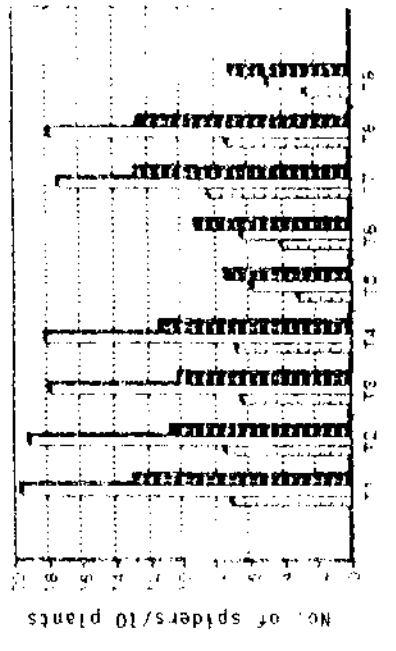
Stage III



Overall



Stage I



Stage II

Figure 8. Influence of treatments on the spider population on groundnut.

followed were FYM + vermicompost, NPK + neem cake, vermicompost, control, FYM and NPK with sunflower which recorded an average spider population ranging between 2.3 to 3.3 per 10 plants. The highest number of spiders was observed in NPK with NPV (4.0), among the treatments.

During stage II (Tab. 18; Fig. 8) the lowest population of spiders was recorded in NPK with seed treatment (2.66) but it was on par with neem cake (3.10). The treatments NPK + neem cake (4.10), vermicompost (6.44) FYM + vermicompost (6.77), control (7.11), NPK with sunflower (7.33) and FYM (7.44) recorded a moderate population. The highest population of spiders was recorded in NPK with NPV (8.44) but it was on par with the preceding two treatments.

Third stage evaluation of spider population (Tab. 18; Fig. 8) revealed no significant difference between the treatments. However, the lowest population was recorded in NPK with seed treatments (16.16) and the highest in NPK with sunflower (18.08).

The data pertaining to the overall spider population observed during *kharif*, 1995 (Tab. 19; Fig. 8) indicated that NPK with seed treatment recorded the lowest population (7.27) followed by neem cake (7.39) and NPK + neem cake (7.87) being on par. The treatments that followed were FYM (8.42), FYM + vermicompost (8.66), vermicompost (8.87), control (8.3), NPK with NPV (9.36) and NPK with sunflower (9.45).

#### **Rabi, 1994-95**

Very low levels of spiders were observed during stage I (Tab. 18, Fig. 8). The treatments that recorded low population density of spiders were NPK with seed treatment and neem cake (1.0 each), NPK + neem cake (1.3), FYM (2.0), vermicompost (3.0) and control (3.3)

**Tab. 19: Overall influence of treatments on spider population (adults / 10 plants) on groundnut.**

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	8.94 <sup>a</sup>	29.10 <sup>b</sup>	19.44
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	8.42 <sup>bc</sup>	27.80 <sup>cd</sup>	18.24
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	8.87 <sup>a</sup>	27.46 <sup>cd</sup>	18.30
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	8.67 <sup>a</sup>	27.60 <sup>cd</sup>	18.66
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	7.40 <sup>d</sup>	22.74 <sup>e</sup>	17.10
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	7.87 <sup>cd</sup>	23.25 <sup>e</sup>	16.44
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	9.36 <sup>a</sup>	25.77 <sup>e</sup>	19.30
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	9.45 <sup>a</sup>	26.24	19.55
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	7.27 <sup>d</sup>	19.96 <sup>e</sup>	16.02
F Test (P=0.05)	*	*	NS
SEm	0.53	1.14	---
CD	1.12	2.24	---

Means followed by same letters are not significantly different (P=0.05) by DMRT.

NS - Non-significant

\* - Significant at 5% level

all being on with each other. The treatments FYM + vermicompost (3.3), NPK with NPV (4.6) and NPK with sunflower (4.6) recorded higher levels of spider population among the treatments.

During stage II (Tab. 18; Fig. 8) NPK with seed treatment recorded the lowest spider population (4.91) followed by neem cake (5.83) being on par. The succeeding treatment NPK + neem cake (6.50), came closely behind and was also on par with neem cake. Higher population of spiders was observed in NPK with NPV (17.33), NPK with sunflower (17.83), vermicompost (17.83) FYM + vermicopost (18.16), FYM (19.08) and control (19.5), all being on par with each other and significantly different from the earlier three treatments.

During III stage (Tab. 18; Fig. 8), although the treatments recorded higher spider population, there was no significant difference. The spider population was lowest in NPK with sunflower (36.75 per 10 plants) and the highest in control (52.5). The other treatments with increasing population were NPK with NPV (37.91), neem cake (39.25), FYM + vermicompost (40.0), NPK with seed treatment (40.5), vermicompost (41.25), FYM(41.66) and control (42.5).

The overall spider population presented in Tab. 19 & Fig. 8 during *rabi* 94-95 revealed that NPK with seed treatment recorded significantly lowest spider population (19.96). The treatments that followed were neem cake (22.74) and NPK + neem cake (23.25). Significantly higher population of spiders were, however, observed in NPK with NPV (25.77), NPK with sunflower (26.24), vermicompost (27.46), FYM + vermicompost (27.6) and FYM (27.80) and all being on par. The highest population of spiders was noticed in control (29.1) but it was on par with the preceding three treatments.

**Rabi, 1995-96**

During stage I the population of spiders was much less and the treatmental variation was also insignificant (Tab. 18; Fig. 8). However, the lowest population was recorded in NPK with seed treatment (1.30) and the highest in NPK with sunflower (4.30).

Lowest population of spiders was observed during stage II (Tab. 18; Fig. 8) in NPK with seed treatment (7.16) and it was followed by neem cake (7.5), NPK + neem cake (9.16) all being on par with each other. A moderate level of population of spiders was recorded in vermicompost (10.25), FYM (10.58) and FYM + vermicompost (11.33). Higher population was noticed in NPK with sunflower (12.5), NPK with NPV (12.75) and control (12.83), all being on par.

During III stage (Tab. 18; Fig. 8) also the predator population between the treatments was non significant. However, higher number of spiders was observed in all the treatments. Among the treatments the lowest number of spiders was recorded in NPK + neem cake (30.41) and the highest in NPK with sunflower (36.16). The treatments within this range were NPK with seed treatment (31.75), neem cake (33.25), FYM (33.75), NPK with NPV (34.50), vermicompost (34.75), control (35.25), NPK with sunflower (36.16) and FYM + vermicompost (36.58).

The overall influence of treatments on spider population during the *rabi* 95-96 (Tab. 19; Fig. 8) revealed no significant difference among the treatments. However, the lowest number of spiders were recorded in NPK with seed treatment (16.02) and the highest in NPK with sunflower (19.55). The treatments in between in ascending order of spider population were NPK + neem cake (16.44), neem cake (17.1), FYM (18.24), vermicompost (18.30), FYM + vermicompost (18.66), NPK with NPV (19.3), control (19.44).

#### 4.1.2.3. Chrysopids

The data pertaining to chrysopids indicated that the population was very low in all the treatments during the three seasons under study (Appendix 8) and the population counts were also not significantly different among the treatments (Tab. 20 & 21; Fig. 9).

##### ***Kharif, 1995***

During stage I, the treatments viz., vermicompost, NPK with NPV and NPK with seed treatment recorded zero population of chrysopids and almost negligible numbers were recorded in the remaining treatments. During stage II evaluation, the lowest population was recorded in vermicompost (2.55 per 10 plants) and the highest in NPK with sunflower (3.88). During III stage as well, the lowest population was recorded in FYM + vermicompost (5.5) and the highest in NPK with NPV (6.55) (Tab. 20; Fig. 9)

The overall influence of treatments on chrysopids indicated the presence of very low population density in all the treatments which ranged between 2.75 and 3.42 per 10 plants (Tab. 21; Fig. 9)

##### ***Rabi, 1994-95***

Comparatively higher population of chrysopids were observed in *rabi* than in *kharif* crop. But the treatments showed no significant variation during all the stages of evaluation (Tab. 20; Fig. 9). During stage I the lowest population was recorded in NPK with seed treatment (1.0) and the highest in FYM (3.0). During the stage II as well, NPK with seed treatment recorded lowest chrysopid population (5.16) and the highest in vermicompost (6.75).

The chrysopid population evaluated during stage III (Tab. 20; Fig. 9) among the treatments was also non significant but the population was higher when compared to stage II

Tab. 20: Influence of treatments on chrysoiid population (adults / 10 plants) on groundnut

Treatments	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
T <sub>1</sub> NPK (Control) @40-60-40 Kg ha <sup>-1</sup>	0.30 (1.13)	2.99 (1.99)	6.08 (2.65)	2.00 (1.72)	6.33 (2.71)	18.91 (4.46)	1.30 (1.52)	5.75 (2.59)	12.08 (3.61)
T <sub>2</sub> FYM @8t ha <sup>-1</sup>	0.30 (1.13)	2.66 (1.91)	6.50 (2.56)	3.00 (1.99)	6.00 (2.64)	19.58 (4.53)	0.30 (1.14)	6.08 (2.66)	12.45 (3.66)
T <sub>3</sub> Vermicompost @3.75t ha <sup>-1</sup>	0.00 (1.00)	2.55 (1.87)	6.00 (2.64)	2.60 (1.90)	6.75 (2.78)	19.33 (4.51)	0.66 (1.28)	5.92 (2.62)	11.15 (3.48)
T <sub>4</sub> FYM @4t ha <sup>-1</sup> + Vermicompost @1.875t ha <sup>-1</sup>	0.30 (1.13)	3.11 (2.02)	5.50 (2.55)	2.30 (1.80)	6.17 (2.67)	20.16 (4.60)	0.66 (1.28)	5.75 (2.60)	11.57 (3.54)
T <sub>5</sub> Neem cake @770 Kg ha <sup>-1</sup>	0.30 (1.13)	3.32 (2.07)	6.16 (2.66)	2.90 (1.75)	6.58 (2.75)	18.75 (4.42)	0.66 (1.28)	5.58 (2.56)	11.25 (3.50)
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + Neem Cake @385 Kg ha <sup>-1</sup>	0.30 (1.13)	2.89 (1.95)	5.86 (2.62)	1.60 (1.58)	6.58 (2.70)	18.16 (4.37)	1.00 (1.41)	5.75 (2.59)	11.33 (3.51)
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @250LE ha <sup>-1</sup>	0.00 (1.00)	3.11 (2.01)	6.55 (2.75)	1.30 (1.52)	6.00 (2.65)	18.98 (4.36)	0.66 (1.23)	5.42 (2.52)	11.41 (3.52)
T <sub>8</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with sunflower	1.60 (1.57)	3.86 (2.20)	6.16 (2.65)	2.30 (1.82)	5.92 (2.63)	19.66 (4.54)	1.00 (1.41)	5.75 (2.59)	11.08 (3.48)
T <sub>9</sub> NPK @40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @250g Kg <sup>-1</sup> seed	0.00 (1.00)	3.11 <sup>a</sup> (2.02)	5.75 <sup>a</sup> (2.60)	1.00 (1.41)	5.17 (2.48)	18.83 (4.45)	0.66 (1.28)	5.25 (2.50)	13.41 (3.80)
F Test(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEM	---	---	---	---	---	---	---	0.17	0.14
CD	---	---	---	---	---	---	---	0.00	0.00

Values in parentheses are (X+1)<sup>1/2</sup> transformed values.

NS - Non-significant

Tab. 21: Overall influence of treatments on chrysopid population (adults / 10 plants) on groundnut.

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	3.06	11.83	7.61
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	3.12	11.94	7.80
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	2.87	11.80	7.21
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	2.90	11.61	7.10
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	3.18	11.35	7.55
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	2.75	11.80	7.58
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	3.02	11.55	7.08
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	3.42	11.66	7.19
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	2.93	10.44	7.69
F Test (P=0.05)	NS	NS	NS
SEm	0.00	0.00	0.00
CD	0.00	0.00	0.00

NS - Non-significant

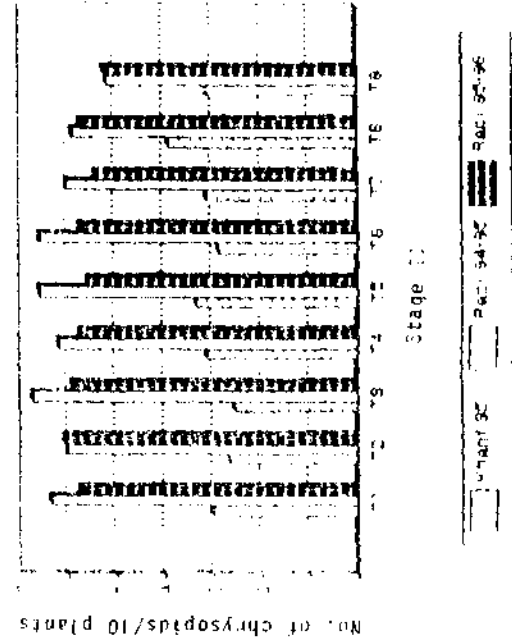
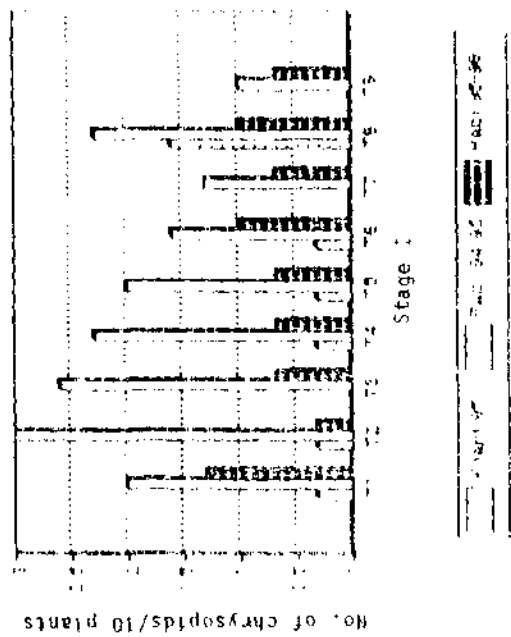
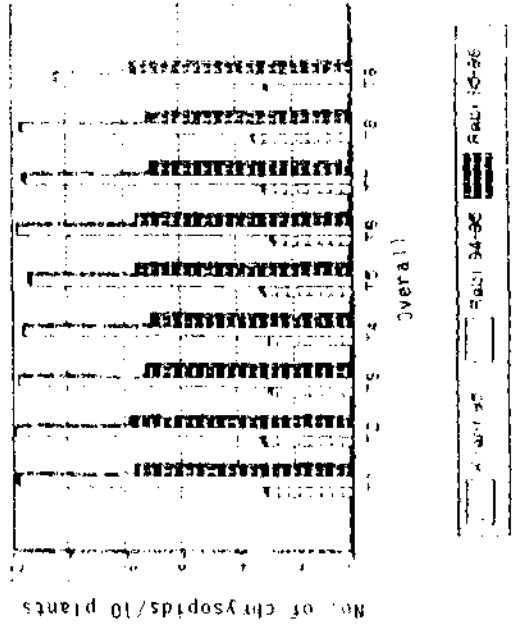
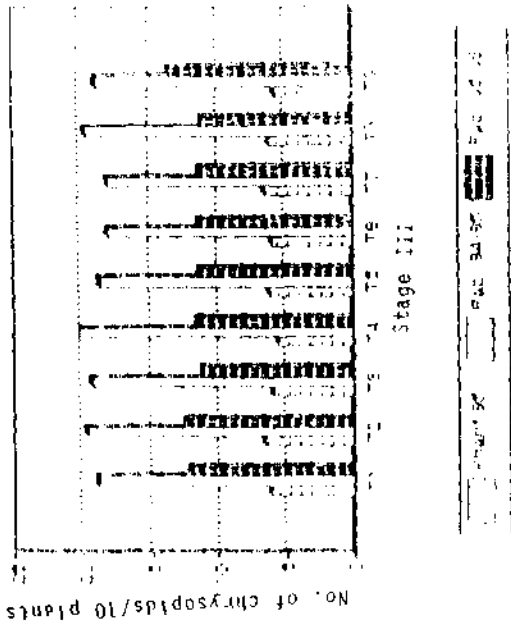


Figure 9. Influence of treatments on the chrysoptid population on groundnut.

However, the lowest population was recorded in NPK with NPV (18.08) and the highest, 20.16 per 10 plants, in FYM + vermicompost. The population of chrysopids in the remaining treatments in ascending order was NPK + neem cake (18.16), neem cake (18.75), NPK with seed treatment (18.83), control (18.91), vermicompost (19.23), FYM (19.58) and NPK with sunflower (19.66).

The overall influence of treatments (Tab. 21, Fig. 9) on chrysopid population indicated that all the treatments recorded a population ranging between 10 to 12 per 10 plants and all were on par with each other.

#### **Rabi, 1995-96**

During the second *rabi* crop as well the population of chrysopids recorded in different treatments was insignificant during all the stages of evaluation. The population observed during stage I and stage II, ranged between 5.25 to 6.08 chrysopids per 10 plants in all the treatments. Among the treatments in stage III lowest population was noticed in NPK with seed sunflower (11.08) and the highest in NPK with seed treatment (13.41) (Tab. 20; Fig. 9).

The overall chrysopid population during *rabi* 1995-96 indicated that all the treatments were on par pertaining to the chrysopid population with a mean population ranging between 7.08 and 7.80 per 10 plants (Tab. 21; Fig. 9).

#### **4.2. INFLUENCE OF TREATMENTS ON BIOCHEMICAL CONSTITUENTS OF GROUNDNUT LEAVES**

The influence of treatments on the biochemical constituents of leaves viz. nitrogen (N), crude protein (CP), total free amino acids (TFAA), carbohydrates, phenols and tannins estimated at the three different stages of crop growth viz. flowering period (21 DAS, I stage), peg penetration (49 DAS, II stage) and pod formation (77 DAS, III stage) are presented season wise in Tables 22 to 33 and Figures 10 to 15.

#### 4.2.1. Nitrogen (N)

##### *Kharif, 1995*

The treatments showed significant difference in the nitrogen content of leaves during I and II stages. The data (Tab. 22, Fig. 10) revealed that the nitrogen content decreased from stage I to III in all the treatments indicating higher content of nitrogen in leaves during flowering stage. Among the treatments, during stage I, neem cake recorded significantly lower quantity of nitrogen (3.07%) followed by FYM (3.20%) being on par with each other. FYM was also on par with its succeeding treatment, vermicompost (3.26%). Among the remaining treatments, FYM + vermicompost (3.53%), NPK + neem cake (3.69%) and control (3.70%) recorded higher content of nitrogen in leaves and were on par. The other straight fertilized treatments NPK with NPV (4.03%), NPK with seed treatment (4.26%) and NPK with sunflower (4.49%) recorded still higher levels of nitrogen than the organically manured treatments.

During stage II (Tab. 22; Fig. 10) the lowest nitrogen content of leaves was once again recorded in neem cake (2.24%). The treatments that followed were FYM (2.67%), vermicompost (2.74%), NPK + neem cake (2.74%), FYM + vermicompost (2.86%), NPK with NPV (2.90%), NPK with seed treatment (2.90%), NPK with sunflower (2.91%) and control (3.02%).

During stage III, there was no significant difference in nitrogen content of leaves in different treatments and its range varied between 1.86% (FYM + vermicompost) and 2.3% (NPK with NPV) (Tab. 22; Fig. 10)

The overall influence of treatments (Tab. 23; Fig. 10) showed that the lowest nitrogen content of leaves was recorded in neem cake (2.61%) followed by FYM (2.65%), vermicompost (2.73%) and FYM + vermicompost (2.75%) being on par with each other. The next treatments

Tab. 22: Influence of treatments on nitrogen content (%) of groundnut leaves.

Treatments	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	3.70 <sup>a</sup>	3.02 <sup>a</sup>	2.33	3.26 <sup>a</sup>	4.48 <sup>a</sup>	2.56 <sup>cd</sup>	3.52 <sup>a</sup>	4.29 <sup>ab</sup>	3.58 <sup>ab</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	3.20 <sup>cd</sup>	2.97 <sup>bc</sup>	2.30	3.94 <sup>abc</sup>	3.37 <sup>a</sup>	2.23 <sup>de</sup>	4.26 <sup>a</sup>	3.58 <sup>ab</sup>	3.29 <sup>bc</sup>
T <sub>3</sub> Vermicompost @ 2.75t ha <sup>-1</sup>	3.26 <sup>b</sup>	2.74 <sup>bc</sup>	2.30	4.09 <sup>ab</sup>	3.70 <sup>bc</sup>	2.56 <sup>de</sup>	3.60 <sup>a</sup>	3.81 <sup>a</sup>	3.01 <sup>c</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	3.53 <sup>b</sup>	2.86 <sup>bc</sup>	1.86	4.48 <sup>ab</sup>	3.87 <sup>abc</sup>	2.16 <sup>f</sup>	4.20 <sup>a</sup>	3.60 <sup>a</sup>	3.17 <sup>bc</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	3.07 <sup>cd</sup>	2.24 <sup>d</sup>	2.20	3.02 <sup>c</sup>	3.33 <sup>a</sup>	2.33 <sup>de</sup>	3.70 <sup>a</sup>	3.92 <sup>a</sup>	3.21 <sup>bc</sup>
T <sub>6</sub> NPK @ 20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	3.60 <sup>b</sup>	2.74 <sup>bc</sup>	2.33	3.91 <sup>ab</sup>	3.66 <sup>bc</sup>	2.80 <sup>c</sup>	3.70 <sup>a</sup>	3.73 <sup>ab</sup>	3.40 <sup>bc</sup>
T <sub>7</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	3.63 <sup>b</sup>	2.90 <sup>bc</sup>	2.33	4.08 <sup>ab</sup>	4.11 <sup>a</sup>	2.73 <sup>d</sup>	3.91 <sup>a</sup>	4.34 <sup>a</sup>	3.43 <sup>bc</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	4.40 <sup>a</sup>	2.91 <sup>bc</sup>	2.15	4.76 <sup>ab</sup>	4.26 <sup>a</sup>	2.40 <sup>d</sup>	4.73 <sup>a</sup>	4.15 <sup>a</sup>	3.90 <sup>bc</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	4.26 <sup>a</sup>	2.90 <sup>bc</sup>	2.06	4.91 <sup>a</sup>	3.95 <sup>a</sup>	2.36 <sup>de</sup>	5.05 <sup>a</sup>	4.16 <sup>a</sup>	3.44 <sup>bc</sup>
F Test (P=0.05)	*	*	NS	*	*	*	*	*	*
SEM	0.0829	0.156	---	0.225	0.125	0.107	0.166	0.110	0.084
CD	0.1750	0.331	---	0.500	0.260	0.227	0.352	0.234	0.179

Means followed by same letters are not significantly different (P=0.05) by DMRT  
 NS - Non-significant  
 \* - Significant at 5% level

Tab. 23: Overall influence of treatments on nitrogen content (%) of groundnut leaves.

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	2.955 <sup>a</sup>	4.103 <sup>d</sup>	4.464 <sup>c</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	2.650 <sup>a</sup>	3.168 <sup>b</sup>	3.088 <sup>d-e-d</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	2.737 <sup>d</sup>	3.526 <sup>bc</sup>	3.475 <sup>c</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	2.750 <sup>d</sup>	3.506 <sup>bc</sup>	3.687 <sup>bc</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	2.617 <sup>c</sup>	3.031 <sup>a</sup>	3.637 <sup>bc</sup>
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	2.854 <sup>d</sup>	3.4567 <sup>bc</sup>	3.702 <sup>cd</sup>
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	3.08 <sup>c</sup>	4.053 <sup>d</sup>	4.286 <sup>bc</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	3.182	3.810 <sup>bc-d</sup>	4.183 <sup>cd</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	3.406 <sup>bc</sup>	3.752 <sup>bc-d</sup>	4.216 <sup>bc</sup>
F Test (P=0.05)	*	*	*
SE <sub>err</sub>	0.081	0.254	0.2579
CD	0.1718	0.5385	0.5469

Means followed by same letters are not significantly different (P=0.05) by DMRT

\* Significant at 5% level

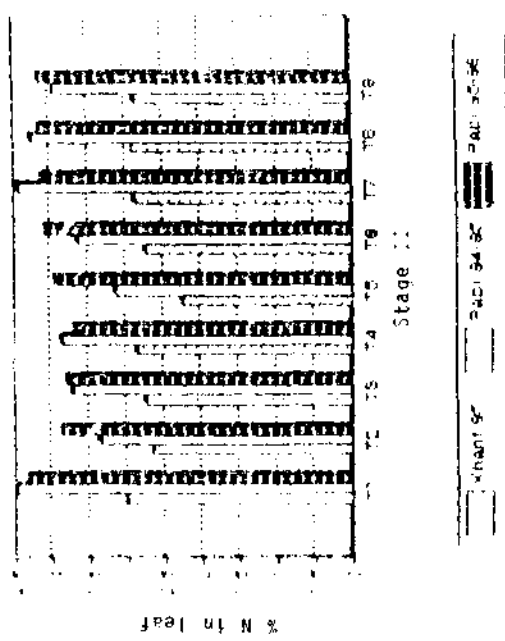
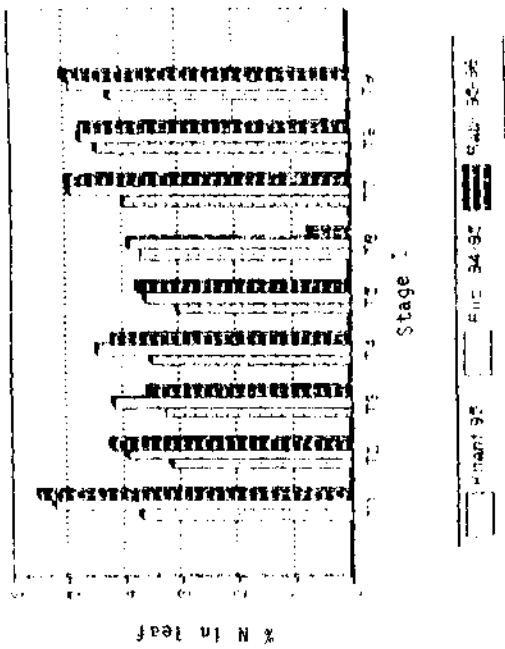
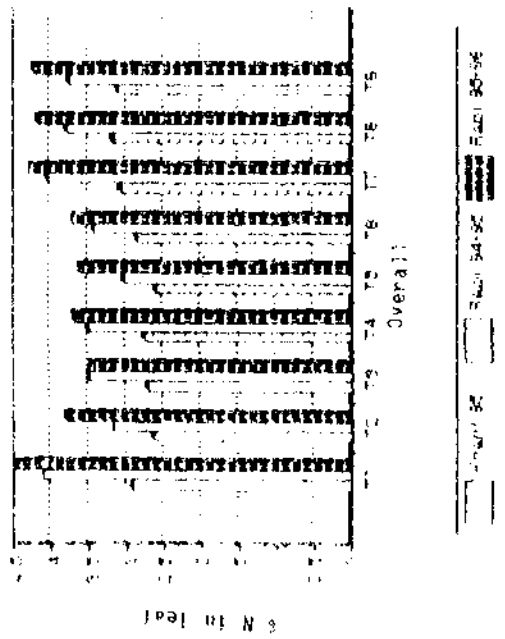
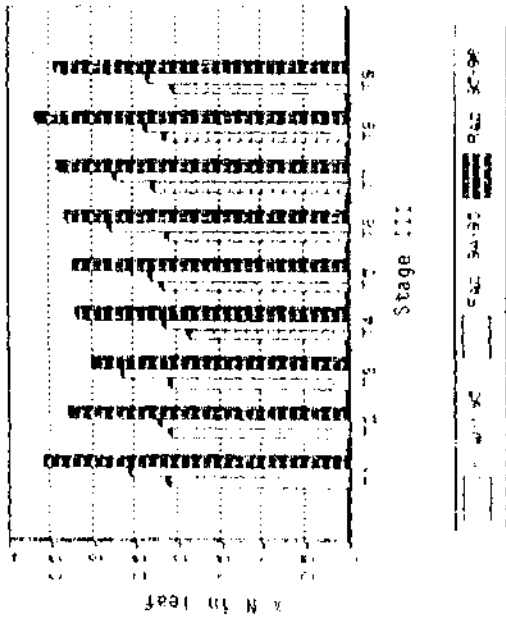


Figure 10. Influence of treatments on the nitrogen content (%) of groundnut leaves.

in the ascending order of N content of leaves were NPK + neem cake (2.85%) and control (2.95%). Among the treatments the N content of leaves was higher in NPK with NPV (3.08%), NPK with seed treatment (3.10%) and NPK with sunflower (3.18%), all being on par with one another.

