MANAGEMENT OF KALAHASTI MALADY
(*Tylenchorhynchus brevilineatus*) IN GROUNDNUT
(*Arachis hypogaea* L.)

By

B. SREENIVASULU, B Sc., (Ag)

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ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY
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CERTIFICATE

Mr. B.SREENIVASULU has satisfactorily prosecuted the course of research and that the thesis entitled "**MANAGEMENT OF KALAHASTI MALADY (*Tylenchorhynchus brevilineatus*) IN GROUNDNUT (*Arachis hypogaea* L.)**" 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 degree of any university.

Date : 3-3-2000
Place : TIRUPATI

P. Harinatha Naidu

Dr.P.HARINATHA NAIDU
(Major Advisor)
SENIOR SCIENTIST
Plant Pathology
Regional Agricultural Research Station
S. V. Agricultural College Campus
TIRUPATI - 517 502.

CERTIFICATE

This is to certify that the thesis entitled " **MANAGEMENT OF KALAHASTI MALADY (*Tylenchorhynchus brevilineatus*) IN GROUNDNUT(*Arachis hypogaea* L.)**" submitted in partial fulfillment of the requirements for degree of **Master of Science in Agriculture** of the **Acharya N.G.Ranga Agricultural University,** Hyderabad, is a record of the bonafide research work carried out by **Mr.B.SREENIVASULU** 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 or has been published. The published part has been fully acknowledged. All assistance and help received during the course of investigations have been duly acknowledged by the author of the thesis.

3-3-2000

(Dr. P.HARINATHA NAIDU)
Chairman of the Advisory Committee

Thesis approved by the Student Advisory Committee:

Chairman : **(Dr.P.HARINATHA NAIDU)**
Senior Scientist
Department of Plant Pathology
Regional Agricultural Research Station
Tirupati

SENIOR SCIENTIST
Plant Pathology
Regional Agricultural Research Station
S. V. Agricultural College Campus
TIRUPATI - 517 502.
3-3-2000

Member : **(Dr.S.V.RAMAKRISHNA RAO)**
Associate Professor
Department of Plant Pathology
S.V. Agricultural College, Tirupati

Associate Professor
Dept. of Plant Pathology
S. V. Agricultural College
TIRUPATI - 517 502
3/3/2000

Member : **(Dr.V.KRISHNA RAO)**
Associate Professor
Department of Plant Pathology
S.V. Agricultural College, Tirupati

3/3/2000

Member : **(Dr. J.SURYA PRAKASA RAO)**
Associate Professor and Head
Department of Plant Physiology
S.V. Agricultural College, Tirupati

3/3/2000

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B. Sreenivasulu

B.SREENIVASULU

DECLARATION

I **Mr. B.SREENIVASULU** hereby declare that the thesis entitled "**MANAGEMENT OF KALAHASTI MALADY (*Tylenchorhynchus brevilineatus*) IN GROUNDNUT(*Arachis hypogaea* L.)**" submitted to **Acharya N.G.Ranga Agricultural University,** for the Degree of **Master of Science in Agriculture** is the result of original work done by me. I also declare that the material contained in this thesis has not been published earlier.

B. Sreenivasulu

(B.SREENIVASULU)

Date : 3/3/2000

ABSTRACT

Author	:	**B.SREENIVASULU**
Title of the thesis	:	**MANAGEMENT OF KALAHASTI MALADY (*Tylenchorhynchus brevilineatus*) IN GROUNDNUT (*Arachis hypogaea* L.)**
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Groundnut (*Arachis hypogaea* L.) is the major oil seed crop grown in southern zone of Andhra Pradesh. Kalahasti malady is the most important disease and major constraint to groundnut production in this zone. It is a typical pod disease contributing to huge losses in pod yield. Pathogenicity test conducted with *Tylenchorhynchus brevilineatus* on groundnut variety JL-24 showed typical disease symptoms of kalahasti malady and confirmed the parasitic nature of the nematode.

A field experiment was conducted in Andhra Pradesh State Seed Development Corporation farm at Srikalahasti to find out the combined effect of organic soil amendments and carbofuran at different levels on *T.brevilineatus* population, disease severity and pod yield of groundnut. Application of organic soil amendments has significantly reduced the nematode population and disease severity besides increasing pod yield. Among the amendments tried, sawdust @ 2500 kg ha^{-1} and neem cake 1000 kg ha^{-1} were found to be significantly superior followed by poultry manure @ 5000 kg ha^{-1}. Carbofuran @ 2,3, and 4 kg a.i. ha^{-1} had significant effect in reducing *T.brevilineatus* population and disease severity and in increasing pod yield of groundnut. Sawdust and neem cake in combination with carbofuran at 4 kg a.i ha^{-1} showed the lowest population of *T.brevilineatus* and disease severity and highest pod yield. Application of sawdust in combination with carbofuran reduced the dosage of carbofuran from 4 kg a.i ha^{-1} to 3 kg a.i ha^{-1} for effective management of the disease.

A survey was conducted to assess the severity of kalahasti malady in the villages of five mandals surrounding Srikalahasti. Thondamanadu, Eguvaveedu and Mittakandriga villages of Srikalahasti and Katuru and Parapalli villages of B.N.Kandriga mandals showed maximum disease severity with highest *T.brevilineatus* population (400 to 460 nematodes/250 cc of soil). Sandy and sandy loam soils were found to be more favourable in the buildup of nematode population than clay and clayloam soils.

Thirty groundnut genotypes were screened for their resistance to the nematode disease kalahasti malady. Among them ten resistant genotypes and ten moderately susceptible genotypes were identified. Six genotypes (viz., TCGS-305, TCGS-245 TCGS-320, TCGS-337, TCGS-597 and TPT-3) in resistant category and five genotypes (TCGS-596, TCGS 285, TCGS-292, CGS-305 and TCGS 298) in moderately susceptible category exhibited high pod yield (28 to 39 q ha^{-1}) and pod yield parameters which were found to be suitable for cultivation in kalahasti malady sick soils.

Pod shells of resistant and susceptible groundnut genotypes were bio-chemically analyzed to know the nature of resistance. The resistant genotypes and moderately susceptible genotypes had comparatively more amount of total phenols and lignin. Among the resistant genotypes TCGS-303, has recorded the highest amount of total phenols (21.6 mg/g) and TPT-3 showed highest amount of lignins (39.7 mg/g). These observations have clearly indicated that phenols and lignins might be two possible factors in imparting resistance to groundnut genotypes against *T.brevilineatus.*

LIST OF ABBREVIATIONS

a.i.	:	Active ingredient
@	:	At the rate of
cm	:	Centimeter
cv	:	Coefficient of variation
cd	:	Critical difference
cc	:	Cubic centimeter
^oC	:	Degree centigrade
DAS	:	Days after sowing
et. al.	:	Co-workers
Fig	:	Figure
g	:	Gram
h	:	Hour
ha^{-1}	:	Per hectare
i.e.,	:	That is
kg	:	Kilogram
lt	:	Litre
ml	:	Millilitre
mm	:	Millimeter
mg	:	Milli gram
No.	:	Number
NS	:	Non significant
q	:	Quintals
PDI	:	Per cent disease index
RF	:	Rainfall
RH	:	Relative humidity
Rs	:	Rupees
SEM	:	Standard error between means
spp.	:	Species
var.	:	Variety
vs	:	Versus
viz.,	:	Namely
%	:	Percentage

INTRODUCTION

CHAPTER I

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is the prime oil seed crop grown in India and plays a vital role in Indian edible oil economy. It is grown in an area of 72.80 lakh ha with a production of 78.45 lakh tonnes and thus occupies the top position in oilseed production in India. Andhra Pradesh with an area of 22,03,000 ha and production of 20,85,900 t of groundnut ranks first in groundnut cultivation in India (Statistical Abstract India, 1998). The southern districts of Andhra Pradesh (Chittoor, Nellore and Cuddapah) hold key position with a coverage of 5.5 lakh ha area (25%) and a contribution of 6.035 lakhs tonnes of total production (28.9%) in the state (Economic Survey of Andhra Pradesh, 1998-99).

Leaf spots, rust, collar rot, stem rot and bud necrosis are the major constraints in the production of groundnut contributing to considerable yield losses (Ghewanade, 1990). Annual yield losses due to plant parasitic nematodes in groundnut were estimated to be about 12 per cent in the world and more than 27 species of plant parasitic nematodes were found associated with groundnut in different regions of India (Sharma and Mc. Donald, 1992).

Of late, Kalahasti malady, a nematode disease of restricted distribution but of considerable local importance is affecting groundnut production and contributing to major yield loss in southern zone of Andhra Pradesh (Reddy *et al.*, 1984).

The nematode disease was first observed in the year 1975-76 in rabi irrigated groundnut crop around Srikalahasti in Chittoor district of Andhra Pradesh and hence it was named as kalahasti malady. The disease is characterised by brownish to black necrotic lesions on roots, pod stalks and pod surface and reduction in pod size (Reddy *et al.*, 1984 and Naidu, 1996). This disease is also locally known as Chittikaya (small pod) or Nalla macha tegulu (black lesions on pods), based on the symptoms of the disease. An ectoparasitic nematode *Tylenchorhynchus brevilineatus* Williams was found associated with the disease (Reddy *et al.*, 1984, Mehen *et al.*, 1993 and Naidu, 1996).

Losses in pod yield ranged from 20-60 per cent depending upon the severity of the disease (Reddy *et al.*, 1984).

In recent years the malady has been spreading and causing concern to the groundnut growers in Chittoor, Nellore and Cuddapah districts of Andhra Pradesh. Groundnut as a major cultivated crop in, plays an important role in the economy of people in these districts. Keeping in view of the economic importance of this disease, detailed investigations were carried out with the following objectives.

1. To survey groundnut crop for the incidence of Kalahasti malady in Srikalahasti and surrounding areas of Chittoor district.
2. Screening of groundnut germplsam for their resistance to kalahasti malady in the nematode sick soils.
3. To find out the combined effect of different organic amendments and chemical on the nematode disease.
4. To estimate the total phenols and lignin in pod shells of both disease resistant and susceptible groundnut varieties for knowing the nature of resistance.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

2.1 PLANT PARASITIC NEMATODES ASSOCIATED WITH GROUNDNUT CROP

Groundnut crop is found to be attacked by a number of plant parasitic nematodes which contributed to huge yield losses. Many scientists reported different groups of plant parasitic nematodes associated with groundnut.

Groundnut plant is the host to many plant parasitic nematodes. Sasser (1954) reported that groundnut was highly susceptible to *Meloidogyne arenaria* and *M.hapla* while resistant to *M. incognita*, *M.acrita* and *M. javanica*. *M.hapla* produces small galls and extensive root proliferation. Galls caused by *M.javanica* and *M.arenaria* were larger than those caused by *M.hapla*. The foliage of nematode affected plants appear light green to yellow resembling nutritional deficiencies.

Sakhuja (1984) reported heavy losses in groundnut due to *M.javanica* in Punjab state. Survey of groundnut fields in Andhra Pradesh also showed the presence of *M. javanica* (Sharma and Kumar, 1993). Bhat and Krishnappa (1990) found that *Meloidogyne javanica* damaged groundnut cv.TMV-2 at an inoculum level of 1000 juveniles per kg of soil .

Root lesion nematodes (*Pratylenchus brachyurus, P.coffeae, P.penetrans*) have been found to be associated with and wide spread in groundnut in southeastern United States (Graham, 1951).

Ring nematode (*Criconemella ornata*) was commonly present in most of the groundnut growing areas in southeastern United States of America (Machmer, 1953; Graham, 1955). Barker *et al.* (1981) observed severe damage and significant loss in groundnut yields even with low population of *C.ornata*.

Trichodorus christiei is an ecto-parasite stubby-root nematode recorded in tropical and temperate regions of the world with a wide host range (Christie, 1952). Species of *Xiphinema* feed on the roots of groundnut by piercing with long and powerful stylet. *X.diversicaudatum* produces galls in roots and increases the mersitematic activity of the root tip leading to development of stubby and malformed roots (Feakins and Susan, 1973).

Aphasmatylenchus straturatus was first described by Germani (1970) from soil around roots of groundnut in upper Volta in West Africa.

O'Bannon *et al*, (1971) observed for the first time that the seed coat of groundnut was infected by the burrowing nematode (*Radopholus similis*). Six groundnut cultivars were found susceptible to the physiological races of *R.similis* in Florida and the banana race was found to be more pathogenic than the citrus.

Scutellonema cavenessi, S.clathricaudatum had been implicated as major nematode parasites causing serious damage to groundnut. Lateral roots were reduced in size with poor development of plants that distributed in patches which persisted and increased in size during subsequent growing seasons, (Sharma, 1988).

2.2 SYMPTOMATOLOGY

The disease Kalahasti malady was characterized by brownish black discoloration of pods and reduction in pod size. Affected plants had dark green foliage and were stunted in growth. The disease appeared in patches in the field. *Tylenchorhynchus brevilineatus* was found responsible for the disease (Reddy *et al.*, 1984; Ratnakumar, 1988; Naidu, 1996). *T. mashoodi* and *T.brevilineatus* were found associated with the roots of sugarcane and castor, respectively in Haryana and Bihar states (Gupta and Uma, 1985). *T.brevilineatus* caused a significant reduction in plant growth in wheat variety Sonalika. Yellowing, stunting, reduced tillering with reduced grain yields were also recorded (Thaker *et al.*, 1986).

2.3 DISEASE MANAGEMENT THROUGH ORGANIC SOIL AMENDMENTS:

The beneficial effects of plant residues and other organic amendments in reducing the severity of fungal diseases have long been known (Papavizas, 1966). Similarly organic soil amendments were found to reduce nematode diseases. The amendments may alter physical and chemical conditions of the soil (Singh and Sitaramaiah, 1970).

Singh and Sitaramaiah (1971) noted effective control of *M. javanica* in okra and tomato in nematode infested soil amended with 25 q ha^{-1} of sawdust followed by inorganic nitrogenous fertilizers along with P and K applied at the time of planting. Oil cakes of margosa, groundnut, castor, mustard, linseed, mahua and coconut when applied at 25 q ha^{-1} three weeks before planting significantly reduced root-knot (*M. javanica*) in okra and tomato (Singh and Sitaramaiah, 1973).

Alam and Khan (1974) reported that the greatest reduction in the population of stylet bearing nematodes in spinach took place with neem cake and nemagon followed by mahua (*Madhuca indica*) cake, DD, mustard cake, groundnut cake and castor cake.

Amendment of soil with oil cakes of neem, groundnut, mustard and castor was effective in reducing the population of *Tylenchorhynchus brassicae* around the roots of cabbage and cauliflower. Although the inorganic fertilizers increased plant growth, the population of *T.brassica* remained comparatively high. The build up in population may adversely affect succeeding cauliflower or cabbage crops (Siddiqui *et al.*, 1976).

A significant reduction of 59.7 per cent in nematode populations of *Meloidogyne javanica*, *Helicotylenchus incisus*, *Rotylenchulus reniformis*, *Hirschmaniella mucronata* was observed in beds of betelvine amended with chopped and shade dried calotropis leaves followed by neem cake (Sivakumar and Marimuthu, 1986).Saw dust at 2 t ha^{-1} and neem cake at 1 t ha^{-1} significantly reduced the *M.incognita* populations in betelvine (Acharya and Padhi, 1988).

Poultry manure @ 4 t ha^{-1} and above has been reported effective for the control of root-knot nematodes and increasing the growth and fruit yield of tomato (Chindo and Khan, 1990). Amendment of soil in tomato with chicken litter suppressed *M.arenaria* and provided practical control of root-knot nematodes (Kaplan and Noe, 1993).

Press mud, farmyard manure, neem cake, coir waste, poultry manure, neem leaves were evaluated for control of *Hirschmaniella oryzae* in rice by Jonathan and Pandiarajan, 1991. Neem cake at one t/ha and pressmud at cake 10 t/ha significantly reduced nematode population upto 60 days after transplanting.

Alam (1991) found that sawdust of mango significantly reduced population of plant parasitic nematodes in carrot, radish, table beet, turnip, wheat and barley in microplot experiment. Soil application of castor cake, mustard cake or neem cake at 1000kg/ha was found to improve plant growth, pod and fodder yield and decrease the root-knot index (*Meloidogyne javanica*) in groundnut significantly (Dhedhi *et al.*, 1994).

Detailed investigations were conducted by Tiyagi and Alam (1995) to know the efficacy of oil cakes of neem (*Azadirachta indica*), castor (*Ricinus communis*), mustard (*Brassica campestris*) and duan (*Eruca sativa*) against plant parasitic nematodes and soil inhabiting fungi infecting mung bean (*Phaseolus aureus/Vigna radiata*) and subsequent chickpea crop. The results revealed that the plant parasitic nematodes, *M.incognita, Rotylenchulus reniformis, Tylenchorhynchus brassicae, Helicotylenchus indicus* and the frequency of the pathogenic fungi were significantly reduced but the frequency of saprophytic fungi increased.

Carbofuran and neem cake were effective in increasing plant growth parameters, while carbofuran, neem cake and castor cake reduced root-knot and reniform nematode population in brinjal (Kumar and Vadivelu. 1996). Rao *et al,* (1997) found an increase in leaf yield of 29.6 and 25.9 per cent over check in the plots treated with sawdust at 2 t ha^{-1} +NPK fertilizer, and neem cake at 2 t ha^{-1} respectively in betelvine.

Mishra *et al,* (1997) reported that the application of sawdust or oil cakes of mustard (*Brassica campestris*), neem (*Azadirachta indica)*, linseed (*Linum usitatissimum)*, mahuva *(Madhuca longifolia)* or castor (*Ricinus communis)* increase growth of soyabean and reduced nematode damage.

2.4 DISEASE MANAGEMENT THROUGH PESTICIDES:

Soil disinfestation using nematicides for control of plant parasitic nematodes was used when cultural and biological methods fail to reduce the nematode population. The main objectives were to restrict the nematode multiplication, improve quality and quantity of the produce.

Out of six chemicals viz., thionazin, aldicarb, fensulfothion, methomyl, carbofuran and TCPP tried against root-knot in tomato, fensulfothion, methomyl and carbofuran gave fairly satisfactory control (Reddy and Seshadri, 1971).

Singh and Bindra (1974) studied the effect of carbofuran as seed treatment and granular soil treatment alone and in combination for control of nematodes associated with maize. Studies revealed that carbofuran as seed treatment can be effectively used for initial protection against nematode infection and the subsequent build up can be prevented by granular soil application.

Reddy *et al*, (1984) reported that soil application of carbofuran and aldicarb at 6 kg a.i. ha^{-1} 25 days after sowing was effective in reducing the incidence of kalahasti malady (*T.brevilineatus)* which increased plant height, length of pod stalks, number of matured pods per plant and total pod yield.

The severity of kalahasti malady was reduced and final pod yield was increased by 24.85 and 27.82 per cent respectively over control when aldicarb and carbofuran were applied at 6 kg a.i.ha^{-1} (NARP, 1995). Furadan (Carbofuran) 2 per cent and oncol (benfurcarb) 2 per cent eliminated galling due to *M. incognita* infesting *Cajanus cajan* and reduced multiplication of nematodes in soil (Mishra, 1986).

Phipps *et al.* (1987) reported that planting time treatments with carbofuran banded application in soil at 13 to 20 lb/acre plus aldicarb application in furrows at 7 lb/acre resulted in significantly lower root galling due to *M.hapla* and higher peanut yields compared to other treatments.

Poornima and Vadivelu (1990) found that the nematicides carbofuran, fenamiphos and phorate were the most effective chemicals in reducing *M.incognita*, *Pratylenchus delattrei* and *Rotylenchulus reniformis* number in brinjal. Fenamiphos being the best followed by carbofuran and phorate.

Gogoi and Phukan (1990) reported that carbofuran, diazinin and ekalux at 2 per cent w/w were effective in reducing the number of galls and egg masses of *M.incognita* and increasing yield in lentil.

2.5 DISEASE MANAGEMENT THROUGH COMBINED APPLICATION OF ORGANIC SOIL AMENDMENTS AND NEMATICIDES:

Final root knot index (*Meloidogyne incognita*) in ginger was lowest in the treatment with neem cake at 2.5 t/ha before planting followed by carbofuran at 1 kg a.i/ha 45 days after planting (Mohanty *et al.*, 1992). Oil cakes of castor, groundnut, honge (*Pongamia pinnata*) and neem each at 1t/ha and nematicide carbofuran at 2 kg a.i/ha significantly reduced the root gall index and increased the yield in bhendi (Reddy and Khan, 1993).

Mohanty *et al.* (1995) reported that preplanting application of neem cake @ 1 t/ha followed by post planting application of carbofuran (1 kg a.i/ha) 45 days after planting gave the best result in terms of suppression of *M. incognita* population and in increasing yield of ginger.

Patel *et al.* (1996) obtained effective nematode control of *M.arenaria* and *M.javanica* in groundnut by using carbofuran 2 kg a.i/ha and neem cake at 1000 kg/ha.

