MANAGEMENT OF TERMITES IN GROUNDNUT

A

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Management of termites in groundnut

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ABSTRACT

The investigations on population dynamics, screening of different groundnut varieties, effect of organic amendments and seed treatments with insecticides on termites incidence in groundnut were carried out under field conditions during *summer and kharif,* 2012 at Agronomy farm, B. A. College of Agriculture, Anand Agricultural University, Anand.

The activity of termites commenced from 1st week of March [10th standard meteriological week (SMW)] and continued till 2nd week of June (14th SMW) during *summer,* whereas 4th week of July (30th SMW) to 1st week of November (43rd SMW) during *kharif.* The pest activity was found higher in groundnut field during 2nd week of March (11nd SMW) to 2nd week of June (23th SMW) in *summer,* whereas it was 3rd week of September (37nd SMW) to the end of the crop period during *kharif.* The pest activity was at peak level on 2nd week of June (23rd SMW) and 2nd week of October (40th SMW) during *summer* and *kharif* season, respectively.

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The evaporation, minimum, maximum and mean temperature, soil temperature at 5 cm, 10 cm, and 15 cm depth at afternoon hours and soil temperature at 15 cm depth at morning hours had highly significant positive relationship with termites activity in groundnut in both the seasons. Morning, evening and mean vapour pressure had highly significant negative relationship and wind speed had significant negative association with termites population in groundnut in both the seasons. Morning, evening and mean relative humidity had negative relationship with termites population but non-significant in *summer* and significant in *kharif* season.

The varieties GG-11, TG-26 and TG-37 were found superior in suppressing the damage of termites and produced higher yield of pod and haulm of groundnut. These varieties were categorized in to resistant to highly resistant group. The groundnut varieties GG-5, GG-20, GG-7 and GJG-31 were noticed less susceptible to termites incidence and they were categorized in to susceptible to resistant group. The remaining varieties (GG-6, TPG-41 and GG-2) had poor performance against termites which reflect on yield too. These varieties were categorized in to highly susceptible to susceptible group.

Among the nine organic amendments tested, soil application of neem cake, castor cake and vermicompost @ 1 tonne/ha at the time of land preparation before sowing were found to be more effective in suppressing the incidence of termites in groundnut during *summer* and *kharif* seasons. These treatments produced

higher (1878 to 2283 kg/ha) pod and haulm (3967 to 4282 kg/ha) yield during *summer* as well as in *kharif* season (2141 to 2411 kg/hapod and (3693 to 4227 kg/ha) haulm). Increased in yield over control was 39.88 to 50.55 per cent of pod and 47 to 51.33 per cent of haulm in *summer*, whereas it was 48.80 to 54.54 per cent of pod and 46.62 to 52.99 per cent of haulm in *kharif* season. The loss in pod was up to 7.22 per cent and in haulm was up to 3.48 per cent in *summer,* while in *kharif* it was 7.80 per cent of pod and 7.04 per cent of haulm. The NICBR of these amendments were 1:4.59, 1:2.64 and 1:2.44, during *summer,* while in *kharif* it was 1:56.61, 1:5.94 and 1:2.88, respectively. There was no detrimental effect of evaluated amendments on the seed germination in groundnut.

Of the evaluated nine insecticides, seed treatment of fipronil 5 SC @ 5 ml/kg, chlorpyriphos 20 EC 4 ml/kg and imidacloprid 600 FS @ 3 ml/kg seed were found highly effective in suppressing the termite population in groundnut and produced 2207 to 2487 kg/ha yield of pod and 4066 to 4373 kg/ha haulm in *summer*, whereas it was 2207 to 2500 kg/ha of pod and 4108 to 4459 kg/ha of haulm yield in *kharif* season. These treatments increased 50.34 to 55.93 per cent pod and 51.62 to 55.01 per cent haulm yield over control in *summer,* while it was 51.11 to 56.84 per cent of pod and 48.22 to 52.30 per cent of haulm in *kharif* season. The avoidable losses was up to11.26 per cent of pod and up to 7.02 per cent in case of haulm in *summer*, whereas it was up to 11.72 per cent of pod and up to 7.87 per cent of haulm in *kharif* season. The NICBR of these

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insecticides were 1:87.35, 1:148.68 and 1:59.87 for *summer* season, while for *kharif* it was 1:88.92, 1:158.71 and 1:60.46, respectively. The evaluated insecticides had no adverse effect on seed germination in groundnut.