#### **Rabi, 1994-95**

The organically manured treatments during stage I (Tab. 22; Fig. 10) recorded lower N content of leaves than the treatments which received straight fertilizers. The lowest N content of leaves was seen in neem cake (3.63%) and it was followed by NPK + neem cake (3.91%), FYM (3.94%), all being on par. The treatments vermicompost (4.19%), FYM + vermicompost (4.48%) recorded the next higher levels of N and were also on par. Among the treatments, the straight fertilized treatments viz. NPK with sunflower (4.76%), NPK with seed treatment (4.96%), NPK with NPV (4.98%) and control (5.26%) recorded higher levels of N content in the leaves, all being on par.

Significantly lower amounts of N content in the leaves was noticed during stage II (Tab. 22; Fig. 10) in neem cake (3.13%) and FYM (3.37%) and were also on par. NPK + neem cake (3.66%), vermicompost (3.72%), FYM + vermicompost (3.87%) followed the earlier treatments and were on par with each other. NPK with seed treatment recorded 3.95% N content in leaves. Once again the straight fertilized treatments, NPK with sunflower (4.26%), NPK with NPV (4.43%) and control (4.48%) recorded significantly higher N content of leaves, all being on par with each other.

During the third stage there was no clear distinction between straight fertilized and organically manured treatments with regard to N content of leaves (Tab. 22; Fig. 10). Among the treatments, lowest leaf N was recorded in FYM + vermicompost (2.16%) followed by FYM

(2.23%), neem cake (2.33%) and NPK with seed treatment (2.36%). The treatments that followed were NPK with sunflower (2.40%), control (2.56%), vermicompost (2.66%) and NPK with NPV (2.73%) which recorded slightly higher levels of N content of leaves. The highest N was recorded in NPK + neem cake (2.80%)

The overall influence of treatments (Tab. 23, Fig. 10) on N content of the leaves showed lower levels in neem cake (3.03%) and FYM (3.16%) followed by NPK + neem cake (3.45%), FYM + vermicompost (3.50%) and vermicompost (3.52%) all being on par. Higher N content of leaves was recorded in NPK with seed treatment (3.75%), NPK with sunflower (3.81%), NPK with NPV (4.05%) and control (4.10%), all being on par

#### **Rabi, 1995-96**

The N content of leaves decreased from stage I to stage III (Tab. 22; Fig. 10) as observed in the earlier two seasons. Lower amount of leaf N was recorded in vermicompost (3.6%), NPK + neem cake (3.70%) and neem cake (3.78%) all being on par during stage I. Moderate levels of leaf N was seen in FYM + vermicompost (4.2%) and FYM (4.26%). Significantly higher levels of N content in leaves was seen in straight fertilizer treatments viz. NPK with sunflower (4.74%), NPK with NPV (5.01%), and NPK with seed treatment (5.05%). The highest leaf N was observed in control (5.52%), among the treatments

During II stage as well (Tab. 22; Fig. 10) all the organically manured treatments recorded lower levels of leaf N with an average ranging between 3.69% and 4.10% than the straight fertilized treatments with an average ranging between 4.15% and 4.44%. FYM + vermicompost (3.69%), vermicompost (3.81%), FYM (3.88%) and neem cake (3.92%) recorded lower levels of N content and all were on par with each other. Moderate level of N was noticed in NPK + neem

cake (4.10%) while comparatively higher amount of N content was recorded in NPK with sunflower (4.15%), NPK with seed treatment (4.16%), control (4.29%) and NPK with NPV (4.44%), among the treatments

During III stage, the lowest leaf N was noticed in vermicompost (3.01%) and was closely followed by FYM + vermicompost (3.17) the two being on par. The treatments that followed were neem cake (3.21%), FYM (3.28%), NPK + neem cake (3.30%), NPK with NPV (3.41%) and NPK with seed treatment (3.44%). Among the treatments control (3.58%) and NPK with sunflower (3.66%) were on par and recorded comparatively much higher N content in the leaves (Tab. 22; Fig. 10).

The overall influence of treatments on N content of leaves (Tab. 23; Fig. 10) revealed that the treatments which received organic manures recorded lower amounts of N content in the leaves than those that received straight fertilizers. The lowest leaf N was seen in vermicompost (3.47%) and was closely followed by neem cake (3.63%), FYM + vermicompost (3.68%), NPK + neem cake (3.70%) and FYM (3.80%) all being on par. Higher amounts of N content in leaves among the treatments was recorded in NPK with sunflower (4.18%), NPK with seed treatment (4.21%), NPK with NPV (4.28%) and control (4.46%)

#### **4.2.2. Crude Protein (CP)**

##### ***Kharif, 1995***

The treatments showed significant difference in the crude protein (CP) levels in leaves during I and II stages and no such significant variation was observed during III stage. The data (Tab. 24; Fig. 11) revealed that the CP content decreased from stage I to III in all the treatments indicating that higher content of CP present in leaves during flowering stage. Among the treatments during stage I, neem cake recorded significantly lower quantity of CP content

Tab. 24: Influence of treatments on crude protein content (%) of groundnut leaves.

Treatments	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
	T <sub>0</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	20.25 <sup>a</sup>	16.52 <sup>a</sup>	11.65	28.75 <sup>a</sup>	24.47 <sup>a</sup>	15.98 <sup>ab</sup>	30.14 <sup>a</sup>	23.43 <sup>ab</sup>
T <sub>1</sub> FYM @ 8t ha <sup>-1</sup>	17.50 <sup>ab</sup>	14.57 <sup>a</sup>	11.47	21.54 <sup>abc</sup>	18.41 <sup>a</sup>	12.18 <sup>ab</sup>	23.26 <sup>a</sup>	21.18 <sup>ab</sup>	17.24 <sup>a</sup>
T <sub>2</sub> Vermicompost @ 5.75t ha <sup>-1</sup>	17.85 <sup>a</sup>	14.99 <sup>ab</sup>	11.47	22.89 <sup>ab</sup>	20.54 <sup>ab</sup>	14.52 <sup>abc</sup>	19.66 <sup>a</sup>	20.80 <sup>a</sup>	16.47 <sup>ab</sup>
T <sub>3</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	19.29 <sup>a</sup>	15.61 <sup>ab</sup>	10.16	24.49 <sup>ab</sup>	20.65 <sup>ab</sup>	11.79 <sup>a</sup>	22.92 <sup>a</sup>	20.14 <sup>a</sup>	17.32 <sup>ab</sup>
T <sub>4</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	16.77 <sup>a</sup>	12.23 <sup>a</sup>	12.01	19.84 <sup>a</sup>	17.08 <sup>a</sup>	12.72 <sup>ab</sup>	20.64 <sup>a</sup>	21.40 <sup>abc</sup>	17.54
T <sub>5</sub> NPK @ 20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	20.14 <sup>a</sup>	14.90 <sup>ab</sup>	11.63	21.36 <sup>ab</sup>	19.98 <sup>a</sup>	15.29 <sup>a</sup>	20.20 <sup>a</sup>	22.38 <sup>abc</sup>	18.05 <sup>a</sup>
T <sub>6</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	22.02 <sup>a</sup>	15.86 <sup>ab</sup>	12.56	27.22 <sup>ab</sup>	24.25 <sup>a</sup>	14.90 <sup>ab</sup>	27.30 <sup>a</sup>	24.24 <sup>a</sup>	18.67 <sup>a</sup>
T <sub>7</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	24.53 <sup>a</sup>	15.90 <sup>ab</sup>	11.74	26.02 <sup>ab</sup>	23.29 <sup>a</sup>	13.10 <sup>bc</sup>	25.88 <sup>a</sup>	22.63 <sup>ab</sup>	19.98 <sup>a</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	25.29 <sup>a</sup>	15.83 <sup>ab</sup>	12.25	27.00 <sup>ab</sup>	21.56 <sup>a</sup>	12.88 <sup>abc</sup>	27.57 <sup>a</sup>	22.71 <sup>a</sup>	18.81 <sup>ab</sup>
F Test (P=0.05)	*	*	NS	*	*	*	*	*	*
SEm	0.452	0.851	0.001	1.39	0.685	0.585	0.906	0.601	0.463
CD	0.959	1.806	0.001	2.948	1.452	1.242	1.921	1.277	0.977

Means followed by same letters are not significantly different (P=0.05) by DMRT  
 NS - Non-significant  
 \* - Significant at 5% level

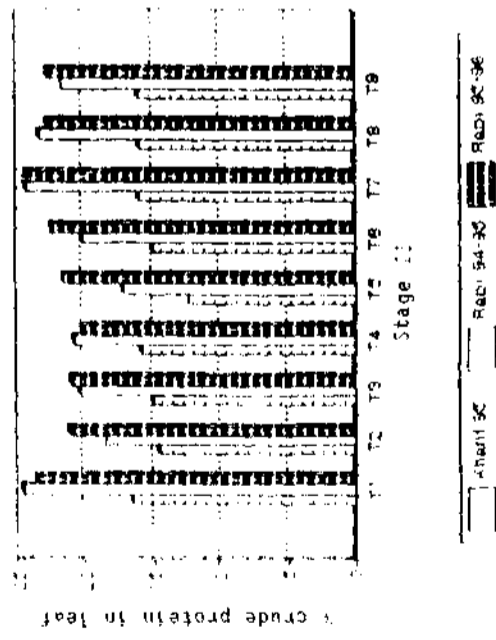
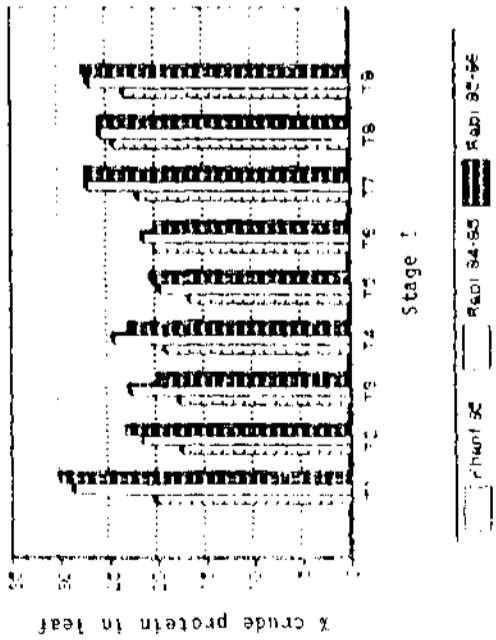
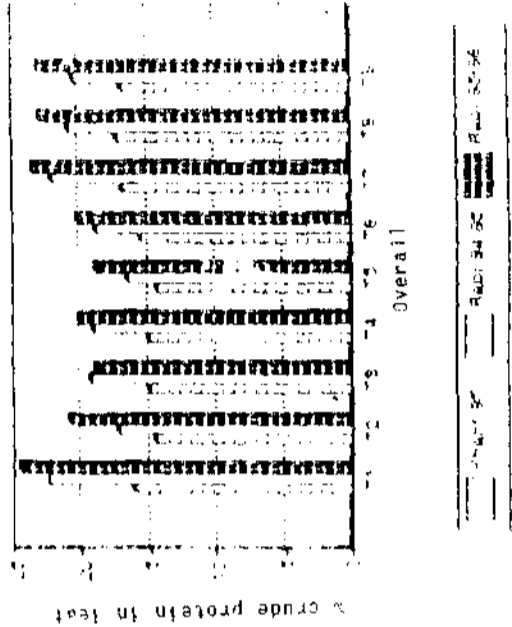
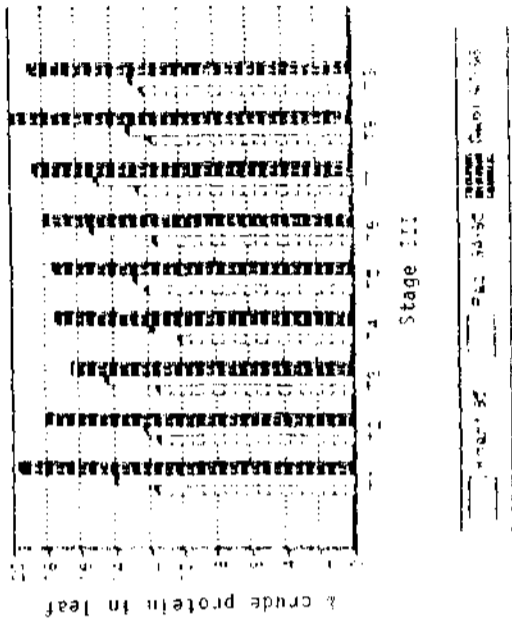


Figure 11. Influence of treatments on the crude protein content (%) of groundnut leaves.

(16.77%) followed by FYM (17.50%) which were on par with each other. FYM was also on par with its succeeding treatment vermicompost (17.83%). Among the remaining treatments, FYM + vermicompost (19.29%), NPK + neem cake (20.14%), control (20.23%) recorded higher levels of CP and on par. The other straight fertilized treatments viz NPK with NPV (22.02%), NPK with seed treatment (23.29%) and NPK with sunflower (24.53%) recorded higher CP content among the treatments.

During stage II (Tab. 24; Fig. 11), the lowest CP content of leaves was once again recorded in neem cake received plot (12.23%). The treatments that followed were FYM (14.57%), vermicompost (14.99%), NPK + neem cake (14.99%), FYM + vermicompost (15.61%), NPK with seed treatment (15.83%), NPK with sunflower (15.90%) and control (16.52%)

During stage III, there was no significant difference in CP content in leaves in different treatments and its range varied between 10.16% (FYM + vermicompost) and 12.56% (NPK with NPV) and do not follow a trend (Tab. 24; Fig. 11)

The overall influence of treatments (Tab.25; Fig. 11) showed that the lowest CP content of leaves was recorded in neem cake (14.28%) followed by FYM (14.51%), vermicompost (14.94%) and FYM + vermicompost (15.01%) being on par with each other. The treatments in the ascending order of CP content of leaves were NPK + neem cake (15.58%), control (16.13%) Among the treatments the CP content of leaves was higher in NPK with NPV (16.8%), NPK with seed treatment (16.95%) and NPK with sunflower (17.37%) all being on par with each other

#### **Rabi, 1994-95**

The organically manured treatments, during stage I (Tab. 24; Fig. 11) recorded lower CP content in leaves than the treatments which received straight fertilizers. The lowest CP content

**Tab. 25: Overall influence of treatments on crude protein content (%) of groundnut leaves.**

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	16.13 <sup>cd</sup>	22.40 <sup>d</sup>	24.37 <sup>c</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	14.51	17.29 <sup>c</sup>	20.79 <sup>abcd</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	14.94 <sup>bc</sup>	19.25 <sup>bc</sup>	18.97 <sup>a</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	15.61 <sup>d</sup>	19.14 <sup>bc</sup>	20.13 <sup>ab</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	14.28 <sup>c</sup>	16.54 <sup>c</sup>	19.85 <sup>bc</sup>
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	15.58 <sup>d</sup>	18.87 <sup>bc</sup>	20.21 <sup>bc</sup>
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	16.81 <sup>bc</sup>	22.12 <sup>cd</sup>	23.40 <sup>b</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	17.37 <sup>c</sup>	20.80 <sup>bcd</sup>	22.83 <sup>cd</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	16.95 <sup>bc</sup>	20.48 <sup>bcd</sup>	23.01 <sup>cd</sup>
F Test (P=0.05)	*	*	*
SEm	0.442	1.386	1.4081
CD	0.938	2.94	2.986

Means followed by same letters are not significantly different (P=0.05) by DMRT

\* - Significant at 5% level

was seen in neem cake (19.84%) followed by NPK + neem cake (21.36%), FYM (21.54%) all being on par. The treatments vermicompost (22.89%), FYM + vermicompost recorded the next higher levels of CP and were also on par. Among the treatments, straight fertilized treatments viz. NPK with sunflower (26.02%), NPK with seed treatment (27.0%), NPK with NPV (27.22%) and control (28.75%) recorded higher levels of CP content in the leaves and all being on par.

During II stage (Tab. 24, Fig. 11), significantly lower amounts of leaf CP was noticed in neem cake (17.08%) and FYM (18.41%) applied treatments and were on par. The treatments, NPK + neem cake (19.98%), vermicompost (20.34%), FYM + Vermicompost (20.65%) and NPK with seed treatment (21.56%) followed the trend and were on par with each other. Among the treatments, NPK with sunflower (23.29%) and control (24.47%) recorded significantly higher CP content in leaves and all were on par with each other.

During third stage, there was no clear distinction between straight fertilized and organically manured treatments with regard to CP content of leaves (Tab 24; Fig 11). Among the treatments, lowest CP was recorded in FYM + vermicompost (11.79%) followed by FYM (12.18%), neem cake (12.72%) and NPK with seed treatment (12.88%). The treatments that followed were NPK with sunflower (13.10%), control (13.98%), vermicompost (14.52%) and NPK with NPV (14.9%) recorded higher levels of CP content. The highest CP was observed in NPK + neem cake treatment (15.29%).

The overall influence of treatments (Tab. 25, Fig. 11) on CP content of leaves showed that lower levels were recorded in neem cake (16.54%) and FYM (17.29%) followed by NPK + neem cake (18.87%), FYM + vermicompost (19.14%) and vermicompost (19.25%) all being on par. Higher levels of CP content in leaves was recorded in NPK with seed treatment (20.48%), NPK with sunflower (20.8%), NPK with NPV (22.12%) and control (22.4%) all being on par.

**Rabi, 1995-96**

The CP content of leaves was decreased from stage I to III (Tab. 24, Fig. 11) as observed in the two earlier seasons. Lower amounts of CP was recorded in vermicompost (19.66%), NPK + neem cake (20.2%) and neem cake (20.64%) all being on par during stage I. Moderate levels of CP content of leaves was seen in FYM + vermicompost (22.93%) and FYM (23.26%). Significantly higher levels of CP content was seen in straight fertilized treatments viz. NPK with sunflower (25.88%), NPK with seed treatment (27.57%). The highest CP content was recorded in control (30.14%) among the treatments.

During II stage as well (Tab. 24, Fig. 11), all the organically manured treatments recorded lower levels of CP content of leaves (ranging between 20.14% to 22.38%) than the treatments which received straight fertilizers (22.65% to 24.24%). FYM + vermicompost (20.8%), FYM (21.18%) and neem cake (21.4%) recorded comparatively lower levels of CP and all being on par with each other. Moderate levels of CP among the treatments was seen in NPK + neem cake (22.38%), while comparatively higher amount of CP was recorded in NPK with sunflower (22.65%), NPK with seed treatment (22.7%), control (23.43%) and NPK with NPV (24.24%).

During III stage (Tab. 24, Fig. 11), the lowest CP was noticed in vermicompost (16.47%) and was closely followed by FYM + vermicompost (17.32%) the two being on par. The treatments that followed were neem cake (17.54%), FYM (17.94%), NPK + neem cake (18.05%), NPK with NPV (18.63%) and NPK with seed treatment (18.64%). Among the treatments, control (19.54%) and NPK with sunflower (19.98%) being on par and recorded comparatively much higher CP content in the leaves.

The overall influence of treatments on the CP content of leaves (Tab. 25, Fig. 11) revealed that the treatments which received organic manures recorded lower amounts of CP content in the leaves than those that received straight fertilizers. The lowest CP content was recorded in vermicompost (18.97%) and was closely followed by neem cake (19.85%), FYM + vermicompost (20.13%), NPK + neem cake (20.21%) and FYM (20.79%) and all were on par. Higher amounts of CP was, however, recorded in NPK with sunflower (22.83%), NPK with seed treatment (20.01%), NPK with NPV (23.40%) and control (24.37%).

#### 4.2.3. Total free amino acids (TFAA)

##### *Kharif, 1995*

The total free amino acid content present in leaves at 21 DAS of groundnut crop is presented in Tab. 26 and Fig. 12. The data revealed that the lowest quantity of TFAA content was recorded in neem cake (1.47 mg g<sup>-1</sup> fresh leaf) followed by FYM (1.52 mg) and vermicompost (1.52 mg) being on par with each other. The treatments that followed were FYM + vermicompost (1.67 mg), NPK + neem cake (1.74 mg), NPK with NPV (1.74 mg), NPK with seed treatment (1.91 mg) and NPK with sunflower (1.93 mg) being significantly different from control (2.31 mg) which recorded the highest TFAA.

The TFAA content in groundnut leaves estimated at 49 DAS (Tab. 26, Fig. 12) were on higher side when compared to 21 DAS. However, among the treatments, lower amounts were recorded in neem cake (2.41 mg g<sup>-1</sup> fresh leaf) followed by FYM (2.44 mg), FYM + vermicompost (2.58 mg), vermicompost (2.47 mg) and NPK + neem cake (2.58 mg) all being on par. Higher amount of TFAA content was recorded in straight fertilized treatments viz. NPK with seed treatment (2.84 mg), NPK with NPV (2.98 mg), control (3.11 mg) and NPK with sunflower (3.24 mg) and were on par with each other.

Tab. 26: Influence of treatments on the levels of total free amino acids (TFAA) (mg g<sup>-1</sup> fresh leaves) in groundnut.

Treatments	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	2.31 <sup>a</sup>	3.11 <sup>a</sup>	1.07	3.23 <sup>a</sup>	2.58 <sup>ab</sup>	0.62 <sup>bc</sup>	2.75 <sup>cd</sup>	3.86 <sup>h</sup>	1.26
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	1.52 <sup>ab</sup>	2.44 <sup>ab</sup>	0.75 <sup>b</sup>	1.70 <sup>a</sup>	2.00 <sup>b</sup>	0.198 <sup>a</sup>	1.92 <sup>b</sup>	2.30 <sup>f</sup>	1.13
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	1.52 <sup>ab</sup>	2.58 <sup>ab</sup>	0.75 <sup>b</sup>	1.53 <sup>a</sup>	2.13 <sup>ab</sup>	0.182 <sup>a</sup>	1.60 <sup>ab</sup>	2.44 <sup>f</sup>	1.21
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	1.67 <sup>abc</sup>	2.47 <sup>ab</sup>	0.78 <sup>b</sup>	1.60 <sup>a</sup>	2.12 <sup>ab</sup>	0.521 <sup>b</sup>	1.54 <sup>a</sup>	2.99 <sup>g</sup>	1.26
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	1.47 <sup>a</sup>	2.41 <sup>ab</sup>	0.50 <sup>b</sup>	1.76 <sup>a</sup>	2.52 <sup>cd</sup>	0.56 <sup>b</sup>	1.42 <sup>a</sup>	2.30 <sup>f</sup>	1.19
T <sub>6</sub> NPK @ 20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	1.74 <sup>ab</sup>	2.58 <sup>ab</sup>	0.83 <sup>b</sup>	1.86 <sup>a</sup>	2.54 <sup>cd</sup>	0.44 <sup>a</sup>	1.22 <sup>a</sup>	2.83 <sup>g</sup>	1.21
T <sub>7</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	1.74 <sup>ab</sup>	2.98 <sup>cd</sup>	1.03 <sup>bc</sup>	2.26 <sup>a</sup>	2.60 <sup>cd</sup>	0.475 <sup>a</sup>	2.50 <sup>cd</sup>	3.50 <sup>h</sup>	1.43
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	1.93 <sup>abc</sup>	3.24 <sup>cd</sup>	0.96 <sup>bc</sup>	2.33 <sup>a</sup>	2.50 <sup>cd</sup>	0.86 <sup>b</sup>	2.37 <sup>b</sup>	3.42 <sup>g</sup>	1.32
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	1.91 <sup>abc</sup>	2.84 <sup>cd</sup>	0.92 <sup>bc</sup>	2.14 <sup>a</sup>	2.76 <sup>cd</sup>	0.79 <sup>cd</sup>	2.67 <sup>b</sup>	3.34 <sup>g</sup>	1.26
F Test (P=0.05)	*	*	*	*	*	*	*	*	NS
SEM	0.083	0.1966	0.0602	0.109	0.113	0.09	0.193	0.05	---
CD	0.1765	0.4168	0.1276	0.231	0.239	0.201	0.419	0.086	---

Means followed by same letters are not significantly different (P=0.05) by DMRT.

NS - Non-significant

\* - Significant at 5% level

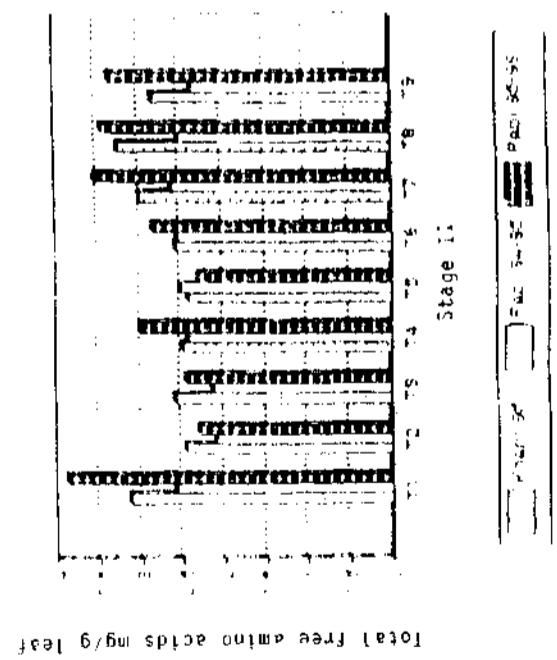
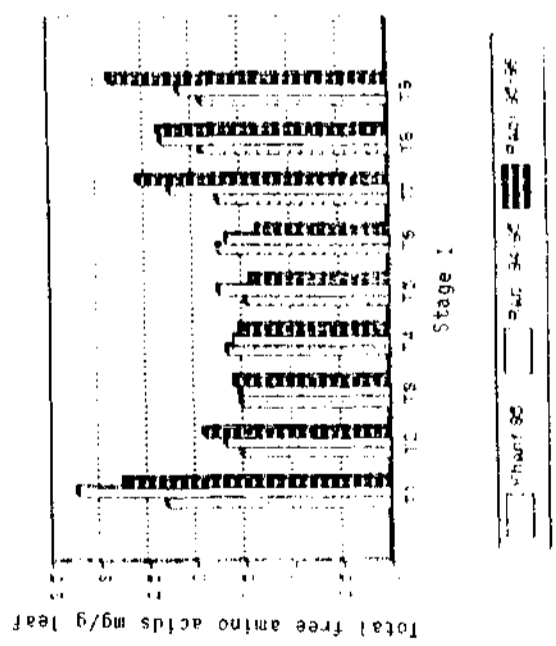
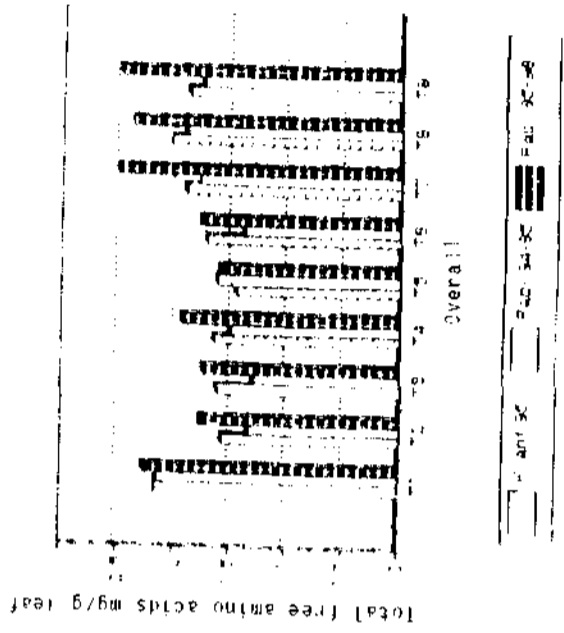
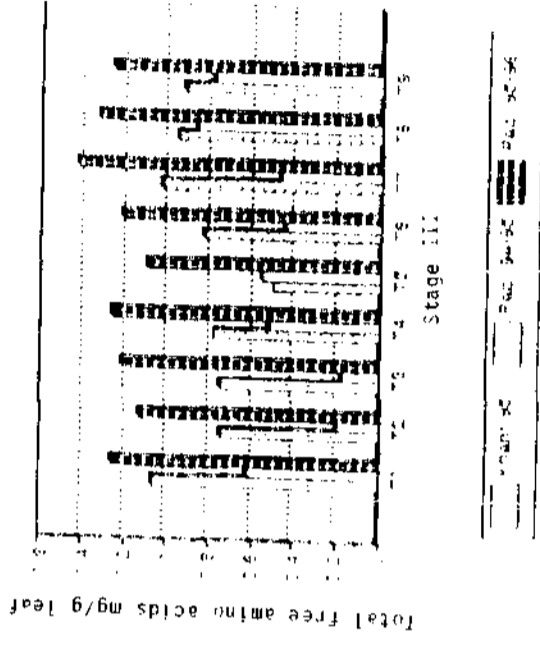


Figure 12. Influence of treatments on the total free amino acids (TFAA) ( $\text{mg g}^{-1}$  fresh leaf) of groundnut leaves.