Poultry manure applied at 2t/ha followed by the combined application of seed dressing with carbofuran 3G @ 3 % w/w + neem cake at 1 t/ha gave best result in green gram in the control of *M.incognita* (Barman and Das, 1996).

Carbofuran 2 kg a.i/ha, neem (*Azadirachta indica*) cake (250 kg/ha) and neem cake + carbofuran (100 kg ha^{-1} + 1 kg a.i. ha^{-1}) soil application gave the best plant growth of scoparia with significant nematode inhibitory effect in reniform nematode infested soil (Pathak and Kumar, 1997).

2.6 SURVEY OF KALAHASTI MALADY:

Sharma (1988) conducted preliminary survey on nematode diseases in 15 groundnut growing areas of Andhra Pradesh, India. *Pratylenchus* sp., *Tylenchorhynchus* sp., *Criconemoides* sp. were always found to be the most prominent nematodes at each site surveyed. In Guttivaripalli village stunt nematode *Tylenchorhynchus* sp. was the most predominant and was found associated with kalahasti malady. In addition to *Tylenchorhynchus* sp. populations of the spiral nematode, *Helicotylenchus sp.* the ring nematode, *Criconemoides* sp., and the root knot nematode *Meloidogyne* sp., were more frequent at Guttivaripalli in comparison to other locations surveyed. In one field white females of *Heterodera* were attached to the roots. The burrowing nematode *Radopholus similis* was observed on banana roots in a field adjacent to the groundnut.

Mani and Ratnakumar (1990) surveyed groundnut in Chittoor and Nellore districts of Andhra Pradesh and recorded the presence of 28 plant parasitic nematode genera with a higher occurrence and density in rabi than kharif season. *Bitylenchus brevilincatus* *Basiralaimus* sp., and *Tylenchorhynchus* sp. were predominant in the surveyed areas.

Darekar *et al.* (1990) conducted survey in intensive *Arachis hypogaea* growing areas in Maharastra state and found five species of plant parasitic nematodes viz., These were *Helicotylenchus* spp., *Meloidogyne arenaria*, *Pratylenchus thornei*, *Hoplolaimus indicus* and *Tylenchorhynchus* spp.

Groundnut fields in Tirupati region of Andhra Pradesh surveyed showed association of *Tylenchorhynchus brevilineatus*, *T.nudus*, *Meloidogyne arenaria* and *Helicotylenchus dihystera* in large numbers with the kalahasti malady disease of groundnut (Prasad and Rangappa, 1994).

Sharma *et al.* (1996) reported occurrence of kalahasti malady causing nematode *Tylenchorhynchus brevilineatus* in Tamil Nadu also.

Naidu (1996) surveyed groundnut growing areas in Chittoor, Cuddapah and Nellore districts in southern zone of Andhra Pradesh and recorded increased incidence of kalahasti malady in groundnut.

2.7 SCREENING OF GROUNDNUT VARIETIES:

Rao *et al.* (1986) studied the reaction of 43 spanish bunch and 5 virginia bunch varieties along with certain popular varieties such as TMV-2, JL-24 and J-11 against Kalahasti malady under field conditions. It was found that the cultivars exhibited wide variation in their susceptibility to the disease and the damage to pods ranged from 16.22 to 89.91%.

Ratnakumar (1988) screened 418 germplasm accessions against *Tylenchorhynchus brevilineatus* under field conditions in a severely infected field at Ramapuram village in Srikalahasti, Chittoor district. Thirty lines (10 bunch and 20 spanish) were found highly resistant and 90 lines (22 bunch and 68 spanish) resistant to the disease.

Mehen *et al,* (1993) investigated the reaction of 1599 groundnut germplasm accessions and breeding lines against the stunt nematode disease in severely infested fields. Of these, 21 genotypes were resistant to the disease. However, most of them had undesirable pod characters. The genotype TCGS-1518 was found to be high yielding and resistant to Kalahasti malady. Naidu, (1996) screened eighty six groundnut entries and promising varieties for their reaction to nematode.

2.8 BIOCHEMICAL RESISTANCE:

Phenolic compounds are known to play a major role in the defense mechanism of plants against various infectious agents. The accumulation of phenolic compounds in the nematode injured area and the activation of associated oxidative enzymes have been reported by Rhode (1965). Accumulation of phenols in nematode infected tissues occurs possibly as a result of host-parasite interaction and as a means of defense mechanism (Balasubramanian and Purushothaman, 1972).

Feldman and Hanks (1968) reported increased amount of phenolic content in the roots and leaves of tolerant and susceptible citrus cultivars attacked by *Radopholus similis.* Bajaj *et al.* (1983) found higher phenolic content in resistant tomato cultivar compared to susceptible cultivar infected by *Meloidogyne incognita.* Thakar and Yadav (1986) observed that increased phenolic content has increased the resistance in redgram seedling against *Rotylenchulus reniformis.*

Dhawan and Dasgupta (1992) observed that total phenol content in shoots of healthy and resistant barley cultivars (RD-2052 and C164) to *Heterodera avenae* was higher as compared to susceptible cultivar (DL- 482). There was significant difference in the total phenol content in the shoots of healthy and resistant cultivar of barley against cereal cyst nematode *Heterodera avena.* The phenol content in the two resistance cultivars (RD-2052 and 164) was significantly more as compared to susceptible cultivar DL-482 of barley.

Tomato leaves infected with *Meloidogyne javanica* showed increased phenolic compounds (Ahmed and Jehan, 1992). Phenolics and amino acids were higher in tolerant cultivars of tomato followed by susceptible and highly susceptible cultivars. Percentage increase in both phenolics and amino acids were higher in tolerant and lowest in highly susceptible cultivars when inoculated with *Rotylenchulus reniformis* (Mahmood and Siddiqui, 1993).

The resistance of plants against nematodes may be related to the presence of phenolic compounds and extent of lignification on the roots. Source of resistance to *R.similis* were identified by screening 10 *Musa cultivars* from different genomic groups. Histological studies revealed relatively greater number of preformed phenolic cells in roots of the resistant and moderately resistant cultivars compared with other cultivars tested. However, in another resistant cultivar Pisang jori buya fewer phenolic cells were found but this clone had higher number of cells with lignified walls suggesting a different mechanism of resistance. An interesting correlation was found between level of susceptibility to *R.similis*, and root dry matter. A possible role of lignin in resistance to *R.similis* in musa was noticed by Fogain and Gowen (1996).

MATERIALS & METHODS

CHAPTER-III

MATERIALS AND METHODS

3.1 GENERAL

Laboratory experiments were conducted at S.V. Agricultural College, Tirupati and field experiments on the evaluation of different organic soil amendments in combination with nematicide carbofuran at different levels and screening of groundnut genotypes for nematode resistance were conducted in nematode sick soil at Andhra Pradesh State Seed Development Corporation (APSSDC) farm, Srikalahasti in Chittoor District of Andhra Pradesh during 1998-99 post rainy season.

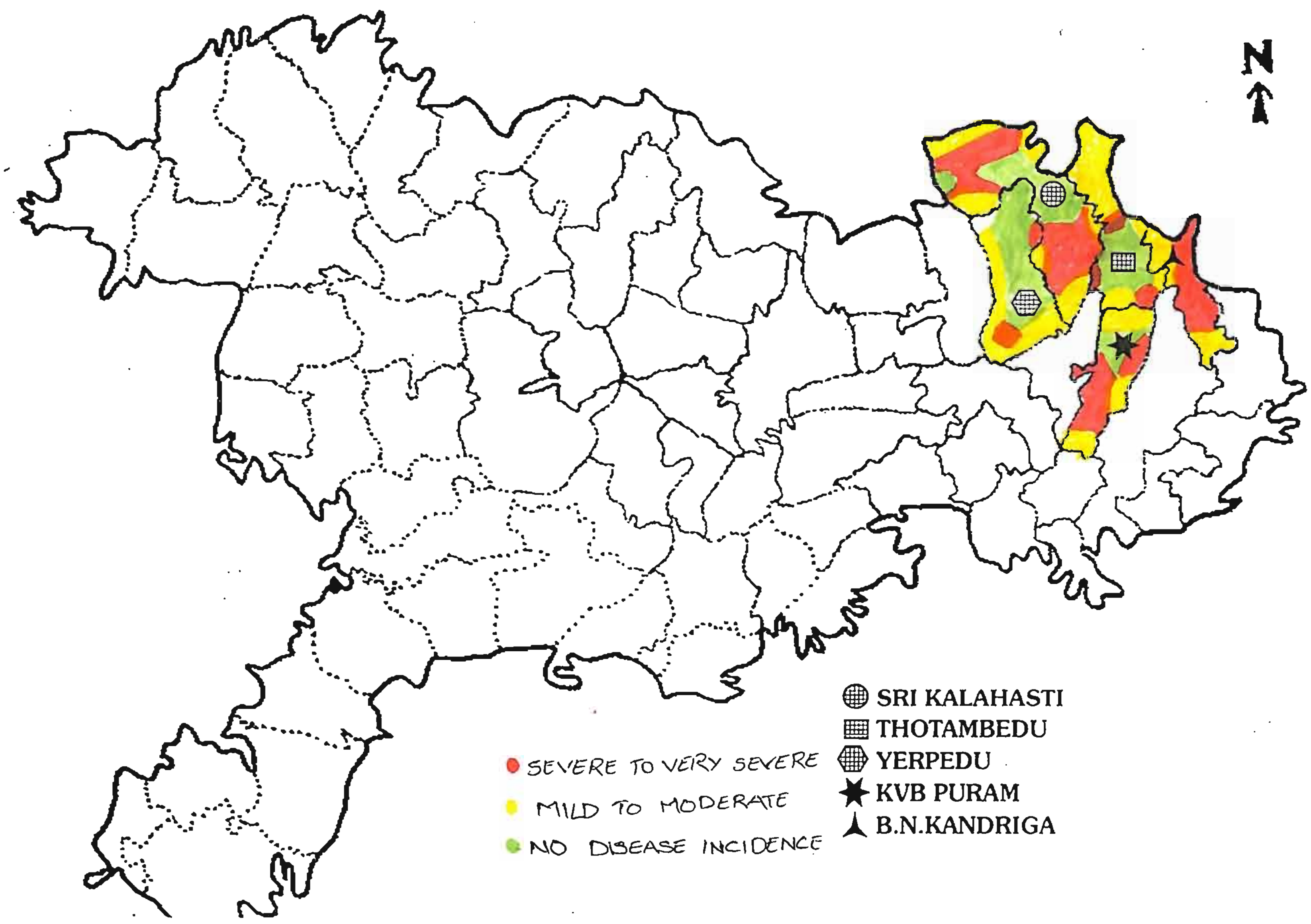
3.2 CLIMATE

The meteorological data of Srikalahasti (APSSDC Farm) for the crop period during 1998-99 post rainy season were presented in Appendix 1.

3.3 SURVEY

To study the severity of kalahasti malady of groundnut in different groundnut growing areas in Srkalahasti and surrounding mandals of Chittoor District, Andhra Pradesh during 1998-99 post rainy season, a field survey was conducted (Fig.1). Field visits were undertaken during the pod maturity stage of the crop (80-110 days after sowing). A total of 80 pod samples were collected at random from five mandals in Chittoor District. The relevant observations on area, type of soil, crop variety, date of sowing, cultural practices

Fig - 1 : MAP SHOWING KALAHASTI MALADY DISEASE IN SURVEYED MANDALS OF CHITTOOR DISTRICT



adopted, cropping system followed and its effect on nematode disease was recorded in a standard proforma. Information relating to the disease was also collected from the farmers and officials of Department of Agriculture, Government of Andhra Pradesh.

To estimate the disease severity in each field, pod samples were collected randomly from each field and disease scoring was done. They were categorised into five different groups as per the 1 to 5 disease scale (Plate 1) described by Reddy *et al.*, (1984) which is given below:

Rating: Description

1 No disease symptoms

2 Pods are normal in size with few dark brown to black lesions covering 1-25 per cent of pod surface.

3 Pods are normal in size with lesions covering 26-50 per cent of pod surface.

4 Pods are smaller in size with lesions covering 51-75 per cent of pod surface

5 Pods are much smaller in size with lesions covering more than 75 per cent of pod surface.

3.4 SYMPTOMATOLOGY OF NEMATODE DISEASE

The symptomatology of kalahasti malady in groundnut was studied in the disease infected fields and observations on plant height, colour of the foliage, pod sizes, pod stalk length and lesions on the pods were recorded.

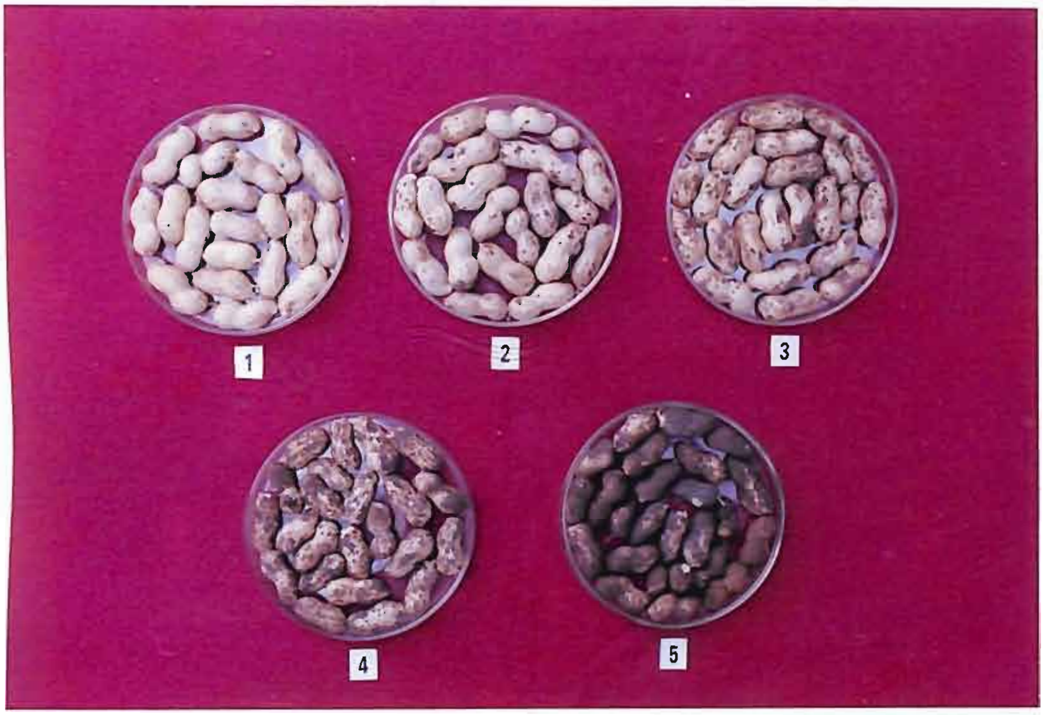


Plate 1: 1-5 Kalahasti malady disease scale

Scale	Description
1	No infection
2	Pods showing 1-25 per cent of nematode infestation
3	26-50 per cent of nematode infestation
4	51-75 per cent of nematode infestation and pod size reduced
5	76-100 per cent of nematode infestation and pod size reduced

The causal organism of kalahasti malady of groundnut i.e., *Tylenchorhynchus brevilineatus* (Plate 3) isolated from soils collected from kalahasti malady sick areas were multiplied on susceptible variety JL-24 of groundnut.

3.5 PATHOGENICITY TEST

Earthen pots of 30 cm diameter and 30 cm depth were filled with a mixture of steam sterilized sand, soil and farm yard manure in 2:1:1 ratio. Groundnut variety JL-24 seed was sown in the pots. Six pots each containing two JL-24 groundnut plants were used for nematodes inoculation. Fifteen days old plants in each pot were inoculated with about 500 nematodes (Naidu, 1996). These pots were maintained in glass house at normal temperature of 25-30°C. The pots were harvested 110 days after sowing and observed for the symptoms of kalahasti malady.

3.6 SCREENING OF GROUNDNUT GENOTYPES FOR NEMATODE DISEASE RESISTANCE

The groundnut genotypes developed by Regional Agricultural Research Station (RARS), Tirupati were screened for their resistance to the kalahasti malady disease. The screening test was carried out during 1998-99 post rainy season in APSSDC farm, Srikalahasti in Chittoor district in nematode sick soil. The design used was simple Randomized Block Design (RBD) replicated three times (Plate 2). Each variety was sown in two rows of five meters length and between the two test genotypes one row of JL-24 (check) was sown.

Plate 2: General field view of groundnut varietal screening trial laidout in Andhra Pradesh State Seed Development Corporatioin Farm at Srikalahasti

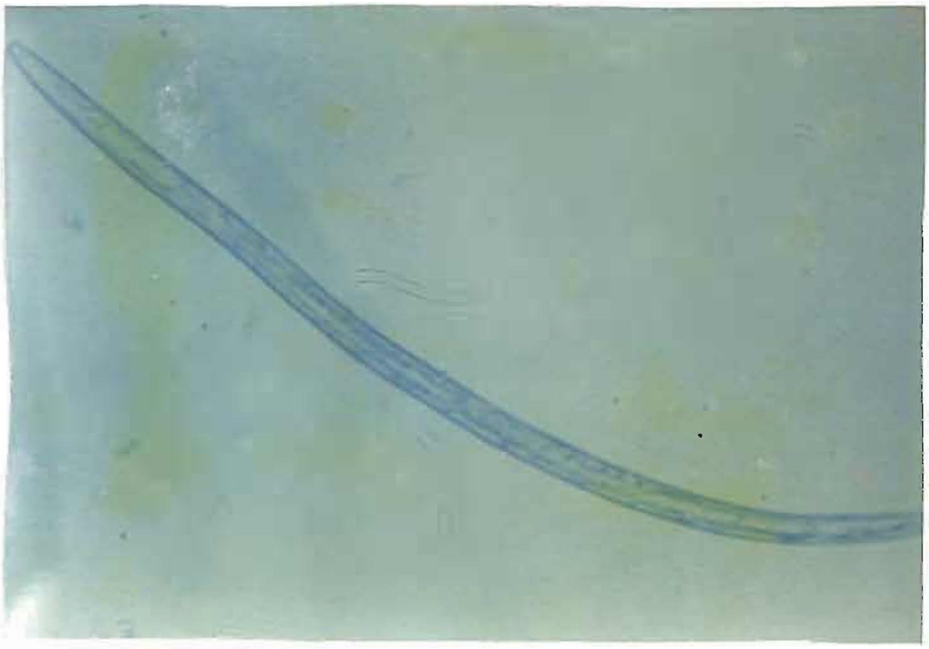


Plate 3: *Tylenchorhynchus brevilineatus*

Thirty groundnut genotypes were screened for resistance to kalahasti malady. The genotypes used for varietal screening includes both popular varieties of groundnut and the cultures under developmental trials.

The variety TPT-3 was used as a resistant check and highly susceptible variety JL-24 was used as a susceptible check. Each variety was sown in 5m rows; for every two test rows one row of susceptible check JL-24 was sown. A randomized block design was followed with three replications. Standard agronomic practices recommended by Acharya N.G.Ranga Agricultural University viz., fertilizers at Nitrogen 30 kg, P_2O_5 40 kg and K_2O 50 kg ha^{-1}, gypsum at 500 kg ha^{-1}. spacing 30 x 10 cm, seed rate at 150 kg ha^{-1} were followed. The crop was harvested at 110 days after sowing. The nematode disease severity was recorded on 1-5 disease scale (Reddy *et al.*, 1984).

In each variety the disease incidence was recorded by observing lesions on pod surface which is the characteristic symptom of the disease. All the varieties used for screening were categorized into resistant, moderately susceptible and susceptible groups based on the disease severity. Yield parameters viz., number of pods per plant, 100 pod weight, 100 kernel weight, shelling percentage, pod yield and disease severity were recorded for each variety.

3.6.1 The details of the genotypes screened are as follows:

1. TCGS –245
2. TCGS –285
3. TCGS –292
4. TCGS –298
5. TCGS –303
6. TCGS –305
7. TCGS –307
8. TCGS –309
9. TCGS –318
10. TCGS –320
11. TCGS –325
12. TCGS –328
13. TCGS –332
14. TCGS –334
15. TCGS –337
16. TCGS –341
17. TCGS –343
18. TCGS –356
19. TCGS –413
20. TCGS –421
21. TCGS –428
22. TCGS –435
23. TCGS –445
24. TCGS –451
25. TCGS –596
26. TCGS –597
27. ICGS –76
28. TPT – 1
29. TPT – 3
30. K –134
31. JL–24 (Check variety)

3.7 FIELD STUDIES

A field experiment was conducted during 1998-99 post rainy season in existing sick soil at APSSDC farm, Srikalahasti with a view to find out the combined effect of different organic soil amendments and nematicide at different dosages on nematode disease severity. The population of *Tylenchorhynchus brevilineatus* were estimated at sowing, one month and two months after sowing and at harvesting.