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C E R T I F I C A T E

This is to certify that the thesis entitled **MANAGEMENT OF TERMITES IN GROUNDNUT** submitted by **GOHIL AJITSINH LAKHUBHAI (Reg. No. 04-1553-2011)** in partial fulfillment of the requirements for the degree of **Master of Science (Agriculture)** in **Agricultural Entomology** of the Anand Agricultural University, Anand is a record of bonafide research work carried out by him under my guidance and supervision. The thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place: Anand **(P. K. Borad)**
Date: /05/2013 **Major Guide**

DECLARATION

This is to certify that whole of the research work reported in the thesis in partial fulfillment of the requirement for the award of the degree of **Master of Science** in Agriculture in the subject of **Agricultural Entomology** is the result of investigation done by undersigned under the direct guidance and supervision of **Dr. P. K. Borad, Professor and Head, Department of Agricultural Entomology**, **B. A. College of Agriculture, Anand Agricultural University, Anand** and no part of the research work has been submitted for any other degree so far.

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LIST OF ABBREVIATIONS

Anon.	:	Anonymous
@	:	At the rate of
a. i.	:	Active ingredient
cm	:	Centimeter
C. D.	:	Critical difference
C. V.	:	Coefficient of variation
^{0}C	:	Degree Celsius
et al	:	et allii; and others
etc.	:	Etcetera
EC	:	Emulsifiable Concentrate
Fig.	:	Figure
FS	:	Flowable Suspension
FYM	:	Farm yard manure
g	:	Gram
>	:	Greater than
<	:	Less than
ha	:	Hectare
i. e.	:	That is
Kg	:	Kilogram
m	:	Meter
mm	:	Millimeter
ml	:	Milliliter
l	:	Liter
NS	:	Non significant
SC	:	Soluble concentrate
SL	:	Soluble Liquid
t	:	Tonne
Rs.	:	Rupees
S. Em. ±	:	Standard error of mean
SMW	:	Standard meteorological week
viz.,	:	Videlicet
%	:	Per cent
WAS	:	Week After Sowing

I. INTRODUCTION

Groundnut (*Arachis hypogaea* Linnaeus*)* is an annual legume crop and belongs to family Leguminoceae. It is also known as peanut, earthnut, monkeynut and goobers. It is world's largest source of edible oil and ranks 13th among the food crops as well as 4th most important oilseed crop of the world (Ramanathan, 2001). It is grown in tropical and sub-tropical regions and in the continental part of temperate countries. The seed (kernels) contains up to 50 per cent of a non drying oil, 40-50 per cent fat, 20-50 per cent protein and 10-20 per cent carbohydrate (Mehta, 2002).

Groundnut seeds are nutritional source of vitamin E, calcium, phosphorus, magnesium, zinc, iron, riboflavin, thiamine and potassium. Groundnut oil is considered as stable and nutritive as it contains just the right proportion of Oleic (40-50 %) and Linoleic (25-35 %) acids (Mathur and Khan, 1997). Groundnut kernels are consumed directly as raw, roasted, fried or boiled products and also used in varieties of culinary preparations like peanut butter, peanut milk, chocolates etc. Oil extracted from the kernel is used for culinary purpose. The cakes and straws are used as cattle feed. These multiple uses of groundnut plant make it an excellent cash crop for domestic markets as well as for foreign trade in several developing and developed countries (Kumar *et al*., 2007). Cultivated groundnut has been reported to be originated from South America (Wiess, 2000).

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Asia possesses first rank in area (63.4%) and production (71.1%) of groundnut. Major groundnut growing countries are India (26%), China (19%) and Nigeria (11%). Groundnut is grown in 43.20 Lakh hectare with a production of 38.70 million tonne and productivity of 691 kg/ha in India, It is mainly grown in southern and north-western states. Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Madhya Pradesh together occupy about 90 per cent of the groundnut area in the country. Gujarat ranks first in production (30%) of groundnut in the country with the production of 3.57 million tonne on an area of 1.83 million hectare with a Productivity of 1861 $kgha^{-1}$ (Anon., 2012). Gujarat ranks first in production of 3.30 million tonne and grown in area of 1.86 million hectare with a productivity of 1717 $kgha^{-1}$.