The TFAA content estimated at 77 DAS (Tab. 26; Fig. 12), showed that in general, the amounts were lower compared to 21 and 49 DAS. The lowest quantity of TFAA content was recorded in neem cake ( $0.5 \text{ mg g}^{-1}$  fresh leaf) and was significantly different from other treatments. The treatments that followed were vermicompost (0.75 mg), FYM (0.75 mg), FYM + vermicompost (0.78 mg) and NPK + neem cake (0.83 mg). Higher amount of TFAA content among the treatments was recorded in NPK with seed treatment (0.93 mg), NPK with sunflower (0.96 mg), NPK with NPV (1.03 mg) and control (1.07 mg), the last three being on par.

The overall influence of treatments on TFAA content (Tab. 27; Fig. 12) in leaves revealed that the lowest quantity was recorded in neem cake ( $1.46 \text{ mg g}^{-1}$  fresh leaf) but it was on par with FYM (1.57 mg), vermicompost (1.61 mg) and FYM + vermicompost (1.64 mg) all being on par with each other. The treatments that followed were NPK + neem cake (1.71 mg), NPK with seed treatment (1.89 mg) but were on par with NPK with NPV (1.9 mg). The highest TFAA content was recorded in control (2.16 mg) but it was on par with NPK with sunflower (2.04 mg).

#### **Rabi, 1994-95**

The data furnished in Tab. 26 revealed higher amount of TFAA content in leaves during peg penetration (49 DAS, II stage) while very low quantities were seen during pod formation (77 DAS, III stage) stage. The TFAA content was the lowest in vermicompost ( $1.53 \text{ mg g}^{-1}$  fresh leaf) at 21 DAS and was followed by FYM + vermicompost (1.60 mg), NPK + neem cake (1.66 mg) and FYM (1.70 mg) all being on par with each other and significantly different from other treatments. Neem cake (1.76 mg) was the next treatment with slightly higher TFAA content in the leaves. The treatments NPK with seed treatment (2.14 mg), NPK with NPV (2.26 mg) and NPK with sunflower (2.33 mg) were on par and recorded higher amounts of TFAA content among the treatments, while control (3.23 mg) recorded the highest TFAA content.

Tab. 27: Overall influence of treatments on the levels of total free amino acids (TFAA) (mg g<sup>-1</sup> fresh leaf) of groundnut.

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	2.165 <sup>a</sup>	2.148 <sup>a</sup>	2.263 <sup>bc</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	1.571 <sup>d</sup>	1.331 <sup>e</sup>	1.783 <sup>cd</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	1.616 <sup>cd</sup>	1.281 <sup>e</sup>	1.750 <sup>cd</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	1.644 <sup>cd</sup>	1.513 <sup>bc</sup>	1.930 <sup>bc</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	1.460 <sup>e</sup>	1.617 <sup>d</sup>	1.606 <sup>d</sup>
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	1.717	1.382 <sup>de</sup>	1.786 <sup>bc</sup>
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	1.917 <sup>b</sup>	1.782 <sup>c</sup>	2.518 <sup>d</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	2.043 <sup>b</sup>	1.90 <sup>c</sup>	2.371 <sup>cd</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	1.893 <sup>c</sup>	1.767 <sup>c</sup>	2.490 <sup>d</sup>
F Test (P=0.05)	*	*	*
SEm	0.102	0.073	0.2801
CD	0.2168	0.156	0.5939

Means followed by same letters are not significantly different (P=0.05) by DMRT.

\* - Significant at 5% level

The data pertaining to the TFAA content of leaves at 49 DAS (Tab. 26; Fig. 12) indicated lowest quantity in FYM (2.09 mg g<sup>-1</sup> fresh leaf) but it was on par with vermicompost (2.13 mg). The treatments that followed were, NPK with seed treatment (2.36 mg), FYM + vermicompost (2.42 mg), NPK with sunflower (2.50 mg), neem cake (2.52 mg), NPK + neem cake (2.54 mg) and control (2.58 mg). The highest TFAA content was recorded in NPK with NPV (2.60 mg).

The TFAA content estimated at 77 DAS (Tab. 26; Fig. 12) indicated that vermicompost and FYM recorded significantly lower amounts of TFAAs (0.18 and 0.198 mg g<sup>-1</sup> fresh leaf respectively) among the treatments. NPK + neem cake (0.442 mg), NPK with NPV (0.475 mg), FYM + vermicompost (0.521 mg) and neem cake (0.56 mg) recorded higher levels of TFAA content. Though non significant, much higher levels of TFAA content was recorded in control (0.621 mg), NPK with seed treatment (0.796 mg) and NPK with sunflower (0.866 mg) among the treatments, all being on par.

The overall influence of treatments on TFAA content (Tab. 27; Fig. 12) indicated that the organically manured treatments recorded lower amounts of TFAA content (1.28 to 1.61 mg g<sup>-1</sup> fresh leaf) compared to the straight fertilized treatments (1.76 to 2.14 mg). Among the treatments lower quantity of TFAA was recorded in vermicompost (1.28 mg), FYM (1.33 mg) and NPK + neem cake (1.38 mg), being on par. Slightly higher quantity of TFAA content among the treatments was recorded in FYM + vermicompost (1.51 mg) and neem cake (1.61 mg). The straight fertilized treatments NPK with seed treatment (1.76 mg), NPK with NPV (1.78 mg) and NPK with sunflower (1.90 mg) recorded much higher quantity of TFAA content and were on par. The highest was recorded in control (2.14 mg) which was significantly different from all the other treatments.

**Rabi, 1995-96**

The treatments showed significant variation in the TFAA content in leaves at 21 and 49 DAS as indicated by the data presented in Tab. 26. Estimation of TFAA content in leaves at 21 DAS showed that significantly lower TFAAs were recorded in organically manured treatments (1.32 to 1.92 mg g<sup>-1</sup> fresh leaf) than the straight fertilized treatments (2.372 to 2.87 mg). The lowest quantity of TFAAs among the treatments was noticed in NPK + neem cake (1.32 mg) and was closely followed by neem cake (1.42 mg), FYM + vermicompost (1.54 mg) and vermicompost (1.60 mg) all being on par. FYM recorded next higher level of TFAAs (1.92 mg), NPK with sunflower (2.37 mg), NPK with NPV (2.59 mg), control (2.75 mg) and NPK with seed treatment (2.87 mg) recorded much higher levels of TFAA content compared to organically manured treatments.

The treatments significantly varied with respect to TFAA content in leaves at 49 DAS (Tab. 26; Fig. 12). Each treatment significantly different from the other treatments. However, lower amounts of TFAA content was recorded in the treatments that received organic manures (2.30 to 2.99 mg g<sup>-1</sup> fresh leaf) than the straight fertilized treatments (3.34 to 3.86 mg). The increasing order of TFAAs in different treatments was FYM (2.30 mg) and neem cake (2.30 mg) < vermicompost (2.44 mg) < NPK + neem cake (2.83 mg) < FYM + vermicompost (2.99 mg) < NPK with seed treatment (3.34 mg) < NPK with sunflower (3.42 mg) < NPK with NPV (3.53 mg) < control (3.86 mg).

At 77 DAS there was no significant variation in TFAA content among the treatments. However, the organically manured treatment, neem cake recorded the lowest (1.10 mg g<sup>-1</sup> fresh leaf) TFAA content and the straight fertilized NPK with NPV recorded the highest TFAA content (1.43 mg) (Tab. 26; Fig. 12).

The overall influence of treatments (Tab. 27; Fig. 12) showed variation in TFAA content of leaves in different treatments. The treatments that received organic manures recorded comparatively lower amounts of TFAA content than the straight fertilized treatments. Neem cake (1.60 mg g<sup>-1</sup> fresh leaf), vermicompost (1.75 mg), FYM (1.78 mg), NPK + neem cake (1.78 mg) and FYM + vermicompost (1.93 mg) recorded lower amounts of TFAA content and were on par with each other. Control (2.26 mg), NPK with sunflower (2.37 mg), NPK with seed treatment (2.49 mg) and NPK with NPV (2.51 mg) recorded higher quantities of TFAA content among the treatments, being on par with each other.

#### 4.2.4. Carbohydrates

##### *Kharif, 1995*

Estimation of carbohydrate content of leaves at 21 DAS (Tab. 28; Fig. 13) showed that significantly lower quantities were recorded in NPK + neem cake (51.3 mg g<sup>-1</sup> dry leaf) followed by neem cake (52.3 mg), FYM (53.3 mg), vermicompost (54.0 mg) and FYM + vermicompost (54.3 mg), all being on par. Among the treatments higher carbohydrate content was recorded in control (60.0 mg) but was significantly different from NPK with sunflower (73.3 mg) and NPK with NPV (77.0 mg). The highest carbohydrate content was recorded in NPK with seed treatment (79.3 mg).

The carbohydrate content of leaves estimated at 49 DAS (Tab. 28; Fig. 13) showed that FYM (55.3 mg) and FYM + vermicompost (61.0 mg) being on par, recorded significantly lower amounts (55.3 and 61 mg) than all the other treatments. The carbohydrate content in leaf in ascending order was vermicompost (72.0 mg) < control (78.0 mg) < NPK with sunflower (79.6 mg) < NPK with NPV (84.3 mg) < neem cake (89.3 mg). Among the treatments, NPK with seed treatment (96.0 mg) and NPK + neem cake (98.6 mg) recorded significantly higher carbohydrate content.

Tab. 28: Influence of treatments on carbohydrate content (mg g<sup>-1</sup> dry leaf) of groundnut.

Treatments	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	60.00 <sup>a</sup>	78.00 <sup>bc</sup>	49.60 <sup>a</sup>	60.66 <sup>a</sup>	137.60 <sup>a</sup>	71.00 <sup>a</sup>	56.12 <sup>a</sup>	132.28 <sup>a</sup>	80.70 <sup>a</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	55.30 <sup>a</sup>	55.30 <sup>a</sup>	51.00 <sup>ab</sup>	58.66 <sup>ab</sup>	120.30 <sup>ab</sup>	62.00 <sup>bc</sup>	53.30 <sup>a</sup>	80.13 <sup>a</sup>	73.50 <sup>a</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	54.00 <sup>a</sup>	72.00 <sup>a</sup>	55.00 <sup>a</sup>	56.00 <sup>a</sup>	109.00 <sup>a</sup>	49.70 <sup>a</sup>	49.14 <sup>a</sup>	93.55 <sup>a</sup>	55.14 <sup>a</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	54.30 <sup>a</sup>	61.00 <sup>a</sup>	42.00 <sup>a</sup>	72.00 <sup>a</sup>	88.60 <sup>a</sup>	51.00 <sup>a</sup>	45.04 <sup>a</sup>	87.62 <sup>ab</sup>	62.72 <sup>a</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	52.30 <sup>a</sup>	89.30 <sup>a</sup>	46.30 <sup>a</sup>	55.30 <sup>a</sup>	101.90 <sup>a</sup>	50.30 <sup>a</sup>	44.27 <sup>a</sup>	55.42 <sup>a</sup>	58.85 <sup>a</sup>
T <sub>6</sub> NPK @ 20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	51.30 <sup>a</sup>	98.60 <sup>a</sup>	47.30 <sup>a</sup>	108.60 <sup>a</sup>	96.60 <sup>a</sup>	58.00 <sup>a</sup>	51.18 <sup>a</sup>	87.57 <sup>ab</sup>	71.87 <sup>a</sup>
T <sub>7</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	77.00 <sup>b</sup>	84.30 <sup>b</sup>	47.30 <sup>a</sup>	68.00 <sup>a</sup>	115.00 <sup>a</sup>	58.70 <sup>a</sup>	81.29 <sup>a</sup>	133.90 <sup>a</sup>	81.80 <sup>a</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	73.30 <sup>b</sup>	79.90 <sup>b</sup>	50.60 <sup>ab</sup>	80.30 <sup>a</sup>	122.30 <sup>a</sup>	65.30 <sup>a</sup>	65.32 <sup>a</sup>	121.20 <sup>a</sup>	84.57 <sup>a</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	79.30 <sup>b</sup>	96.00 <sup>b</sup>	59.00 <sup>ab</sup>	57.60 <sup>ab</sup>	124.60 <sup>a</sup>	52.30 <sup>a</sup>	76.13 <sup>ab</sup>	94.16 <sup>a</sup>	78.90 <sup>a</sup>
F Test (P=0.05)	*	*	*	*	*	*	*	*	*
SEM	2.09	3.39	1.43	2.15	2.96	2.25	0.16	4.39	1.69
CD	4.45	6.57	3.03	4.56	6.28	4.78	0.35	9.32	3.59

Means followed by same letters are not significantly different (P=0.05) by DMRT

\* - Significant at 5% level

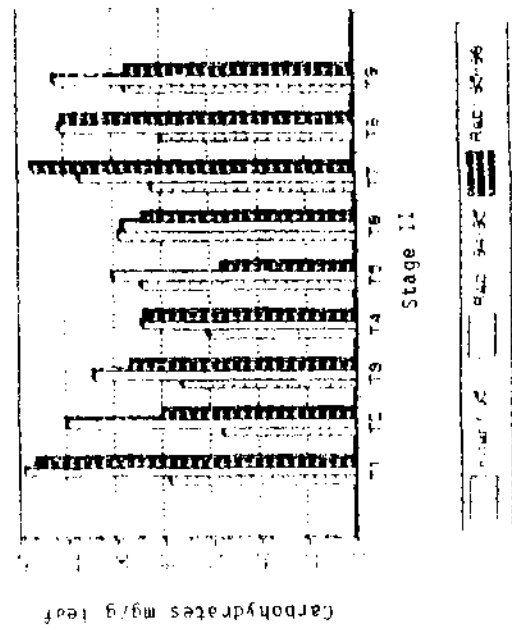
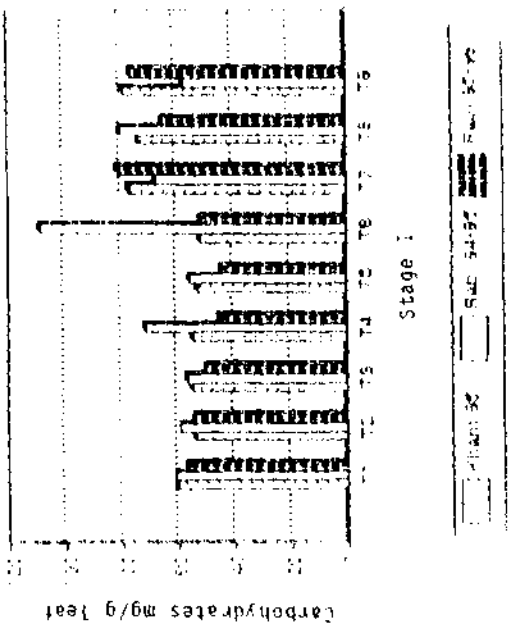
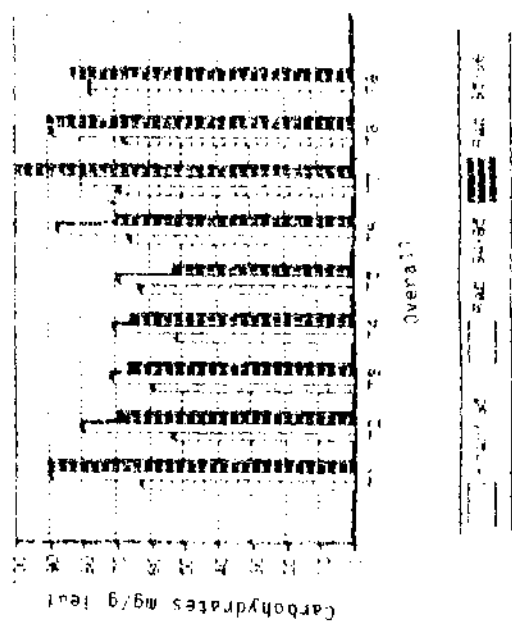
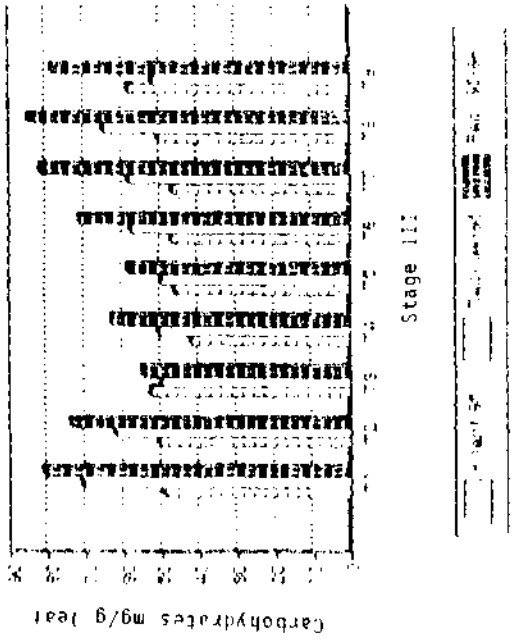


Figure 13. Influence of treatments on the carbohydrate content ( $\text{mg g}^{-1}$  dry leaf) of groundnut leaves.

The leaves analysed at 77 DAS (Tab. 28; Fig. 13) revealed that lowest carbohydrate content in FYM + vermicompost (42.0 mg), Neem cake (46.3 mg), NPK + neem cake (47.3 mg), NPK with NPV (47.3 mg), control (49.6 mg), NPK with sunflower (50.6 mg), FYM (51.0 mg) and vermicompost (53.0 mg) recorded higher carbohydrate content in leaves among the treatments. The highest carbohydrate content, was observed in NPK with seed treatment (59.0 mg).

The overall influence of treatments (Tab. 29; Fig. 13) on total carbohydrate content of leaves revealed that, FYM + vermicompost (52.44 mg) and FYM (52.22 mg) recorded significantly lower quantities among the treatments. The treatment vermicompost (59.6 mg) came next, while control (62.44 mg), neem cake (62.66 mg), NPK + neem cake (65.77 mg) and NPK with sunflower (67.88 mg) were on par with higher carbohydrate content. NPK with NPV (69.55 mg) recorded much higher levels of carbohydrate content. The highest carbohydrate content was recorded in NPK with seed treatment (78.10 mg).

#### **Rabi, 1994-95**

The leaf carbohydrate content was low in neem cake (55.3 mg), vermicompost (56.0 mg), NPK with seed treatment (57.66 mg) and FYM (58.6 mg) among the treatments, all being on par at 21 DAS. The other treatments that recorded higher quantities of carbohydrate content were control (60.66 mg), NPK with NPV (68 mg), FYM + neem cake (72 mg), NPK with sunflower (80.3 mg). The highest quantity of carbohydrate content was recorded in NPK + neem cake (108.66 mg), among the treatments (Tab. 28; Fig. 13)

Analysis of leaves at 49 DAS (II stage) (Tab. 28; Fig. 13) indicated that significantly lower amounts of carbohydrate was seen in FYM + vermicompost (88.66 mg). The treatments with next higher quantity of carbohydrate content were neem cake (101.66 mg), NPK + neem cake (101.66 mg), vermicompost (109.0 mg), NPK with NPV (115.66 mg) and FYM (120.33 mg).

Tab. 29: Overall influence of treatments on carbohydrate content ( $\text{mg g}^{-1}$  dry leaf) of groundnut.

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	62.44	89.77 <sup>c</sup>	89.70 <sup>de</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	53.22	80.33 <sup>b</sup>	68.97 <sup>abcd</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	59.60 <sup>c</sup>	71.55 <sup>c</sup>	65.93 <sup>bc</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	52.44	70.55 <sup>d</sup>	65.12 <sup>bc</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	62.66	69.21 <sup>d</sup>	52.84 <sup>a</sup>
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	65.77	87.77 <sup>c</sup>	70.20 <sup>abcd</sup>
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	69.55 <sup>c</sup>	80.77 <sup>d</sup>	98.99 <sup>c</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	67.88 <sup>bc</sup>	89.33 <sup>c</sup>	90.29 <sup>de</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	78.10 <sup>d</sup>	78.22 <sup>d</sup>	83.06 <sup>bcde</sup>
F Test (P=0.05)	*	*	*
SEm	1.290	1.364	9.803
CD	2.735	2.892	20.787

Means followed by same letters are not significantly different (P=0.05) by DMRT.

\* - Significant at 5% level

very high levels of carbohydrate content was observed in NPK with sunflower (122.33 mg) and NPK with seed treatment (124.6 mg). Among the treatments, the highest carbohydrate content was recorded in control (137.6 mg g<sup>-1</sup> dry leaf)

During III stage analysis of leaves collected at 77 DAS (Tab. 28; Fig. 13 mg) vermicompost, neem cake, FYM + vermicompost and NPK with seed treatment recorded significantly lower amounts of carbohydrates among the treatments, ranging between 49.7 to 52.3 mg g<sup>-1</sup> dry leaf and all were on par with each other. Higher levels of carbohydrate content among the treatments was seen in NPK + neem cake, NPK with NPV, FYM and NPK with sunflower ranging between 58.0 to 65.33 mg g<sup>-1</sup> dry leaf. Highest carbohydrate content among the treatments, was recorded in control (71.0 mg g<sup>-1</sup> dry leaf).

The overall influence of treatments on the levels of carbohydrate content in leaves (Tab.29) revealed that neem cake (69.21 mg), FYM + neem cake (70.55 mg) and vermicompost (71.55 mg) recorded significantly lower quantity of carbohydrate content among the treatments and were on par with each other. Moderate levels of carbohydrate content, however, was recorded in NPK with seed treatment (78.22 mg), FYM (80.33 mg) and NPK with NPV (80.77 mg). Among the treatments significantly higher quantity of carbohydrate content was seen in NPK + neem cake (87.77 mg), NPK with sunflower (89.33 mg) and control (89.77 mg) being on par.

#### **Rabi, 1995-96**

The data pertaining to the analysis of leaves for carbohydrates at three different stages of crop growth revealed that the carbohydrate levels increased upto II stage and decreased later (Tab. 28; Fig. 13). The treatments that received organic manures recorded lower levels of carbohydrate content than those that received straight fertilizers during all the stages of crop

growth. At I stage analysis of leaves, neem cake recorded the lowest leaf carbohydrate content (44.27 mg g<sup>-1</sup> dry leaf) and was followed by FYM + vermicompost (45.05 mg), vermicompost (49.14 mg), NPK + neem cake (51.18 mg) and FYM (53.3 mg). Higher quantities of carbohydrates were recorded in control (56.12 mg), NPK with sunflower (65.32 mg) and NPK with seed treatment (76.13 mg). Among the treatments, the highest carbohydrate content of leaf was recorded in NPK with NPV (81.29 mg)

During II stage (Tab. 28, Fig. 13) as well the trend was same. Neem cake recorded the lowest carbohydrate content among the treatments (55.42 mg g<sup>-1</sup> dry leaf). It was followed by FYM (80.13 mg), NPK + neem cake (87.57 mg) and FYM + vermicompost (87.62 mg) all being on par with each other. Vermicompost (93.53 mg) and NPK with seed treatment (94.16 mg) recorded slightly higher quantity of carbohydrate content and were on par. The treatment that followed was NPK with sunflower (121.2 mg). Among the treatments, control (132.28 mg) and NPK with NPV (133.91 mg) being on par, recorded significantly higher quantities of carbohydrate content.

During III stage (Tab. 28, Fig. 13) lowest carbohydrate content was seen in vermicompost (55.14 mg g<sup>-1</sup> dry leaf) and the highest in NPK with sunflower (84.37 mg) among the treatments. The remaining treatments that recorded intermediate levels of carbohydrate content were neem cake (58.85 mg) < FYM + vermicompost (62.72 mg) < NPK + neem cake (71.87 mg) < FYM (73.5 mg) < NPK with seed treatment (78.9 mg) < control (80.7 mg) < NPK with NPV (81.8 mg)

The overall influence of treatments on the carbohydrate content of leaves (Tab. 29; Fig. 13) showed that neem cake (52.84 mg), FYM + vermicompost (65.12 mg), vermicompost (65.93 mg), FYM (68.97 mg) and NPK + neem cake (70.20 mg) recorded lower carbohydrate

content among the treatments and all were on par with each other. Higher quantities of carbohydrate content in leaves, among the treatments was recorded in NPK with seed treatments (83.06 mg), control (89.70 mg), NPK with sunflower (90.29 mg) and NPK with NPV (98.99 mg) and all were on par

#### 4.2.5. Phenols

##### *Kharif, 1995*

As observed from the data (Tab. 30; Fig. 14), the phenolic content in groundnut leaves increased with the growth of the plant and higher amounts were observed at 77 DAS. The results are expressed in  $\text{mg g}^{-1}$  fresh leaf. During all the three stages, the straight fertilized treatments recorded significantly lower quantity of phenols in leaves when compared to all the organically manured treatments in *kharif*, 1995

The treatments that received straight fertilizers were significantly inferior to the treatments that received organic manures by recording lower levels of phenols. The treatments, control (1.17 mg), NPK with NPV (1.17 mg), NPK with sunflower (1.28 mg), NPK with seed treatment (1.34 mg) recorded significantly lower amounts of phenols among the treatments and were on par with each other. Vermicompost (2.05 mg), FYM + vermicompost (2.09 mg), FYM (2.14 mg), neem cake (2.28 mg) and NPK + neem cake (2.28 mg) recorded significantly higher amounts of phenols ranging between 2.05 to 2.28  $\text{mg g}^{-1}$  leaf and were also on par with each other (Tab. 30; Fig. 14)

The phenols estimated at 49 DAS (Tab. 30; Fig. 14) indicated that once again the treatments which received straight fertilizers recorded significantly lower amounts of phenols than those which received organic manures. Among the treatments, NPK with NPV (1.41 mg), NPK with sunflower (1.58 mg), control (1.73 mg) and NPK with seed treatment (1.80 mg)

Tab. 30: Influence of treatments on the levels of phenols (mg g<sup>-1</sup> fresh leaf) in groundnut.