There were six main treatments including control, replicated three times in split plot design. Each main treatment was split into four sub-treatments with a plot size of 2.5 m x 5 m (Plate 9). The details of the treatments are as follows:

Main treatments	Dosage in kg
1. Neem cake	1000 kg/ha
2. Saw dust	2500 kg /ha
3. Pressmud cake	2500 kg/ha
4. Poultry manure	5000 kg/ha
5. Farmyard manure	10000 kg /ha
6. Check	with out any soil amendment

Sub treatments	Dosage
1. Carbofuran	0 kg a.i/ha
2. Carbofuran	2 kg a.i/ha
3. Carbofuran	3 kg a.i/ha
4. Carbofuran	4 kg a.i/ ha

All the organic soil amendments were incorporated into the soil, mixed well and leveled two weeks before sowing. The nematode susceptible groundnut variety JL-24 was sown in the plots. The nematicide carbofuran (3G) was applied in different dosages (0, 2, 3 and 4 kg a.i ha^{-1}), 25 days after sowing. Standard agronomic practices recommended by Acharya N.G.Ranga Agricultural University viz., fertilizer N 30 kg, P_2O_5 40 kg, K_2O 50kg ha^{-1}, spacing 22.5 x 10 cm, seed rate 190-200 kg ha^{-1} were followed uniformly during the period of experimentation. The crop was harvested 110 days after sowing and the following observations were recorded from each treatment.

i) Number of pods per plant

ii) Pod yield

iii) 100 pod weight

iv) 100 kernel weight

v) Shelling per cent were recorded

Later the pod yield per plot was converted into pod yield ha^{-1}. Average number of pods per plant was calculated from the three replications for each treatment.

vi) The disease severity was calculated by the following formula.

$$\text{Per cent Disease Index (PDI)} = \frac{\text{Sum of total disease ratings}}{\text{Total number of ratings x maximum disease grade}} \times 100$$

3.7.1 Isolation and Estimation of Nematode Population

Soil samples were collected from the experimental plots in polythene bags and were brought to the lab. These samples were processed by modified Cobb's sieving and decanting method (Cobb, 1918). The standard procedure followed is given below.

The representative samples were collected from composite samples by coning and quartering method. They were used for the estimation of nematode population. About 250 cc of soil was transferred into a plastic bowl and 500 ml of water was added to it. Later, it was stirred to make the soil suspension and allowed to settle for a minute. The suspension was poured through 20 mesh sieve (840 μ) into a second plastic bowl. The above process was repeated for 3 to 4 times. The debris remained on the course mesh was discarded and the first bowl was cleaned. The suspension in the second bowl was stirred up and poured through 60 mesh sieve (250 μ) which was kept over the first bowl, bigger nematodes were retained here. The debris deposited on the 60 mesh sieve was transferred to a 250 ml beaker with water and labelled as 60 mesh. This process was repeated over 100 mesh, 200 mesh and 400 mesh sieves. Two fold tissue paper was kept in a wire gauge support and the residue collected in beakers was transferred separately into separate wire gauge tissue papers and placed on petridishes with water. It was kept like that over night and then used for the estimation of nematode population.

The nematode suspensions were collected in 100ml beakers and concentrated to half the volume by decanting the supernatant water after allowing the suspension to remain undisturbed for four hours. The volume of water was made up to 50 ml. The nematode suspension was bubbled with the help of a 10 ml pipette and an aliquot of one ml was transferred to a nematode counting dish for counting the nematodes under a low power stereoscopic binocular microscope. The aliquots were examined from each sample and the average population was calculated. The identification of nematode was done as per the description given by Mai *et al.* (1968).

3.8 BIOCHEMCIAL METHODS

The defense mechanisms operating in plants are morphological and biochemical and are either pre-existing or post inflectional. An attempt was made in the present studies to understand the nature of pre-existing bio-chemical resistant factors involved in resistant varieties compared to susceptible.

Total phenols and lignins in pod shells of both resistant and susceptible genotypes of groundnut were estimated by following methods.

3.8.1 Estimation of phenols

The total phenol content in the pod shells of both resistant and susceptible groundnut genotypes was estimated as per the method of Sadasivam and Manickam (1996). The pods were dried properly after harvest of the crop and shells were powdered. Exactly 0.5 g powdered shell sample was taken and ground it with a pestle and mortar in 80 per cent ethanol of 10 times sample volume. The homogenate was centrifuged at 10,000 rpm for 20 minutes. The supernatant was taken, re-extracted the residue with 80 per cent ethanol five times the volume of sample. The supernatant was centrifuged, pooled and evaporated to dryness. The residue was dissolved in a known volume of distilled water (10 ml) and pippeted out an aliquote (0.2 ml) into test tube. The volume in each tube was made upto 3 ml with water and then added 0.5 ml of Folin-ciocaltean reagent and after 3 min. 2 ml of 20 per cent sodium carbonate solution to each tube. The content of tube was mixed thoroughly and then the tubes were placed in a boiling water for exactly one minute. The content was cooled and absorbance measured at 650 nm against a reagent blank in Spectronic-20. Then the standard curve was prepared using different concentrations of catechol. The amount of total phenols in each sample was calculated from the standard curve prepared with catechol.

3.8.1.1. **Preparation of Reagents** : Eighty per cent ethanol was prepared by adding 80 ml of absolute alcohol and made up to 100 ml by using distilled water. Twenty per cent sodium carbonate was prepared by dissolving 20 g sodium carbonate in 100 ml of distilled water.

3.8.2 Estimation of Lignins

Lignin content in the groundnut shells of both resistant and susceptible genotypes was estimated by following the principle and procedure given by Sadsivam and Manikam (1996).

The sample material was refluxed with acid detergent solution. The water soluble and materials other than the fibrous component was removed. The left over material was weighed after filtration, dried, treated with 72 per cent $H_2 So_4$ and filtered, dried and ashed. The loss of weight on ignition gave the acid detergent lignin.

The Acid Detergent Fibre (ADF) was first estimated from which Acid Detergent Lignin (ADL) was determined.

One gram of powdered sample was taken in a round bottom flask and 100 ml of acid detergent solution was added to it. Then it was heated to boil in 5 to 10 minutes. Later the heat was reduced to avoid foaming. When boiling begun the contents were refluxed for one hour after the onset of boiling. Boiling was adjusted to slow even level. After refluxion, the container was removed, swirled and the contents were filtered through a pre weighed sintered glass crucible (G2) by suction and washed with hot water twice.

The filtrate was washed with acetone and the lumps were broken up. Then acetone washing was repeated until the filtrate is colorless and dried at 100°C for overnight. The contents were weighed after cooling in a desiccator. ADF content was expressed in percentage.

$$ADF\ \% = \frac{W}{S} \times 100$$

Where, W was the weight of the fibre

S was the weight of sample

ADL was determined from this estimated ADF, ADF obtained was transferred to a 100ml beaker and 25-50 ml of 72 per cent sulphuric acid was added. 1g of asbestos was added to it. It was allowed to stand for 3 h with intermittent stirring with a glass rod. The acid was diluted with distilled water and filtered with pre-weighed whatman no.1 filter paper.

The glass rod and the residue were washed several times to get rid of the acid. The filter paper was dried at 100°C and weighed after cooling in a desiccator. It was transferred to a preweighed silica crucible and was ashed with the content in a muffle furnace at 550°C for about 3 h. The crucible was cooled in a desiccator and weighed and then the ash content was calculated. A blank was maintained by taking 1 g of asbestos and 72 per cent H_2So_4 and following the same procedure.

$$\%\ ADL = \frac{\text{Weight of 72\% } H_2So_4 \text{ washed fibre (Test-Asbestos blank)} - \text{Ash (Test-Asbestos blank x 100)}}{\text{Weight of sample}}$$

Lignin = Residue after extraction with 72% H_2So_4 – ash.

3.8 ECONOMIC ANALYSIS:

Total cost of cultivation was calculated based on input cost. Details of cost of production under different treatments are given in Appendix II. Gross returns and net returns per hectare were computed considering the existing market price of inputs and outputs. Incremental benefit cost ratio was worked out for different treatments by dividing the additional returns by corresponding additional cost of treatments.

3.9 STATISTICAL ANALYSIS:

The data recorded on disease severity, yield parameters of groundnut, nematode population during the course of investigation was statistically analyzed following the analysis of variance technique for split plot design as suggested by Gomez and Gomez (1984). The data wherever applicable were transformed to angular and square root values and later subjected to statistical analysis. The data wherever applicable were transformed to angular and square root values and later subjected to statistical analysis. Wherever the treatment difference was found significant, 'F' test critical differences were worked out at five per cent probability level and the values are furnished. 'NS' denoted the treatment differences those were not significant.

RESULTS

CHAPTER IV

RESULTS

4.1 SYMPTOMATOLOGY

The diseased plants showed brownish to black necrotic lesions on roots, pegs, pod stalks and on pod surface. The symptoms appeared initially as small yellow to brown lesions. As the disease advanced the lesions turned deep brown to black and covered the whole pod surface (Plate 4). Pegs affected in initial stages failed to develop into pods leading to heavy losses in pod yield. In severe cases, it reduced pod stalk length, pod size and kernel size. Affected plants were stunted in growth with dark green foliage. Necrotic lesions could be seen only on the pod surface without any damage to kernels. The kernels were apparently healthy (Plate 5). Affected pods exhibited scabby appearance (Plate 6).

4.2 PATHOGENICITY OF *T.brevilineatus* ON GROUNDNUT VARIETY JL-24

Groundnut variety JL-24 was used in the pathogenicity test. The pods collected from the nematode *T.brevilineatus* inoculated pots showed brownish to black lesions (Plate 7). The lesions were also found on roots, pod stalks and pegs (Plate 8). Diseased pods were severely discoloured and showed reduction in size. Kernels from affected pods were apparently healthy. No disease symptoms were observed on roots, pod stalks, pegs and pods in control (uninoculated) plants.

Plate 4: Groundnut pods showing severe symptoms of kalahasti malady

Plate 5 : Kernels from healthy and kalahasti malady affected groundnut pods

Plate 6: Comparision o f healthy and kalahasti malady affected groundnut pods

Plate 7: Kalahasti malady symptoms on developing groundnut pods

Plate 8: Kalahasti malady symptoms on developed groundnut pods and roots

4.3 SURVEY OF SRIKALAHASTI AND SURROUNDING MANDALS FOR KALAHASTI MALADY IN GROUNDNUT

The data given in table 1 indicated that 92.5 per cent of the pod samples collected from different villages in five mandals around Srikalahasti were found affected with kalahasti malady. Of which 8.75, 27.5, 30.0 and 26.25 per cent pod samples showed mild, moderate, severe and very severe disease symptoms respectively.

The observations revealed that the disease occurrence and severity were varying from village to village in the five mandals surveyed viz., B.N.Kandriga, K.V.B.Puram, Srikalahasti, Thottambedu and Yerpedu. Of all the pod samples collected from three villages in B.N.Kandriga one sample showed moderate and 14 pod samples severe to very severe nematode infestation. Out of 15 pod samples collected from three villages in K.V.B.Puram mandal, two pod samples were found free from the disease. Moderate and severe disease symptoms were recorded on five and eight pod samples, respectively.

All the twenty pod samples collected from three villages in Srikalahasti mandal showed kalahasti malady. Five samples showed moderate and 15 samples severe to very severe disease symptoms. Of the 15 pod samples collected from three villages in Thottambedu mandal, two samples were found free from disease while mild, moderate and severe disease symptoms were recorded on three, seven and three samples, respectively. Among 15 pod samples collected from three villages in Yerpedu mandal, two were free from the disease. Mild and moderate disease symptoms were observed on four samples each and severe to very severe disease symptoms on five pod samples. Maximum nematode population (400 to 460 / 250 cc soil) was recorded in Thondamanadu, Eguvaveedu and Mittakandriga villages of Srikalahasti and Katur and Parapalli villages of B.N.Kandriga mandals.

Table 1: Severity of kalahasti malady of groundnut in Srikalahasti and surrounding mandals in Chittoor district Andhra Pradesh during 1998-99 post rainy season

S.No.	Name of the mandals and village	No.of pods samples observed*	Samples free from disease		severity of disease in samples										Nematode population (in 250 cc soil) *T.brevilineatus*
					Mild		Moderate		severe		Very severe		total		
			No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	
1.	B.N.Kandriga														
	▪ Katuru	5	-	-	-	-	-	-	2	40	3	60	5	100	408
	▪ Pallamala	5	-	-	-	-	1	20	2	40	2	40	5	100	370
	▪ parapalli	5	-	-	-	-	-	-	2	40	3	60	5	100	425
2.	K.V.B.Puram														
	▪ Rajula kandriga	5	2	40	-	-	1	20	2	40	-	-	3	60	290
	▪ Timmasamudram	5	-	-	-	-	2	40	2	40	1	20	5	100	332
	▪ Kotha kandiriga	5	-	-	-	-	2	40	1	20	2	40	5	100	345
3.	Srikalahasti														
	▪ Thondamanadu	7	-	-	-	-	2	28.6	2	28.6	3	42.9	7	100	440
	▪ Eguvaveedu	7	-	-	-	-	2	28.6	3	42.9	2	28.6	7	100	422
	▪ Mittakandriga	6	-	-	-	-	1	16.7	2	33.3	3	50.0	6	100	460
4.	Thottambedu														
	▪ Chittaturu	5	1	-	2	40	2	40	-	-	-	-	4	80	275
	▪ Gurrapunaidu kandriga	5	-	-	1	20	2	40	1	20	1	20	5	100	320
	▪ Pedda kandriga	5	1	-	-	-	3	60	1	20	-	-	4	80	290
5.	Yerpedu														
	▪ Chintala pallum	5	2	40	1	20	2	40	-	-	-	-	3	60	240
	▪ Panguru	5	-	-	2	40	1	20	2	40	-	-	5	100	280
	▪ Sitarampeta	5	-	-	1	20	1	20	2	40	1	20	5	100	335
	Total	80	6	7.5	7	8.75	22.0	27.5	24	30	21	26.25	74	92.5	

* Number includes pod samples collected during 1998-99 post rainy season

Grade	Ratings of Disease
Nil	Healthy
Mild	1-25 per cent of pod area affected
Moderate	26-50 per cent of pod area affected
Severe	51-75 per cent of pod area affected
Very severe	above 75 per cent of pod area affected

4.4 EFFECT OF COMBINED APPLICATION OF ORGANIC SOIL AMENDMENTS AND LEVELS OF CARBOFURAN ON *T.brevilineatus* POPULATION

The population of *T.brevilineatus* was estimated at various growth stages of crop viz., initial (after sowing), 30 days, 60 days and final (at harvest) differed significantly due to combined effect of different organic soil amendments and levels of carbofuran. The interaction between organic soil amendments and levels of carbofuran was also found to be significant.

4.4.1 *T.brevilineatus* population at sowing

All the organic soil amendments were found to be highly significant in reducing the *T.brevilineatus* population when compared to the unamended check (Table 2 and Fig. 2). Among the organic soil amendments used, sawdust was found to be more effective in reducing the nematode population (254) followed by neem cake (269), poultry manure (300), pressmud cake (316) and farm yard manure (309). No interaction effect between carbofuran application and organic soil amendments in the initial nematode population was observed.

4.4.2 *T.brevilineatus* population at 30 days

T.brevilineatus population was significantly influenced by various organic soil amendments as well as the levels of carbofuran (Table 3, Fig.3).

Table 2. Effect of organic soil amendments and levels of carbofuran on *T.brevilineatus* initial population (in 250 cc of soil)

S.No.	Main treatments	Sub treatments (carbofuran at different levels)				Mean
	Organic soil amendments	0 kg a.i. ha^{-1}	2 kg a.i. ha^{-1}	3 kg a.i. ha^{-1}	4 kg a.i. ha^{-1}	
1.	Neem cake 1000 kg ha^{-1}	270 (16.13)	275 (16.50)	265 (16.26)	268 (16.36)	269.5 (16.40)
2.	Sawdust 2500 kg ha^{-1}	260 (16.10)	258 (16.05)	246 (15.67)	254 (15.94)	254.5 (15.94)
3.	Pressmud cake 2500 kg ha^{-1}	320 (17.86)	315 (17.74)	320 (17.88)	310 (17.60)	316.5 (17.77)
4.	Poultry manure 5000 kg ha^{-1}	300 (17.31)	295 (17.16)	305 (17.46)	303 (17.40)	300.75 (17.33)
5.	Farmyard manure 10000 kg ha^{-1}	310 (17.6)	315 (17.75)	308 (17.22)	312 (17.62)	305.75 (17.55)
6.	Unamended	420 (20.5)	415 (20.37)	425 (20.61)	410 (20.24)	417.5 (20.43)
	Mean	313.3 (17.63)	312.2 (17.60)	311.5 (17.52)	309.5 (17.52)	

	SEM ±	**CD (p=0.05)**
M	0.23	0.51
S	NS	NS
S at M	NS	NS
M at S	NS	NS

Figures in parenthesis are square root transformed values and CD pertains to them

Table 3. Effect of organic soil amendments and levels of carbofuran on *T.brevilineatus* population at 30 days (in 250 cc of soil)

S.No.	Main treatments	Sub treatments (carbofuran at different levels)				Mean
	Organic soil amendments	0 kg a.i. ha^{-1}	2 kg a.i. ha^{-1}	3 kg a.i. ha^{-1}	4 kg a.i. ha^{-1}	
1.	Neem cake 1000 kg ha^{-1}	250 (15.80)	209 (14.45)	175 (13.25)	142 (11.91)	194 (13.85)
2.	sawdust 2500 kg ha^{-1}	240 (15.49)	200 (14.14)	156 (12.48)	130 (11.40)	181.5 (13.38)
3.	Pressmud cake 2500 kg ha^{-1}	290 (17.03)	245 (15.49)	195 (13.96)	172 (13.30)	225.5 (14.94)
4.	Poultry manure 5000 kg ha^{-1}	280 (16.73)	238 (15.42)	190 (13.78)	168 (13.15)	219 (14.77)
5.	Farmyard manure 10000 kg ha^{-1}	305 (17.46)	250 (15.25)	198 (14.02)	175 (15.54)	232 (15.57)
6.	Unamended	410 (19.18)	295 (17.03)	215 (14.26)	185 (13.22)	276.25 (15.92)
	Mean	296 (16.95)	239.5 (15.30)	188.2 (13.62)	162 (13.09)	

	SEM ±	CD (p=0.05)
M	0.46	1.02
S	0.39	0.78
S at M	0.95	1.91
M at S	1.16	2.32

Figures in parenthesis are square root transformed values and CD pertains to them

Among the organic soil amendments tested, maximum reduction was recorded in sawdust treatment (181) followed by neem cake (194), poultry manure (219), pressmud cake (225) and farm yard manure (232). All the organic soil amendments were found to be significantly effective in reducing the *T.brevilineatus* population over the check.

All the three levels of carbofuran viz., 2,3 and 4 kg a.i ha^{-1} significant by reduced nematode population.

The interaction was found to be significant between different organic soil amendments and levels of carbofuran. Sawdust application showed maximum reduction of *T.brevilineatus* population both with and without the combination of carbofuran . The maximum reduction in *T.brevilineatus* nematode population was observed with carbofuran @ 4 kg a.i. ha^{-1} combined with sawdust and it was on par with the combination of neem cake and carbofuran (4 kg a.i ha^{-1}). Sawdust plus carbofuran @3 kg a.i.ha^{-1} was found equally effective as carbofuran @ 4 kg a.i ha^{-1} in reducing the nematode population.

4.4.3 *T.brevilineatus* population at 60 days:

Organic soil amendments and levels of carbofuran individually and in combination significantly reduced the *T.brevilineatus* population over the control (Table 4 and Fig.4).

Table 4: Effect of organic soil amendments and levels of carbofuran on *T.brevilineatus* population at 60 days (in 250 cc of soil)

S.No.	Main treatments	Sub treatments (carbofuran at different levels)				Mean
	Organic soil amendments	0 kg a.i. ha^{-1}	2 kg a.i. ha^{-1}	3 kg a.i. ha^{-1}	4 kg a.i. ha^{-1}	
1.	Neem cake 1000 kg ha^{-1}	235 (15.32)	198 (14.06)	165 (13.26)	134 (11.57)	183 (13.55)
2.	sawdust 2500 kg ha^{-1}	225 (15.00)	186 (13.63)	151 (12.28)	125 (11.17)	171.75 (13.02)
3.	Pressmud cake 2500 kg ha^{-1}	275 (16.56)	235 (15.32)	186 (13.63)	164 (12.71)	215 (14.56)
4.	Poultry manure 5000 kg ha^{-1}	270 (16.43)	226 (15.03)	182 (14.82)	159 (12.60)	209.25 (14.72)
5.	Farmyard manure 10000 kg ha^{-1}	296 (17.20)	242 (15.50)	192 (13.85)	172 (13.11)	225.5 (14.93)
6.	Unamended	390 (19.74)	280 (16.73)	205 (14.31)	180 (13.41)	263.75 (16.05)
	Mean	281.8 (16.71)	227.83 (15.06)	180.2 (13.69)	155.67 (12.43)	

	SEM ±	CD (p=0.05)
M	0.32	0.71
S	0.24	0.50
S at M	0.60	1.20
M at S	0.76	1.52

Figures in parenthesis are square root transformed values and CD pertains to them.