The crop is mainly attacked by 500 species of arthropod pests. The major insect pests damaging the groundnut crop are aphid (*Aphis craccivora* Koch), leaf miner (*Stomopteryx nertara* Meyrick), stem borer (*Sphenoptera perotett* Cameron), white grub (*Holotrichia consanguinea* Blanchard), bihar hairy cater pillar (*Spilosoma oblique* Walker), red hairy caterpillar (*Amsacta albistriga* Butler), leaf eating caterpillar (*Spodoptera litura* Fabricius), pod borer (*Helicoverpa armigera* (Hubner) Hardwick), jassid (*Empoasca kerri* Pruthi), thrips (*Scritothrips dorsalis* Lindman), jewel beetle (*Sphenoptera indica*), termites (*Odontoterms* obesus Rambur) and grasshopper

(*Hieroglypus banian* Fabricius) reported by Atwal and Dhaliwal (2008).

Termites are most primitive social insects of the animal kingdom belongs to order Isoptera. The termites present in a colony consist of several castes *viz.*, workers, soldiers, reproductive queen and king (Watson *et al.,* 1983). Termites are the most problematic pests of the plant kingdom and buildings. Termites are important pests of agricultural crops in tropical and sub-tropical regions of the world. Mehta and Verma (1968) calculated the loss due to termite up to 230 million rupees for all the agricultural crops. Apart from groundnut, it also causes damage to wheat, maize, bajra, rice, barley, sorghum, pigeon pea, cotton, sugarcane *etc*. In groundnut roots damaged causes 25-100 per cent of plants being lost by termites, pod scarification of groundnut as high as 30 per cent has been reported and 30-40 per cent pod damage by termites (Anon., 2013). Loss of 15–25 per cent of maize yield and about 1478 million rupees was estimated in India (Joshi *et al.,* 2005). In wheat, yield losses of 80 per cent (Roonwal, 1979), 43 per cent (Sattar and Salihah, 2001) and 60 per cent (Kakde *et al*., 2006) was reported due to termite infestation.

Termites damaged the seedlings by cutting either just below or above the soil surface. In mature plant, termites feed on root system and inside the stems, which directly kills the plant or indirectly lowers yield through decreased translocation of water and nutrients. Severely infested plants wilt, dry up and can be easily pulled up. It inflicts heavy damage to the crop cultivated in sandy loam soil and damage the crops right from sowing till harvest.

✍.....
.....*Introduction*

Infestation is particularly serious in dry season. The problem is more predominant in rainfed areas than irrigated. Use of undecomposed FYM under un-irrigated conditions can also increase the chances of termite attack.

Termite is the most serious pest of groundnut in Gujarat, however, little information is available on different aspects related to manage the pest. Hence, the present investigations were carried out with the following objectives.

Objectives

1. Population dynamics of termites in groundnut
2. Screening of groundnut varieties against termites
3. Effect of organic amendments on the incidence of termites in groundnut
4. Efficacy of insecticides as seed treatments against termites in groundnut

II. REVIEW OF LITERATURE

Groundnut is an important legumenouse crop more profitably cultivated as a *summer* and *kharif* crop in Gujarat state. Among the different factors responsible for lower production of groundnut, insect pests are major one. Of these, termite is a serious pest of groundnut which causes considerable damage to the crop.

An attempt was made to review the available literature on the management of termites in groundnut. A little information is available on population fluctuation and management through varietal susceptibility, seed treatment of chemicals as well as organic amendments for termites in groundnut. The brief account of the related previous work is given here under.

2.1 Population dynamics of termites in groundnut

The information available on population dynamics of termite in groundnut, cereals, pulses, wheat, sugarcane as well as vegetable crops and its correlation with weather parameters are reviewed hereunder for supporting the outcome of present study.

Kishen *et al*. (1972) reported that *Tanymecus indicus* and *M. obesi* were the main pests of wheat damaging 14 and 2 per cent of the plants, respectively in Uttar Pradesh. *Microtermes obesi* caused a significant reduction (1.67%) in weat grain yield. The differences in grain yield between field to field was observed due to application of plant protection measures as compared to unprotected fields.