Treatments	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	1.17 <sup>a</sup>	1.73 <sup>b</sup>	1.86 <sup>a</sup>	1.10 <sup>a</sup>	1.48 <sup>a</sup>	2.16 <sup>a</sup>	1.19 <sup>a</sup>	1.51 <sup>a</sup>	1.76 <sup>a</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	2.14 <sup>a</sup>	2.55 <sup>c</sup>	2.63 <sup>b</sup>	2.28 <sup>abc</sup>	2.55 <sup>c</sup>	2.80 <sup>abc</sup>	2.39 <sup>b</sup>	2.38 <sup>b</sup>	2.50 <sup>abc</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	2.05 <sup>a</sup>	2.60 <sup>c</sup>	2.66 <sup>b</sup>	2.63 <sup>ab</sup>	2.74 <sup>bc</sup>	2.96 <sup>ab</sup>	2.32 <sup>b</sup>	2.87 <sup>b</sup>	2.80 <sup>abc</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	2.09 <sup>a</sup>	2.61 <sup>c</sup>	2.78 <sup>b</sup>	2.61 <sup>cd</sup>	3.07 <sup>c</sup>	3.36 <sup>b</sup>	2.47 <sup>b</sup>	3.06 <sup>ab</sup>	2.95 <sup>abc</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	2.28 <sup>a</sup>	2.46 <sup>c</sup>	2.86 <sup>b</sup>	2.17 <sup>bc</sup>	2.68 <sup>cd</sup>	3.02 <sup>b</sup>	2.29 <sup>b</sup>	3.15 <sup>ab</sup>	3.35 <sup>b</sup>
T <sub>6</sub> NPK @ 20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	2.28 <sup>a</sup>	2.50 <sup>c</sup>	2.80 <sup>b</sup>	2.88 <sup>a</sup>	2.98 <sup>bc</sup>	3.11 <sup>b</sup>	2.22 <sup>b</sup>	3.41 <sup>a</sup>	3.64 <sup>b</sup>
T <sub>7</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	1.17 <sup>a</sup>	1.41 <sup>a</sup>	1.80 <sup>a</sup>	1.61 <sup>ab</sup>	1.75 <sup>ab</sup>	1.90 <sup>a</sup>	1.56 <sup>a</sup>	1.78 <sup>a</sup>	2.14 <sup>ab</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	1.28 <sup>a</sup>	1.58 <sup>ab</sup>	1.76 <sup>a</sup>	1.27 <sup>a</sup>	1.52 <sup>ab</sup>	2.36 <sup>ab</sup>	1.56 <sup>a</sup>	1.65 <sup>a</sup>	2.27 <sup>abc</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	1.34 <sup>a</sup>	1.80 <sup>b</sup>	1.80 <sup>a</sup>	1.44 <sup>a</sup>	1.86 <sup>b</sup>	2.23 <sup>ab</sup>	1.42 <sup>a</sup>	1.65 <sup>a</sup>	2.31 <sup>abc</sup>
F Test (P=0.05)	*	*	*	*	*	*	*	*	*
SEM	0.17	0.124	0.125	0.326	0.176	0.283	0.218	0.206	0.337
CD	0.36	0.263	0.267	0.692	0.374	0.464	0.464	0.438	0.715

Means followed by same letters are not significantly different (P=0.05) by DMRT  
\* - Significant at 5% level

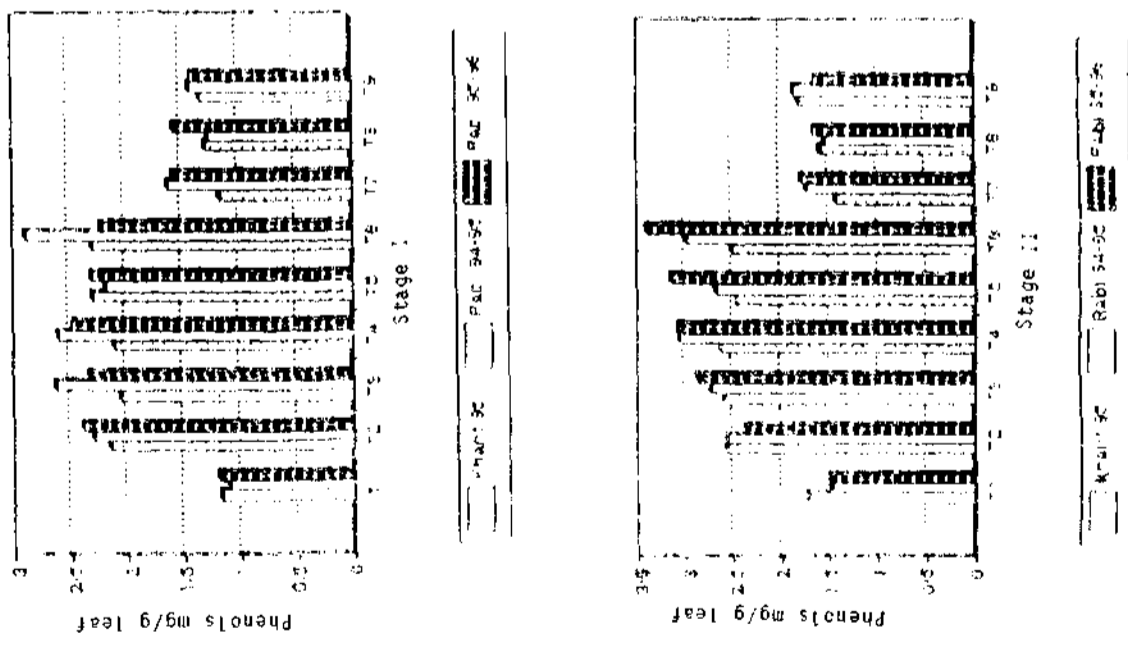
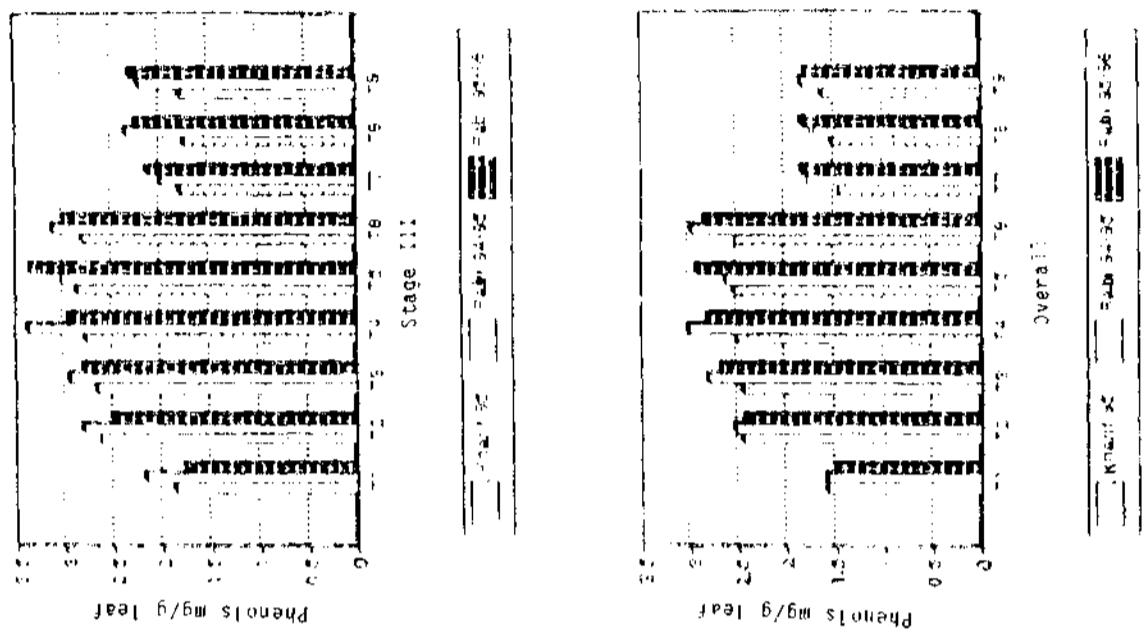


Figure 14. Influence of treatments on the phenol content ( $\text{mg g}^{-1}$  fresh leaf) of groundnut leaves.

recorded significantly lower quantities of phenols. The treatments viz. neem cake (2.46 mg), NPK + neem cake (2.5 mg), FYM (2.55 mg) vermicompost (2.60 mg) and FYM + vermicompost (2.61 mg) recorded significantly higher amounts of phenols among the treatments and were on par with each other.

During the III stage (Tab. 30; Fig. 14 mg) as well, the straight fertilized treatments viz. NPK with sunflower (1.76 mg), NPK with NPV (1.8 mg), NPK with seed treatment (1.8 mg) and control (1.86 mg) recorded significantly lower amounts of phenols among the treatments, all being on par with each other. Significantly higher amounts of phenols were recorded in the treatments that received organic manures viz. FYM (2.63 mg), vermicompost (2.66 mg), FYM + vermicompost (2.78 mg), NPK + neem cake (2.80 mg) and neem cake (2.86 mg), all being on par with each other.

The overall influence of treatments on the leaf phenolic content (Tab. 31, Fig. 14) revealed that, the treatments which received straight fertilizers recorded significantly lower amounts of phenols than those which received organic manures. Among the treatments NPK with NPV (1.46 mg), NPK with sunflower (1.54 mg), control (1.59 mg) and NPK with seed treatment (1.64 mg) recorded significantly lower quantities of phenols and all were on par with each other. The treatments that received organic manures viz. Vermicompost (2.44 mg), FYM (2.44 mg), FYM + vermicompost (2.49 mg), NPK + neem cake (2.52 mg) and neem cake (2.53 mg), however, recorded significantly higher amounts of leaf phenols and were on par with each other.

#### **Rabi, 1994-95**

Among the treatments, control (1.10 mg), NPK with sunflower (1.27 mg), NPK with seed treatment (1.44 mg), and NPK with NPV (1.61 mg) showed lower amounts of phenols at 21 DAS

Tab. 31: Overall influence of treatments on the levels of phenols ( $\text{mg g}^{-1}$  fresh leaf) in groundnut.

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	1.590 <sup>a</sup>	1.584 <sup>a</sup>	1.491 <sup>a</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	2.443 <sup>b</sup>	2.547 <sup>b</sup>	2.427 <sup>b</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	2.44 <sup>b</sup>	2.801 <sup>bcd</sup>	2.665 <sup>bc</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	2.495 <sup>b</sup>	3.017 <sup>d</sup>	2.828 <sup>c</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	2.535	2.629 <sup>bc</sup>	2.933 <sup>c</sup>
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	2.529 <sup>b</sup>	2.991 <sup>d</sup>	2.852 <sup>bc</sup>
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	1.46 <sup>a</sup>	1.779 <sup>a</sup>	1.829 <sup>a</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	1.545 <sup>a</sup>	1.720 <sup>a</sup>	1.831 <sup>a</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	1.646 <sup>a</sup>	1.847 <sup>a</sup>	1.798 <sup>a</sup>
F Test (P=0.05)	*	*	*
SEm	0.095	0.181	0.228
CD	0.201	0.385	0.485

Means followed by same letters are not significantly different (P=0.05) by DMRT.

\* - Significant at 5% level

and were on par with each other. The treatments that followed with increasing levels of phenols were neem cake (2.17 mg), FYM (2.28 mg), FYM + vermicompost (2.61 mg) and vermicompost (2.63 mg). The highest quantity of phenols were noticed in NPK + neem cake (2.88 mg) but it was on par with the last three treatments (Tab. 30; Fig. 14).

The phenols estimated at 49 DAS also revealed that among the treatments viz. control, and NPK with sunflower, NPK with NPV and NPK with seed treatment recorded significantly lower amounts of phenols ranging between 1.48 to 1.86 mg g<sup>-1</sup> fresh leaf. The other treatments with increasing order of phenols were FYM < neem cake < vermicompost < NPK + neem cake which recorded 2.55 to 2.98 mg g<sup>-1</sup> fresh leaf. The highest quantity, among the treatments, was recorded in FYM + vermicompost (3.07 mg) but it was also on par with the last two treatments (Tab. 30; Fig. 14).

During the third stage analysis as well (Tab. 30; Fig. 14), lower amounts of phenols were recorded in the straight fertilized treatments viz. NPK with NPV, control, NPK with seed treatment and NPK with sunflower ranging between 1.99 to 2.36 mg g<sup>-1</sup> fresh leaf, all being on par with each other. The organically manured treatments (in the increasing order) were FYM, vermicompost, neem cake, FYM + neem cake and FYM + vermicompost recorded the higher amounts of phenols with an average ranging between 2.80 to 3.36 mg g<sup>-1</sup> fresh leaf.

The overall influence of treatments (Tab. 31; Fig. 14) on the leaf phenolic content indicated distinct variation among the treatments. Control (1.58 mg), NPK with sunflower (1.72 mg), NPK with NPV (1.78 mg) and NPK with seed treatment (1.84 mg) recorded significantly lower amounts of phenols among the treatments and were on par with each other. Evidently higher quantities of phenols were recorded in the treatments that received organic manures viz. FYM (2.54 mg), neem cake (2.63 mg), vermicompost (2.80 mg) and NPK + neem

cake (2.99 mg). Among the treatments, the highest quantity of phenols was recorded in FYM + vermicompost (3.01 mg) but it was also on par with all the other organically manured treatments

#### **Rabi, 1995-96**

The trend pertaining to the phenolic content of leaf in groundnut during 1995-96 was more or less similar to that of *rabi* 1994-95 and *kharif* 1995. Again the straight fertilized treatments showed their inferiority over the organically manured treatments in recording significantly lower amounts of phenols at 21 DAS (Tab. 30; Fig. 14). Among the treatments control (1.19 mg), NPK with seed treatment (1.42 mg), NPK with NPV (1.56 mg) and NPK with sunflower (1.56 mg) recorded significantly lower amounts of phenols and were also on par with each other. The treatments with significantly higher amounts of phenols were NPK + neem cake (2.22 mg), neem cake (2.29 mg), vermicompost (2.32 mg), FYM (2.39 mg) and FYM + vermicompost (2.47 mg), all being on par with each other.

The leaf analysis at 49 DAS (stage II) (Tab. 30; Fig. 14) once again indicated that control (1.51 mg), NPK with sunflower (1.65 mg), NPK with seed treatment (1.65 mg), NPK with NPV (1.78 mg) recorded significantly lower amounts of phenols among the treatments and were on par with each other. Moderately higher quantity of phenols was recorded in FYM (2.38 mg). The treatments with increasing order of phenols were vermicompost (2.87 mg), FYM + vermicompost (3.06 mg), neem cake (3.15 mg) and the highest being recorded in NPK + neem cake (3.41 mg).

The analysis of leaves at 77 DAS (stage III) (Tab. 30; Fig. 14) also indicated that the lowest quantity of phenols in control (1.76 mg g<sup>-1</sup> fresh leaf) and the highest in neem cake (3.35 mg). The other treatments that fell in between the two extremes were NPK with NPV (2.14 mg), NPK with sunflower (2.27 mg), NPK with seed treatment (2.31 mg), FYM (2.5 mg), vermicompost (2.8 mg), FYM + vermicompost (2.95 mg) and NPK + neem cake (3.04 mg).

The overall influence of treatments on the leaf phenolic content clearly indicated that significantly lower amounts of phenols among the treatments were noticed in all the straight fertilized treatments viz. control (1.49 mg), NPK with seed treatment (1.79 mg), NPK with NPV (1.83 mg) and NPK with sunflower (1.83 mg), all being on par with each other. The treatments that received organic manures, FYM (2.47 mg), vermicompost (2.66 mg), FYM + vermicompost (2.82 mg) and NPK + neem cake (2.85 mg) recorded significantly higher amounts of phenols and all were on par. The highest quantity, however was recorded in neem cake (2.93 mg) which was also on par with the last three treatments among the organically manured (Tab. 31; Fig. 14).

#### 4.2.6 Tannins

The leaf tannins estimated at 21, 49 and 77 DAS in different treatments indicated lower quantities during flowering stage (21 DAS) and higher amounts during pod formation stage (77 DAS) (Tab. 32 & Fig. 15).

During the three seasons under study, higher quantities of leaf tannins were observed in both the *rabi* seasons than in *kharif*. The leaf tannin content was expressed in mg g<sup>-1</sup> leaf on dry weight basis.

#### ***Kharif, 1995***

The tannin content present in leaves was found to be significantly influenced by the treatments. The treatments that received organic manures were found significantly superior to the treatments applied with straight fertilizers in recording higher amounts of tannins during all the three stages of leaf analysis (Tab. 32, Fig. 15)

Tab. 32: Influence of treatments on the levels of tannins (mg g<sup>-1</sup> dry leaf) in groundnut.

Treatments	Kharif 1995			Rabi 1994-95			Rabi 1995-96		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
	6.12 <sup>b</sup>	8.37 <sup>b</sup>	11.22 <sup>ab</sup>	6.08 <sup>b</sup>	9.60 <sup>b</sup>	9.53 <sup>b</sup>	7.24 <sup>bc</sup>	8.91 <sup>ab</sup>	13.40 <sup>ab</sup>
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	6.12 <sup>b</sup>	8.37 <sup>b</sup>	11.22 <sup>ab</sup>	6.08 <sup>b</sup>	9.60 <sup>b</sup>	9.53 <sup>b</sup>	7.24 <sup>bc</sup>	8.91 <sup>ab</sup>	13.40 <sup>ab</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	8.79 <sup>ab</sup>	12.00 <sup>bc</sup>	15.66 <sup>c</sup>	11.40 <sup>a</sup>	17.53 <sup>d</sup>	18.06 <sup>c</sup>	11.61 <sup>c</sup>	15.08 <sup>c</sup>	17.93 <sup>c</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	8.81 <sup>ab</sup>	11.10 <sup>b</sup>	14.73 <sup>bc</sup>	13.30 <sup>a</sup>	16.12 <sup>c</sup>	16.33 <sup>bc</sup>	11.58 <sup>c</sup>	13.21 <sup>c</sup>	16.43 <sup>c</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	9.00 <sup>a</sup>	11.77 <sup>ab</sup>	15.46 <sup>c</sup>	12.87 <sup>ab</sup>	14.00 <sup>c</sup>	14.19 <sup>c</sup>	11.90 <sup>c</sup>	14.02 <sup>c</sup>	18.93 <sup>c</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	7.21 <sup>c</sup>	12.74 <sup>c</sup>	6.20 <sup>c</sup>	9.33 <sup>c</sup>	10.34 <sup>c</sup>	18.58 <sup>c</sup>	15.14 <sup>c</sup>	14.29 <sup>c</sup>	16.00 <sup>bc</sup>
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	8.52 <sup>b</sup>	11.95 <sup>ab</sup>	15.60 <sup>c</sup>	12.70 <sup>ab</sup>	14.29 <sup>c</sup>	15.51 <sup>c</sup>	10.59 <sup>c</sup>	13.55 <sup>c</sup>	18.33 <sup>c</sup>
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	5.01 <sup>d</sup>	6.06 <sup>d</sup>	9.20 <sup>d</sup>	7.54 <sup>d</sup>	9.56 <sup>d</sup>	9.63 <sup>d</sup>	7.04 <sup>d</sup>	10.66 <sup>d</sup>	11.65 <sup>d</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	5.70 <sup>cd</sup>	6.26 <sup>d</sup>	9.41 <sup>d</sup>	7.35 <sup>d</sup>	9.36 <sup>cd</sup>	10.89 <sup>d</sup>	6.81 <sup>d</sup>	8.89 <sup>cd</sup>	10.89 <sup>d</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	5.85 <sup>cd</sup>	8.19 <sup>c</sup>	9.83 <sup>d</sup>	6.94 <sup>d</sup>	7.68 <sup>d</sup>	10.77 <sup>d</sup>	7.47 <sup>d</sup>	8.52 <sup>d</sup>	10.55 <sup>d</sup>
F Test (P=0.05)	*	*	*	*	*	*	*	*	*
SEM	0.473	0.707	1.708	0.770	0.82	1.52	1.509	0.837	1.54
CD	1.00	1.50	3.62	1.634	1.74	3.236	3.188	1.773	3.27

Means followed by same letters are not significantly different (P=0.05) by DMRT  
 \* - Significant at 5% level

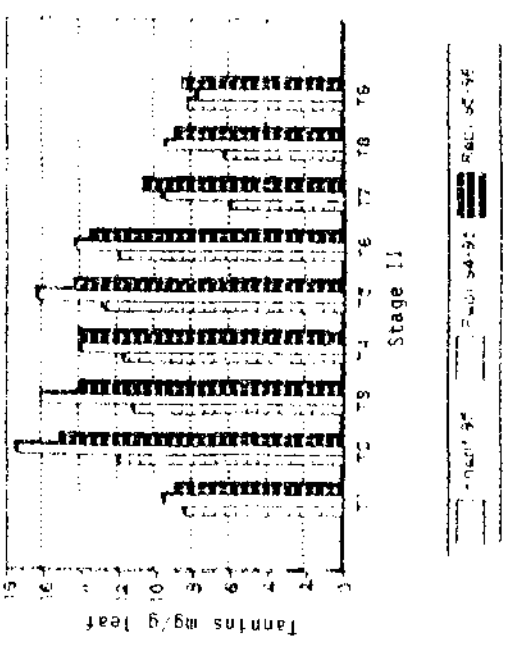
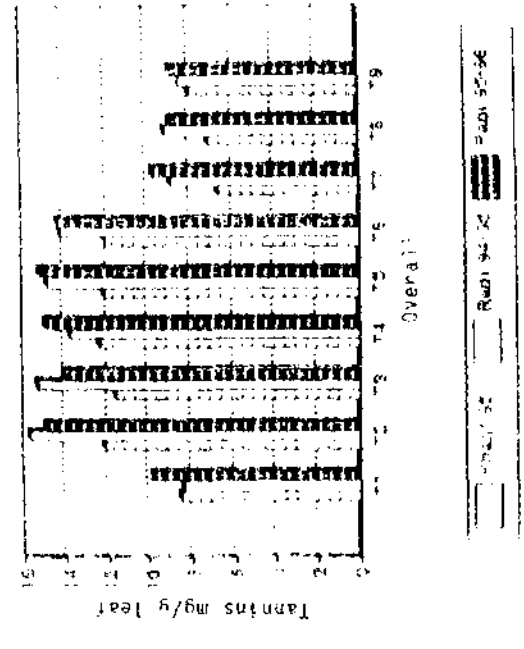
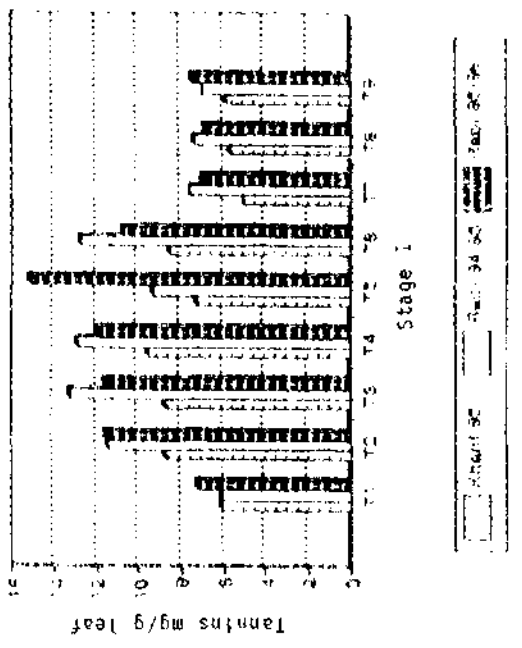
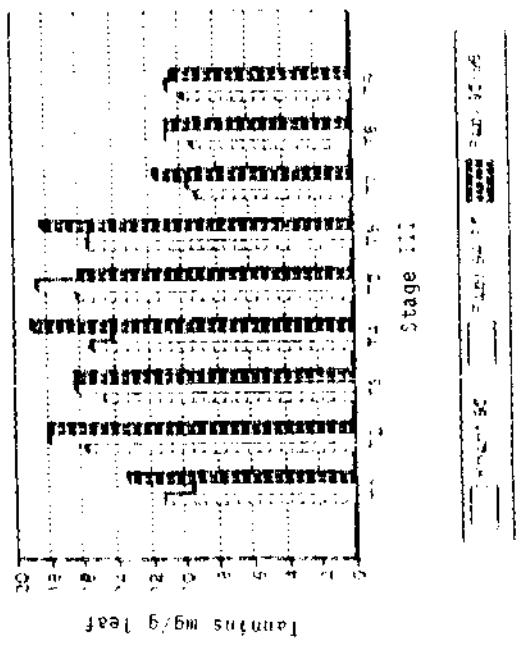


Figure 15. Influence of treatments on the tannin content ( $\text{mg g}^{-1}$  dry leaf) of groundnut leaves

During stage I (Tab. 32; Fig. 15) NPK with NPV (5.01 mg g<sup>-1</sup> dry leaf), NPK with sunflower (5.7 mg), NPK with seed treatment (5.85 mg) and control (6.12 mg) recorded significantly lower amounts of leaf tannins. Higher amounts of leaf tannins were observed in neem cake (7.21 mg), NPK + neem cake (8.52 mg), FYM (8.79 mg), and vermicompost (8.81 mg). FYM + vermicompost recorded the highest quantity of leaf tannins (9.60 mg) but was also on par with last two treatments.

During second stage leaf analysis (49 DAS) (Tab. 32; Fig. 15), as well, the straight fertilized treatments NPK with NPV (6.06 mg), NPK with sunflower (6.26 mg), NPK with seed treatment (8.19 mg) and control (8.37 mg) recorded significantly lower amounts of leaf tannins ranging between 6.06 to 8.37 mg g<sup>-1</sup> dry leaf. However, the first two treatments were on par and showed significantly lower quantities of tannins than the latter two. The treatments that recorded higher tannin content in leaves were vermicompost, FYM + vermicompost, NPK + neem cake and FYM with an average leaf tannin content ranging between 11.1 to 12.0 mg g<sup>-1</sup> dry leaf. The highest amount was noticed in neem cake (12.74 mg) but it was also on par with the last two treatments.

During the III stage as well (Tab. 32; Fig. 15) the organically manured treatments dominated with higher levels of leaf tannins. The four straight fertilized treatments viz. NPK with NPV (9.2 mg), NPK with sunflower (9.41 mg), NPK with seed treatment (9.83 mg) and control (11.22 mg) were on par and recorded lower amounts of leaf tannins among the treatments, while higher quantities were recorded in vermicompost (14.73 mg), FYM + vermicompost (15.46 mg), NPK + neem cake (15.6 mg), FYM (15.66 mg) and neem cake (16.2 mg), all being on par with each other.

The overall influence of treatments (Tab. 33, Fig. 15) on the tannin content of leaves indicated distinct variation among the treatments. The treatments that received straight fertilizers viz. NPK with NPV, NPK with sunflower, NPK with seed treatment and control were significantly inferior in recording lower amounts of tannins (6.75, 7.12, 7.96 and 8.57 mg g<sup>-1</sup> dry leaf respectively) than the organically manured treatments, vermicompost (11.54 mg), NPK + neem cake (12.02 mg), neem cake (12.05 mg), FYM (12.15 mg) and FYM + vermicompost (12.28 mg).