Highly significant reduction in nematode population was observed in all the organic soil amendments when compared to the unamended check. Among the organic soil amendments, highest reduction of the nematode population was recorded in sawdust treatment (172) followed by neem cake (183), poultry manure (209), pressmud cake (215) and farm yard manure (225).

Carbofuran at four levels 0, 2, 3 and 4 kg a.i. ha^{-1} significantly reduced *T.brevilineatus* population and the reduction was progressive from 2 kg a.i. to 4 kg a.i. ha^{-1}.

Regarding interaction effect all the organic soil amendments showed significant reduction with each successive addition of carbofuran i.e., 2,3 and 4 kg a.i. ha^{-1}. The combination of sawdust and carbofuran @ 4 kg a.i. ha^{-1} had lowest *T.brevilineatus* population (125) but was on par with the neem cake and carbofuran @ 4 kg a.i. ha^{-1}(134). Both sawdust and neem cake in combination with carbofuran @ 4 kg a.i. ha^{-1} were found significantly superior over the application of carbofuran alone @ 4 kg a.i. ha^{-1}.

4.4.4. *T.brevilineatus* population at harvest

Organic soil amendments and levels of carbofuran alone and their interaction have significantly influenced the final nematode population (Table 5, Fig.5). Maximum reduction in *T.brevilineatus* nematode population was recorded in sawdust (161) followed by neem cake (171), poultry manure (202), pressmud cake (208) and farm yard manure (217). All the organic soil amendments showed lower plant parasitic nematode population compared to the unamended check.

Table 5: Effect of organic soil amendments and levels of carbofuran on *T.brevilineatus* population before harvest (in 250 cc of soil)

S.No.	Main treatments	Sub treatments (carbofuran at different levels)				Mean
	Organic soil amendments	0 kg a.i. ha^{-1}	2 kg a.i. ha^{-1}	3 kg a.i. ha^{-1}	4 kg a.i. ha^{-1}	
1.	Neem cake 1000 kg ha^{-1}	220 (14.85)	190 (13.78)	156 (12.48)	120 (10.95)	171.50 (13.01)
2.	sawdust 2500 kg ha^{-1}	210 (14.48)	180 (13.41)	145 (12.03)	110 (10.48)	161.25 (12.06)
3.	Pressmud cake 2500 kg ha^{-1}	262 (16.17)	230 (15.16)	182 (13.48)	158 (12.56)	208 (14.34)
4.	Poultry manure 5000 kg ha^{-1}	258 (16.05)	220 (14.85)	178 (13.33)	154 (12.42)	202.5 (14.06)
5.	Farmyard manure 10000 kg ha^{-1}	287 (16.96)	236 (15.36)	186 (13.63)	161 (12.68)	217.5 (14.66)
6.	Unamended	382 (19.54)	275 (16.56)	202 (14.06)	172 (13.11)	257.75 (15.82)
	Mean	270 (16.34)	222 (14.85)	153 (13.17)	145.8 (12.03)	

	SEM ±	CD (p=0.05)
M	0.27	0.61
S	0.17	0.34
S at M	0.42	0.84
M at S	0.60	1.20

Figures in parenthesis are square root transformed values and CD pertains to them

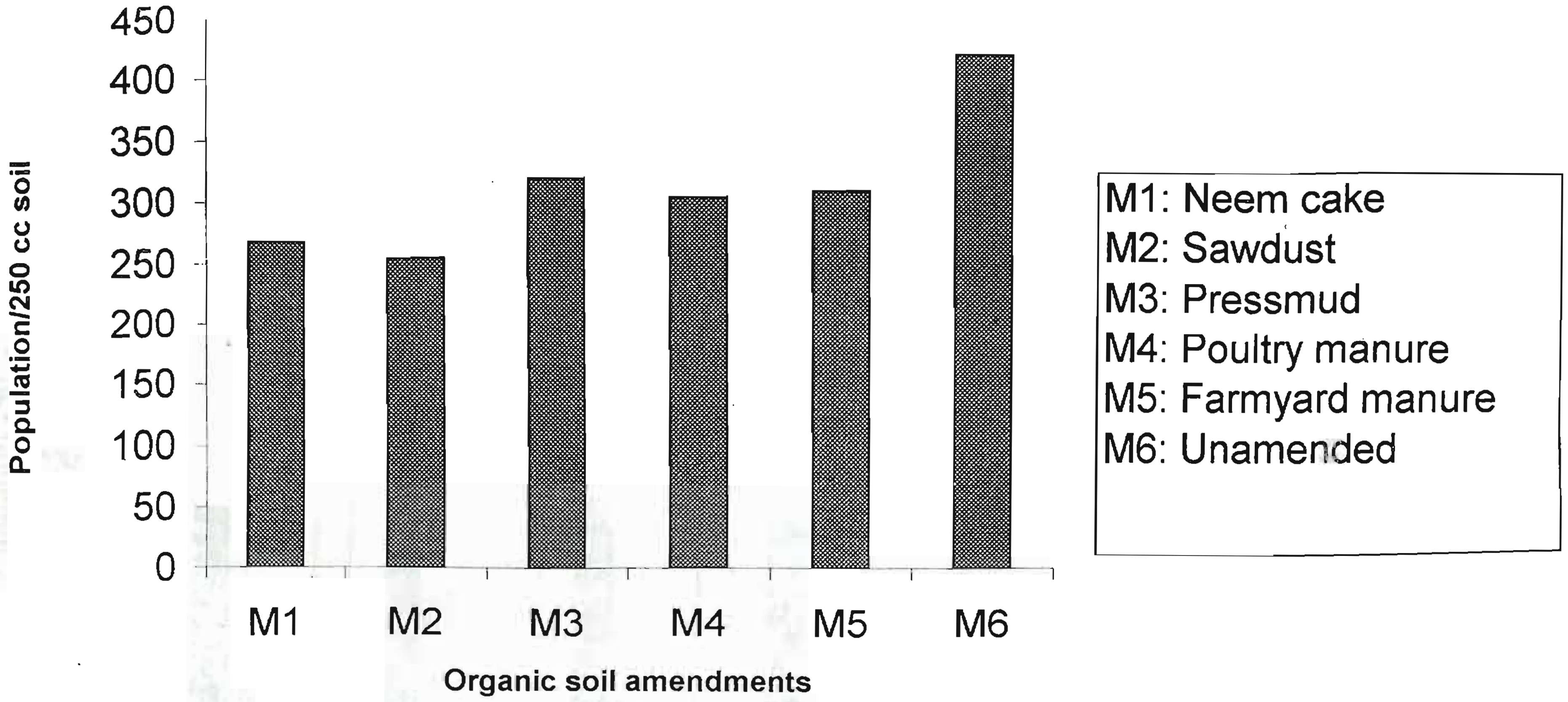


Fig 2: Effect of organic soil amendments on T.brevilineatus initail population at sowing

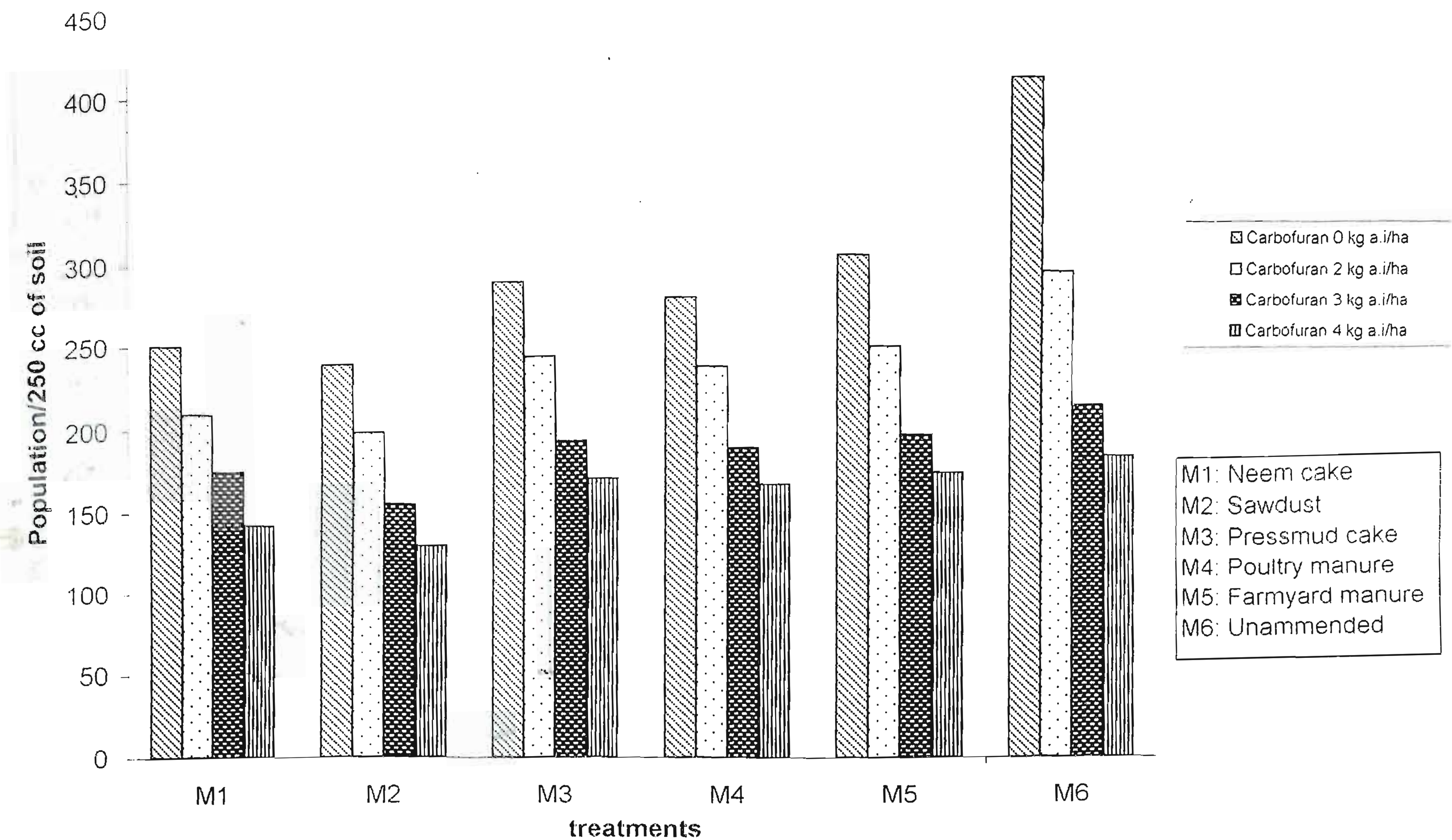


Fig 3: Combined effect of organic soil amendments and carbofuran on *T.brevilineatus* population at 30 DAS

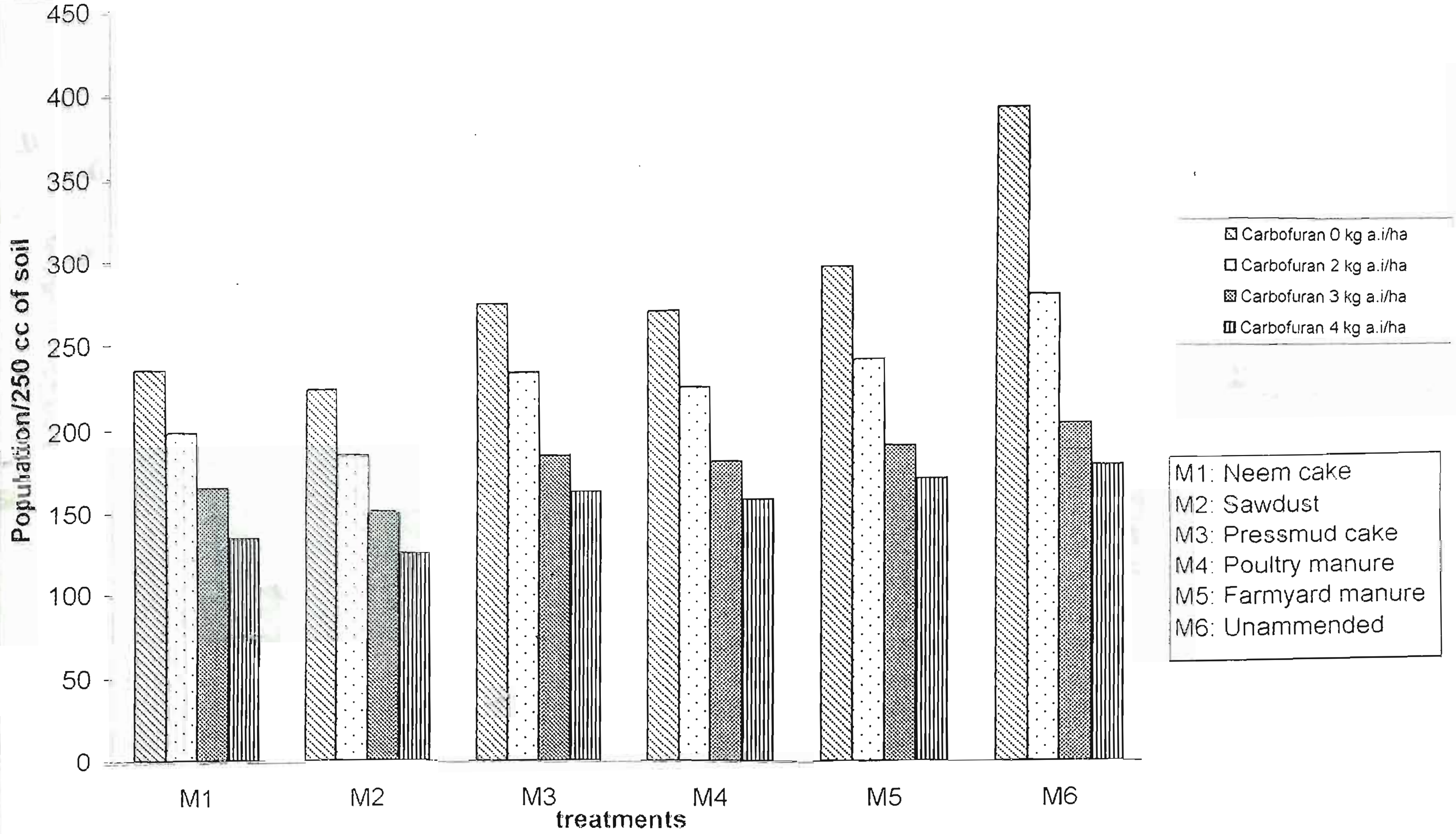


Fig 4: Combined effect of organic soil amendments and carbofuran on *T.brevilineatus* population at 60 DAS

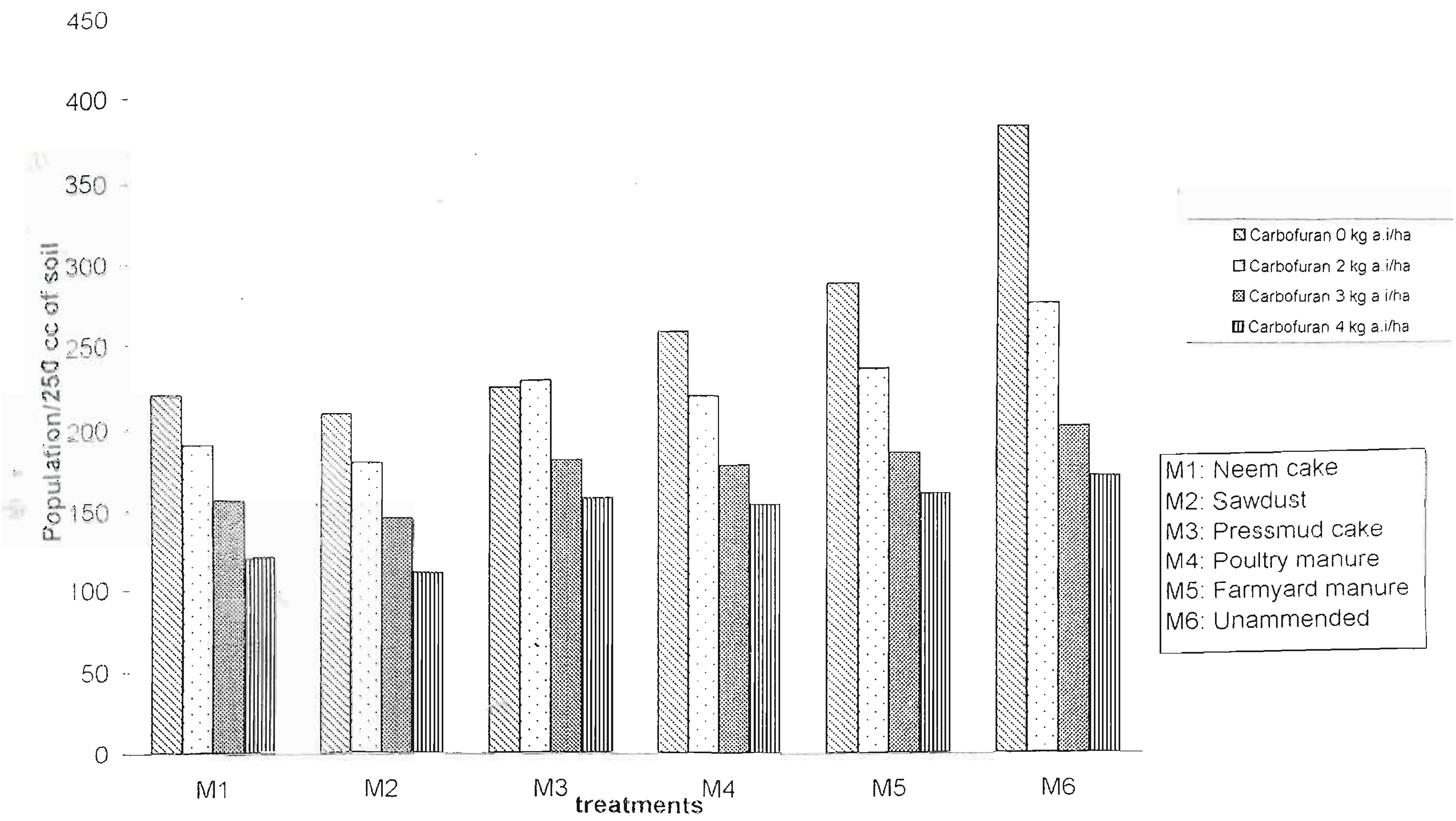


Fig 5: Combined effect of organic soil amendments and carbofuran on *T.brevilineatus* population at harvest

Carbofuran at all levels had significant effect in reducing the nematode population. Carbofuran @ 4 kg a.i. ha^{-1} showed lowest nematode population (146). The added levels of carbofuran reduced the nematode population significantly in decreasing order.

Organic soil amendments and carbofuran levels exhibited a noticeable trend of interaction in the reduction of nematode population. Maximum reduction of the nematode population (110) was obtained with sawdust coupled with carbofuran @ 4 kg a.i. ha^{-1} which is on par with neem cake and carbofuran (4 kg a.i. ha^{-1}) combined application (120). Reduction in nematode population due to carbofuran @ 4 kg a.i. ha^{-1} was on par with sawdust and carbofuran @ 3 kg a.i ha^{-1} treated plot.

4.5 EFFECT OF COMBINED APPLICATION OF ORGANIC SOIL AMENDMENTS AND CARBOFURAN AT DIFFERENT LEVELS ON NEMATODE DISEASE SEVERITY AND YIELDS OF GROUNDNUT CROP (var.JL-24)

Groundnut yield parameters (100 pod weight, 100 kernel weight, shelling percentage, number of pods per plant, yield per hectare) and nematode disease severity were recorded and the results are presented in Tables 5 to 11, Plates. 9 and 10.

4.5.1 <u>100 Pod weight (g):</u>

Organic soil amendments and carbofuran levels alone and in combination showed significant effect on 100 pod weight (Table 6).

Table 6: Effect of organic soil amendments and levels of carbofuran on 100 pod weight (g)

S.No.	Main treatments	Sub treatments (carbofuran at different levels)				Mean
	Organic soil amendments	0 kg a.i. ha^{-1}	2 kg a.i. ha^{-1}	3 kg a.i. ha^{-1}	4 kg a.i. ha^{-1}	
1.	Neem cake 1000 kg ha^{-1}	79.17	80.67	82.68	83.67	81.55
2.	sawdust 2500 kg ha^{-1}	79.67	81.49	83.21	84.70	82.27
3.	Pressmud cake 2500 kg ha^{-1}	76.01	79.78	82.10	83.53	80.35
4.	Poultry manure 5000 kg ha^{-1}	78.47	79.96	83.09	83.30	81.20
5.	Farmyard manure 10000 kg ha^{-1}	75.88	79.37	80.67	82.70	79.70
6.	Unamended	70.06	76.96	79.40	81.64	77.00
	Mean	76.56	79.70	81.86	83.26	

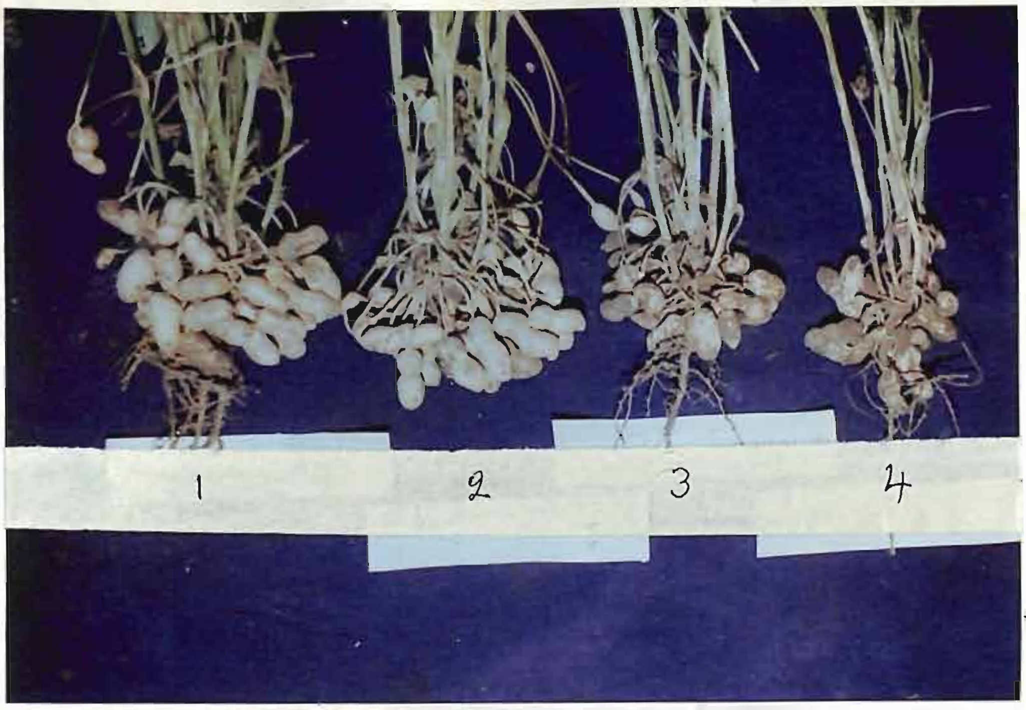
	SEM ±	CD (p=0.05)
M	0.4	0.9
S	0.52	1.04
S at M	1.28	2.56
M at S	1.31	2.61

Plate 9: Field view of kalahasti malady management trial laidout in Andhra Pradesh State Seed Development Corporation Farm at Srikalahasti

Table 7: Effect of organic soil amendments and levels of carbofuran on 100 Kernel weight (g)

S.No.	Main treatments	Sub treatments (carbofuran at different levels)				Mean
	Organic soil amendments	0 kg a.i. ha^{-1}	2 kg a.i. ha^{-1}	3 kg a.i. ha^{-1}	4 kg a.i. ha^{-1}	
1.	Neem cake 1000 kg ha^{-1}	35.00	35.00	40.67	42.20	38.97
2.	sawdust 2500 kg ha^{-1}	35.40	38.20	41.47	42.50	39.39
3.	Pressmud cake 2500 kg ha^{-1}	34.20	37.50	39.60	40.10	37.90
4.	Poultry manure 5000 kg ha^{-1}	34.41	37.62	39.60	41.20	38.21
5.	Farmyard manure 10000 kg ha^{-1}	33.50	36.20	39.33	40.00	37.26
6.	Unamended	30.50	34.50	37.50	40.00	35.62
	Mean	33.83	37.00	39.19	41.00	

	SEM ±	CD (p=0.05)
M	0.54	1.20
S	0.63	1.23
S at M	1.20	2.40
M at S	1.25	2.50


1
2
3
4


1
2
3
4

Plate 10c : Plants showing pods in different treatments

1. Pressmud cake @ 2500 kg ha^{-1}
2. Pressmud cake @ 2500 kg ha^{-1}+carbofuran @ 2 kg a.i. ha^{-1}
3. Pressmud cake @ 2500 kg ha^{-1}+carbofuran @ 3 kg a.i. ha^{-1}
4. Pressmud cake @ 2500 kg ha^{-1}+carbofuran @ 4 kg a.i. ha^{-1}

Plate 10d : Plants showing pods in different treatments

1. poultry manure @ 5000 kg ha^{-1}
2. poultry manure @ 5000 kg ha^{-1} + carbofuran @ 2 kg a.i. ha^{-1}
3. Polutry manure @ 5000 kg ha^{-1} + carbofuran @ 3 kg a.i. ha^{-1}
4. Poultry manure @ 5000 kg ha^{-1} + carbofuran @ 4 kg a.i. ha^{-1}


1
2
3
4


1
2
3
4

Plate 10e : Plants showing pods in different treatments

1. Farm yard manure @ 10000 kg ha^{-1}
2. Farm yard manure @ 10000 kg ha^{-1} + carbofuran @ 2 kg a.i. ha -
3. Farm yard manure @ 10000 kg ha^{-1} + carbofuran @ 3 kg a.i. ha -
4. Farm yard manure @ 10000 kg ha^{-1} + carbofuran @ 4 kg a.i. ha -

Plate 10f : Plants showing pods in different treatments

1. with out organic soil amendments (unamended)
2. Unamended + carbofuran @ 2 kg a.i. ha^{-1}
3. Unamended + carbofuran @ 3 kg a.i. ha^{-1}
4. Unamended + carbofuran @ 4 kg a.i. ha^{-1}


1
2
3
4


1
2
3
4

Levels of carbofuran exhibited significant difference in 100 kernel weight and weight increased with each successive addition of carbofuran up to the highest level. Carbofuran @ 4 kg a.i. ha^{-1} gave maximum 100 kernel weight (41 g).

Sawdust in combination with carbofuran @ 4 kg a.i. ha^{-1} showed maximum 100 kernel weight (42.5 g) which was on par with neem cake combined with carbofuran @ 4 kg a.i. ha^{-1} (42.21g). Irrespective of organic soil amendment, there was a gradual increase in100 kernel weight with each addition of 1 kg a.i. ha^{-1} carbofuran. Sawdust and neem cake in combination with carbofuran @ 4 kg a.i. ha^{-1} were found on par with each other and superior than other treatments.

4.5.3. Shelling percentage

Organic soil amendments and carbofuran levels noticeably increased the shelling percentage of groundnut. Significant increase in the shelling percentage was recorded in all the organic soil amendment treated plots compared to unamended check. Sawdust application exhibited highest shelling per cent (79%) followed by neem cake (78.5%). They were found on par with sawdust. Other organic soil amendments also improved shelling percentage significantly over the check (Table 8).

Added levels of carbofuran increased the shelling percentage gradually up to 4 kg a.i. ha^{-1}. The highest shelling percentage (80.48%) was recorded with carbofuran @ 4 kg a.i. ha^{-1}.

Table 8: Effect of organic soil amendments and levels of carbofuran on shelling percentage of groundnut

S.No.	Main treatments	Sub treatments (carbofuran at different levels)				Mean
	Organic soil amendments	0 kg a.i. ha^{-1}	2 kg a.i. ha^{-1}	3 kg a.i. ha^{-1}	4 kg a.i. ha^{-1}	
1.	Neem cake 1000 kg ha^{-1}	75.00 (60.00)	78.00 (62.03)	80.00 (63.43)	81.00 (64.17)	78.50 (62.41)
2.	Sawdust 2500 kg ha^{-1}	76.00 (60.67)	78.50 (62.40)	80.00 (63.37)	81.00 (64.87)	79.00 (62.32)
3.	Pressmud cake 2500 kg ha^{-1}	75.50 (60.33)	77.80 (61.90)	79.00 (62.73)	80.57 (63.37)	78.22 (62.27)
4.	Poultry manure 5000 kg ha^{-1}	75.63 (60.40)	77.00 (61.33)	78.57 (62.47)	80.83 (64.07)	78.00 (62.07)
5.	Farmyard manure 10000 kg ha^{-1}	72.50 (58.40)	77.40 (61.63)	78.50 (62.37)	80.50 (60.83)	77.20 (60.81)
6.	Unamended	59.00 (50.17)	72.00 (58.03)	78.00 (62.63)	79.00 (62.73)	72.00 (58.24)
	Mean	72.27 (58.33)	76.78 (61.22)	79.00 (62.73)	80.48 (63.09)	

	SEM ±	CD (p=0.05)
M	0.49	1.10
S	0.59	1.17
S at M	1.44	2.88
M at S	1.51	3.02

Figures in parenthesis are angular transformed values and CD pertains to them

Significant interaction was found between organic soil amendments and carbofuran levels. Sawdust in combination with carbofuran @ 4 kg a.i. ha^{-1} recorded the highest shelling percentage (81%) which was on par with the combination of neem cake and carbofuran at the same level (81 %). Irrespective of organic soil amendments there was a gradual increase in shelling percentage with each successive addition of carbofuran.

4.5.4 Number of pods per plant.

Number of pods per plant was significantly increased by the application of organic soil amendments and carbofuran levels, while the interaction did not exert any influence (Table 9).

Among all the organic soil amendments, sawdust gave highest number of pods per plant (14.9). The other organic soil amendments were also significantly effective in increasing the number of pods per plant over check. Except farm yard manure all of them were found on par with sawdust in influencing the number of pods per plant. Each successive increase of carbofuran @1 kg a.i. ha^{-1} increased the number of pods per plant significantly but only up to 3 kg a.i. ha^{-1}. Sawdust in combination with carbofuran @ 4 kg a.i. ha^{-1} yielded maximum number of pods per plant (17.13) which is on par with neem cake (16.9) and pressmud cake (16.27) with the same level of carbofuran.

4.5.5 Disease severity (Per cent disease index)

Organic soil amendments and carbofuran levels noticeably influenced the per cent disease index of kalahasti malady on groundnut (Table 10 and Fig 6).

Table 9: Effect of organic soil amendments and levels of carbofuran on number of pods per plant

S.No.	Main treatments	Sub treatments (carbofuran at different levels)				Mean
	Organic soil amendments	0 kg a.i. ha^{-1}	2 kg a.i. ha^{-1}	3 kg a.i. ha^{-1}	4 kg a.i. ha^{-1}	
1.	Neem cake 1000 kg ha^{-1}	11.93	13.90	15.67	16.90	14.60
2.	sawdust 2500 kg ha^{-1}	12.73	13.80	15.93	17.13	14.90
3.	Pressmud cake 2500 kg ha^{-1}	11.73	13.30	15.10	15.73	13.96
4.	Poultry manure 5000 kg ha^{-1}	11.80	13.80	15.37	16.27	14.31
5.	Farmyard manure 10000 kg ha^{-1}	11.13	13.00	15.10	14.83	13.52
6.	Unamended	10.13	11.33	13.43	14.37	12.32
	Mean	11.58	13.19	15.10	15.87	

	SEM ±	**CD (p=0.05)**
M	0.54	1.20
S	0.38	0.75
S at M	NS	NS
M at S	NS	NS

Table 10 : Effect of organic soil amendments and levels of carbofuran on disease severity

S.No.	Main treatments	Sub treatments (carbofuran at different levels)				Mean
	Organic soil amendments	0 kg a.i. ha^{-1}	2 kg a.i. ha^{-1}	3 kg a.i. ha^{-1}	4 kg a.i. ha^{-1}	
1.	Neem cake 1000 kg ha^{-1}	66.27 (54.50)	45.03 (42.24)	32.50 (34.76)	20.90 (27.20)	41.24 (39.67)
2.	Sawdust 2500 kg ha^{-1}	68.07 (55.60)	48.00 (43.85)	31.00 (33.83)	22.70 (28.45)	42.44 (40.43)
3.	Pressmud cake 2500 kg ha^{-1}	70.67 (57.23)	59.70 (50.60)	36.00 (36.87)	24.00 (29.33)	47.60 (43.50)
4.	Poultry manure 5000 kg ha^{-1}	70.00 (56.80)	62.00 (51.95)	34.90 (36.21)	24.40 (29.60)	47.82 (43.64)
5.	Farmyard manure 10000 kg ha^{-1}	71.20 (57.47)	55.40 (48.13)	31.00 (33.83)	24.20 (29.47)	45.45 (42.22)
6.	Unamended	90.70 (72.37)	66.20 (54.46)	36.50 (36.99)	25.20 (30.13)	54.65 (48.48)
	Mean	72.82 (58.99)	56.05 (48.54)	33.65 (35.41)	23.57 (29.03)	

	SEM ±	**CD (p=0.05)**
M	0.85	1.90
S	0.65	1.36
S at M	1.67	3.34
M at S	2.06	4.13

Figures in parenthesis are angular transformed values and CD pertains to them

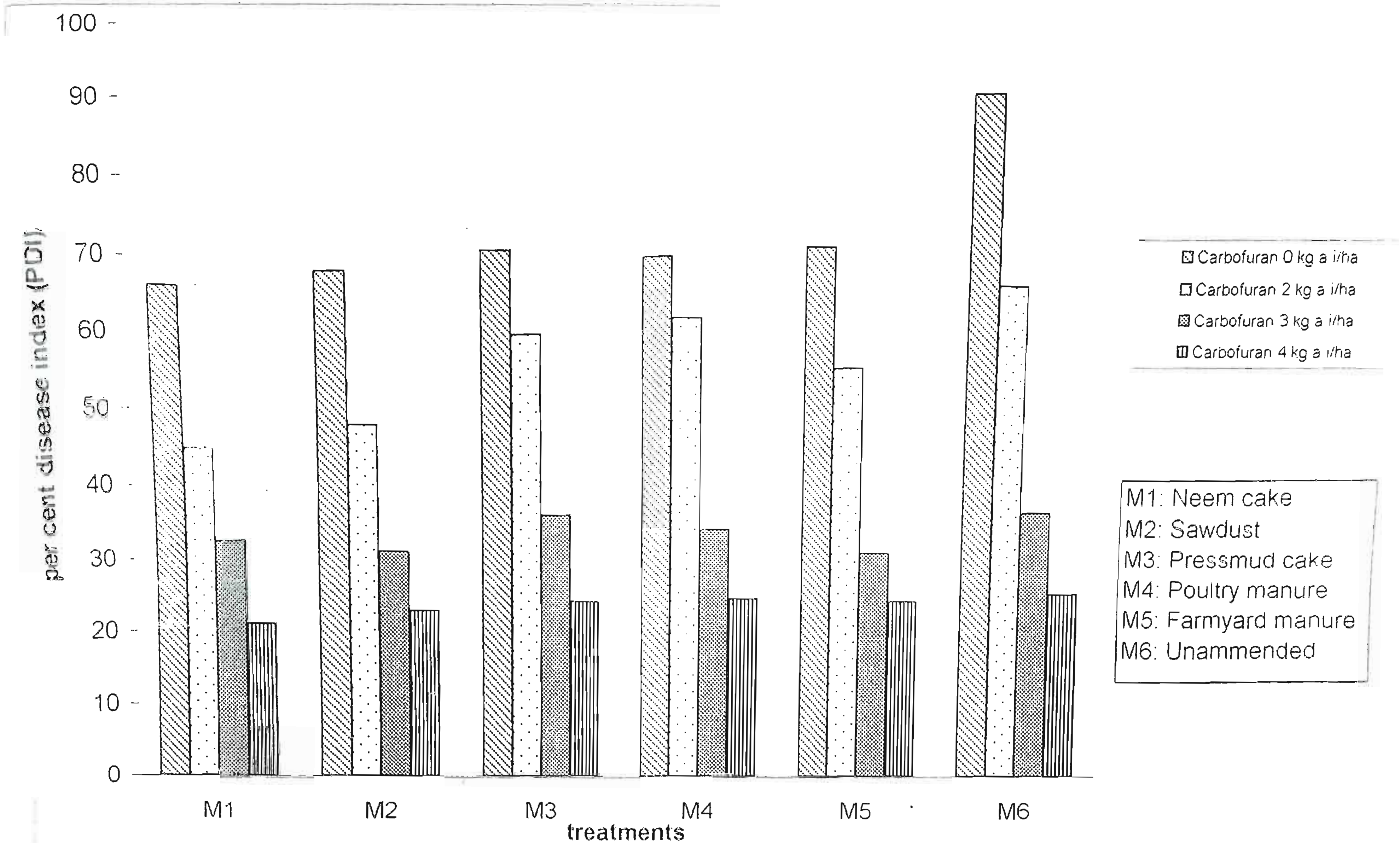


Fig 6: Combined effect of organic soil amendments and carbofuran on kalahasti malady disease severity in groundnut cv. JL-24

The per cent disease index was decreased significantly in all the organic soil amendments applied plots compared to the unamended check. Neem cake and sawdust were found on par with each other in reducing disease severity (Plates 17, 18, 19, 20, 21 and 22). Carbofuran at all levels decreased the disease severity significantly over control. Lowest disease severity (23.57) was recorded in carbofuran @ 4 kg a.i. ha^{-1}. Neem cake in combination with carbofuran @ 4 kg a.i. ha^{-1} recorded lowest disease severity of 20.9 which was on par with sawdust in combination with carbofuran at the same level (22.7 PDI). Sawdust in combination with carbofuran @ 3 kg a.i ha^{-1} was on par with carbofuran @ 4 kg a.i. ha^{-1} in reduction of disease severity.

4.5.6 Pod yield

Organic soil amendments and levels of carbofuran as well as their interaction increased the pod yield significantly (Table 11 and Fig.7).

All the organic soil amendments significantly increased the pod yield over check. Sawdust gave significantly highest pod yield of 32.45 q ha^{-1} over other treatments but was on par with neem cake (31.5 q ha^{-1}). Unammended check gave lowest pod yield of 25.5 q ha^{-1}.

Carbofuran @ 4 kg a.i. ha^{-1} significantly out yielded (34.01 q ha^{-1}) all other levels, while carbofuran at 0 kg a.i. ha^{-1} recorded lowest pod yield of 21.74 q ha^{-1}. The added levels of carbofuran increased the pod yield significantly and progressively.