#### **Rabi, 1994-95**

During *rabi* 1994-95 also, higher amounts of tannins were recorded in the treatments applied with organic manures compared to those applied with straight fertilizers. At 21 DAS (Tab. 32; Fig. 15), among the treatments, control, NPK with seed treatment, NPK with sunflower and NPK with NPV recorded significantly lower amounts of tannins ranging between 6.08 to 7.54 mg g<sup>-1</sup> dry leaf. Moderate quantity but distinct from other treatments was, however, recorded in neem cake (9.33 mg). The other organically manured treatments viz. FYM, NPK + neem cake, FYM + vermicompost and vermicompost recorded significantly higher tannin content in leaves (11.40 to 13.3 mg) among the all the treatments.

The analysis of leaves at 49 DAS (Tab. 32; Fig. 15) also revealed that the treatments NPK with seed treatment, NPK with sunflower, NPK with NPV and control recorded significantly lower amount of tannins ranging between 7.68 to 9.60 mg g<sup>-1</sup> dry leaf as compared to the others. Higher content was recorded in FYM + vermicompost (14.0 mg) and NPK + neem cake (14.29 mg) being on par. The highest levels of tannin content in leaves was recorded in vermicompost, neem cake and FYM (16.12, 16.34 and 17.53 mg g<sup>-1</sup> dry leaf respectively) being on par with each other.

**Tab. 33: Overall influence of treatments on the levels of tannins (mg g<sup>-1</sup> dry leaf) in groundnut.**

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	8.57 <sup>a</sup>	8.40 <sup>a</sup>	9.85
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	12.15	15.66 <sup>b</sup>	14.87 <sup>b</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	11.54	15.25 <sup>b</sup>	13.97 <sup>b</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	12.28	13.68 <sup>b</sup>	14.95 <sup>b</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	12.05 <sup>*</sup>	14.75 <sup>b,c</sup>	15.11 <sup>b</sup>
T <sub>6</sub> NPK @ 20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	12.02 <sup>*</sup>	14.16 <sup>b</sup>	14.19 <sup>b</sup>
T <sub>7</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	6.75 <sup>a</sup>	8.91 <sup>a</sup>	9.78 <sup>a</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	7.12	9.20 <sup>a</sup>	8.86 <sup>a</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	7.96 <sup>a</sup>	8.46 <sup>a</sup>	8.84 <sup>a</sup>
F Test (P=0.05)	*	*	*
SEm	0.599	0.582	0.632
CD	1.270	1.234	1.339

Means followed by same letters are not significantly different (P=0.05) by DMRT.

\* - Significant at 5% level

During the third stage analysis as well control, NPK with NPV, NPK with seed treatment and NPK with sunflower recorded significantly lower tannin content (9.53 to 10.89 mg) all being on par with each other. Once again higher content was seen in the organically manured treatments (14.19 to 18.5 mg) all being on par with each other.

The overall influence of treatments on leaf tannin content (Tab 33; Fig. 15) also indicated distinct grouping among the treatments. All the organically manured treatments viz. FYM + vermicompost, NPK + neem cake, neem cake, vermicompost and FYM recorded significantly higher quantities of leaf tannin which ranged between 13.68 to 15.66 mg g<sup>-1</sup> dry leaf. The straight fertilized treatments viz control, NPK with seed treatment, NPK with FYM and NPK with sunflower recorded significantly lower quantity of tannin content ranging between 8.40 to 9.2 mg g<sup>-1</sup> dry leaf

#### **Rabi, 1995-96**

The first stage analysis of leaves pertaining to tannin content (Tab. 32; Fig. 15) indicated that NPK with sunflower and NPK with NPV recorded lower levels of tannin content (6.81 and 7.04 mg g<sup>-1</sup> dry leaf) being on par and were closely followed by control and NPK with seed treatment (7.24 and 7.47 mg) also both being on par. The tannin content in all the four treatments was significantly lower than the other treatments. Moderate level of leaf tannins was recorded in NPK + neem cake (10.69 mg). Among the treatments significantly higher quantities of tannin was seen in vermicompost, FYM and FYM + vermicompost (11.58, 11.61 and 11.9 mg respectively) while neem cake recorded 15.14 mg g<sup>-1</sup> dry leaf, the highest in the treatments.

During II stage analysis of leaves (Tab. 32; Fig. 15) once again all the organically manured treatments (NPK + neem cake < vermicompost < FYM + vermicompost < neem cake < FYM) recorded significantly higher tannin content in the leaves ranging between 13.55 to

15.08 mg g<sup>-1</sup> dry leaf and all were on par with each other. Significantly, lower quantities were observed in straight fertilized treatments with an average tannin content ranging between 8.52 to 10.66 mg g<sup>-1</sup> dry leaf.

During the III stage as well (Tab 32; Fig. 15), the same trend was observed. The data indicated that the straight fertilized treatments (NPK with seed treatment, NPK with sunflower, NPK with NPV and control) showed their inferiority in recording lower amounts of leaf tannin (8.84 to 9.85 mg g<sup>-1</sup> dry leaf) over organically manured viz. vermicompost, NPK + neem cake, FYM, FYM + vermicompost and neem cake with a leaf tannin content between 13.97 to 15.11 mg g<sup>-1</sup>.

The overall influence of treatments on the tannin contents of leaves (Tab 33; Fig. 15) showed distinct segregation of treatments as seen under phenol content of leaves. The treatments which received NPK through inorganic means viz. NPK with seed treatment (8.84 mg g<sup>-1</sup> dry leaf), NPK with sunflower (8.86 mg), NPK with NPV (9.78 mg) and control (9.85 mg) recorded significantly lower amounts of tannins than those which received NPK through organic means viz. vermicompost (13.97 mg), NPK + neem cake (14.19 mg), FYM (14.87 mg), FYM + vermicompost (14.95 mg) and neem cake (15.11 mg).

#### 4.3. RELATIONSHIP BETWEEN BIOCHEMICAL CONSTITUENTS OF GROUNDNUT LEAVES AND PESTS AND PREDATORS

The pest population evaluated at three stages of crop growth was correlated with the biochemical constituents of leaves analysed at flowering (21 DAS, I stage), peg penetration (49 DAS, II stage) and pod formation (77 DAS, III stage) (Tab 34 to 36)

The five insect pests viz *E. kerri*, *A. craccivora*, *A. modicella*, *S. litura* and *H. armigera* showed in general, positive correlation with N, CP, TFAA and carbohydrates; and negative correlation with phenols and tannins during three seasons under study.

#### 4.3.1. Jassids, *E. kerri*

The relation between *E. kerri* and the six biochemical constituents of groundnut leaves viz. N, CP, TFAA, carbohydrates, phenols and tannins are presented in the following sections

##### 4.3.1.1. Nitrogen/Crude Protein (N/CP)

During the three seasons, the relationship between N/CP and *E. kerri* was found positive. It was significant during stage I of both the *rabi* seasons (0.7326\* and 0.7415\*), during stage II of *kharif*, 1995 (0.6721\*) and *rabi* 94-95 (0.8223\*\*) and during stage III of *rabi* 95-96 (0.8581\*\*) (Tab. 34). The overall relationship between N/CP and *E. kerri* was positive and significant in the three seasons viz. *kharif*, 1995 (0.6736\*), *rabi* 94-95 (0.8836\*\*) and *rabi* 95-96 (0.8062\*\*) (Tab. 36).

##### 4.3.1.2. Total free amino acids (TFAA)

As observed in N/CP, the relationship between TFAA and jassids was found positive and it was also significant during stage I of both the *rabi* seasons (0.7118\* and 0.6728\*) Highly significant positive relation was found during stage II and III of *kharif* 1995 (0.8592\*\* and 0.8519\*\*) and significant during II and III stages of *rabi* 95-96 (0.7225\* and 0.7780\*) (Tab. 34). It was clear from Tab. 36 that TFAA and jassids were associated positively and the relationship was significant at 5% level in *rabi* 94-95 (0.7920\*) and 1% level in *kharif* 1995 (0.9014\*\*) and *rabi* 95-96 (0.8108\*\*) (Tab. 36)

#### 4.3.1.3. Carbohydrates

The association between carbohydrates and jassids was positive and it was significant in stage II (0.8956\*\*) and III (0.8286\*\*) of *rabi* 95-96 (Tab.34). The overall relationship was positive and significant during *rabi* 94-95 (0.7645\*) and *rabi* 95-96 (0.8944\*\*) and non-significant but positive during *kharif* 1995 (Tab. 36).

#### 4.3.1.4. Phenols

The relationship between phenols and jassids was negative and significant during all the three stages of *kharif* 1995 (-0.6682\*; -0.7971\*; -0.7785\*); III stage of *rabi* 94-95 (-0.800\*\*) and I (-0.8232\*\*) and III stage (-0.8142\*\*) of *rabi* 95-96 (Tab. 35). Significant negative overall correlation was found between phenols and *E. kerri* during the two *rabi* seasons (-0.7834\* and -0.7851\*) and it was highly significant in *kharif* 1995 (-0.8122\*\*) (Tab. 36)

#### 4.3.1.5. Tannins

Like phenols, tannins also showed negative correlation with jassids during the three seasons. It was significant (-0.7829\*) in stage I of *rabi* 95-96; stage II of *kharif* 1995 (-0.8261\*\*) and stage III of all the three seasons (-0.7261\*, -0.8686\*\* and -0.7190\*) (Tab. 35). The overall relationship between tannins and *E. kerri* revealed significant negative correlation during the three seasons (-0.7549\*; -0.8195\*\* and -0.7755\*) under study (Tab. 36).

#### 4.3.2. Aphids, *A. craccivora*

During the three seasons viz *kharif* 1995; *rabi* 94-95 and *rabi* 95-96 and at all the stages positive correlation was observed between N / CP, TFAA and carbohydrates and *A. craccivora*. In contrast, a negative relationship was observed with phenols and tannins (Tables 34 to 36).

Tab. 34: Correlation matrix : Influence of biochemical constituents of leaves on pests of groundnut.

Pest	Stage	Nitrogen /Crude protein			Total free amino acids			Carbohydrates		
		Khariif 1995	Rabi 1994-95	Rabi 1995-96	Khariif 1995	Rabi 1994-95	Rabi 1995-96	Khariif 1995	Rabi 1994-95	Rabi 1995-96
<i>E. kerri</i>	I	0.5201	0.7326**	0.7415	0.4493	0.7118	0.6728	0.4561	0.1032	0.6116
	II	0.6721	0.8223**	0.6361	0.8592**	0.5007	0.7225	0.0646	0.3911	0.8956**
	III	0.3944	0.4855	0.8581**	0.8519	0.4187	0.7780*	0.2506	0.6452	0.8286**
<i>A. craccivora</i>	I	0.5781	0.6880*	0.6765	0.6527	0.7554	0.5941	0.4174	0.1833	0.5457
	II	0.5522	0.8453**	0.7764	0.8308**	0.6184	0.7925	0.1944	0.5664	0.8534**
	III	0.4322	0.3149	0.8207**	0.9035**	0.4761	0.6214	0.3407	0.7402	0.7706**
<i>A. modicella</i>	I	0.5651	0.6277	0.6259	0.6476	0.6826	0.4979	0.8838	0.2658	0.4528
	II	0.5594	0.8712	0.7549	0.8294**	0.5851	0.8067**	0.2105	0.5226	0.8282**
	III	0.2828	0.4326	0.7886	0.8379**	0.6129	0.7585	0.5743	0.7357	0.7687**
<i>S. litura</i>	I	----	0.530	0.5648	----	0.6208	0.4275	----	0.2771	0.3367
	II	0.4572	0.8444**	0.5759	0.8050**	0.6313	0.7034	0.3826	0.5162	0.8497**
	III	0.5208	-0.2784	-0.0717	0.7147	-0.2265	-0.5637	-0.1303	0.0589	-0.2075
<i>H. armigera</i>	I	----	0.5712	0.4615	----	0.544	0.5576	----	0.0195	0.2255
	II	0.5177	0.8387**	0.3908	0.7700*	0.6169	0.5802	-0.1155	0.4989	0.7910*
	III	----	-0.1670	0.5041	----	0.8102**	0.6166	----	0.3705	0.4776

\* Significant at 5% level

\*\* Significant at 1% level

**Tab. 35: Correlation matrix: Influence of biochemical constituents of leaves on pests of groundnut.**

Pest	Stage	Phenols			Tannins		
		Kharif 1995	Rabi 1994-95	Rabi 1995-96	Kharif 1995	Rabi 1994-95	Rabi 1995-96
<i>P. kerri</i>	I	-0.6682*	-0.6101	-0.8232**	-0.5390	-0.4840	-0.7829
	II	-0.7971*	-0.5656	-0.5533	-0.8261**	-0.4505	-0.5237
	III	-0.7785*	-0.809**	-0.8142**	-0.7261**	-0.8686**	-0.7190
<i>A. craccivora</i>	I	-0.6790*	-0.6501	-0.8092**	-0.6427	-0.5692	-0.7046
	II	-0.7485*	-0.7622*	-0.6575	-0.7277*	-0.6298	-0.6594
	III	-0.9340**	-0.7622*	-0.6971*	-0.9259**	-0.7783*	-0.8111**
<i>A. modicella</i>	I	-0.6649	-0.553	-0.6380	-0.6085	-0.5045	-0.6498
	II	-0.6892*	-0.7578*	-0.5809	-0.6763*	-0.6542	-0.6682*
	III	-0.9142**	-0.7374	-0.8187**	-0.9041**	-0.8308**	-0.6029
<i>S. litura</i>	I	---	-0.4786	-0.6138	---	-0.3780	-0.6616
	II	-0.7830*	-0.7436*	-0.5631	-0.7373*	-0.6026	-0.5515
	III	-0.6569	0.2678	0.0530	-0.6818*	0.2538	0.3059
<i>H. armigera</i>	I	---	-0.5847	-0.5232	---	-0.4295	-0.6475
	II	-0.6572	-0.7300*	-0.3621	-0.6637	-0.5912	-0.3243
	III	---	-0.5873	-0.5775	---	-0.8611**	-0.2209

\* Significance at 5% level

\*\* Significance at 1% level

**Tab. 36: Overall correlation matrix: Influence of biochemical constituents of leaves on pests of groundnut.**

Pest	Season	Nitrogen / Protein	Amino acids	Carbohydrates	Phenols	Tannins
<i>E. kerri</i>	Kharij 1995	0.6736	0.9014	0.3199	-0.8122	-0.7549
	Rabi 94-95	0.8836	0.7920	0.7645	-0.7834	-0.8195
	Rabi 95-96	0.8062	0.8108	0.8944	-0.7851	-0.7755
<i>A. craccivora</i>	Kharij 1995	0.8034	0.9397	0.4839	-0.8619	-0.8369
	Rabi 94-95	0.8244	0.7887	0.7725	-0.7557	-0.7481
	Rabi 95-96	0.8479	0.8021	0.8370	-0.7831	-0.7616
<i>A. modicella</i>	Kharij 1995	0.7760	0.8998	0.5034	-0.7676	-0.7505
	Rabi 94-95	0.8175	0.7832	0.7759	-0.7339	-0.7624
	Rabi 95-96	0.7835	0.7541	0.8206	-0.7319	-0.6984
<i>S. litura</i>	Kharij 1995	0.7184	0.7755	0.3942	-0.7046	-0.7186
	Rabi 94-95	0.1245	0.2378	0.2570	-0.0691	-0.0028
	Rabi 95-96	0.3603	0.1347	0.1694	-0.3754	-0.2631
<i>H. armigera</i>	Kharij 1995	0.5304	0.7228	0.0190	-0.6227	-0.5939
	Rabi 94-95	0.8979	0.7974	0.6270	-0.7573	-0.8691
	Rabi 95-96	0.6303	0.6213	0.6820	-0.5729	-0.5729

\* Significance at 5% level

\*\* Significance at 1% level

#### 4.3.2.1. Nitrogen / Crude Protein (N/CP)

The relationship between N/CP and aphid population was positive. It was significant during I (0.688\*) and II stage (0.8433\*\*) of *rabi* 94-95 and all the three stages of *rabi* 95-96 (0.6765\*, 0.7764\* and 0.8207\*\*) (Tab. 34). The overall relationship between N/CP and *A. craccivora* indicated a highly significant positive correlation during the three seasons viz. *kharif* 1995 (0.8034\*\*), *rabi* 94-95 (0.8244\*\*) and *rabi* 95-96 (0.8479\*\*) (Tab. 36).

#### 4.3.2.2. Total free amino acids (TFAA)

TFAA and *A. craccivora* showed significant positive correlation in stage I of *rabi* 94-95 (0.7534\*); stage II (0.8508\*\*) and stage III (0.9035\*\*) of *kharif* 1995 and stage II of *rabi* 95-96 (0.7923\*) (Tab. 34). The overall relationship indicated a significant positive correlation between TFAA and aphids at 5% level during *rabi* 94-95 (0.7887\*) and at 1% level during the remaining two seasons i.e. *kharif* 1995 (0.9397\*\*) and *rabi* 95-96 (0.8021\*\*) (Tab. 36).

#### 4.3.2.3. Carbohydrates

Carbohydrates and *A. craccivora* exhibited positive correlation and it was significant only during III stage of *rabi* 94-95 (0.7402\*) and II and III stages of *rabi* 95-96 (0.8534\*\* and 0.7706\*) (Tab. 34). The overall relationship showed significant positive correlation during the two *rabi* seasons (0.7725\* and 0.8370\*\*) as observed in jassids, while it was positive but non-significant during *kharif* 1995 (Tab. 36).

#### 4.3.2.4. Phenols

Phenols and *A. craccivora* had significant negative correlation except in stage I of *rabi* 94-95 and stage II of *rabi* 95-96 where the relationship was positive but non significant (Tab. 35). The overall relationship between phenols and *A. craccivora* depicted significant negative

correlation during all the three seasons viz *kharif* 1995-96 (-0.7676\*), *rabi* 94-95(-0.7339\*) and *rabi* 95-96 (-0.7319\*) (Tab. 36).

#### 4.3.2.5. Tannins

Tannins and *A. craccivora* were negatively correlated and it was significant in stage I of *rabi* 95-96 (-0.7046\*), stage II of *kharif* 1995 (-0.7277\*) and stage III of all the three seasons (-0.9259\*\*, -0.7783\* and -0.8111\*\*) (Tab. 35). As observed in phenols, the overall relationship indicated a significant negative correlation in all the three season viz. *kharif* 1995 (-0.8364\*\*), *rabi* 94-95(-0.7481\*) and *rabi* 95-96 (-0.7616\*) (Tab 36) between tannins and *A. craccivora*.

#### 4.3.3. Leaf miner, *A. modicella*

##### 4.3.3.1. Nitrogen / Crude Protein (N/CP)

The correlation between N/CP content and *A. modicella* was positive in all the three seasons. It was significant in stage II of both *rabi* seasons(0.8712\*\* and 0.7549\*) and stage III of *rabi* 95-96 (0.7886\*) (Tab. 34) The overall relationship of N/CP with leaf miner indicated significant positive correlation during *kharif* 1995 (0.7760\*), *rabi* 94-95 (0.8175\*\*) and *rabi* 95-96 (0.7835\*) (Tab. 36).

##### 4.3.3.2 Total free amino acids (TFAA)

Significant positive correlation was obtained between TFAA and *A. modicella* during stage I of *rabi* 94-95 (0.6826\*); stage II and III of *kharif* 1995 (0.8294\*\* and 0.8370\*\*) and *rabi* 95-96 (0.8067\*\* and 0.7585\*) (Tab. 34). The overall relationship revealed positive relationship between TFAA and *A. modicella* during the three season, *kharif* 1995 (0.8998\*\*), *rabi* 94-95 (0.7832\*) and *rabi* 95-96 (0.7541\*) (Tab. 36)

#### 4.3.3.3. Carbohydrates

The association between carbohydrates and leaf miner was positive and it was significant only in stage II of *rabi* 95-96 (0.8282\*\*) and stage III of both the *rabi* seasons (0.7357\* and 0.7987\*) (Tab. 34). The overall relationship between carbohydrates and leaf miner indicated a significant positive correlation in both the *rabi* seasons (0.7759\* and 0.8206\*\*), while it was non-significant though positive during *kharif*, 1995 (Tab. 36).

#### 4.3.3.4. Phenols

The correlation between phenols and *A. modicella* was negative during all the three stages of all the three seasons. It was significant during II and III stages of *kharif*, 1995 (-0.6892\* and 0.9142\*\*) *rabi* 94-95 (-0.7578\* and -0.7374\*) and III stage of *rabi* 95-96 (-0.8187\*\*) (Tab. 35). The overall relationship was negative and significant during the three seasons, *kharif* 1995 (-0.7676\*), *rabi* 94-95 (-0.7339\*) and *rabi* 95-96(-0.7319\*), *rabi* 94-95 (-0.7319\*) (Tab.36).

#### 4.3.3.5. Tannins

As observed in phenols, the relationship between tannins and *A. modicella* was negative during all the three stages of all the three seasons. It was significant during II stage of *kharif* 1995 (-0.6763\*) and *rabi* 95-96 (-0.6682\*) and III stage of *kharif* 1995(-0.9041\*\*) and *rabi* 94-95 (-0.8308\*\*) (Tab.35). The overall relationship was negative and significant during the three seasons viz. *kharif* (-0.7505\*), *rabi* 94-95 (-0.7624\*) and *rabi* 95-96 (-0.6984\*) (Tab. 36).

#### 4.3.4. Tobacco Caterpillar, *S. litura*

##### 4.3.4.1. Nitrogen / Crude Protein (N/CP)

The relationship between N/CP and *S. litura* indicated a positive relationship which was significant only during II stage of *rabi* 94-95 (0.8444\*\*) However, during the III stage of both the

*rabi* seasons, negative but non significant relationship was obtained (Tab. 34). The overall correlation between N/CP and *S. litura* revealed significant positive relationship in *kharif* 1995 (0.7184\*) while it was non significant though positive during the two *rabi* seasons (Tab. 36)

#### 4.3.4.2. Total free amino acids (TFAA)

The relationship between TFAA and *S. litura* population was positive and it was significant in II stage of *kharif* 1995 (0.8059\*\*), *rabi* 95-96 (0.7034\*) and III stage of *kharif* 1995 (0.7147\*)(Tab. 34). The overall relationship indicated a significant positive correlation with TFAA during *kharif* 1995 only (0.7755\*) and while it was non significant though positive in the two *rabi* seasons (Tab. 36).

#### 4.3.4.3. Carbohydrates

Positive relationship was observed between carbohydrate content and *S. litura* and it was significant only in II stage of *rabi* 96 (0.8497\*\*) However, negative but non significant correlation was obtained during the I stage of *kharif* 1995 and *rabi* 95-96 . Though positive relationship was noticed between carbohydrate and *S. litura*, it was non significant during all the three seasons (Tab. 36).

#### 4.3.4.4. Phenols

The data presented in Tab. 35 revealed the presence of a negative relationship between phenols and *S. litura* except in III stage of two *rabi* seasons where it was non significantly positive. However, significant negative relationship was observed in II stage of *kharif* 1995 (-0.7830\*) and *rabi* 94-95 (-0.7436\*) (Tab. 35). The overall relationship indicated negative association between phenols and *S. litura* which was significant during *kharif* 1995 (-0.7046\*), while it was non significant, in the two *rabi* seasons (Tab. 36).

#### 4.3.4.5. Tannins

Tannins and *S. litura* were related negatively in all the stages during all the seasons except III stage of both the *rabi* seasons where it was positively non significant. Significant negative relationship was observed during II and III stages of *kharif*, 1995 (-0.7373\* and -0.6815\*) (Tab. 35). The overall relationship was negative and significant in *kharif* 1995 (-0.7186\*) while non-significant negative correlation was observed in the two *rabi* seasons (Tab. 36).

#### 4.3.5. Gram Pod Borer, *H. armigera*

##### 4.3.5.1. Nitrogen /Crude Protein (N/CP)

A positive correlation was found between N/CP and *H. armigera* which was significant only during II stage of *rabi* 94-95 (0.8387\*\*). During III stage of *rabi* 94-95, non significant negative correlation was observed (Tab. 34). The overall relationship indicated, significant positive association in *rabi* 94-95 (0.8979\*\*) and non significant positive relationship during the remaining two seasons (Tab. 36).

##### 4.3.5.2. Total free amino acids (TFAA)

Significant positive correlation between TFAA and *H. armigera* was noticed in stage II of *kharif* 1995 (0.77\*) and stage III of *rabi* 94-95 (0.8102\*\*)(Tab. 34). The *kharif* 1995 (0.7228\*) and *rabi* 94-95 (0.7974\*) crops showed significantly positive overall relationship between TFAA and *H. armigera* (Tab. 36).

##### 4.3.5.3. Carbohydrates

A positive relationship was observed between carbohydrates and *H. armigera* which was significant only during II stage of *rabi* 95-96 (0.7910\*) However, during II stage of *kharif* 1995.

non significant negative correlation was observed (Tab. 34). The overall relationship revealed significant positive association during *rabi* 95-96 (0.6820\*) while it was non significant though positive during the remaining two seasons (Tab. 36)

#### 4.3.5.4. Phenols

The relationship between phenols and *H. armigera* was negative and significant only during II stage of *rabi* 94-95 (-0.730\*) (Tab. 35). The overall relationship was negative between phenols and *H. armigera* which was significant in *rabi* 94-95 (-0.7573\*) (Tab. 36).

#### 4.3.5.5. Tannins

Negative correlation was observed between tannins and *H. armigera* in all the three stage of the three seasons. It was significant in III stage of *rabi* 94-95 (-0.8611\*\*) (Tab.35) The overall relationship revealed a negative relationship in all the seasons but significant only in *rabi* 94-95 (-0.8691\*\*) (Tab. 36).

#### 4.3.6. Predators (Coccinellids, Spiders and Chrysopids)

The data pertaining to the relationship between the biochemical constituents of groundnut leaves and the coccinellids and spiders did not indicate any clear association. In general, as observed with the pest complex the relationship with N/CP, carbohydrates and TFAA was positive during both the *rabi* seasons with predator population. However, during *kharif*, N/CP and carbohydrates with coccinellids and carbohydrates with spiders showed negative association. As observed with the pests the phenols and tannins showed negative association with coccinellids as well as spiders. The chrysopid population was very low and did not follow any trend (Tab. 37 to Tab. 39).

Tab. 37: Correlation matrix : Influence of biochemical constituents of leaves on predators of groundnut pests.