Table 11: Effect of organic soil amendments and levels of carbofuran on pod yield of groundnut (q/ha)

S.No.	Main treatments	Sub treatments (carbofuran at different levels)				Mean
	Organic soil amendments	0 kg a.i. ha^{-1}	2 kg a.i. ha^{-1}	3 kg a.i. ha^{-1}	4 kg a.i. ha^{-1}	
1.	Neem cake 1000 kg ha^{-1}	25.00	30.00	34.00	37.00	31.50
2.	sawdust 2500 kg ha^{-1}	25.80	31.00	35.00	38.00	32.45
3.	Pressmud cake 2500 kg ha^{-1}	21.10	26.50	30.00	33.00	27.65
4.	Poultry manure 5000 kg ha^{-1}	20.50	27.00	30.00	33.80	27.97
5.	Farmyard manure 10000 kg ha^{-1}	20.00	26.00	30.50	31.67	27.04
6.	Unamended	18.03	25.00	28.00	31.00	25.51
	Mean	21.74	27.58	31.42	34.01	

	SEM ±	**CD (p=0.05)**
M	0.74	1.65
S	0.67	1.48
S at M	1.63	3.26
M at S	1.91	3.81

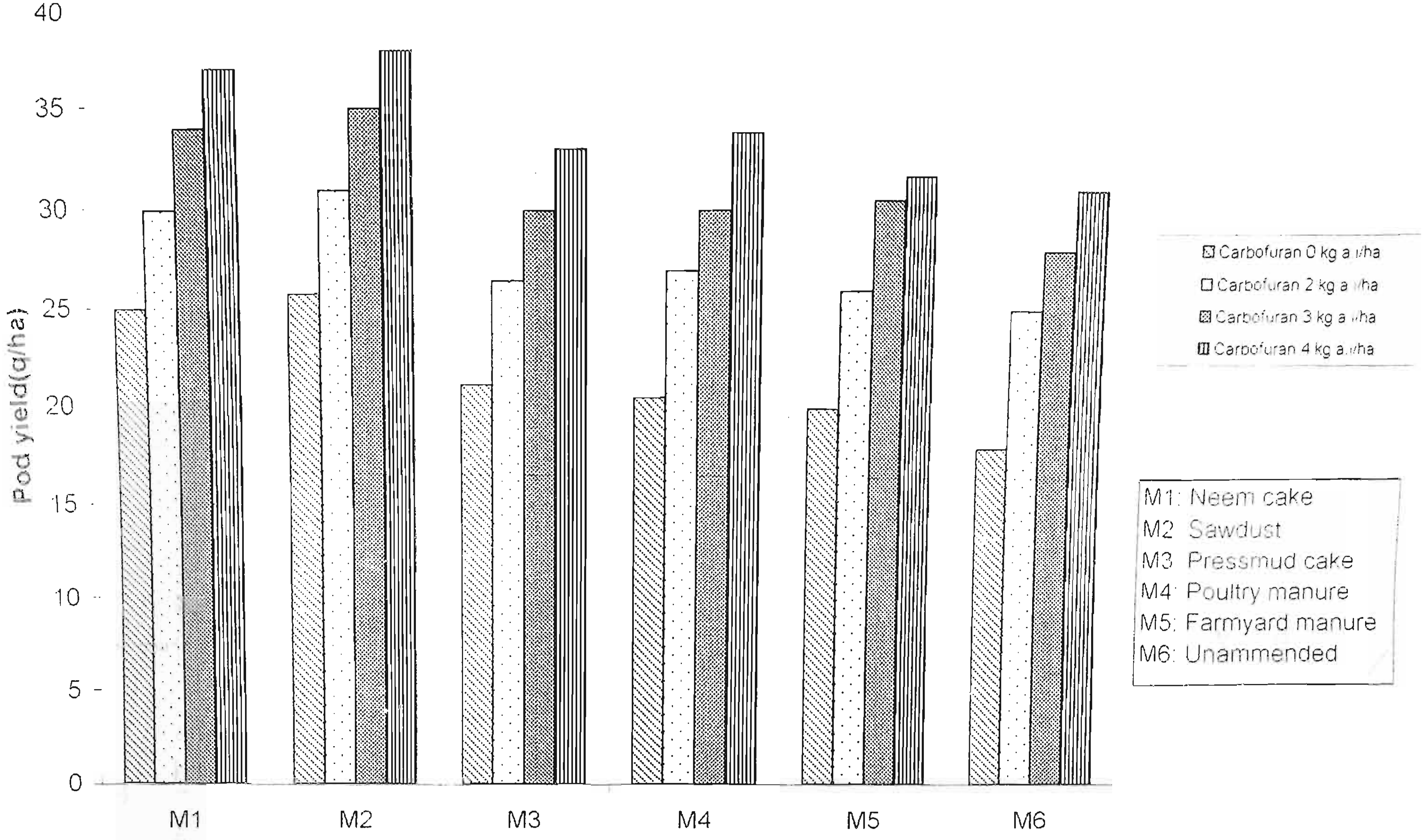


Fig 7: Combined effect of organic soil amendments and carbofuran on pod yield of groundnut cv. JL-24

Organic soil amendments and carbofuran increased pod yield of groundnut. The highest pod yield (38 q ha^{-1}) was obtained with sawdust coupled with carbofuran @ 4 kg a.i. ha^{-1}. Combined application of sawdust and carbofuran at all levels was found superior to all other organic soil amendments in combination with carbofuran except neem cake and carbofuran combination which was on par with sawdust. Pod yield obtained from sawdust and carbofuran @ 2 kg a.i.ha^{-1} treated plot was on par with carbofuran alone @ 4 kg a.i. ha^{-1} treated plot.

4.5.7 Correlation studies

Simple correlation among nematode population, disease severity and pod yield of groundnut have been worked out to assess the extent of relationship among them and correlation coefficients are presented in Table 12. There was significant positive correlation between nematode population levels at different growth stages and kalahasti malady disease severity. Significant negative correlation was recorded between nematode population and pod yield; disease severity and pod yield.

4.5.8 Economics

Different organic soil amendments and levels of carbofuran and their combinations exerted significant influence on gross as well as net returns and incremental benefit cost ratios of groundnut production (Table 13). The details of cost of cultivation and treatments are presented in Appendex II.

Table 12 : Correlation coefficients (r values) among the nematode population, disease severity and pod yield of groundnut.

S.No.	Factor	'r' values
1.	*T.brevilineatus* population at initial (before sowing) Vs disease severity	+ 0.410321*
2.	*T.brevilineatus* population at 30 days Vs disease severity	+ 0.932496**
3.	*T.brevilineatus* population at 60 days Vs disease severity	+ 0.924551**
4.	*T.brevilineatus* population at harvest Vs disease severity	+ 0.912634**
5.	*T.brevilineatus* population at initial (before sowing) Vs pod yield	- 0.426*
6.	*T.brevilineatus* population at 30 days Vs pod yield	-0.948**
7.	*T.brevilineatus* population at 60 days Vs pod yield	-0.9123**
8.	*T.brevilineatus* population at harvest Vs pod yield	-0.9457**
9.	Disease severity Vs pod yield	-0.804**

* Significant at 5%
** Significant at 1%

Table 13 : Economics of disease management through organic soil amendments and carbofuran at different levels.

S.No	Treatments	Yield ($kg\ ha^{-1}$)		Additional yield ($kg\ ha^{-1}$)		Additional returns ($Rs.\ h^{-1}$)	Additional expenditure ($Rs.\ ha^{-1}$)	Additional net returns ($Rs.\ ha^{-1}$)	Incremental benefit cost ratio
		Pod	Haulm	Pod	Haulm				
1.	Neem cake 1000 kg ha^{-1}	2500	3600	700	1100	8950	5000	4950	1.79
2.	Neem cake 1000 kg ha^{-1} + Carbofuran @ 2 kg a.i ha^{-1}	3000	4100	1200	1600	15200	9092	6108	1.67
3.	Neem cake 1000 kg ha^{-1} + Carbofuran @ 3 kg a.i ha^{-1}	3400	4500	1600	2000	20200	11200	9000	1.8
4.	Neem cake 1000 kg ha^{-1} + Carbofuran @ 4 kg a.i ha^{-1}	3700	4800	1900	2300	23950	13246	10704	1.81
5.	Sawdust 2500 kg ha^{-1}	2580	3600	780	1100	9910	2500	7410	3.96
6.	Sawdust 2500 kg ha^{-1} + Carbofuran @ 2kg a.i ha^{-1}	3100	4000	1300	1500	16350	6592	10258	2.48
7.	Sawdust 2500 kg ha^{-1} + Carbofuran @ 3 kg a.i ha^{-1}	3500	4400	1700	1900	21350	8700	13150	2.45
8.	Sawdust 2500 kg ha^{-1} + Carbofuran @ 4 kg a.i ha^{-1}	3800	4700	2000	2200	25100	10746	14854	2.34
9.	Pressmud cake 2500 kg ha^{-1}	2110	3400	310	900	4170	1000	3170	4.32
10.	Pressmud cake 2500 kg ha^{-1} + Carbofuran @ 2 kg a.i ha^{-1}	2650	4000	850	1500	10950	5092	5858	2.15
11.	Pressmud cake 2500 kg ha^{-1} + Carbofuran @ 3 kg a.i ha^{-1}	3000	4200	1200	1700	15250	7200	8050	2.12
12.	Pressmud cake 2500 kg ha^{-1} + Carbofuran @ 4 kg a.i ha^{-1}	3300	4500	1500	2000	19000	9246	9754	2.05
13.	Poultry manure 5000 kg ha^{-1}	2050	3300	250	800	3400	2000	1400	1.7
14.	Poultry manure 5000 kg ha^{-1} + Carbofuran @ 2 kg a.i ha^{-1}	2700	3900	900	1400	11500	6092	5408	1.89
15.	Poultry manure 5000 kg ha^{-1} + Carbofuran @ 3kg a.i ha^{-1}	3060	4200	1260	1700	15970	8200	7770	1.95
16.	Poultry manure 5000 kg ha^{-1} + Carbofuran @ 4 kg a.i ha^{-1}	3380	4600	1580	2100	20010	10246	9764	1.95
17.	Farm yard manure 10000 kg ha^{-1}	2000	3800	200	1300	3050	3000	50	1.02
18.	Farm yard manure 10000 kg ha^{-1} + Carbofuran @ 2 kg a.i ha^{-1}	2600	4200	800	1700	10450	7092	3358	1.47
19.	Farm yard manure 10000 kg ha^{-1} + Carbofuran @ 3 kg a.i ha^{-1}	3050	4600	1250	2100	16050	9200	6850	1.74
20.	Farm yard manure 10000 kg ha^{-1} + Carbofuran @ 4 kg a.i ha^{-1}	3170	5000	1370	2500	17690	11246	6444	1.57
21.	Unammended	1800	2500	--	--	--	--	--	--
22.	Unammended + carbofuran @ 2 kg a.i ha^{-1}	2500	3400	700	900	8850	4092	4758	2.16
23.	Unammended + carbofuran @ 3 kg a.i ha^{-1}	2800	4100	1000	1600	12800	6200	6600	2.06
24.	Unammended + carbofuran @ 4 kg a.i ha^{-1}	3100	4400	1300	1900	16550	8246	8304	2.01

Pod yield Rs. 12-00 per kg
Haulm yield Rs. 0.40 per kg

Among the organic soil amendments, pressmud cake gave highest additional returns and incremental benefit cost ratio (4.2) followed by sawdust (3.98), poultry manure (2.15), whereas farm yard manure gave the lowest returns and incremental benefit cast ratio (1.57).

Added levels of carbofuran application has progressively enhanced the additional returns and incremental benefit cost ratio up to the highest level of carbofuran @ 4 kg a.i ha^{-1} irrespective of the organic soil amendments applied. Application of sawdust along with carbofuran @ 2,3 and 4 kg a.i. ha^{-1} gave the highest additional returns and incremental benefit cost ratios of 2.48, 2.45 and 2.34 respectively. Pressmud cake in combination with carbofuran @ 2,3 and 4 kg a.i. ha^{-1} found to be next best with incremental benefit cost ratio of 2.15, 2.17 and 2.05 respectively.

4.6 VARIETAL SCREENING

The data (Table 14) indicated that none of the groundnut genotypes were completely free from the nematode disease. The genotypes differed significantly in the disease severity. All the thirty genotypes screened were significantly superior over the check variety JL-24 (Plates 11 to 13).

Among all the 30 genotypes screened, ten genotypes viz., TCGS-245, TCGS-303, TCGS-320, TCGS-337, TCGS-421, TCGS-428, TCGS-435, TCGS-445, TCGS-597 and TPT-3 were found resistant to nematode disease with disease severity of 2.0 on 1 to 5 disease scale (Plates 11a to 11f). Among the resistant genotypes, nine genotypes gave significantly more 100 pod weight over check JL-24. The genotype TCGS-320 gave

Table 14: Reaction of groundnut genotypes/varieties to kalahasti malady (*T.brevilineatus*)

S.No. (1)	Genotypes / varieties (2)	Disease severity (1-5 sclae) (3)	100 pod weight (g) (4)	100 kernel weight (g) (5)	Shelling percentage (%) (6)	No.of pods per plant (No) (7)	Pod yield (q/ha) (8)	Per cent yield increase or decrease over control (%) (9)
1.	TCGS-245	2.00	97.8	40.7	62.7 (52.4)	13	33.00	64
2.	TCGS-285	2.80	94.7	37.1	73.0 (58.7)	16	31.82	58
3.	TCGS-292	2.60	90.0	37.6	62.1 (52.0)	17	30.62	52
4.	TCGS-298	2.13	85.1	36.5	74.5 (59.7)	15	29.36	46
5.	TCGS-303	2.00	97.2	34.4	69.1 (56.2)	16	34.21	70
6.	TCGS-305	2.90	83.7	36.2	70.7 (57.3)	18	30.13	50
7.	TCGS-307	3.20	73.2	30.5	70.5 (57.1)	18	27.67	37
8.	TCGS-309	3.00	87.2	35.5	77.9 (62.0)	16	30.70	53
9.	TCGS-318	2.20	77.8	33.0	77.9 (62.0)	16	28.63	42
10.	TCGS-320	2.00	120.2	49.0	72.7 (58.7)	19	39.98	99
11.	TCGS-325	3.26	82.4	35.8	60.2 (50.9)	16.3	30.90	54
12.	TCGS-328	3.86	76.2	33.0	65.7 (54.2)	19	28.58	42
13.	TCGS-332	3.50	61.8	29.6	58.0 (49.6)	18.2	27.00	34
14.	TCGS-334	2.50	68.7	29.6	77.6 (61.8)	16	23.10	15
15.	TCGS-337	2.00	73.2	41.9	56.6 (48.8)	15	29.65	47
16.	TCGS-341	3.16	60.2	27.2	70.4 (57.0)	19	25.10	25
17.	TCGS-343	3.70	71.8	33.9	75.7 (60.5)	16	26.13	30

Plate 11 : Groundnut genotypes showing Kalahasti malady

Plate 11a : TCGS 298 JL 24 TCGS 245

Plate 11b : TCGS 292 TCGS 320 JL 24

Plate11c : TCGS 303 TCGS 334 JL 24

Plate11d : TCGS 356 TCGS 428 TCGS 435 JL 24

Table 14 (Cont.).

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
18.	TCGS-356	2.67	71.0	40.0	42.3 (40.6)	15	26.62	32
19.	TCGS-413	3.10	59.0	26.6	76.9 (61.3)	17	22.60	12
20.	TCGS-421	2.00	117.0	43.0	72.9 (58.7)	15.5	36.36	81
21.	TCGS-428	2.00	100.0	38.8	68.6 (55.9)	16.8	34.75	73
22.	TCGS-435	2.00	82.0	37.4	71.0 (57.4)	15	27.06	35
23.	TCGS-445	2.00	66.3	34.4	78.4 (62.3)	15	24.86	24
24.	TCGS-451	2.10	73.3	32.9	76.1 (60.8)	17	28.00	39
25.	TCGS-596	2.64	93.0	43.4	74.0 (59.4)	16	32.74	63
26.	TCGS-597	2.00	92.0	35.7	71.5 (57.7)	15	30.36	51
27.	ICGS-76	3.10	98.0	46.2	72.9 (58.6)	14	32.93	64
28.	TPT-1	3.16	91.0	31.1	62.5 (52.2)	16	27.66	37
29.	TPT-3	2.00	91.0	38.4	74.7 (59.8)	12	28.40	41
30.	K-134	3.24	71.0	27.9	68.5 (55.9)	15	23.43	16
31.	JL-24	4.33	70.3	30.8	69.4 (56.4)	11	20.10	
32.	SEM ±	0.15	0.73	0.45	1.7	1.1	0.78	
33.	CD (P=0.05)	0.43	1.45	0.90	3.5	3.0	1.64	
34.	CV	2.80	1.07	1.53	3.1	2.4	1.20	

1-5 disease scale (disease severity)

1 No disease
2 Normal sized pods with a few small lesions on pod surface
3 Normal sized pods with many small lesions covering 25-50 per cent pod surface
4 Pods slightly reduced in size, 50-75 per cent pod surface discoloured
5 Pods much reduced in size over 75 per cent pod surface discoloured.

* Each figure is an average of twenty plants

Figures in the parentheses are angular transformed values and CD pertains to them

Plate11e : TCGS 445 ICGS 76 JL 24

Plate11f : TCGS 597 TPT 3 JL 24

Plate 11 : Groundnut genotypes showing Kalahasti malady

Plate 11a : TCGS 298 JL 24 TCGS 245

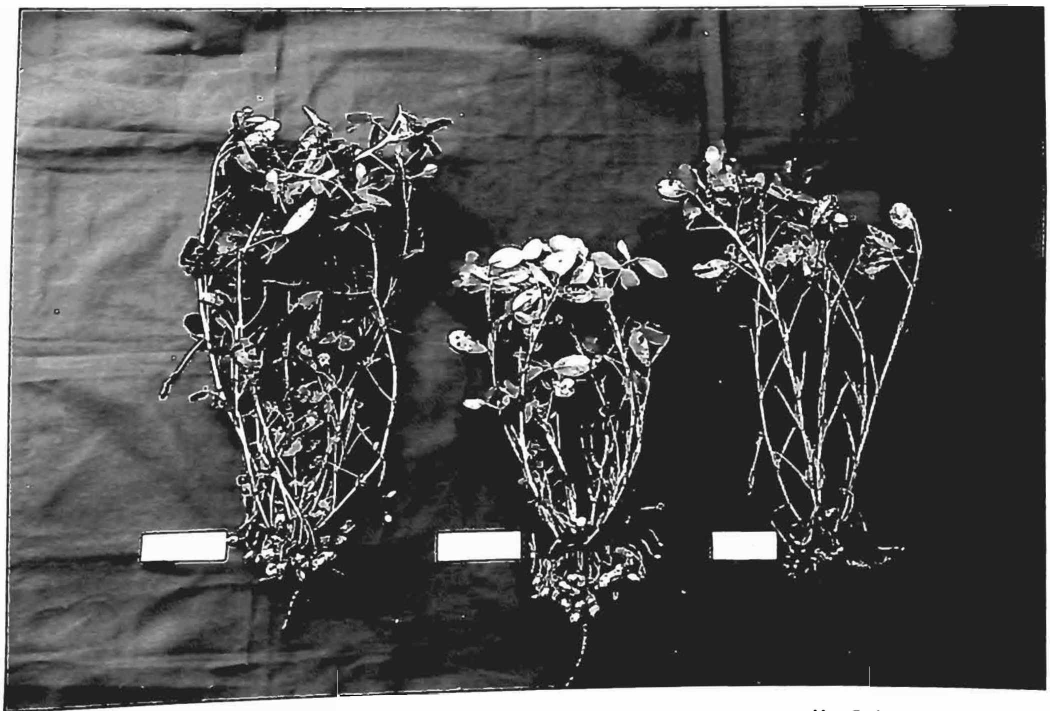


Plate 11b : TCGS 292 TCGS 320 JL 24

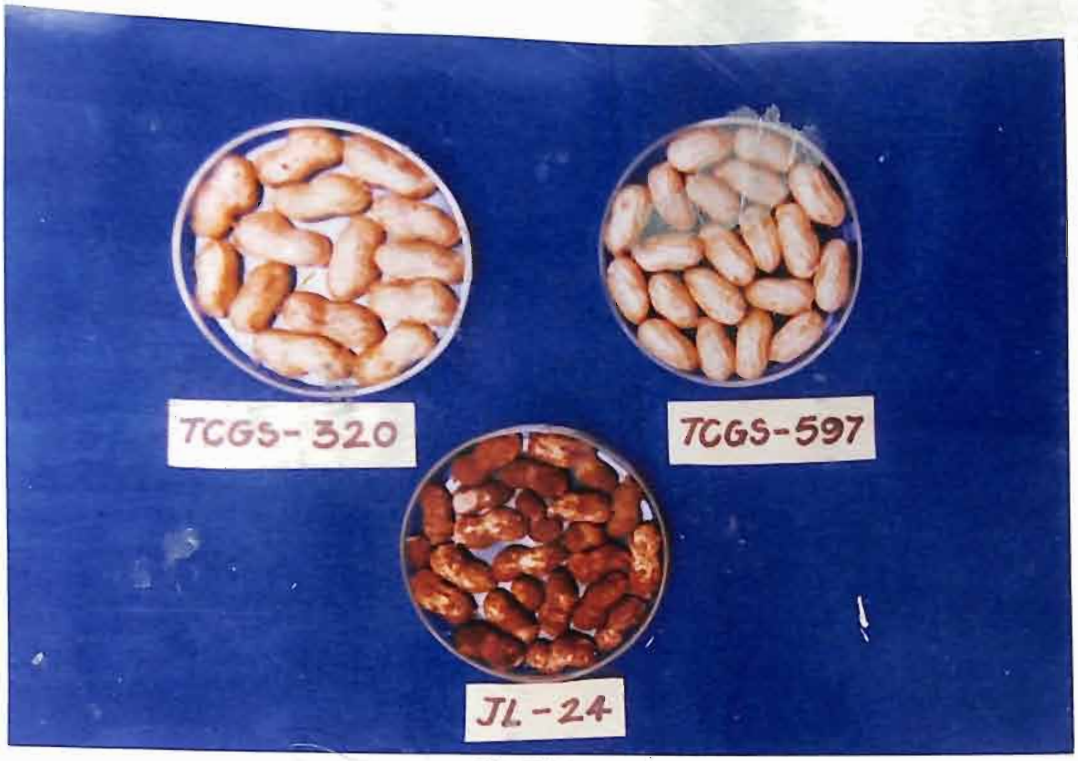


Plate12 : Comparison of pods taken from resistant groundnut genotypes TCGS 320 and TCGS 597 with susceptible cv.JL 24.(check)