Predator	Stage	Nitrogen / Crude Protein			Total free amino acids			Carbohydrates		
		Kharif 1995	Rabi 1994-95	Rabi 1995-96	Kharif 1995	Rabi 1994-95	Rabi 1995-96	Kharif 1995	Rabi 1994-95	Rabi 1995-96
Coccinellids	I	0.2076	-0.0273	0.3662	0.3579	0.1638	0.2970	-0.0013	0.5751	0.2893
	II	0.5474	0.1841	0.1257	0.8015**	0.0438	0.2387	-0.1481	-0.1923	0.4482
	III	-0.1101	0.2110	0.2673	-0.1015	0.2282	-0.0009	0.2525	-0.6390	0.0395
Spiders	I	0.2111	0.5693	0.2595	0.2430	0.3427	0.1271	0.1834	-0.0699	-0.0864
	II	0.4887	0.4322	0.3225	0.3601	-0.2230	0.5311	-0.6533	0.2706	0.7886*
	III	0.1870	0.0137	0.1149	0.4627	-0.4939	0.3272	-0.0687	0.0615	0.0019
Chrysopids	I	0.4446	-0.4222	0.3887	0.2429	-0.2891	0.2526	0.1420	-0.2033	0.0955
	II	0.0449	-0.3219	-0.5384	0.5498	0.0175	-0.4829	0.2823	-0.4299	-0.1821
	III	0.7982	-0.7572	0.2203	0.1014	-0.0212	-0.0896	0.0667	-0.0590	0.3372

\* Significance at 5% level

\*\* Significance at 1% level

**Tab. 38: Correlation matrix: Influence of biochemical constituents of groundnut leaves on predators of groundnut.**

Predator	Stage	Phenols			Tannins		
		Kharif 1995	Rabi 1994-95	Rabi 1995-96	Kharif 1995	Rabi 1994-95	Rabi 1995-96
Coccinellids	I	-0.1055	0.0336	-0.3312	-0.0371	0.1168	-0.4427
	II	-0.6580	0.1398	0.0709	-0.7004	0.3471	0.0293
	III	-0.0707	0.2416	0.0623	-0.0202	0.0308	0.1157
Spiders	I	-0.4340	-0.2615	-0.1119	-0.1880	-0.1409	-0.2937
	II	-0.2782	-0.2305	-0.4341	-0.3970	0.0359	-0.2635
	III	-0.3517	0.2212	-0.2955	-0.3475	0.2646	0.0884
Chrysopids	I	-0.1900	0.3339	0.5782	-0.1958	0.4948	-0.4698
	II	-0.5433	0.5135	0.3460	-0.5056	0.6575	0.5797
	III	-0.2538	0.3904	-0.3865	-0.2183	0.1989	-0.2729

\* Significance at 5% level

\*\* Significance at 1 % level

Tab. 39: Overall correlation matrix: Influence of biochemical constituents of leaves on predators of groundnut.

Predator	Season	Nitrogen / Crude Protein	Total free amino acids	Carbohydrates	Phenols	Tannins
Coccinellid beetles	<i>Kharif</i> 1995	-0.0410	0.2220	-0.3522	-0.2584	-0.2019
	<i>Rabi</i> 1994-95	0.2969	0.3597	0.1724	-0.1484	-0.0508
	<i>Rabi</i> 1995-96	0.0922	0.0738	0.2104	-0.0472	-0.0657
Spiders	<i>Kharif</i> 1995	0.3508	0.4784	-0.2323	-0.4228	-0.4170
	<i>Rabi</i> 1994-95	0.4643	0.2893	0.0879	-0.4228	-0.4219
	<i>Rabi</i> 1995-96	0.3650	0.3803	0.4789	-0.4183	-0.2645
Chrysopids	<i>Kharif</i> 1995	0.2552	0.2584	0.0415	-0.3970	-0.4060
	<i>Rabi</i> 1994-95	-0.0900	-0.2362	0.2488	0.2875	0.4262
	<i>Rabi</i> 1995-96	0.0665	-0.1211	-0.2290	-0.0388	0.1112

#### 4.4. RELATIONSHIP BETWEEN WEATHER PARAMETERS AND PESTS AND PREDATORS

The pest and predator population was correlated with the weather parameters like temperature, relative humidity and rainfall and presented in following sections.

##### 4.4.1. Maximum Temperature

During both the *rabi* seasons maximum temperature had a negative correlation with all the pests and predators under study. Significant negative relationship was observed with *A. craccivora* during the two *rabi* seasons (-0.7572\*\* and -0.8910\*\*); *A. modicella* during *rabi* (-0.7867\*\*) and *S. litura* during *rabi* 95-96(-0.6688\*). During *kharif* 1995, all the pests except jassids were positively correlated. Jassids showed negative correlation but non significant. Significant positive correlation with maximum temperature during *kharif* season was noticed with *A. craccivora* (0.6947\*) and *A. modicella* (0.7543\*\*) (Tab 40)

##### 4.4.2. Minimum Temperature

The data presented in Tab. 40 indicated a negative relationship between minimum temperature and insect pests, in general. However, the relationship was positive with jassids during *rabi* 95-96; *A. modicella* during *rabi* 94-95 and all the pests during *kharif*. Pertaining to the predators the relationship was positive during all the three seasons.

##### 4.4.3. Morning Relative Humidity

The pests and predators showed positive correlation with morning relative humidity. During *kharif* 1995 with *A. craccivora* (0.6269\*) and *A. modicella* (0.7023\*) the relationship was significant and during *rabi* 94-95 also except *A. modicella* it was significant with all the pests. During *rabi* 95-96, *A. modicella* like other pests also showed significant positive relationship (0.5657\*). The predators, showed non significant but positive relationship during the three seasons (Tab. 40).

Tab. 40: Correlation matrix: Influence of weather parameters on pests and predators of groundnut.

Weather factor	Season	<i>E. kerri</i>	<i>A. craccivora</i>	<i>A. modicella</i>	<i>S. litura</i>	<i>H. armigera</i>	Coccinellids	Spiders	Chrysopids
Maximum temperature (°C)	Kharif 95	0.2751	0.0947	0.7542**	0.4595	0.3255	0.4035	0.5267	0.4964
	Rabi 94	-0.3987	-0.7572**	-0.2155	-0.5271	-0.3504	-0.0398	-0.0025	0.0282
	Rabi 95	-0.4433	-0.8910**	-0.7867**	-0.6688	-0.4618	-0.2115	-0.3154	-0.2997
Minimum temperature (°C)	Kharif 95	0.2697	0.7013**	0.7684**	0.4638	0.3327	0.4288	0.5449	0.4985
	Rabi 94	-0.3009	-0.4008	0.0618	-0.1185	-0.2141	0.1674	0.2452	0.2182
	Rabi 95	0.0637	-0.8068**	-0.5497	-0.3337	-0.1821	0.2910	0.2071	0.1255
Morning RH (%)	Kharif 95	0.2530	0.6269	0.7025	0.3975	0.2346	0.4663	0.5561	0.4390
	Rabi 94	0.7153**	0.6277	0.5068	0.5827	0.0668	0.5275	0.4262	0.4655
	Rabi 95	0.3780	0.6080	0.5657	0.4706	0.4542	0.0672	0.1846	0.3708
Evening RH (%)	Kharif 95	0.4270	0.6231	0.6824	0.3900	0.1783	0.5008	0.5593	0.4306
	Rabi 94	0.1576	0.2955	0.4693	0.4897	0.1722	0.4193	0.4460	0.4342
	Rabi 95	-0.3403	0.1324	0.0504	-0.1532	-0.0418	-0.1583	-0.407	-0.0918
Rainfall (mm)	Kharif 95	0.0678	-0.1904	-0.0792	-0.2639	-0.1952	0.0471	-0.0691	-0.2570
	Rabi 94	-0.1389	0.1785	-0.2556	-0.0641	-0.1805	-0.5016	-0.2859	-0.2976
	Rabi 95	----	----	----	----	----	----	----	----

\* Significance at 5% level

\*\* Significance at 1% level

#### 4.4.4. Evening Relative Humidity

Evening relative humidity with few exceptions, in *rabi* 95-96 showed in general, positive correlation with all the pests and predators under study. However, the relationship was significant with *A. craccivora* (0.6231\*) and *A. modicella* (0.6824\*) during *kharif* 1995. During *rabi* 95-96 *E. kerri*, *S. litura*, *H. armigera* and all predators showed negative relationship but it was non significant (Tab. 40).

#### 4.4.5. Rainfall

A non significant negative correlation was observed between rainfall and all the pests except *E. kerri* (*kharif*, 1995), *A. craccivora* (*rabi* 94-95) which showed positive correlation (Tab. 40).

### 4.5. YIELD

#### ***Kharif*, 1995**

The highest yield among the treatments was recorded in neem cake (1437 kg ha<sup>-1</sup>) and it was on par with FYM + vermicompost (1430 kg), vermicompost (1379 kg), NPK with sunflower (1372 kg), FYM (1346 kg) and NPK + neem cake (1341 kg). NPK with NPV also recorded lower yield. Control (1136 kg) and NPK with seed treatment (1120 kg) recorded significantly lower yield than the organically fertilized treatments (Tab. 41).

#### ***Rabi*, 1994-95**

The neem cake recorded the highest yield (2799 kg ha<sup>-1</sup>) followed by FYM + vermicompost (2696 kg), vermicompost (2659 kg) and all being on par. The treatments that followed were NPK with sunflower (2532 kg), FYM (2525 kg), NPK + neem cake (2423 kg) and NPK with NPV (2409 kg). Again the straight fertilized treatments viz. control (2203 kg) and NPK with seed treatment (2183 kg) recorded significantly lower yields among the treatments (Tab. 41).

Tab. 41: Groundnut yield in kg ha<sup>-1</sup>.

Treatment	Kharif 1995	Rabi 1994-95	Rabi 1995-96
T <sub>1</sub> NPK (Control) @ 40-60-40 Kg ha <sup>-1</sup>	1136 <sup>a</sup>	2203 <sup>d</sup>	2238 <sup>c</sup>
T <sub>2</sub> FYM @ 8t ha <sup>-1</sup>	1346 <sup>cd</sup>	2525 <sup>bc</sup>	2580 <sup>b</sup>
T <sub>3</sub> Vermicompost @ 3.75t ha <sup>-1</sup>	1379 <sup>cd</sup>	2659 <sup>ab</sup>	2599 <sup>bc</sup>
T <sub>4</sub> FYM @ 4t ha <sup>-1</sup> + Vermicompost @ 1.875t ha <sup>-1</sup>	1430 <sup>d</sup>	2696 <sup>ab</sup>	2680 <sup>bc</sup>
T <sub>5</sub> Neem cake @ 770 Kg ha <sup>-1</sup>	1437	2799 <sup>a</sup>	2866 <sup>a</sup>
T <sub>6</sub> NPK @20-30-20 Kg ha <sup>-1</sup> + neem cake @ 385 Kg ha <sup>-1</sup>	1341 <sup>cd</sup>	2423 <sup>c</sup>	2529 <sup>b</sup>
T <sub>7</sub> NPK @40-60-40 Kg ha <sup>-1</sup> with NPV @ 250 LE ha <sup>-1</sup>	1311 <sup>cd</sup>	2409 <sup>c</sup>	2562 <sup>b</sup>
T <sub>8</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> with Sunflower	1322 <sup>cd</sup>	2532 <sup>bc</sup>	2491 <sup>b</sup>
T <sub>9</sub> NPK @ 40-60-40 Kg ha <sup>-1</sup> and carbofuran 3G ST @ 250g Kg <sup>-1</sup> seed	1120	2183 <sup>d</sup>	2145
F Test (P=0.05)	*	*	*
SEm	46.84	82.63	113.98
CD	99.32	175.22	241.70

Means followed by same letters are not significantly different (P = 0.05) by DMRT.

\* significant at 5% level.

**Rabi, 1995-96**

As in previous *rabi*, the neem cake treatment recorded the highest yield (2866 kg ha<sup>-1</sup>) followed by vermicompost (2699 kg), FYM + vermicompost (2680 kg) all being on par. The treatments that followed were FYM (2580 kg), NPK with NPV (2562 kg), NPK + neem cake (2529 kg), NPK with sunflower (2491 kg). Straight fertilized treatments viz. control (2238 kg) and NPK with seed treatment (2145 kg) recorded significantly lower yields among the treatments (Tab. 41).

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\* Significant at 5% level

\*\* Significant at 1% level

# *Discussion*

## DISCUSSION

### 5.1. INFLUENCE OF TREATMENTS ON PEST AND PREDATOR POPULATION

#### 5.1.1. Sucking Pests (Jassids and Aphids)

An overview of the results of the present investigation revealed that the incidence of jassids during *kharif*, 1995 was about two times to that of the *rabi* 1994-95 and 1995-96, while the incidence of aphids was vice-versa. The higher level of population of jassids during *kharif*, 1995 was probably due to favourable climatic conditions like minimum temperature, morning and evening relative humidity, rainfall and cloudy days. The high incidence of aphids during *rabi* seasons might also be due to the favourable relative humidity.

Pertaining to the effect of treatments, the organically manured treatments during all the three seasons showed significant superiority in containing the build up of jassids, *E. kerri* and aphids, *A. craccivora* compared to the straight fertilized. The different organically manured treatments are more or less on par. The lowest population of jassids and aphids was recorded in neem cake during *rabi* 1994-95 and *kharif* 1995 while vermicompost showed its significant superiority in curtailing the aphid population during *rabi* 1995-96. Though the beneficial effects of organic manures like FYM, vermicompost etc. was reported by several workers (Painter, 1951; Roger, 1976; Gaur and Prasad, 1970; Gaur *et al.*, 1975; Jackson, 1988; Tirumala Rao, 1994; Bhatnagar and Palta, 1996), no specific reports on pest reduction in groundnut were available. The combined advantage of being an organic manure and possessing a repellent principle, azadirachtin, in neem cake translocated through xylem (Kareem *et al.*, 1988) probably contributed to less incidence of sucking insects in neem cake. It was reported that the residual toxicity of neem cake lasts for four weeks after its application (Dutta, 1974). Neem applied to crops was reported to reduce sucking pests (Goyal *et al.*, 1971; Atwal and Pajni, 1964; Ruscoe, 1972; Hans and Ferenzkoln, 1972). The present results agree with the reports available pertaining to the effect of neem cake on sucking pests on groundnut.

The dearth of literature on the influence of organic manures on groundnut pests necessitated to compare and discuss the infestation of pests on other crops. The incidence of sucking complex was reported to be less in FYM and vermicompost than in straight fertilized plots in chillies (Varma, 1994) and rice (Bhagyanakshatram, 1995; Kishore Kumar, 1996). The pest reduction in these organically manured treatments was due to balanced nutrition throughout the crop period as reported by Bhawalkar and Bhawalkar (1991) and Bhide (1993). The present results on the influence of FYM and vermicompost are in accordance with the reports available

The treatments which received straight fertilizer (NPK) with carbofuran 3G as seed treatment and NPK + neem cake recorded moderate incidence of aphids and jassids but were superior to the straight fertilized treatments during the three seasons under study. Carbofuran seed treatment is reported to have satisfactory control of sucking pests for 30 days after sowing on groundnut (NARP, 1982; Venkata Reddy, 1988) and other crops as well (Dahms and Wood, 1957; Daniels, 1960; Wilson *et al.*, 1960; Hardwood and Bruehl, 1961; Depew, 1964; Guerra-Sobrevilla, 1988). The seed treatment with carboturan was also reported to have phytotonic effect (Ramamoorthy, 1986; Subramanyam *et al.*, 1988). The available reports are in conformity with the present findings pertaining to less infestation of jassids and aphids in NPK with carbofuran seed treatment.

The incidence of sucking pests in straight fertilized treatments was due to the luxuriant growth and succulence of groundnut plants. Earlier, many scientists reported succulence of the plant through nitrogen fertilization leading to vulnerability of crop to sucking pests of cotton (Isley, 1946; Butt *et al.*, 1946; Adkisson, 1957; Chaudhary and Kashyap, 1987). Higher rates of inorganic fertilizer by encouraging rapid growth, produce a more attractive environment for oviposition (Adkisson, 1958; Bishara, 1969). All these reports support the present results

### 5.1.2. Leaf Miner, *A. modicella*

The incidence of groundnut leaf miner, *A. modicella* was higher in all the seasons probably due to the favourable climatic conditions like relative humidity and minimum temperature as evidenced by positive relationship

The organically manured treatments showed their significant superiority over straight fertilized treatments in suppressing the leaf miner population during the three seasons. Among the organically manured treatments, FYM was the best by recording the lowest leaf miner larvae followed by neem cake and vermicompost. Literature is not available on the influence of organic manures on the leaf miner incidence. However, with other insect pests, application of cow manure to maize plots was reported to reduce the incidence of chrysomelid larvae, *D. speciosa* compared to the straight fertilized treatments (Vardasca *et al.*, 1989). The beneficial effect of organic manures on pest reduction was discussed in the previous section under sucking pests. FYM and vermicompost also reported to have lower incidence of lepidopteran pests on rice (Bhagyanakshatram, 1995 and Kishore Kumar, 1996). Neem cake was also reported to reduce the incidence of citrus leaf miner, *P. citrella* (Batra and Sandhu, 1981). The present results are in confirmity with the available reports.

NPK with carbofuran seed treatment and NPK + neem cake recorded moderate leaf miner populations. Carbofuran as seed treatment is reported to reduce groundnut leaf miner population upto 30 days (Venkata Reddy, 1988). Granular insecticides like isofenphos and carbosulfan were found more effective in suppressing *A. modicella* infestation (Rajagopal and Gowda, 1992).

The higher incidence of leaf miner in straight fertilized treatments was due to succulency of leaves. The vulnerability of crop to pests due to succulency in the plant has already been discussed under sucking complex.

### 5.1.3. Tobacco Caterpillar, *S. litura*

The treatment that received NPV application at 50 and 75 days after sowing was significantly superior to the other treatments in recording lowest larval population of *S. litura* during the two *rabi* seasons. The incidence of *S. litura* was very low during III stage of *khanf*, 1995 and hence the NPV was not applied. As NPV is specific, the application of *S. litura* NPV showed its effectiveness in reducing *S. litura* population than all the other treatments. Earlier, it was reported that NPV application reduced the incidence of *S. litura* (Jayaraj *et al.*, 1980; Santharam and Balasubramanian, 1980; Krishnaiah *et al.*, 1984; Sasaki, 1987). The next best treatments in reducing the incidence of *S. litura* are NPK with sunflower, neem cake, vermicompost, FYM and NPK with carbofuran seed treatment. The sunflower planted at a distance of 3 m in the groundnut rows attracted *S. litura* moths for oviposition on leaves. These egg masses were periodically collected and destroyed. The sunflower as a trap crop, diverted the *S. litura* gravid females from groundnut. The sunflower plants by acting as bird perches attracted birds like black drongo (*Dicrurus adsimilis*), common mynah (*Acridotheres tristis*) and egrets which acted as potential vertebrate predators. It was reported that black drongo feeds 50 to 60 larvae per day in pigeonpea (Gopali *et al.*, 1997). The birds have contributed to the less incidence of *S. litura* in groundnut with sunflower as trap crop (Plate 12 & 13) (Ranga Rao *et al.*, 1994). The increase in coccinellids in sunflower as a trap crop has also contributed to the population reduction of *S. litura*. Wightman *et al.* (1990) reported that farmers grow castor plants in groundnut to attract ovipositing *Spodoptera* moths. The moths preferentially lay eggs on the leaves of castor where the eggs are easier to find and destroy. Observations in farmers fields with sunflower as intercrop/mixed crop in post-rainy groundnut of 1993 evidenced its advantage as trap crop (Plate 14) (Ranga Rao *et al.*, 1995; ICRISAT, 1994; Wightman *et al.*, 1994). The fungus infections to *S. litura* also contributed to population decline (Plate 15). It was reported that unrelated plants, when grown among the crops, also provide physical or chemical barriers and interfere with host location by phytophagous insects (Root and Tahvanainen, 1969). The results of the present studies pertaining to the less incidence of *S. litura* in groundnut with sunflower as trap crop give credence to the available literature.



Plate 12: Egrets settling in groundnut crop.



Plate 13: Black drongo alighted on a stick as a bird perch.



Plate 14: Sunflower as a trapcrop on bunds in farmers' field.



Plate 15: *S. litura* infected with *Nomuraea rileyi* fungus.

The low pest incidence in neem cake was due to insecticidal, repellent and other associated actions of neem principle 'azadirachtin' after being translocated into the plant system. It was reported by Rajasekharan and Jayaraj (1990) that neem cake applied to soil, make the plant deter *S. litura*. Azadirachtin translocated into plant acts as growth disruptant to many insect species (Schmutterer, 1987), reduce food conversion efficiency by interfering with digestive processes (Timmins and Reynolds, 1992). The low incidence of *S. litura* on the organic manures was probably due to lack of succulence, thickness and development of hard epidermis of the groundnut leaves. The present results revealing lower incidence of *S. litura* are in accordance with those of Fonesca *et al.* (1988), Rossi *et al.* (1988) and Fratello *et al.* (1989). On the other hand, the higher incidence in straight fertilized treatments might be due to succulence of leaves. The influence of straight fertilizers on the pest build up and succulency of leaves has already been discussed.

#### **5.1.4. Gram Pod Borer, *H. armigera***

The incidence of *H. armigera* was lower than *S. litura* and very low population was observed during *kharif*, 1995. The carbofuran seed treatment proved its upper hand in reducing *H. armigera* build up in groundnut, in general. The efficacy of carbofuran seed treatment has already been discussed under *A. modicella*. The other treatments that followed and showed good control of *H. armigera* than the straight fertilized treatments are neem cake, vermicompost, FYM, NPK + neem cake. It was reported that neem cake as basal dose to soil, reduced the incidence of *Heliothis* species (Ruscoe, 1972; Ketkar and Ketkar, 1985; Rajasekharan and Jayaraj, 1990; Mordue (Luntz) and Blackwell, 1993). Similar reports on *H. armigera* population reduction in vermicompost and FYM applied plots were reported by Varma (1994) in chillies, Dayakar *et al.* (1995) in pigeonpea. Bhagyanakshatram (1995) and Kishore Kumar (1996) also reported less incidence of lepidopteran pests of rice in organically

manured treatments compared to the straight fertilized treatments. The influence of straight fertilizers on population build up of other lepidopteran pests has already been discussed in previous sections. The present results showing the higher incidence of *H. armigera* in straight fertilized treatments are in confirmity with those reported by Fletcher (1941), Adkisson (1958), Venkateswara Rao *et al.* (1989) and Purohit and Despande (1994).

#### 5.1.5. Predators (Coccinellids, Spiders and Chrysopids)

Three species of coccinellid beetles were noticed during the three seasons under study. Among the three, *Verania vincta* population was higher followed by *C. transversalis* and *M. sexmaculatus*. The two *rabi* seasons under study recorded 5-10 times higher coccinellid beetle population than in *kharif*, 1995. The coccinellids were found predating on jassids, aphids, leaf miners, *Spodoptera* egg masses and *Helicoverpa* eggs. It was observed that *V. vincta* was highly predacious on *S. litura* egg masses (Plate 16) and *C. transversalis* on jassids and aphids (Plate 17). The higher coccinellid beetle population during *rabi* seasons was probably due to high pest incidence as evidenced by positive correlation and favourable climatic conditions. Similar reports about coccinellids as effective predators on jassids and aphids are available (Misari *et al.*, 1987; Singh *et al.*, 1991; Kenchaiah and Porte, 1989; Jagadish *et al.*, 1996; Nandakumar and Sheela, 1997).

The present investigation without the use of toxic insecticides as foliar sprays benefited the multiplication of predators viz. coccinellids, spiders and chrysopids. Their population fluctuations were noticed synchronizing with pest population since they are density dependent. Observations on some predators at Kavur, Guntur district of Andhra Pradesh indicated 30 times higher coccinellids predating on *S. litura* egg masses, in groundnut fields without application of insecticides compared to the fields that received insecticidal application (ICRISAT, 1994).

The climatic conditions were also probably congenial for spiders during *rabi* seasons under study than in *kharif*, 1995. Spider abundance (Plate 18) increased with advancement of



Plate 16: *V. vincta* preying on *S. litura* eggmass.



Plate 17: *C. transversalis* grub and adult feeding on aphids.



Plate 18: Spider eggmass on groundnut leaflet.

the season and plant size. On an average *kharif* crop recorded one spider per plant while it was 2.0 to 2.5 per plant during the two *rabi* seasons. As the spiders were also density dependent, the pest population fluctuations affected the spiders. Among the different spiders noticed, the oxypopid, *Oxyopes salticus* was the dominating species followed by *Pardosa pauxilla* and *Lycosa pseudoannulata*. The spiders were found predated on all the insects under study (Plate 19 & 20). Similar results were reported by Agnew and Smith (1989) in groundnut. They reported that spider abundance increased as the season progressed and plant size and structure increased. Lycosids were dependent on a closed canopy and were most successful in irrigated fields. Populations of most species, especially lycosids, declined in drought-stressed rainfed fields. Agnew and Smith (1989) also reported that the prey of spiders included *Heliothis* sp., leaf hoppers and thrips. Entomophagous species constituted about one-half of the spider diet.

During the three seasons under study, coccinellids, and spiders were significantly lower in NPK with carbofuran seed treatment followed by other organically manured treatments. The treatments had little influence on the chrysopid population and the chrysopid population is very low. Significantly higher predator population was noticed in the straight fertilized treatments. Low pest populations in NPK with carbofuran seed treatment and organically manured treatments might have led to low predator population. In contrast, the high pest incidence in the straight fertilized treatments harboured more predators. The systemic action of carbofuran through seed treatment might have also affected the coccinellids through pollen and flowers, which are considered as food sources for adults. Carbofuran is reported to reduce major predators of plant hoppers such as spiders, mirid bugs and rove beetles (Panda and Khush, 1995). Host plant-induced changes in prey physiology and behaviour was reported to modify the success of natural enemies (Painter, 1951). It was reported that plants provide nutrition to the natural enemies in the form of pollen, nectar and extrafloral nectar directly or indirectly through



Plate 19: Spider feeding on flies in groundnut ecosystem.



Plate 20: Spider attacking on *S. litura* larva in groundnut ecosystem.

their insect hosts (Smiley, 1978). Many scientists stated that the organic manures are safe to predators (Bhagyanakshatram, 1995; Kishore Kumar, 1996). It was also reported that, although there was initial reduction in population of spiders and mirids in neem treated plots, there was better recolonization of predators (Mohan *et al.*, 1991). Many scientists reported that neem cake application to plants is relatively safe to the natural enemies like spiders and mirids (Krishnaiah and Kalode, 1985; Wu, 1986; Saxena *et al.*, 1989; Jayaraj, 1992) and coccinellids (Singh *et al.*, 1985). All these reports were made by comparing the natural enemy population in organically manured treatments with that in insecticidal treatments. During the present studies, no insecticidal treatment was given to foliage. Because of the absence of toxic residues on the plants, the natural enemy population fluctuated with the prey density while it was not in straight fertilized and hence high population in straight fertilized treatments.

The application of nitrogenous fertilizers/straight fertilizers resulted in succulent vegetative growth, and the dense canopy created favourable microclimatic conditions for build up of predators. Similar results were reported by Adkisson (1958). It was reported that lady bird beetle populations, *H. convergens* and *O. insidiosus* were influenced by fertilizer treatments and showed no influence on *Chrysopa* and *Nabis* species. Fluctuations in spiders in groundnut ecosystem was accompanied by an increase or decrease in the number of cicadellids (Singh *et al.*, 1991).

## 5.2. INFLUENCE OF TREATMENTS ON BIOCHEMICAL CONSTITUENTS OF GROUNDNUT LEAVES

The treatmental influence on the biochemical constituents of groundnut leaves revealed that, in general, nitrogen (N), crude protein (CP), total free amino acids (TFAA) and carbohydrates were lower in all the organically manured treatments than the straight fertilized treatments. It is evident from the results that, the treatments significantly influenced N, CP, TFAA and carbohydrate content in groundnut leaves. The lack of literature pertaining to the

influence of organic and inorganic manures on biochemical constituents of groundnut leaves necessitated to compare with the literature available in other plants/crops. Fertilizers are known to influence substantial changes in both the quantity and quality of nitrogen. Total foliar N was increased as much as four fold with fertilizers (Pirie 1959). N fertilization is reported to increase both total plant biomass and total protein yields (Rauzi, 1978; Sosulski *et al.*, 1963) because N stimulates continued cell division and elongation (Jessup and Fowler, 1976) as well as photosynthetic activity (Fagerstrom and Lohm, 1977). Fertilization has the greatest effect on the levels of soluble N compounds. Fertilizers are reported to increase amino acid and amide levels (Catlin and Priestley, 1976; Hoff *et al.*, 1974; Weissman, 1964) and inorganic N levels (McDole and McMaster, 1978). These reports support the present findings that straight fertilizers contributed to higher level of N/CP, TFAA and carbohydrates in leaves when compared to organically manured treatments. The levels of phenols and tannins were slightly higher in the two *rabi* seasons 1994-95 and 1995-96 than in the *kharif*, 1995. The comparatively higher amounts of these C-based defense compounds during *rabi* seasons was attributed to higher temperatures, more sunshine hours and cloud free days during *rabi*. Similar reports stating profound influence of light on foliar phenolic levels including tannins are available. Mole *et al.* (1988) found very close positive relationship between light intensity and tannins. Such findings point to the possibility that passive effects governed by abiotic factors may be more important than herbivores in determining concentration of phenols and tannins in plants.