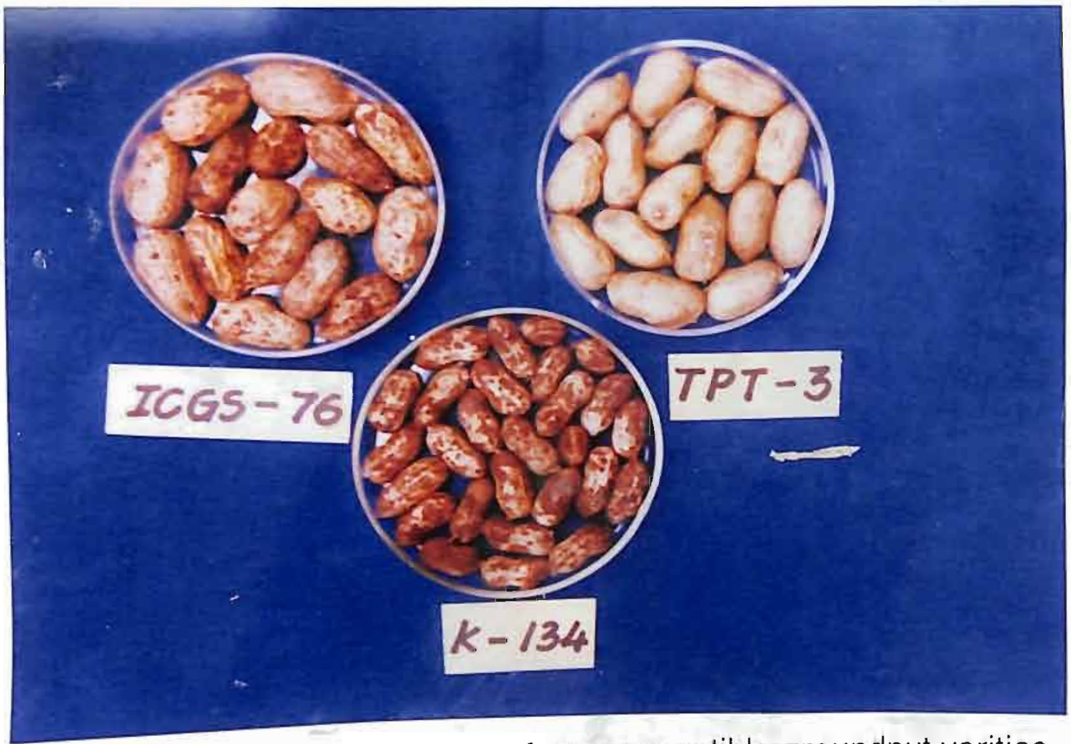


Plate 13 : Comparison of pods taken from susceptible groundnut varities ICGS 76 and K 134 with resistent cv. TPT-3

the highest 100 pod weight of 120.2g followed by TCGS-421, TCGS-428, TCGS-245 and TCGS-303 with 117.3g, 100.3g, 97.8g and 97.2 g,respectively. TCGS-445 was found inferior to JL-24 in 100 pod weight. All ten resistant genotypes recorded significantly more 100 kernel weight over the JL-24. Among them TCGS-320 recorded the highest 100 kernel weight of 49 g followed by TCGS-421, TCGS-337, TCGS-245 and TPT 3 with 43g, 41.9g 40.7g and 38.4g,respectively. Eight among the ten resistant genotypes recorded significantly more shelling percentage over the check. The genotypes TCGS-445 recorded significantly highest shelling percentage of 78.4 followed by TPT-3 (74.7 per cent), TCGS-320 (72.9 per cent), TCGS-421 (72.9 per cent) and TCGS-597 (71.5 per cent). The variety TCGS-320 recorded maximum number of pods (19 per plant) followed by TCGS 428 (16.8), TCGS 303(16), TCGS-421 (15.5) and TCGS-597 (15). All the ten resistant genotypes recorded significantly more pod yield over the check. The variety TCGS-320 recorded highest pod yield of 39.98 q ha^{-1} with 99 per cent increase over JL-24 followed by TCGS-421 (36.36 q ha^{-1}), TCGS-428 (34.75 q ha^{-1}) TCGS-303 (34.21 q ha^{-1}) and TCGS-245 (33 q ha^{-1}) with 81, 73, 70 and 74 per cent increase in pod yield over JL-24,respectively.

Ten genotypes viz., TCGS-285, TCGS-292, TCGS-298, TCGS-305, TCGS-309, TCGS-318, TCGS-334, TCGS-356, TCGS-451 and TCGS-596 were found moderately susceptible to the nematode disease with disease severity of 2.0 to 3.0(Plate 8,9,10 and 11). The variety TCGS-451 showed lowest disease severity of 2.1 followed by TCGS-298 (2.13) and TCGS-318 (2.2). Among them eight genotypes viz., TCGS-285, TCGS-292, TCGS-298, TCGS-305, TCGS-309, TCGS-318, TCGS-451 and TCGS-596 gave significantly more 100 pod weight over the check. The genotypes TCGS-285 recorded highest 100 pod weight of 94.7 g followed by TCGS-596 (93 g) TCGS-292 (90 g) and

TCGS-298 (85.1g). Except TCGS-334, all moderately susceptible genotypes gave significantly more 100 kernel weight over JL-24. The genotype TCGS-596 recorded highest 100 kernel weight of 43.4 g followed by TCGS-356, TCGS-292 and TCGS-285 with 40, 37.6 and 37.1 g respectively.

Eight genotypes viz., TCGS-285, TCGS-298, TCGS-309, TCGS-318, TCGS-334, TCGS-356, TCGS-451 and TCGS-596 gave significantly more shelling percentage over the check. Among them the genotypes TCGS-309, TCGS-318, recorded the highest shelling percentage of 77.9 per cent followed by TCGS-334, TCGS-451 and TCGS-596 with 77.6, 76.1 and 74 per cent respectively over JL-24. All moderately susceptible genotype gave significantly more number of pods per plant over JL-24. The genotypes TCGS-305 recorded the highest number of pods per plant of 18 followed by TCGS-292 and TCGS-451 with 17 pods per plant each. All genotypes recorded significantly more pod yield over JL-24. The genotype TCGS-596 recorded the highest pod yield of 32.74 q ha^{-1} with 64 per cent increase over JL-24 followed by TCGS-285 (31.82 q ha^{-1}), TCGS-309 (30.7 q ha^{-1}) and TCGS-292 (30.6 q ha^{-1}) with 58, 53 and 52 per cent increase over the check JL-24, respectively.

Among all genotypes screened, ten genotypes viz., TCGS-307, TCGS-325, TCGS-328, TCGS-332, TCGS-341, TCGS-343, TCGS-413, ICGS-76, TPT-1 and K-134 were found susceptible to kalahasti malady with the disease severity ranging from 3.0 to 4.0(Plate 15). Of all the ten susceptible genotypes ICGS-76 recorded the highest 100 pod weight, 100 kernel weight and pod yield of 98 g, 46.2 and 32.93 q ha^{-1} respectively (Plate 12). The genotype TCGS-343 exhibited significantly more shelling percentage of

75.7 over JL-24 while TCGS-328 recorded maximum number of pods of 19. However they failed to increase pod yields.

4.7 BIO-CHEMICAL CHANGES

Four genotypes from resistant category (TCGS-303, TCGS-320, TCGS-597 and TPT-3), three genotypes from moderately susceptible category (TCGS-285, TCGS-305 and TCGS-596) and two genotypes from susceptible category (K-134 and TPT-1) and a check variety (JL-24) were used in the biochemical analysis to know the nature of resistance.

Phenols and lignin contents in matured pod shells of these genotypes were estimated and the results are presented in Table 15 and Fig.8.

4.7.1 <u>Phenols</u>

Among the nine test genotypes of groundnut, seven genotypes viz., TCGS-303, TCGA-285, TCGS-320, TCGS-597, TPT-1, TPT-3, TCGS-285, TCGS-596 and K-134 showed significantly higher amount of total phenols compared to the check variety JL-24.

The genotype TCGS-303 in resistant category contained significantly highest total phenols (21.57 mg) with 61 per cent increase in total phenols over the check JL-24 followed by TCGS-597 (17.8 mg), TPT-3 (17.7 mg) and TCGS-320 (17.27 mg) with 33.1, 32.4 and 29.2 per cent increase in total phenols over the check JL-24,respectively.

Among the three genotypes, TCGS-285 in moderately susceptible category contained significantly highest total phenols (16.77 mg) with 25.4 per cent increase followed by TCGS-596 (16.33 mg) with 22.1 per cent increase over the check variety (JL-24).

Of the two genotypes TPT –1 and K-134, the genotype K-134 possessed significantly higher total phenols (14.53 mg) with 8.7 per cent increase over the check.

The genotypes TCGS-305 and TPT-1 were found significantly inferior to check (JL-24) in total phenols. Significantly more phenols were found in nematode infected JL-24 pods compared to the healthy pods of TCGS-305 and TPT-1.

4.7.2 Lignins

The results in the Table 15 clearly showed that among the nine test genotypes analysed for lignin content, the genotypes TCGS-320, TCGS-303, TCGS-597, TPT-3, TCGS-285, TCGS-596 and TCGS-305 showed significantly more lignin content over the check variety JL-24.

Among the four resistant genotypes,the genotypes TPT-3 contained significantly highest lignin (37.67 mg) with 29.1 per cent increase followed by TCGS-597 (39.2 mg), TCGS-303 (37.2 mg) and TCGS-320 (34.53 mg) with 27.6, 21 and 12.36 per cent increase in lignin content over JL-24,respectively.

In moderately susceptible category, the genotype TCGS-305 possessed significantly higher lignin content (34.9 mg) with 13.6 per cent increase followed by TCGS-285 (33.97 mg) and TCGS-596 (33.1 mg) with 10.54 and 7.7 per cent increase in lignin content, respectively over JL-24.

The genotypes K-134 and TPT-1 in susceptible category were found significantly inferior to JL-24 in lignin content. There was no significant difference in lignin content between healthy and diseased pod shells of JL-24 (check).

Table 15 : Total phenols and lignins in pod shells of groundnut resistant and susceptible genotypes to kalahasti malady (*T. brevilineatus*)

S.No.	Groundnut genotypes	Total phenols in mg/g of pod shells (mg)	Percentage increase or decrease over control (%)	Total lignins in mg/g of pod shells (mg)	Percentage increase or decrease over control (%)
Resistant to *T. brevilineatus*					
1.	TCGS-320	17.27	+ 29.2	34.53	+12.36
2.	TCGS-303	21.57	+ 61.3	37.20	+21.00
3.	TCGS-597	17.80	+ 33.1	39.20	+27.60
4.	TCGS-3	17.70	+ 32.4	39.67	+29.1
Moderately susceptible					
5.	TCGS-285	16.77	+ 25.4	33.97	+10.54
6.	TCGS-596	16.33	+ 22.1	33.10	+7.70
7.	TCGS-305	13.47	+ 0.75	34.90	+13.60
Susceptible					
8.	K-134	14.53	+ 8.7	31.00	+0.9
9.	TPT-1	14.27	+ 6.7	31.50	+2.4
10.	JL-24 (Healthy)	11.23	- 16.00	30.10	-2.0
11.	JL-24 (disease)	13.37	-	30.73	-
	CD (p=0.05)	0.96		1.20	
	CV	1.45		2.09	

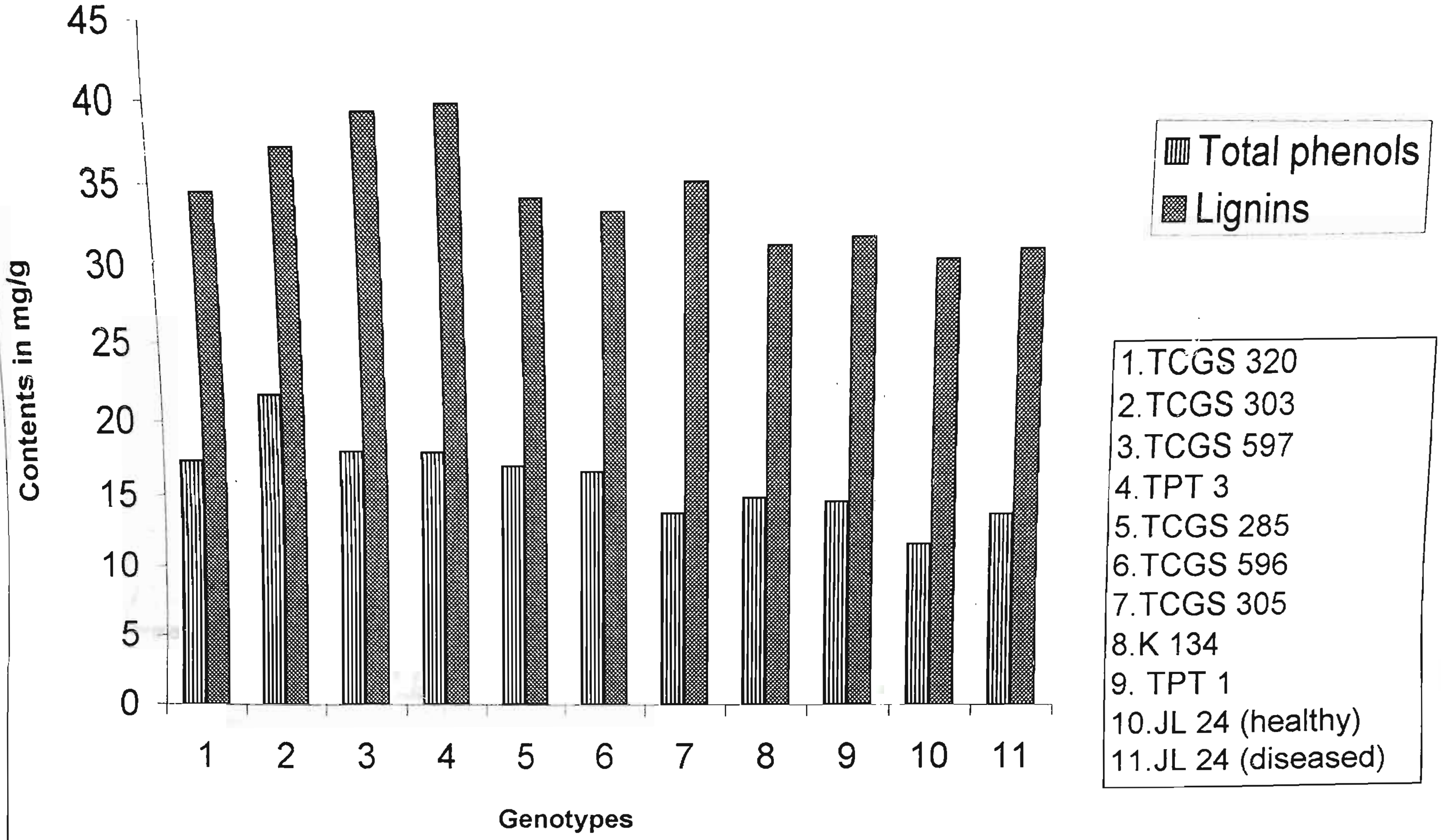


Fig 8: Total phenols and lignins in pod shells of groundnut resistant and susceptible genotypes to kalahasti malady T.brevilineatus

DISCUSSION

CHAPTER V

DISCUSSION

Groundnut (*Arachis hypogaea* L.) is a major oilseed crop grown in India and it has considerable importance in edible oil economy. It is the major crop grown in southern zone of Andhra Pradesh. Kalahasti malady is one the important disease and major constraint to groundnut production in this zone.

Kalahasti malady is a typical pod disease of groundnut and it has been affecting this crop in Chittoor, Nellore and Cuddapah districts of Andhra Pradesh since 1976.- This disease has been fast spreading in recent years and constantly causing huge yield losses of about 20 to 60% depending upon the severity (Reddy *et al.*, 1984; Naidu, 1996).

Most of the existing varieties grown in this zone are susceptible to this disease. Although chemical control measures are available to mange the disease, they are not used widely by farmers due to several reasons. Control of this disease by the application of chemicals may not be economically feasible to small farmers and also it causes environmental pollution.

Keeping this in view, trials were conducted to assess the effect of combined application of nematicide and organic soil amendments. Screening of groundnut genotypes against *T. brevilineatus* was also undertaken. Biochemical analysis of resistant and moderately susceptible genotypes was carried out to understand the nature of resistance. A survey was conducted to know the severity and extent of spread of the disease.

The results of the present investigation given in the proceeding chapter are discussed hereunder.

Pathogenicity test conducted with *Tylenchorhynochus brevilineatus* on groundnut variety JL-24 showed typical disease symptoms of kalahasti malady. Plants inoculated with *T.brevilineatus* showed small brownish yellow lesions on pegs; pod stalks and on young developing pods. In advanced stage of this nematode infestation, pods and pod stalks were greatly reduced in size and length and pod surface became completely discoloured. However the kernels from diseased pods were found healthy. Reddy *et al*, (1984) and Naidu (1996) proved the pathogenicity of *T.brevilineatus* on groundnut varieties TMV-2 and JL-24 and recorded similar disease symptoms. In the present study the observations made on pathogenicity of *T.brevilineatus* confirmed that nematode is highly parasitic in nature and could cause the disease.

Groundnut variety JL-24 was critically examined for kalahasti malady symptom development at different stages of crop growth. The symptoms appeared in about 10 to 15 days after the formation of young pods (about 55 to 60 days after sowing) in nematode sick soil. Initially necrotic lesions appeared as light yellow coloured spots. The spots increased in size and finally covered the entire pod surface. In advanced stages the lesions turned from brown to dark brown and finally to black colour. Discoloration was also observed on roots and pod stalks. In severe cases the length of the pod stalks and size of the pods were drastically reduced. Similar type of symptoms were also recorded by Reddy et *al*, (1984); Prasad and Rangappa (1994) and Naidu (1996).

5.1 DISTRIBUTION AND SEVERITY OF KALAHASTI MALADY

Five mandals viz., Srikalahasti, B.N. Kandriga, Thottambedu, K.V.B.Puram and Yerpedu were surveyed for kalahasti malady incidence. The distribution of nematode population in kalahasti malady sick soils was recorded.

The results revealed that kalahasti malady was widely distributed in Katur, Pallamala and Parapalli villages of B.N.Kandriga mandal, Rajulukandriga, Thimmasamudram and Kothakandriga village of K.V.B.Puram mandal, Thondamanadu, Eguvaveedu and Mittakandriga villages of Srikalahasti mandal, Chittaturu, Gurrapanaidukandriga and Pedda kandriga villages of Tottambedu mandal, Chintalapalem, Panguru and Sitarampeta villages of Yerpedu mandal. Among five mandals surveyed severe to very severe disease incidence was recorded in Srikalahasti and B.N. Kandriga mandals. Highest nematode population of 400 to 460 per 250 cc soil was also recorded in villages of Srikalahasti and B.N.Kandriga mandals. Reddy *et al.* (1984) recorded highest population of *T.brevilineatus* (164 in 100 cc of soil) in farmers field at Guttivaripalli in Chittoor district. Similarly Prasad and Rangappa (1994) recorded the *T.brevilineatus* population ranging from 460 to 1210 per 250 cc of soil in kalahasti malady affected groundnut fields in Tirupati region of Andhra Pradesh. Sharma *et al*, (1996) recorded 360 to 600 nematodes per 100 cc soil in Tamilnadu.

Besides *T.brevilineatus*, the other plant parasitic nematodes observed from rhizosphere of groundnut were *Hoplolaimus indicus*, *Hirschmoniella mucronata*, *Criconemoides ornata*, *Rotylenchulus* sp, *Pratylenchus brachyurus and Meloidogyne arenaria*. Reddy *et al.* (1984), Ratnakumar (1988), Sharma (1988), Prasad and Rangappa (1994) and Naidu (1996) also had recorded these nematodes besides *T.brevilineatus* in the rhizosphere of groundnut.

The type of soil also plays major role in kalahasti malady disease incidence. Heavy soils are generally not favorable for the nematodes and sandy soils were favorable for nematode population buildup (Wallace, 1963). This could be the probable reason for high percentage of kalahasti malady disease incidence in sandy loams of Katuru, Parapalli and Mittakandriga villages than heavy soils in Rajulakandriga and Chintalapalem villages. Reddy *et al.* (1984) also recorded similar observations on the influence of soil type in nematode buildup.

The groundnut varieties JL-24, TMV-2 and K-134 commonly grown in the areas were surveyed. All the three varieties were susceptible to kalahasti malady disease. Groundnut is grown in both *kharif* and *rabi* season continuously in all the five mandals. Growing susceptible groundnut varieties in both the seasons might be the reason for increased incidence of the disease in these areas.

5.2 EFFECT OF COMBINED APPLICATION OF ORGANIC SOIL AMENDMENTS AND CARBOFURAN AT DIFFERENT LEVELS ON KALAHASTI MALADY DISEASE SEVERITY OF GROUNDNUT.

The main objective of the control of phytonematodes is to improve the growth, quality and yield of crop plants. Phytonematode control is achieved mainly through management of their population. The management of nematode population involves attempts to keep the population at a safe level to avoid economic yield loss. This can be achieved by a single method or a combination of several methods. The latter approach is always preferable. In the present study an attempt was made to manage *Tylenchorhynchus brevilineatus* through combined application of organic soil amendments viz., sawdust (25 q ha^{-1}), neem cake (10 q ha^{-1}), pressmud cake (25 q ha^{-1}), poultry manure (50 q ha^{-1}) and farm yard manure (100 q ha^{-1}) and carbofuran at different levels (2, 3 and 4 kg a.i ha^{-1}).