The phenols and tannins were found significantly higher in the organically manured treatments compared to the straight fertilized treatments. Many reports are available stating that low N content in the plant/soil contribute to production of higher levels of phenolics in plants (Vogel, 1931; Heller, 1948; Swaby, 1958; Peach, 1950; Bonner, 1950). Davies *et al.* (1964) showed that growing a number of plants in sandy soils produced high content of polyphenolic substances which was attributed to lack of N or P. The study of McKey *et al.* (1978) provides

support for the hypothesis that vegetation on low-nutrient soil contains relatively high concentrations of polyphenolic compounds deterrent to herbivores. As groundnut is a crop of light soils in coastal areas which are characterized by low N and water holding capacity, represents low fertility of the sandy soils. These sandy soils also represent the stress conditions for the plants in terms of environment or N availability to plants. Phillips and Henshaw (1977) have demonstrated experimentally that adding sucrose to N and P-depleted cell cultures of *Acer pseudoplatanus* results in the synthesis of phenols, whereas adding urea resulted in the inhibition of phenolic synthesis. Increasing plant N through fertilizers is reported to reduce the levels of phenols and lignins (Jones, 1976; Kiraly, 1976; Trolldenier and Zehler, 1976), whereas reducing plant N through culturing in soils raised levels of phenolics (Davies *et al.*, 1964; Forrest, 1975; McKey *et al.*, 1978; Reader, 1979; Szweykowska, 1959). All these reports support the present results revealing higher levels of phenols and tannins in organically manured treatments than in straight fertilized treatments.

### 5.3. RELATIONSHIP BETWEEN BIOCHEMICAL CONSTITUENTS OF GROUNDNUT LEAVES AND PESTS AND PREDATORS

Phytophagous insects are very sensitive to nutritional changes in host plants. The nutrition induces changes in concentration of primary and secondary metabolites of the plant and leads to growth and dynamics of the insect pests that harbour plants. Host plant induced changes in prey physiology and behaviour modify the success of natural enemies also. The present results on the relationship between biochemical constituents of leaves as affected by sources of plant nutrition and the pests and predators are discussed in the following sections with the available literature.

### 5.3.1. Sucking Pests

The results of the present investigation indicate a positive correlation between nitrogen (N), crude protein (CP), total free amino acids (TFAA) and carbohydrates and the sucking complex (jassids and aphids); while the association was negative in case of the two C-based defense compounds viz. phenols and tannins. It was clear from the results that the increase in N, CP, TFAA and carbohydrates favoured the build up of pests; and phenols and tannins reduced the incidence of sucking pests. The higher content of these N-based compounds (N, CP, TFAA and carbohydrates) was relatively higher in leaves of straight fertilized treatments than the organically manured. It was also clear from the results that nitrogen has a negative association with the C- based defense compounds. The straight fertilized treatments recorded higher N-based leaf constituents and lower C-based defense compounds and vice versa, in organically manured treatments. Straight fertilizers increased the levels of amino acids, succulency and increased the palatability of the leaf to the sucking pests. The available literature suggest that the incidence of sucking insects increase on the plants containing higher N content (Rodriguez and Campbell, 1961; Honeyborne, 1969; Chadha and Arora 1982). Sorghum lines resistant to delphacids and aphids recorded lower N content in leaves (Mote and Shahane, 1994). Non-preference of *J. auriculatum* by *D. vulgaris* was reported to be due to low leaf protein content (Sundararaj and David, 1990). It was also reported that lower amounts of total free amino acids and carbohydrates in leaves contribute to resistance of plants to sucking pests. The aphids on the pea varieties deficient in amino acids grow more slowly than normal and secrete less honeydew and produce fewer progeny (Auclair and Cartier, 1960). Higher amounts of amino acids attracted whiteflies in castor (David and Paul, 1973) and jasmine (Sundararaj and David, 1990). Low levels of sugars have been correlated to resistance against sucking pests (Mote and Shahane, 1994). It was reported that sap feeding insects, have more intimate relationship with their host plants than many other pests and are affected by small changes in nitrogen status of host (Wensler 1962)

Low N, CP, TFAA and carbohydrate content as observed in organically manured treatments causes low productivity and implies slow growth and thus prolonged life cycles. These conditions reduce the plants' chances of escaping from injury against herbivores "in space" and damaged much by the pest to meet its body N requirement (Mattson, 1980). A major defense probably be "escape in time" possible through production of antiherbivore compounds and availability of predators and parasites (Bentley, 1977; Janzen, 1974). The phenomenon of escape in time was irrevocably observed with low pest population densities in organically manured treatments. Most herbivores feed preferentially on leaves with high N, protein, water content and a low leaf toughness and a low concentration of antiherbivore compounds (Waterman and McKey, 1989). The nutritional requirements of all the insects are generally same but it is the quantitative factor that play a decisive role in insect-plant interactions (House, 1969). Changes induced in the concentrations of plant metabolites affect the insects at the nutritional level and alter behavioural response towards plants. All the plants possess C-based compounds (like phenols and tannins) but it is their relative proportion of these compounds that give advantage to the host plant. It was reported that the higher levels of phenolics in the plants contributed to resistance against sucking pests (Sundararaj and David, 1990; Mote and Shahane, 1994).

The importance of low N content in leaves in the production of phenols and tannins was reviewed in chapter II under sections 2.2. The low N content in the plant leads to increased phenols, tannins and lignins that contribute to leaf toughness and production of more cell wall related structural components which are not desirable for herbivores (Scriber and Slansky, 1981) and probably affect the penetration of stylets of sucking pests into the mesophyll of the groundnut leaf. Elevated levels of fibres and silica are associated with increase in phenols and tannins, increase the bulk density of the diet to the extent that insects are unable to ingest sufficient quantities of nutrients. The plant constituents like protein and carbohydrates are less

available to herbivores in tough leaves because of the hydrogen bonding between the compounds and tannins (Swain, 1979). The phenols reduced the consumption and digestion of leaf material. Insects avoid astringent food, and even after ingestion, the tannin rich food ruptures the epithelial cells in lumen and also affects the digestion because of the coagulation of proteins in their oral cavity. All the available literature pertaining to the influence of biochemical constituents of leaves on sucking pests conclusively support the present findings of the low incidence of jassids and aphids.

### 5.3.2. Lepidopteran Pests

As in sucking pests, the three lepidopteran pests under study viz *A. modicella*, *S. litura* and *H. armigera* also showed positive relationship with N, CP, TFAA and carbohydrates and negative relationship with phenols and tannins. During the two *rabi* seasons, the NPV of *S. litura* dominated the other treatments and probably resulted in non-significant relationship with all the biochemical constituents. However, *S. litura* showed significant positive relationship with all biochemical constituents of leaves during *kharif*, 1995 wherein NPV of *S. litura* was not applied. The higher plant N hastened the levels of CP, TFAA and carbohydrates and offered suitable diet to the lepidopteran pests. It was reported that low nitrogen, sugars and polyphenols contributed to resistance against lepidopteran pest, *A. modicella* in groundnut (Visalakshi, 1994). The higher N favoured the build up of cutworm on wheat (Kasting and McGinnis, 1959). The amino acid imbalance in wheat made the cutworm *A. ipsilon* to suffer much (McGinnis and Kasting, 1961). Ehatia (1975) also reported that low carbohydrate content was responsible for resistance to anguimoid grain moth. The higher levels of phenols and tannins in cotton also reported to reduce the incidence of bollworms (Chan *et al.*, 1978; Ananthakrishnan *et al.*, 1990).

The incidence of *S. litura* and *H. armigera* was comparatively lower than the sucking pests under study. This was attributed to the increase in the survival rate of sucking insects with

plant N content whereas those of chewing insects like *S. litura* and *H. armigera*, the survival rate often decrease (Bogenschutz and Konig, 1976). However, the indirect effects of lowered plant N through organic manures are presumed to be negative for all the herbivores because prolonged consumption and growing periods are believed to increase losses to abiotic and biotic mortality factors.

The importance of low nitrogen and other associated influences on other biochemical constituents has already been discussed in previous sections. The increase in toughness of leaves probably reduced the incidence of these lepidopteran pests. The toughness of leaves probably resulted in abrasions on mandibles and maxillae and impaired their function. It is also probable that the gut pH of the chewing pests played a role in consumption of the leaves with high phenols and tannins (in organically manured treatments). It is for this reason, though the two pests showed negative relationship, it was not significant like sucking pests. It is assumed that the high gut pH reduce protein-tannin binding. The high gut pH was an adaptive phenomenon, reducing the likelihood of antidiigestive effects of tannins in caterpillars with high tannin diets. It was reported that caterpillars had higher gut pH and consumed higher quantities of tannins (Feeny, 1970; Berenbaum, 1984). It seems that insects habitually feeding on tree foliage and other tannin-rich plants produce a relatively thick protective chitin protein peritrophic membrane from the midgut epithelium (Adang and Spence, 1982) and among the grasshopper species there is a positive correlation between mass of peritrophic membrane and quantities of tannins in the diet (Bernays and Simpson, 1989). In case of grasshoppers, it was proposed that the peritrophic membrane preferentially adsorbed tannins, thereby making them ineffective for binding with important dietary or digestive enzyme proteins (Bernays *et al.*, 1980). An overview of the present findings agree with the available literature pertaining to the association between the biochemical constituents of groundnut leaves and the incidence of the three lepidopteran pests *A. modicella*, *S. litura* and *H. armigera*.

### 5.3.3. Predators

In general, coccinellids and spiders showed positive correlation with N, CP, TFAA and carbohydrates and a negative correlation with phenols and tannins, but the relationship was non-significant. As the natural enemies are at the third trophic level, they were dependent on their prey. Consequently, the pest populations affected the predators also. The pest on the straight fertilized treatments was preferred by the natural enemies. The nutritional substrate offered by a host plant indirectly influence predators. Prey confined to resistant hosts (plants in organically manured treatments) commonly experience reduced growth rate, greater developmental time and mortality, and decreased fecundity. Such alterations of fundamental physiological processes affect the nutritional quality of the prey which in turn affects the predators. A major impact of plant resistance is reduction in predator density due to reduced prey populations (Pimental and Wheeler, 1973). Numerous studies indicate that predator performance may be altered by the host plant of the prey. The results of the present findings pertaining to the relationship of predators with biochemical constituents of the host plant of the prey agree in general with the available literature.

### CONCLUSIONS

The present results throw light on the induced resistance/ecological resistance through variation in chemistry of the plant as influenced by the source of plant nutrition. Such a variation in chemistry of the plant is a kind of protective system preventing herbivores from evolving 'fine tuned' offenses against host plants (Denno and McClure, 1983). The production of phenols and tannins is evolutionarily a primitive phenomenon. With the advent of chemical fertilizers, the plants shifted their nutrient system to fertilizers which developed succulency, increased nitrogen and amino acids in the plant which is considered favourable diet for the insects as compared to the nutrients from organic manures. Since then the capacity to synthesize phenols and tannins by plants has decreased. With this concept, it is possible to create a partial N stress upto certain

period through organic manures without any negative effects on crop growth, and thus "induced resistance" through intrinsic production of defense compounds, which deter the pest attack can be brought. Such processes will short cut the lengthy breeding procedures to develop resistance in a plant which would take years. Unlike other management practices this system is simple, cheap and does not require much technical expertise also.

The use of organic manures like neem cake, FYM and vermicompost should be encouraged to attain ecologically sound life sustaining system which will provide the major nutrients to the plants and the micro and trace elements that are lacking in straight fertilizers. Elevated carbon dioxide and other byproducts from the decomposition of manures also reduce root injury by soil pests (Allee *et al.*, 1993). Development of healthy plants with well developed intrinsic defense system thwart the pest attack of any kind. However, lack of sufficient quantities of these organic manures as alternatives to straight fertilizers can be overcome by judicious combinations of organic and inorganic fertilizers. As these organic manures are also rich in micro nutrients, and thus separate application of micro nutrients is rendered redundant. The shift from chemical to non chemical pest management through organic farming should however be gradual. A sudden switch-over could spell disaster and discourage farmers from taking to this course. At least 6-7 years will be needed for the transition, and during the interim years the farmers could build up a sufficient organic base to fertilize the fields and improve the productivity of the soil. The vermicompost stands an alternative for FYM and neem cake as it can be prepared by the farmer with the available farm waste and the city waste and garbage can be best utilized, as its disposal is posing threat to the environment. The natural proliferations of natural enemies of crop pests such as coccinellid beetles, spiders, chrysopids, mantids, dragon flies, damsel flies and lizards have been known to be effective in keeping pests at a bay

The integrated pest management through non-insecticidal pest management (NIPM) / bioenvironmental control relies heavily on the holistic management of the natural resource base. The agricultural practices that are governed by the principles of ecology and are within the ecological means have been put to practice by some enterprising farmers in Andhra Pradesh, Karnataka and Tamil Nadu and their experiences show that natural farming is an excellent illustration of sustainable agriculture through sustainable plant protection. Ecological farming techniques practiced at the eco-farm of the Kasturi estates at Nerkunpattu in Chengalpattu - MGR district, Tamil Nadu, and the Gloria land of Sri Aurobindo Ashram, Pondicherry, have clearly shown that a holistic approach integrating healthy nutrition through bio-fertilizers, vermicompost, coirpith compost and other organic manures with ingenious and eco-friendly measures would pay rich dividends for groundnut farmers. Such ecological farming systems are highly productive and they should not be mistaken for a reversion to inefficient and less productive methods. These practices will reactivate the fatigued green revolution to move forward through promotion of soil health, package of plant protection measures with each component a blend of tradition and modernity. As greater understanding of plant biology, chemistry and ecology of the pest is attained we will be able to approach the goal of developing pest management strategies that are deliberately and foresightedly designed to be eco-friendly. Further studies in these lines in various other crops and other situations against the innumerable insect pests to encourage the concept is highly appreciable.

# *Summary*

## SUMMARY

Groundnut is an important oilseed crop and is cultivated in 21.52 lac ha in Andhra Pradesh and accounts for 28.4% area and 22.2% production on all India basis (DES,1993). Groundnut farmers to overcome insect pests resorted to indiscriminate use of insecticides which has led to several problems such as insecticidal resistance, outbreak of secondary pests and took a toll of beneficial insects, spiders, birds, lizards etc. Keeping the above problems in view, the present investigations with the basic objective of non insecticidal IPM in groundnut were conducted for three seasons at Bapatla and Kavur, Guntur district of Andhra Pradesh.

The treatments include organic manures like farm yard manure (FYM), vermicompost, FYM + vermicompost, neem cake and the straight fertilized (NPK) treatments viz. NPK with NPV of *S. litura* as a spray at 50 and 75 days after sowing (DAS), NPK with sunflower as a trap crop and NPK with carbofuran seed treatment and NPK as control.

The observations pertaining to the pest and predator counts were recorded at weekly intervals from 20 DAS till the harvest of the crop. The data was evaluated at three stages of crop growth synchronizing with the biochemical analysis of leaves done at 21 DAS (flowering), 49 DAS (peg penetration) and 77 DAS (pod formation stages) of groundnut. The biochemical constituents of groundnut leaves viz. nitrogen (N), crude protein (CP), total free amino acids (TFAA), carbohydrates, phenols and tannins were estimated with standard procedures and correlated with pest and predator incidence.

The results revealed that

1. Organic manures reduced the incidence of all the pests under study. The sucking insects, jassids and aphids were lowest in neem cake followed by the treatments that received organic manures, NPK with carbofuran seed treatment and NPK + neem cake. The straight fertilized treatments recorded higher incidence of jassids and aphids.
2. The treatments that received organic manures and NPK with seed treatment were superior in suppressing the leaf miner population than the straight fertilized treatments. *S. litura* was effectively reduced in NPK with NPV. The other treatments NPK with sunflower, neem cake, vermicompost also showed superiority by recording lower incidence of *S. litura* on groundnut. The straight fertilized treatments recorded higher incidence of *S. litura*. NPK with carbofuran seed treatment showed its superiority in recording low incidence of *H. armigera* followed by neem cake, vermicompost and FYM.
3. The natural enemies like coccinellids and spiders are however, higher in the treatments that received straight fertilizers and lower in organically manured treatments. The low levels of pest population in organically manured treatments resulted in low incidence of predators, a density dependent biotic factor. NPK with seed treatment followed by organic manures recorded lower natural enemy population. The treatments did not influence the chrysopids and in general the population of chrysopids was low.
4. The treatments were found to influence the levels of biochemical constituents of groundnut leaves. The treatments with organic manures recorded significantly lower amounts of N, CP, TFAA and carbohydrates and higher levels of the carbon based defense compounds, phenols and tannins than the straight fertilized treatments. Lower nitrogen in the leaves of

organically manured treatments contributed to higher production of phenols and tannins and vice versa in the treatments that received straight fertilizers.

5. All the pests and predators (except chrysopids) showed positive correlation with N, CP, TFAA and carbohydrates and negative correlation with phenols and tannins. The higher N, CP, TFAA and carbohydrates and low levels of phenols and tannins in straight fertilized treatments contributed to higher pest incidence and vice versa in organic manured treatments.
6. The natural enemies like coccinellid beetles, spiders, chrysopids increased because of the absence of application of insecticides. The two *rabi* seasons recorded 5-10 times higher coccinellid beetle population than *kharif*. The population of spiders was also higher during *rabi* than in *kharif*. Sunflower plants acted as preferred host to *S. litura* and also acted as bird perches and contributed to lower incidence of *S. litura* and *H. armigera*.
7. Present studies throw light on the manipulation of host plant through nutrition to bring induced/ecological resistance in plants. The slight alteration in chemistry of the plant may bring desirable effects without sacrificing the growth and yield. The present studies without the use of insecticidal sprays, and use of organic manures focus on the alternatives for straight fertilizers and manipulate the host plant, making it less attractive for the pest. The studies also reduce the cost of inputs towards insecticides and fertilizers and promote the ecological balance through provision of food to natural enemies and stress the need for ecological/organic farming to attain sustainable plant protection which inturn paves the way for sustainable agriculture.

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# *Appendices*

Appendix 1. Population of jassids, *E. kerri* (nymphs per 10 plants) recorded at weekly intervals.

Season	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS	11WAS	12WAS	13WAS	Average
T <sub>1</sub> Kharif 95	16.00	0.0	16.0	38.6	54.6	89.3	140.0	170.6	138.9	12.6	3.3	61.84
Rabi 94-95	9.33	13.0	13.3	21.3	36.6	46.6	66.6	49.7	27.3	14.0	0.0	24.85
Rabi 95-96	7.00	9.0	16.5	26.5	40.0	58.0	83.3	54.3	35.0	25.2	0.0	29.87
T <sub>2</sub> Kharif 95	8.00	8.0	8.0	20.0	25.3	46.6	88.0	124.0	99.0	10.3	4.3	39.90
Rabi 94-95	2.66	6.5	6.6	8.0	18.3	21.3	24.0	25.3	15.5	12.0	0.0	11.70
Rabi 95-96	1.00	4.3	8.0	10.0	22.0	26.5	30.0	26.6	18.3	24.0	0.0	14.27
T <sub>3</sub> Kharif 95	12.00	0.0	12.0	22.6	36.0	52.0	109.3	140.0	114.9	9.0	3.0	46.45
Rabi 94-95	4.00	6.5	8.0	8.0	20.0	22.6	26.6	21.7	15.9	12.6	0.0	12.18
Rabi 95-96	1.30	5.3	10.0	10.0	24.0	28.0	33.3	27.0	20.0	23.2	0.0	15.22
T <sub>4</sub> Kharif 95	13.30	0.0	13.3	26.0	29.3	37.3	90.0	140.0	96.9	9.3	3.6	41.87
Rabi 94-95	4.00	8.0	9.3	9.3	18.3	24.0	30.6	25.0	17.3	15.3	0.0	15.30
Rabi 95-96	2.00	6.0	11.5	11.5	22.0	30.0	38.3	29.0	18.3	24.0	0.0	16.13
T <sub>5</sub> Kharif 95	9.20	0.0	10.0	30.0	21.3	29.3	69.3	130.6	87.9	9.6	4.0	35.66
Rabi 94-95	0.00	1.5	2.6	5.3	11.6	20.0	26.0	29.0	14.4	12.6	0.0	10.34
Rabi 95-96	2.30	3.6	3.3	6.0	14.0	35.0	33.3	20.0	11.6	20.0	0.0	11.66
T <sub>6</sub> Kharif 95	10.40	0.0	12.0	25.3	28.0	36.0	96.0	134.6	99.6	5.6	3.0	42.84
Rabi 94-95	2.66	6.5	8.0	9.3	28.3	32.0	34.6	37.0	18.8	15.3	0.0	16.07
Rabi 95-96	2.60	4.6	10.0	11.5	34.0	40.0	43.3	30.0	28.3	23.2	0.0	18.99
T <sub>7</sub> Kharif 95	20.00	0.0	20.0	41.3	48.0	73.3	132.0	146.6	110.0	12.6	3.0	56.11
Rabi 94-95	8.00	15.0	16.0	17.3	35.0	48.0	58.6	47.0	27.3	15.3	0.0	23.96
Rabi 95-96	7.00	8.6	20.0	21.3	42.0	60.0	73.3	48.6	35.0	28.6	0.0	28.69
T <sub>8</sub> Kharif 95	18.40	0.0	18.6	36.0	45.3	65.3	110.6	142.6	109.8	12.0	3.3	50.84
Rabi 94-95	9.33	16.5	13.3	16.0	40.0	50.6	61.3	47.0	27.5	14.0	0.0	24.03
Rabi 95-96	7.60	10.3	16.5	20.0	48.0	63.3	76.5	54.0	40.0	26.6	0.0	30.27
T <sub>9</sub> Kharif 95	8.00	0.0	9.3	21.3	28.0	62.6	102.6	144.0	115.8	6.3	3.6	45.72
Rabi 94-95	1.33	1.5	2.6	5.3	11.6	34.6	45.3	41.0	20.4	12.6	0.0	14.72
Rabi 95-96	3.00	4.6	3.3	6.5	14.0	43.3	56.5	37.0	11.6	21.2	0.0	16.80

Appendix 2. Population of aphids, *A. craccivora* (adults per 10 plants) recorded at weekly intervals.

Season	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS	11WAS	12WAS	13WAS	14WAS	Average
T <sub>1</sub> Kharif 95	23.3	0.0	24.3	33.0	36.3	56.0	47.3	38.0	11.33	0.0	0.0	0.0	48.90
Rabi 94-95	35.6	48.6	55.6	75.6	87.0	96.6	74.6	55.0	53.0	35.3	25.3	14.6	109.54
Rabi 95-96	58.0	66.0	84.0	66.0	67.0	46.4	38.0	34.2	38.4	22.0	19.3	0.0	89.92
T <sub>2</sub> Kharif 95	7.0	0.0	8.0	12.3	21.0	26.0	24.0	36.6	10.0	0.0	0.0	0.0	26.40
Rabi 94-95	14.0	17.3	18.3	23.3	33.3	52.6	64.0	37.5	24.9	27.3	22.0	12.3	58.22
Rabi 95-96	14.0	40.0	44.4	44.4	40.0	24.0	32.3	33.6	27.4	20.0	15.3	0.0	55.98
T <sub>3</sub> Kharif 95	8.0	0.0	9.0	13.3	24.0	31.0	26.0	38.6	9.6	0.0	0.0	0.0	29.02
Rabi 94-95	16.3	18.0	19.0	26.0	33.0	51.6	53.3	28.0	27.1	27.6	22.6	13.3	56.96
Rabi 95-96	16.3	38.0	44.0	44.0	41.3	27.0	33.3	29.4	30.4	19.0	13.0	0.0	55.90
T <sub>4</sub> Kharif 95	7.3	0.0	8.6	14.0	22.3	29.0	25.3	35.6	8.0	0.0	0.0	0.0	27.26
Rabi 94-95	15.6	17.6	20.3	25.3	33.0	51.3	62.6	34.0	28.0	32.3	25.3	13.3	60.06
Rabi 95-96	15.3	43.2	45.2	51.3	42.0	27.3	28.6	32.1	29.0	21.0	13.0	0.0	57.90
T <sub>5</sub> Kharif 95	7.0	0.0	7.0	16.0	20.3	23.7	24.3	33.6	12.3	0.0	0.0	0.0	26.34
Rabi 94-95	10.3	14.0	15.3	22.3	27.6	47.3	52.0	37.0	23.3	31.0	24.0	13.6	52.98
Rabi 95-96	26.0	38.6	45.2	46.0	41.3	28.0	36.6	36.3	30.5	19.3	13.0	0.0	61.80
T <sub>6</sub> Kharif 95	16.6	0.0	17.6	21.6	25.3	33.0	35.0	35.0	11.6	0.0	0.0	0.0	35.02
Rabi 94-95	17.3	25.3	27.0	39.3	51.3	67.6	55.0	42.0	37.2	26.3	22.3	11.6	70.40
Rabi 95-96	33.0	44.0	44.0	54.0	47.3	31.0	35.3	33.3	33.7	19.0	14.6	0.0	65.22
T <sub>7</sub> Kharif 95	24.0	0.0	24.3	26.0	35.6	48.6	44.0	33.0	11.6	0.0	0.0	0.0	45.14
Rabi 94-95	33.0	44.0	46.3	61.0	73.3	85.6	66.0	60.0	56.0	35.0	19.0	12.0	98.34
Rabi 95-96	52.0	70.0	67.8	62.6	64.6	51.0	35.0	29.3	38.3	23.3	17.3	0.0	85.22
T <sub>8</sub> Kharif 95	23.3	0.0	26.0	29.3	35.0	44.6	46.0	33.3	12.6	0.0	0.0	0.0	45.50
Rabi 94-95	36.3	47.6	44.3	66.3	76.6	91.6	72.6	54.0	59.9	30.6	22.0	11.6	102.54
Rabi 95-96	49.3	56.0	81.0	62.0	62.6	47.6	35.6	25.3	34.7	22.6	17.3	0.0	83.50
T <sub>9</sub> Kharif 95	6.6	0.0	7.3	16.0	19.0	47.6	44.6	36.3	10.6	0.0	0.0	0.0	33.92
Rabi 94-95	11.0	13.0	16.3	27.6	33.0	56.0	60.0	44.0	37.1	34.6	21.6	12.3	59.08
Rabi 95-96	24.0	38.0	43.3	45.2	40.0	43.3	36.3	29.7	35.8	20.6	19.0	0.0	63.14

Appendix 3. Population of leaf miner, *A. modicella* (larvae per 10 plants) collected at weekly intervals.

Season	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS	11WAS	12WAS	13WAS	14WAS	Average
T <sub>1</sub> Kharif 95	12.0	12.0	0.0	12.0	19.0	21.6	17.3	16.6	15.3	8.3	3.3	3.3	0.00
Rabi 94-95	6.00	8.66	7.0	8.3	12.3	16.6	18.6	18.0	21.3	17.3	8.3	4.6	24.60
Rabi 95-96	7.33	14.6	20.3	23.3	24.0	24.3	19.0	17.0	15.3	8.3	3.3	0.0	29.48
T <sub>2</sub> Kharif 95	4.60	0.0	4.6	6.6	8.0	8.0	8.6	8.0	7.0	3.0	0.0	0.0	10.66
Rabi 94-95	1.33	2.0	1.6	2.0	5.6	6.6	7.3	9.6	11.3	9.3	7.3	3.6	11.48
Rabi 95-96	3.30	4.6	6.6	9.0	13.6	23.3	6.6	7.6	8.0	7.0	3.0	0.0	15.48
T <sub>3</sub> Kharif 95	6.00	0.0	6.0	8.0	11.0	9.6	9.3	7.3	7.0	3.3	0.0	0.0	12.42
Rabi 94-95	1.33	2.0	2.3	2.3	6.3	7.0	8.0	9.0	13.0	8.3	7.3	3.6	11.76
Rabi 95-96	3.00	6.0	8.0	11.3	12.3	22.0	8.0	8.0	7.3	7.0	3.3	0.0	16.10
T <sub>4</sub> Kharif 95	5.30	0.0	5.3	7.3	10.3	8.6	9.3	7.6	6.3	2.3	0.0	0.0	11.38
Rabi 94-95	2.00	2.66	2.6	2.6	6.6	7.3	9.3	0.0	13.6	10.6	8.0	4.6	13.22
Rabi 95-96	3.60	5.3	8.3	12.3	15.3	22.6	7.3	8.0	7.6	6.3	2.3	0.0	16.72
T <sub>5</sub> Kharif 95	5.00	0.0	5.0	7.0	9.3	8.6	8.6	7.0	6.3	3.0	0.0	0.0	11.02
Rabi 94-95	0.66	0.66	0.6	2.0	4.3	7.0	9.3	11.0	13.3	11.6	6.6	3.3	11.76
Rabi 95-96	3.20	6.0	9.3	12.6	14.0	16.6	7.6	7.3	7.0	6.3	3.0	0.0	15.54
T <sub>6</sub> Kharif 95	8.60	0.0	8.6	13	14.6	12.3	10.6	9.6	7.3	4.0	0.0	0.0	18.60
Rabi 94-95	2.66	3.33	3.3	4.0	8.3	10.6	13.0	14.0	17.3	14.0	6.6	4.0	16.88
Rabi 95-96	4.00	8.6	13.0	14.3	17.3	19.0	13.0	12.5	9.6	7.3	4.0	0.0	20.52
T <sub>7</sub> Kharif 95	11.60	0.0	11.6	18.0	21.0	14.6	12.0	13.3	7.6	3.3	0.0	0.0	20.60
Rabi 94-95	6.66	8.0	6.0	7.0	12.0	17.3	17.3	16.0	19.0	16.3	7.0	5.0	23.10
Rabi 95-96	7.30	11.6	18.0	20.3	19.3	25.3	18.0	14.2	13.3	7.6	3.3	0.0	26.42
T <sub>8</sub> Kharif 95	12.60	0.0	12.6	17.3	21.3	15.3	14.0	11.6	7.3	3.3	0.0	0.0	21.02
Rabi 94-95	6.00	9.33	7.3	8.0	13.0	18.0	19.3	17.4	19.3	15.3	6.6	5.3	24.34
Rabi 95-96	7.00	12.66	17.3	23.3	21.0	24.3	17.3	15.6	11.6	7.3	3.3	0.0	26.82
T <sub>9</sub> Kharif 95	4.30	0.0	4.3	6.0	8.3	17.6	17.0	16.6	5.6	3.6	0.0	0.0	14.96
Rabi 94-95	0.00	0.66	0.6	2.3	8.0	10.3	11.6	12.3	15.3	11.3	7.0	3.0	13.26
Rabi 95-96	2.30	6.0	8.3	11.6	11.6	14.0	12.0	11.0	12.0	6.3	3.6	0.0	16.54

Appendix 4. Population of tobacco caterpillar, *S. litura* population (larvae per 10 plants) collected at weekly intervals.

Season	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS	11WAS	12WAS	13WAS	14WAS	Average
T <sub>1</sub> Kharif 95	0.0	0.0	1.3	1.6	4.0	5.60	7.30	2.00	0.00	0.00	0.00	0.00	1.99
Rabi 94-95	7.6	7.3	8.3	13.3	14.3	17.30	15.30	15.00	14.60	12.30	8.30	6.60	11.69
Rabi 95-96	5.0	7.6	9.6	11.6	11.3	16.66	14.00	11.14	10.66	7.33	5.33	3.60	9.51
T <sub>2</sub> Kharif 95	0.0	0.0	0.3	1.0	1.3	2.30	4.00	2.30	0.00	0.00	0.00	0.00	1.03
Rabi 94-95	5.3	5.0	4.0	5.3	7.3	11.60	14.60	14.30	14.00	10.30	5.60	6.30	8.68
Rabi 95-96	2.3	4.0	5.3	6.6	5.9	12.00	11.33	11.20	9.33	6.00	4.66	3.00	6.81
T <sub>3</sub> Kharif 95	0.0	0.0	0.0	0.6	1.6	3.00	4.30	2.30	0.00	0.00	0.00	0.00	1.09
Rabi 94-95	4.6	5.6	4.3	4.6	7.6	12.30	13.60	13.30	14.00	12.60	6.60	6.60	8.85
Rabi 95-96	2.6	4.6	5.6	7.3	7.0	10.00	11.00	11.80	8.66	4.66	4.33	2.30	6.67
T <sub>4</sub> Kharif 95	0.0	0.0	0.0	1.0	2.0	2.60	3.00	2.00	0.00	0.00	0.00	0.00	1.15
Rabi 94-95	5.3	6.0	4.6	5.6	7.3	11.60	12.30	10.40	11.60	9.00	6.30	6.00	8.14
Rabi 95-96	3.0	5.3	6.3	7.3	6.9	11.00	11.33	12.40	9.33	5.33	4.66	2.60	7.38
T <sub>5</sub> Kharif 95	0.0	0.0	0.3	0.6	2.6	3.30	4.30	2.00	0.00	0.00	0.00	0.00	1.18
Rabi 94-95	4.0	4.3	4.0	5.0	7.6	8.60	10.30	10.70	11.60	11.30	8.60	7.30	7.75
Rabi 95-96	2.3	3.3	4.0	7.3	5.7	10.60	11.66	8.60	6.66	7.33	3.33	3.60	6.22
T <sub>6</sub> Kharif 95	0.0	0.0	0.6	1.3	4.0	3.60	6.30	3.30	0.00	0.00	0.00	0.00	1.75
Rabi 94-95	5.3	5.3	5.3	7.3	8.6	10.30	9.60	9.00	12.60	11.00	6.60	7.30	8.22
Rabi 95-96	3.3	4.0	5.6	8.3	7.0	11.30	13.00	10.00	8.66	6.66	4.33	4.00	7.13
T <sub>7</sub> Kharif 95	0.0	0.0	1.0	1.66	5.0	6.00	8.00	2.00	0.00	0.00	0.00	0.00	2.18
Rabi 94-95	7.3	7.3	8.6	12.6	12.3	3.30	3.60	3.90	1.33	3.60	4.30	3.00	6.04
Rabi 95-96	4.3	6.3	8.3	12.6	10.5	1.66	6.33	4.00	1.33	1.33	1.66	3.00	5.13
T <sub>8</sub> Kharif 95	0.0	0.0	1.0	2.0	4.6	6.30	8.00	2.60	0.00	0.00	0.00	0.00	2.24
Rabi 94-95	8.0	7.6	9.0	11.6	11.3	6.60	6.00	7.00	7.30	5.30	5.30	2.60	7.35
Rabi 95-96	5.0	7.3	9.6	11.3	11.6	10.00	10.00	7.80	6.66	7.33	3.33	4.30	8.09
T <sub>9</sub> Kharif 95	0.0	0.0	0.3	0.6	2.6	3.00	4.00	2.30	0.00	0.00	0.00	0.00	1.15
Rabi 94-95	3.3	3.6	3.6	4.3	8.3	14.30	13.00	12.00	12.30	12.00	8.00	7.30	7.91
Rabi 95-96	2.0	3.6	3.3	5.6	4.7	16.33	13.66	11.40	8.66	7.33	4.33	3.60	7.03

Appendix 5. Population of gram pod borer, *H. armigera* (larvae per 10 plants) collected at weekly intervals.

Season	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS	11WAS	12WAS	13WAS	Average
T <sub>1</sub> Kharif 95	0.0	0.0	2.6	3.00	1.41	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rabi 94-95	0.6	1.0	1.3	4.60	7.30	9.0	9.3	8.0	3.83	3.5	2.16	4.18
Rabi 95-96	0.6	1.3	1.6	6.00	8.00	10.6	6.6	5.6	4.6	2.6	0.0	4.27
T <sub>2</sub> Kharif 95	0.0	0.0	1.6	2.00	0.91	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rabi 94-95	0.3	0.3	0.3	2.00	3.60	5.3	6.0	5.7	2.66	3.0	2.0	2.61
Rabi 95-96	0.0	0.3	1.0	4.60	5.60	6.3	5.0	4.0	2.6	3.3	0.0	2.72
T <sub>3</sub> Kharif 95	0.0	0.0	1.5	1.60	0.83	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rabi 94-95	0.3	0.3	0.3	2.00	4.00	5.6	6.6	5.0	2.33	3.16	2.33	2.7
Rabi 95-96	0.3	0.6	1.0	5.30	6.00	6.6	4.6	3.6	3.3	2.0	0.0	2.77
T <sub>4</sub> Kharif 95	0.0	0.0	1.3	2.30	0.91	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rabi 94-95	0.3	0.3	0.6	2.30	3.60	6.0	7.6	5.3	2.66	3.33	2.16	3.45
Rabi 95-96	0.3	0.6	1.3	5.30	6.60	7.3	6.6	4.2	4.0	1.6	0.0	3.18
T <sub>5</sub> Kharif 95	0.0	0.0	1.3	1.60	0.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rabi 94-95	0.0	0.3	0.6	1.30	2.30	5.0	5.0	5.0	2.0	3.16	1.83	2.3
Rabi 95-96	0.0	0.3	0.6	4.00	5.00	5.0	6.0	4.4	3.0	1.3	0.0	2.42
T <sub>6</sub> Kharif 95	0.0	0.0	1.6	2.00	0.91	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rabi 94-95	0.0	0.6	0.6	2.30	5.00	6.0	6.6	5.3	2.66	3.83	1.83	2.91
Rabi 95-96	0.3	0.6	1.0	5.30	5.60	6.3	6.3	5.0	3.3	3.0	0.0	3.08
T <sub>7</sub> Kharif 95	0.0	0.0	2.6	2.60	1.33	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rabi 94-95	0.6	1.0	1.3	4.30	7.00	8.0	8.6	7.0	3.5	3.83	2.66	3.99
Rabi 95-96	0.6	1.6	1.3	5.60	7.30	12.0	5.6	4.1	3.3	3.3	0.0	3.75
T <sub>8</sub> Kharif 95	0.0	0.0	2.0	4.00	1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rabi 94-95	1.0	1.0	1.0	4.00	7.60	10.0	9.0	8.3	4.0	3.5	3.0	4.37
Rabi 95-96	0.6	1.3	1.6	6.00	7.30	8.6	5.3	3.9	4.0	2.6	0.0	3.46
T <sub>9</sub> Kharif 95	0.0	0.0	1.0	1.33	0.58	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rabi 94-95	0.0	0.3	0.6	1.30	4.30	9.0	8.6	8.3	3.66	3.16	2.5	3.41
Rabi 95-96	0.0	0.3	0.6	3.60	3.30	4.6	4.3	3.6	4.3	3.3	0.0	2.35

Appendix 6. Population of coccinellid beetles (adults per 10 plants) recorded at weekly intervals.

Season	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS	11WAS	12WAS	13WAS	14WAS	Average
T <sub>1</sub> Kharif 95	0.66	0.0	1.3	2.6	6.0	9.3	19.0	23.0	5.3	0.0	0.0	0.0	6.12
Rabi 94-95	11.0	16.6	23.3	37.0	55.3	81.6	93.0	100.0	86.0	77.0	58.0	32.6	55.91
Rabi 95-96	16.0	16.6	20.6	28.6	45.9	72.3	87.9	89.3	112.6	70.0	32.6	26.6	51.46
T <sub>2</sub> Kharif 95	0.66	0.0	1.0	1.6	5.3	8.3	18.3	24.0	6.0	0.0	0.0	0.0	5.93
Rabi 94-95	9.6	13.0	19.3	32.0	49.3	54.6	66.6	88.0	77.0	54.6	39.3	39.3	44.66
Rabi 95-96	16.0	11.2	18.0	26.6	37.2	64.8	82.8	90.4	96.9	48	28.6	24.6	44.94
T <sub>3</sub> Kharif 95	0.66	0.0	1.3	2.0	4.0	9.0	19.0	25.3	7.0	0.0	0.0	0.0	6.18
Rabi 94-95	9.6	15.3	19.0	38.3	52.0	56.3	78.0	94.0	78.6	58.0	52.6	42.0	49.49
Rabi 95-96	14.0	14.6	21.0	24.0	39.9	76.8	73.8	87.6	99.9	77.3	34.6	25.3	48.38
T <sub>4</sub> Kharif 95	0.33	0.0	1.0	2.0	4.6	9.8	19.3	21.6	5.0	0.0	0.0	0.0	5.72
Rabi 94-95	10.3	16.0	22.3	35.3	56.3	52.3	69.0	97.0	52.6	55.3	49.3	38.0	47.94
Rabi 95-96	12.6	13.2	21.0	28.6	42.0	6.9	73.8	94.3	109.8	70.6	30.6	37.2	49.52
T <sub>5</sub> Kharif 95	0.33	0.0	0.6	1.6	4.3	8.0	18.0	23.3	5.6	0.0	0.0	0.0	5.63
Rabi 94-95	9.0	14.3	19.0	31.3	49.0	53.6	75.6	95.3	88.6	56.0	56.6	29.0	48.11
Rabi 95-96	13.0	14.6	15.2	26.0	42.4	72.0	75.9	89.1	115.8	67.2	29.2	26.6	48.61
T <sub>6</sub> Kharif 95	0.66	0.0	1.0	3.3	4.3	7.6	16.6	19.0	5.6	0.0	0.0	0.0	5.21
Rabi 94-95	11.6	14.6	22.6	31.0	46.3	46.3	81.0	81.0	84.3	54.0	44.6	32.0	44.66
Rabi 95-96	14.6	12.6	17.2	27.6	46.4	69.9	81.0	93.0	105.0	65.2	35.2	30.6	49.52
T <sub>7</sub> Kharif 95	0.33	0.0	1.0	3.0	6.0	8.6	18.0	21.3	6.3	0.0	0.0	0.0	5.90
Rabi 94-95	9.6	16.0	25.3	32.6	60.0	51.3	65.0	97.0	86.0	49.0	55.0	33.3	48.33
Rabi 95-96	18.0	16.6	21.0	23.3	43.3	51.9	87.9	97.0	100.8	73.2	36.0	26.0	49.94
T <sub>8</sub> Kharif 95	0.66	0.0	1.6	3.3	6.3	7.6	17.0	23.3	6.3	0.0	0.0	0.0	5.84
Rabi 94-95	13.3	15.6	25.0	33.6	50.0	65.6	70.0	99.0	77.3	46.6	55.0	28.3	48.30
Rabi 95-96	16.0	17.3	22.0	30.0	46.3	93.9	93.0	96.0	105.0	64.6	46.6	26.6	54.97
T <sub>9</sub> Kharif 95	0.66	0	1.0	1.6	3.6	7.6	17.3	22.0	7.3	0.0	0.0	0.0	5.51
Rabi 94-95	5.6	7.6	12.3	17.3	20.3	40.0	53.3	88.0	77.0	71.3	51.3	28.0	37.19
Rabi 95-96	11.3	8.3	11.0	16.0	23.2	42.0	52.8	87.0	95.2	70.0	36.0	20.6	39.49

Appendix 7. Population of spiders (adults per 10 plants) recorded at weekly intervals.

Season	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS	11WAS	12WAS	13WAS	14WAS	Average
T <sub>1</sub> Kharif 95	3.3	0.0	4.3	6.0	11.0	19.3	23.3	22.6	5.66	2.6	0.0	0.0	8.93
Rabi 94-95	3.3	9.0	13.6	22.3	33.3	44.6	42.0	40.0	43.3	32.6	31.6	33.6	29.10
Rabi 95-96	3.3	8.3	9.3	11.6	22.0	28.0	49.0	40.0	24.0	18.3	11.6	7.6	19.44
T <sub>2</sub> Kharif 95	3.3	0.0	3.6	5.6	11.6	15.3	22.6	22.3	7.0	3.0	0.0	0.0	8.42
Rabi 94-95	2.0	8.6	12.0	19.0	36.3	40.6	41.6	42.0	42.3	29.0	26.0	29.3	27.80
Rabi 95-96	2.6	7.3	7.0	8.6	19.0	22.2	52.0	36.0	24.6	19.0	14.0	6.0	18.24
T <sub>3</sub> Kharif 95	3.0	0.0	4.0	5.0	10.3	18.0	21.6	23.0	8.6	4.0	0.0	0.0	8.87
Rabi 94-95	3.0	6.0	11.6	18.0	35.6	48.0	39.3	36.0	41.6	33.3	29.3	27.6	27.46
Rabi 95-96	2.6	7.0	7.6	8.3	18.0	22.0	53.6	38.0	25.3	21.0	9.6	6.0	18.30
T <sub>4</sub> Kharif 95	2.3	0.0	3.3	6.3	10.6	17.3	22.0	22.0	6.3	5.0	0.0	0.0	8.66
Rabi 94-95	2.3	7.0	12.6	18.0	35.0	43.0	43.6	29.0	44.3	30.6	28.6	36.0	27.60
Rabi 95-96	3.66	8.0	8.0	9.3	20.0	22.6	54.3	25.0	31.0	22.0	12.6	6.0	18.66
T <sub>5</sub> Kharif 95	1.0	0.0	2.0	2.6	4.6	11.6	23.3	22.3	8.33	3.3	0.0	0.0	7.39
Rabi 94-95	1.0	3.3	5.6	6.3	8.0	42.6	38.0	37.0	39.3	29.6	31.3	30.6	22.74
Rabi 95-96	1.6	4.0	4.0	6.0	15.3	22.6	46.0	39.0	25.3	20.0	13.3	7.3	17.10
T <sub>6</sub> Kharif 95	2.3	0.0	3.0	3.6	5.6	15.0	22.0	24.0	6.0	5.0	0.0	0.0	7.87
Rabi 94-95	1.3	4.3	6.0	7.0	8.6	42.0	39.0	46.0	36.0	31.3	28.3	29.0	23.25
Rabi 95-96	1.6	5.0	6.6	7.6	17.3	22.6	43.3	31.0	24.6	18.0	11.6	7.0	16.44
T <sub>7</sub> Kharif 95	4.0	0.0	5.0	8.0	12.3	18.0	20.3	24.6	6.3	4.3	0.0	0.0	9.36
Rabi 94-95	4.6	7.6	12.3	17.3	31.0	35.6	41.6	34.0	40.3	30.6	20.3	25.3	25.77
Rabi 95-96	2.3	8.0	9.6	10.3	23.3	27.0	45.3	38.0	27.6	19.6	12.6	8.6	19.30
T <sub>8</sub> Kharif 95	3.3	0.0	4.0	7.0	11.0	19.0	23.0	23.3	7.3	6.3	0.0	0.0	9.45
Rabi 94-95	3.0	8.0	13.3	21.0	29.0	39.0	39.3	31.0	37.6	32.0	32.0	32.0	26.24
Rabi 95-96	4.3	8.3	7.3	11.6	22.6	27.0	1.6	39.0	27.0	17.6	12.3	5.6	19.55
T <sub>9</sub> Kharif 95	1.3	0.0	1.3	2.3	4.3	12.6	21.0	24.0	7.0	6.0	0.0	0.0	7.27
Rabi 94-95	1.0	3.0	4.0	5.3	7.3	42.0	40.3	39.0	40.6	30.3	26.6	31.0	19.96
Rabi 95-96	1.3	3.6	4.6	6.3	14.0	24.3	47.6	28.0	27.0	17.3	12.6	5.3	16.02

Appendix 8. Population of chrysopids (number per 10 plants) recorded at weekly intervals.

Season	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS	11WAS	12WAS	13WAS	14WAS	Average
T <sub>1</sub> Kharif 95	0.3	0.0	0.66	4.0	4.3	7.0	6.6	7.6	2.6	0.0	0.0	0.0	3.06
Rabi 94-95	2.0	4.0	5.0	7.3	9.0	14.0	23.6	20.0	18.0	18.0	12.0	8.6	11.83
Rabi 95-96	1.3	3.3	4.0	7.0	8.6	13.3	11.3	10.0	13.6	9.3	5.3	4.0	7.61
T <sub>2</sub> Kharif 95	0.3	0.0	0.66	4.0	3.3	7.0	7.6	8.6	2.6	0.0	0.0	0.0	3.12
Rabi 94-95	3.0	3.3	5.3	6.3	9.0	15.6	24.0	22.0	16.6	15.6	13.6	7.3	11.94
Rabi 95-96	0.3	3.6	5.6	7.0	7.6	13.0	12.0	12.0	12.0	8.3	4.0	3.6	7.80
T <sub>3</sub> Kharif 95	0.0	0.0	0.66	4.0	3.0	7.3	6.0	7.6	2.3	0.0	0.0	0.0	2.87
Rabi 94-95	2.6	4.6	5.3	7.0	9.0	13.0	22.3	24.0	18.0	16.3	11.3	7.0	11.80
Rabi 95-96	0.6	3.3	6.6	7.6	6.6	10.6	11.3	11.3	11.3	9.0	4.3	4.0	7.21
T <sub>4</sub> Kharif 95	0.3	0.0	0.66	4.3	4.0	5.6	7.3	6.6	2.3	0.0	0.0	0.0	2.90
Rabi 94-95	2.3	3.3	5.3	7.0	8.6	13.3	25.3	25.0	17.0	14.0	13.3	7.6	11.01
Rabi 95-96	0.6	4.0	6.0	5.3	7.3	9.3	12.3	12.3	12.3	9.0	4.3	2.6	7.10
T <sub>5</sub> Kharif 95	0.3	0.0	0.66	4.3	5.0	6.0	8.33	7.0	3.3	0.0	0.0	0.0	3.18
Rabi 94-95	2.0	3.6	6.0	7.3	8.6	13.3	23.3	19.0	17.3	14.0	11.6	7.3	11.35
Rabi 95-96	0.6	2.6	3.6	5.6	8.3	15.0	9.0	10.0	11.0	8.0	6.0	4.6	7.55
T <sub>6</sub> Kharif 95	0.3	0.0	0.66	5.0	3.0	6.0	6.60	6.3	2.6	0.0	0.0	0.0	2.75
Rabi 94-95	1.6	4.0	6.3	7.6	8.3	14.6	22.0	17.0	19.0	15.0	13.3	7.6	11.80
Rabi 95-96	1.0	3.3	5.0	7.3	8.0	11.6	12.6	11.0	11.6	7.6	6.3	4.6	7.58
T <sub>7</sub> Kharif 95	0.0	0.0	0.66	4.0	4.6	7.3	8.0	6.6	2.0	0.0	0.0	0.0	3.02
Rabi 94-95	1.3	3.3	5.3	6.0	9.3	15.0	20.3	22.0	18.3	16.6	12.3	8.6	11.55
Rabi 95-96	0.6	3.0	5.6	5.0	8.0	13.6	11.6	11.0	9.3	8.6	3.6	4.6	7.08
T <sub>8</sub> Kharif 95	1.6	0.0	2.3	3.6	5.3	7.6	7.0	7.0	3.0	0.0	0.0	0.0	3.42
Rabi 94-95	2.3	3.3	4.3	6.6	9.3	12.6	23.0	24.0	19.0	14.3	13.3	7.0	11.66
Rabi 95-96	1.0	4.0	5.0	5.6	8.3	15.0	11.0	10.0	8.3	7.6	5.6	4.6	7.19
T <sub>9</sub> Kharif 95	0.0	0.0	0.66	4.6	4.0	6.0	7.0	7.6	2.6	0.0	0.0	0.0	2.93
Rabi 94-95	1.0	2.0	3.0	6.6	9.0	13.3	21.0	20.0	21.0	16.3	12.0	8.3	10.44
Rabi 95-96	0.6	1.3	5.0	5.3	9.3	14.0	13.0	12.0	14.6	7.6	4.6	4.6	7.69

**Appendix 9. Weather data: Weekly averages**

***Kharif 1995***

Sl No	Date of Observation	WAS	DAS	Temp °C		Relative humidity %		Rainfall mm.
				Max	Min	Morning	Evening	
1	24-08-95	3	21	34.9	25.75	83	75	51.20
2	31-08-95	4	28	31.7	23.58	92	84	169.9
3	07-09-95	5	35	32.8	25.54	70	61	----
4	14-09-95	6	42	32.8	25.10	82	72	17.90
5	21-09-95	7	49	32.0	25.40	86	75	71.90
6	28-09-95	8	56	33.5	25.40	78	74	----
7	05-10-95	9	63	33.5	25.70	83	76	0.80
8	12-10-95	10	70	30.3	24.10	92	90	84.30
9	19-10-95	11	77	30.1	24.2	89	86	93.20
10	26-10-95	12	84	30.6	24.6	89	86	60.90
11	02-11-95	13	91	31.6	22.9	84	77	----
12	09-11-95	14	98	32.0	22.5	83	72	6.60

***Rabi 1994-95***

1	28-12-94	3	21	28.0	16.1	83	61	0.2
2	05-01-95	4	28	28.9	15.1	89	64	----
3	12-01-95	5	35	27.6	19.8	91	76	89.4
4	19-01-95	6	42	26.8	19.3	89	77	48.9
5	26-01-95	7	49	28.0	17.7	93	68	----
6	02-02-95	8	56	28.9	17.2	88	63	----
7	09-02-95	9	63	29.3	17.9	93	68	----
8	16-02-95	10	70	29.5	18.2	97	72	----
9	23-02-95	11	77	30.1	21.9	89	78	----
10	02-03-95	12	84	30.4	21.1	83	74	----
11	09-03-95	13	91	31.9	20.0	88	67	----
12	16-03-95	14	98	31.5	20.4	83	69	----
13	23-03-95	15	105	33.2	20.5	83	57	----

***Rabi 1995-96***

1	28-12-95	3	21	29.70	17.1	91	61	----
2	04-01-96	4	28	29.20	16.4	89	66	----
3	11-01-96	5	35	29.60	16.6	94	63	----
4	18-01-96	6	42	29.50	17.7	83	66	----
5	25-01-96	7	49	30.20	17.4	94	66	----
6	01-02-96	8	56	30.10	17.2	95	61	----
7	08-02-96	9	63	30.20	19.7	91	54	----
8	15-02-96	10	70	30.90	18.9	84	63	----
9	22-02-96	11	77	30.80	18.9	89	64	----
10	29-02-96	12	84	32.14	20.3	83	68	----
11	07-03-96	13	91	33.50	18.4	84	57	----
12	14-03-96	14	98	33.60	19.9	82	65	----
13	21-03-96	15	105	33.70	20.1	87	63	----