The decomposition of organic matter brings about important physical, chemical and biotic changes in the soil. Changes in the soil environment is an important means of inducing biological control against plant parasitic nematodes. The nematode population can be changed in any desired direction by suitable manipulation of the soil environment. The beneficial effects of plant residues and organic soil amendments in reducing the plant parasitic nematodes have long been proved (Sing and Sitaramaiah, 1966; 1970; 1973).

Incorporation of easily decomposable organic materials into nematode infested soils have been recognized as the most efficient method of reducing many plant parasitic nematodes besides increasing the crop yield. Application of organic soil amendments increase the activity of certain rhizosphere microflora and microfauna which directly affect various activities of nematodes by releasing toxic substances (Singh and Sitaramaiah, 1970; Sitaramaiah, 1990).

The results of the field experiment revealed that all the organic soil amendments tested reduced *T.brevilineatus* population significantly. The population of *T.brevilineatus* and the severity of kalahasti malady were significant and positively correlated with each other. Significant reduction of *T.brevilineatus* was recorded in carbofuran 3 G application at 2,3 and 4 kg a.i ha^{-1} compared to unamended check. This is due to the nematicidal activity of carbofuran in soil. Among the three levels of carbofuran tested, carbofuran at 3 and 4 kg a.i ha^{-1} each proved to be the most effective doses and reduced *T.brevilineatus* population and disease severity and also increased groundnut yield. Similar results were reported earlier in carbofuran treated soil by Sitaramaiah and Viswakarma (1978) against *M.incognita* in okra and tomato; Reddy *et al*, (1984) against *T.brevilineatus* in groundnut; Mishra (1986) against *M.incognita* in *Cajanus cajan*; Phipps *et al*, (1987) against *M.hapla* in peanut; Ratnakumar (1988) against *T.brevilineatus* in groundnut; Bhat and Krishnappa (1990) against *M.javanica* in groundnut; Alam (1991) against *Tylenchorhynchus* sp population in maize; Dwivedi and Upodhyay (1992) against *M.javanica* in groundnut; and Naidu (1996) against *Tylenchorhynchus brevilineatus* in groundnut.

The results in the present study revealed that sawdust @ 2500kg ha^{-1} and sawdust in combination with carbofuran @ 4 kg a.i.ha^{-1} significantly reduced *T.brevilineatus* population and disease severity and increased pod yield over other treatments. Sawdust in combination with carbofuran at lower doses i.e. @ 2kg a.i.ha^{-1} and 3 kg a.i.ha^{-1} was on par with carbofuran at 4 kg a.i.ha^{-1} in reducing of nematode population and disease severity besides increasing pod yield. Singh and Sitaramaiah (1970 and 1971) have reported that amendment of soil with sawdust gave a highly significant control of root knot caused by *Meloidogyne javanica* in okra and tomato. Similar results on the effect of sawdust in the control of rhizosphere nematodes in tomato, (Singh *et al*, 1983), *M.incognita* in betelvine (Archarya and Padhi, 1988), *M.javanica* in tomato (Muktar *et al*, 1994), *M.incognita* in soybean (Mishra *et al*, 1997) and *Rotylenchulus reniformis* and *Helicotylenchus indicus* in betelvine (Rao *et al*, 1997) are reported.

Among the organic soil amendments tested, neem cake was found to be the second best in reducing *T.brevilineatus* population and the nematode disease severity. It has also increased pod yield over unamended plot. Siddiqui *et al*. (1976) also reported that the application of neem cake was effective in reducing *T.brassicae* population in cabbage and cauliflower. Similar reports were also made earlier in the control of sugarcane rhizosphere nematodes (*Meloidogyne incognita, Pratylenchus coffeae* and *Helicotylenchus dihystera*) by Jonathan *et al.* (1991), *M.javanica* in groundnut (Dhedhi *et al*, 1994), plant parasitic nematodes *M.incognita, Rotylenchulus reniformis, Tylenchorhynchus brassicae, Helicotylenchus indicus* in chickpea (Tiyagi and Alam, 1995) and *Meloidogyne incognita* and *Rotylenchulus reniformis* nematodes in brinjal (Kumar and Vadivelu, 1996).

In the present investigation, poultry manure (50 q ha^{-1}), pressmud cake (25 q ha^{-1}) and farm yard manure (100 q ha^{-1}) were found effective in reducing *T.brevilineatus* population and disease severity and increased groundnut pod yield. Chindo and Khan (1990) reported significant reduction of root knot nematode population *M.incognita* in tomato due to poultry manure (4 t ha^{-1}). Similarly the effect of poultry manure was also studied on *M.incognita* in cowpea (Ahmed *et al*, 1991) and *M.arenaria* in tomato (Kaplan and Noe, 1993). Pressmud cake at 25 q ha^{-1}significantly reduced *T.brevilineatus* population and disease severity and it also increased pod yield in present studies. Estioko *et al*, (1988) reported that press mud cake treatment was very effective in reducing plant parasitic nematodes. The effect of pressmud cake in reducing sugarcane rhizosphere nematodes *Meloidogyne incognita, Pratylenchus coffeae* and *Helicotylenchus dihystera* was earlier reported by Jonathan *et al*, (1991). Farmyard manure has significantly reduced the *T.brevilineatus* population and disease severity and increased pod yield in the present study. Babatola (1989) reported significant reduction of plant parasitic nematodes in both farm yard manure and poultry manure treated plots of tomato crop.

Nematicidal action of organic soil amendments on plant parasitic nematodes including *T.brevlineatus* in groundnut crop could be attributed to several reasons. Nematotoxic substances and other harmful products were released after dissolution of organic amendments in water i.e., phenolic compounds (Sitaramaiah and Singh, 1978b), fatty acids (Sitaramaiah and Singh, 1978 a), ammonia (Khan *et al*, 1974) formaldehyde (Alam *et al*, 1979) and other chemicals (Singh and Sakhuja, 1984) were found to be toxic to plant parasitic nematodes. Changes in soil physico chemical properties inimical to nematodes (Jairajpuri *et al*, 1990), decomposed products of oil cakes are directly absorbed by roots and enhances host resistance to nematode invasion (Sitaramaiah, 1990).

Combined application of neem cake (10 q ha^{-1}) and carbofuran at 2,3 and 4 kg a.i ha^{-1} has shown significant reduction in *T.brevilineatus* population and disease severity besides increasing pod yield. Similar findings on combined application of neem cake and carbofuran in reducing *M. incognita* in ginger (Mohanty *et al.*, 1992, 1995) and *M.javanica* in okra (Reddy and Khan, 1993) are earlier reported.. Neem cake was found effective in reducing the movement of nematicides by way of surface adsorption, thus inhibiting leaching of the nematicides deeper into the soil.

5.3 SCREENING OF GROUNDNUT GENOTYPES FOR KALAHASTI MALADY (*Tylenchorhynchus brevilineatus*) RESISTANCE

In the present studies, thirty groundnut genotypes were screened against *T.brevilineatus* in nematode sick soil to identify resistant genotypes. It was evident from the results (Table 4.4) that none of the groundnut genotype was completely resistant to the disease.

The resistant test genotypes, TCGS-303, TCGS-245, TCGS-320, TCGS-337, TCGS-597 and resistant check TPT-3 gave better pod yields (28.4 to 39.98 q ha^{-1}) with an increase in pod yield of 41 to 99 per cent. Naidu (1996) also reported resistant and high pod yield characters of TCGS-337. The variety TPT-3 used as resistant check was earlier utilized as a parent in developing the disease resistant varieties. It is a high yielding breeding line developed at Regional Agricultural Research Station (RARS), Tirupati and was released for cultivation in nematode disease affected areas in Chittoor, Nellore and Cuddapah districts of Andhra Pradesh (Mehen *et al.*., 1993).

Most of the varieties under resistant category have pods with hard shells and prominent ribbing and kernels with pink colour, indicating that morphological characters of pods also are associated with nematode disease resistance. Mehen *et al.*(1993) observed similar pod characters in resistant genotypes of groundnut against Kalahasti malady.

TCGS-596, TCGS-285, TCGS-292, TCGS-305 and TCGS-298 with moderately susceptible disease reaction gave maximum increase in pod yield ranging from 40 to 63 per cent in the present studies. Naidu (1996) also recorded similar observations on TCGS-285, TCGS-292, TCGS-298, TCGS-305, TCGS-309, TCGS-318 and TCGS-334.

Among the genotypes screened, ten genotypes viz., TCGS-305, TCGS-307, TCGS-325, TCGS-328, TCGS-341, TCGS-343, TCGS-413, ICGS-76, TPT-1 and K-134 showed susceptible reaction with disease score ranging from 3 to 4. Naidu (1996) reported resistant and moderately susceptible reaction of TCGS-307 and TCGS-305, respectively. Among all the susceptible genotypes, ICGS-76, TCGS-325 and TCGS-292 inspite of being susceptible to the nematode disease gave maximum increase in pod yield ranging from 52 to 64 per cent over JL-24. Rao *et al.* (1986) studied the reaction of groundnut varieties (TMV-2, JL-24 and J-11) against kalahasti malady. Ratnakumar (1988) identified 120 disease resistant lines.

Of all the thirty genotypes screened six genotypes viz., TCGS-303, TCGS-245, TCGS-320, TCGS-337, TCGS-597 and TPT-3 in resistant category and five genotypes viz., TCGS-596, TCGS-285, TCGS-292, TCGS-305 and TCGS-298 in moderately susceptible category exhibited high pod yield and possessed desirable agronomic characters. Hence those eleven genotypes can be recommended for commercial cultivation on farmers fields where *T.brevilineatus* is a persistent problem. Though the genotypes TCGS-421, TCGS-428, TCGS-435 and TCGS-445 exhibited resistant reaction to the nematode disease but gave less pod yield. Hence these genotypes can be used in groundnut breeding program for developing high yielding nematode disease resistant varieties. Replacement of susceptible varieties with resistant ones appears to be the most economic and feasible method of disease control.

5.4 BIOCHEMICAL COMPOSITION OF GROUNDNUT POD SHELLS AND THEIR POSSIBLE RELATIONSHIP TO NEMATODE DISEASE RESISTANCE

Total phenols and lignin in the pod shells of kalahasti malady resistant groundnut genotypes (TCGS-303, TCGS-320, TCGS-597 and TCGS-303) moderately susceptible genotypes (TCGS-285, TCGS-305 and TCGS 596), susceptible genotypes (K-134 and TPT-1) and in the check variety JL-24 were analyzed to find out their relationship with the nematode disease resistance. Healthy and diseased pod shells of susceptible check variety JL-24 were analysed for finding out the chemical composition.

Pod shells of resistant and moderately susceptible genotypes of groundnut contained higher total phenols over JL-24. The resistant genotypes TCGS-303 contained maximum total phenols with 61.3 per cent increase over the check (JL-24). Similar observations on higher quantities of total phenols were recorded in cauliflower resistant to an ectoparasitic nematode *Tylenchorhynchus brassicae* (Khan *et al*, 1980), brinjal cultivars resistant to *Meloidogyne incognita* (Singh *et al*, 1978) and reniform nematode *Rotylenchulus reniform* (Kumar, 1997), tomato cultivars resistant to *Meloidogyne* *incognita* (Bajaj *et al*, 1983). Banana cultivars resistant to *Radopholus similis* (Valette *et al*, 1997), barley cultivars resistant to *Heterodera avenae* (Dhawan and Dasgupta, 1992), pigeonpea varieties resistant to reniform nematode *Rotylenchulus reniformis* (Thakar and Yadav, 1986).

Moderately susceptible genotypes also possessed significantly more amount of total phenols over JL-24. Among them,TCGS-285 possessed maximum amount of total phenols with 25.4 per cent increase over JL-24. The susceptible genotypes K-134 and TPT-1 possessed significantly more total phenols over JL-24 but less than that of resistant genotypes. In check variety, JL-24 *T.brevilineatus* infestation increased total phenols in the pod shells. Similar observations were made by Feldman and Hanks (1968) in the roots and leaves of tolerant and susceptible citrus cultivars attacked by *Radopholus similis* and by Ahmed and Jehan (1992) in tomato due to *M.javanica* infestation.

Pod shells of resistant and moderately susceptible genotypes exhibited higher amount of lignin as compared to susceptible check variety JL-24. The variety TPT-3 possessed maximum amount of lignin followed by TCGS-320, TCGS-597 and TCGS-303. Susceptible genotypes K-134 and TPT-1 had lignin content on par with JL-24. Healthy pod shells of JL-24 were on par with diseased pod shells in lignin content. The observations recorded on the higher amount of lignin in pod shells of resistant groundnut genotypes gets support from Giebel *et al*, (1970) who reported an increase in lignification due to the infestation of *Heterodera rostochiensis* larvae in the potato cultivars Sagitta and Spekula. The *Radopholus similis* resistant banana cultivar Pisang jari buya possessed high number of cell with lignified walls (Fogain and Gowen, 1996). The barley cultivars

Hordeum chilense resistant to *Meloidogyne nassi* possessed higher lignin content (Balhaderf *et al*, 1995).

The resistance of plants against nematodes may be related to the presence of phenolic compounds and the extent of lignification. Accumulation of phenols in plants has been reported as possible resistant factor to nematode infestation, (Balasubramanian and Purushothaman, 1972). Higher concentration of phenolic compounds in plant tissues are directly related to nematode disease resistance (Giebel, 1974).

In the present study higher lignin content in nematode resistant genotypes could act as a barrier for nematode penetration. Lignin may make cell walls more resistant to mechanical penetration (Ride, 1978). It is generally held that lignin increases resistance of walls to compressive forces and lignification of cell walls at the point of attack may render it resistant to dissolution by enzymes secreted by the nematodes (Dropkin, 1963, 1969 and Vance *et al*, 1980).

In the present study the observations recorded on total phenols and lignin content in both resistant and susceptible genotypes indicated that phenols and lignin are two possible factors of resistance to *T. brevilineatus* in groundnut genotypes.

SUMMARY

CHAPTER VI

SUMMARY

Groundnut is the major oil seed crop grown in southern zone of Andhra Pradesh. The kalahasti malady nematode *Tylenchorhynchus brevilineatus* is a major limiting factor in successful cultivation of groundnut in this zone.

The symptomatological studies revealed that the disease symptoms appeared on pod surface in about 10 to 15 days after the formation of young pods in nematode sick soil. Discolouration was also observed on roots and pod stalks. In advanced stages, the lesions turned brown to dark brown and black. The length of pod stalks and size of the pods were drastically reduced. Pathogenicity test conducted with *Tylenchorhynchus brevilineatus on* groundnut variety JL –24 showed typical disease symptoms of kalahasti malady and confirmed the parasitic nature of the nematode.

Organic soil amendments applied in the field trials viz; Neem cake @ 1000kg ha^{-1}, Sawdust @ 2500kg ha^{-1} pressmud cake @ 2500 kg ha^{-1}, poultry manure @ 5000 kg ha^{-1} and farm yard manure @ 10,000 kg ha^{-1} significantly reduced the nematode population and disease severity and increased pod yield. Among the different organic soil amendments imposed, saw dust @ 2500 kg ha^{-1} and neem cake 1000kg ha^{-1} were proved to be significantly superior in reducing the *T.brevilineatus* population and disease severity and in increasing pod yield over other treatments. Poultry manure, pressmud cake and farm yard manure also had significantly reduced nematode population and disease severity besides increasing pod yield over the unamended check. Carbofuran at different levels

@ 2, 3 and 4 kg a.i ha^{-1} showed significant effect in reducing *T.brevilineatus* population and disease severity and in increasing pod yield of groundnut. Combined application of sawdust @ 2500 kg ha^{-1} and carbofuran at 4 kg a.i.ha^{-1} showed the lowest *T.brevilineatus* population and disease severity besides giving highest pod yield (38 q ha^{-1}) followed by neem cake amendment in combination with carbofuran at 4 kg a.i.ha^{-1} (37q ha^{-1}). Sawdust in combination with carbofuran @ 3 kg a.i. ha^{-1} was as effective as carbofuran alone @ 4 kg a.i.ha^{-1} in reducing nematode population and disease severity besides higher pod yield.

During the survey for kalahasti malady severe incidence of disease was recorded in Katuru and Parapalli villages of B.N.Kandriga mandal and Thondamanadu, Eguvaveedu and Mittakandriga villages of Srikalahasti mandal. The incidence of the disease was found to be more in sandy and sandy loam soils which were favourable to nematode population build up than the clay and clay loam soils.

Thirty groundnut genotypes were screened for their reaction to the nematode disease. Six genotypes viz., TCGS-305, TCGS-245, TCGS-320, TCGS-337, TCGS-597 and TPT-3 in resistant category and five genotypes viz., TCGS-596, TCGS-285, TCGS 292, TCGS 305 and TCGS 298 in moderately susceptible category gave higher pod yield ranging from 32-40 q ha^{-1}. They can be recommended for cultivation in nematode sick soils. In spite of showing resistant reaction to the nematode disease the genotypes TCGS-421, TCGS-428, TCGS-435 and TCGS-445 gave low pod yield hence these genotypes can be used in groundnut breeding programme for developing high yielding nematode disease resistant varieties.

Biochemical analysis of pod shells of resistant and susceptible genotypes was carried out for finding the nature of resistance. The resistant groundnut genotypes viz., TCGS-303, TCGS-320, TCGS-597 and TPT-3 and moderately susceptible genotypes viz., TCGS-285, TCGS-303 and TCGS-596 contained comparatively more amount of total phenols and lignin. The resistant genotype TCGS 303 and TPT-3 possessed highest amount of total phenols and lignin respectively. *T.brevilineatus* infestation has increased total phenols in pod shells of susceptible genotype. The observations recorded on total phenols and lignin have indicated that they are the two possible factors in groundnut for contributing resistance to *T.brevilineatus*.

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* **Originals not seen**

APPENDICES

Table 1: Weather data pertaining to the crop period (03-12-1998 to 15-04-1999)

Standard Week	Date	Month	Mean Temperature °c				Mean R.H %		Mean Sunshine (Hours)		Evaporation (mm/day)		Rainfall (mm)		Rainy days	
			Maximum		Minimum											
			A	DN	A	DN	A	DN	A	DN	A	DN	A	DN	A	DN
49.	3-9	December	27.9	-0.44	20.8	2.74	73.5	-	6.9	-1.21	3.7	-0.92	-	-38.62	-	-1.4
50.	10-16	December	26.7	-1.39	20.0	2.06	83	13.7	8.8	0.08	2.2	-2.55	172.2	131.62	4	2.9
51.	17-23	December	28.2	0.08	16.1	-1.95	73	-0.4	4.3	-5.1	4.0	-1.03	-	-6.51	-	-0.6
52.	24-31	December	27.6	-1.13	16.4	1.02	71	2.1	4.7	-6.09	3.7	-1.78	-	-1.0	-	-0.1
1.	1-7	January	28.3	-0.7	16.6	0.28	66.5	-1.5	8.8	0.4	4.6	0.3	-	-1.81	-	-0.2
2.	8-14	January	29.3	0.64	16.84	-0.13	65	0.7	7.3	-0.93	4.3	0.23	-	-3.84	-	-0.3
3.	15-21	January	28.3	-1.49	16.3	-0.53	67.5	1.8	8.6	0.34	4.4	0.16	-	-2.8	-	-0.4
4.	22-28	January	29.4	-0.95	13.8	-2.05	68	4.75	7.4	-1.93	4.3	-0.66	-	-	-	-
5.	29-4	February	31.0	0.02	15.4	-0.9	66.5	5.65	9.2	-0.5	5.3	0.04	-	-	-	-
6.	5-11	February	31.1	-0.77	19.4	2.14	69	9.55	7.9	-0.8	5.3	-0.17	-	-	-	-
7.	12-18	February	32.0	-0.8	17.0	-0.71	64	7.6	9.4	-0.1	5.5	-0.32	-	-	-	-
8.	19-25	February	32.4	-1.41	16.5	-3.56	56	0.35	6.8	-2.92	5.7	-0.38	-	-	-	-
9.	26-4	March	33.9	0.77	15.3	-3.22	45	-6.75	6.2	-3.68	6.4	-0.14	-	-0.58	-	-0.1
10.	5-11	March	36.0	1.1	18.3	-1.56	36.5	-14.5	9.5	-0.08	6.9	0.19	-	-1.16	-	-0.1
11.	12-18	March	35.3	-0.62	18.3	-2.01	43.5	-5.75	9.5	-0.38	6.5	-0.32	-	-0.55	-	-0.1
12.	19-25	March	37.6	0.32	23.5	1.85	53.5	0.5	7.1	-2.66	6.1	-1.42	-	-0.52	-	-
13.	26-1	April	38.4	1.17	23.3	0.08	46.5	-6.5	8.7	-0.45	6.8	-0.65	-	-1.14	-	-0.2
14.	2-8	April	32.8	-4.39	22.9	-0.76	46.0	-4.65	10.0	0.18	7.6	-0.04	-	-11.11	-	-0.5
15.	9-15	April	40.6	2.85	26.2	2.13	38.0	-13.75	8.5	-0.88	8.6	0.95	-	-0.99	-	-0.3
			32.48		18.33		57.38		7.87		5.6		-		-	