There was a significant negative relationship between the percentage of tap roots invaded by termite, *Microtermes* sp in

groundnut and annual rainfall, during the latter part of the cropping season when the soil moisture is reduced (Johnson *et al.*, 1981). Bhanot *et al.* (1984) in Haryana studied the population dynamics of termites in barley fields and found that the termite species *Microtermes mycophagus, M. obesi, Microtermes sp., Odontotermes gurdaspurensis, O. latigula, O. latiguloides and O. obesus* were most common in barley. The correlation study indicated that the termite population was positively correlated with maximum and minimum temperature. Low populations of termites were observed whenever there was a heavy rain in the previous week indications that there was significant negative correlation between rainfall and termite population. The populations of workers and pseudo workers were high during October to February (Sen-Sarma, 1986). The peak (148.2/m^2) activity of *M. unicolor* and *E. paradoxalis* was recorded in October from the upper 15 cm soil only, while *M. mycophagus* and *M. obesi* found up to the depth of 15, 30 and 45 cm. Damage due to termite was greatest (3.3%) during August in cotton. There was a significant negative correlation between the height of plants and per cent damage (Akhtar and Shahid, 1989).

Umeh *et al*. (1999) observed that localities in West Africa with less than 800 mm annual rainfall had greater termite infestation and damage in groundnut than those with high rainfall. According to Chattopadhyay (2001), termite attack was noticed from the first week of May to the third week of June and maximum infestation was observed in the first week of June (just before the monsoon).

Bharpoda (2006) noticed the activity of termite during later part of summer and early part of monsoon in aonla orchard being maximum (7.0% damaged trees) during second fortnight of June.

Gadhiya (2012) recorded the activity of termite from 2nd week of December [49th Standard meteorological week (SMW)] to 2nd week of March (10th SMW) in wheat crop. The incidence of termite ranged from 3.76 to 101.36 per stick (5cm) during crop period. During 4th week of December (51st SMW) pest activity was increased about four times and found 22.68 termites per stick. The first peak (58.88 termites/stick) was noticed during end of December (52nd SMW). Then after, the termite population was slightly decreased in subsequent weeks and fluctuating between 39 and 56 termites per stick during January and February months (1st to 8th SMW). Again, the population of termite was increased (72.84 per stick) during 1st week of March (9th SMW). The second peak (101.36 termites/stick) was observed at the time of maturity of the crop.

2.2 Screening of groundnut varieties against termites

The use of resistant varieties in reducing the population and the damage caused by insect pests is one of the well known approaches in pest management. The resistant variety has the added advantages that it involves a heritable varietal character and would therefore inexpensive in the long term and further the problem of pesticide hazards would be eliminated. It is indicative from the available literature that the work on susceptibility of different varieties of groundnut to *M. obesi* is limited.

Mohapatra *at al*. (1995) assessed the termites damage to groundnut at harvest in varietal screening trials conducted at the Orissa University of Agriculture and Technology, Bhubaneswar over two seasons, the 1987 rainy season (season I) and 1988/89 post rainy(winter) season (season II). In season I, 23 varieties were sown on 1st July and harvested on 28 oct 1987; in season II, 20 of these 23 varieties were sown on 18 nov 1988 and harvested on 3 April 1989. Pod damage by termites differed significantly among varieties in both seasons. This difference in termite damage was probably due to differences in moisture levels. Termites infestation on groundnut is more serious during dry season and pod damage per cent higher in winter (11 to 28 %) than rainy season.

2.3 Effect of organic amendments on incidence of termites in groundnut

It was indicative from the available literature that the work on the impact of organic amendments on termites infesting groundnut is very scanty. Hence, the work done on groundnut and other crops has been reviewed and presented hereunder. Mercer (1978) reported that close spacing in groundnut helps to deter termites infestation. The high density sowing, followed by thinning of surviving plants where necessary to reduce competition, offsets anticipated losses due to termites (Wardell, 1987 and Wood and Cowie, 1988).

The complete destruction of mounds and removal of queen termites are effective control measures against mound-building

species belonging to the sub-family Macrotermitinae such as *Macrotermes* spp. (Darlington, 1985 and Sieber, 1985).

In a preliminary trial with four mulches to protect drying groundnut pods against scarification by *Odontotermes* spp. and *Microtermes obesi*, sunhemp mulches increased termites damage, neem cake and *Ipomoea fistulosa* mulches seemed to act as repellent barriers between the soil and the pods; *Celosia argentea* mulches afforded intermediate protection. Damage was less in pods placed on top of mulches than mixed in them. Scarification of groundnut was 80-90 per cent lower for pods dried in neem cake or *I. fistulosa* mulches than for pods dried directly on the soil (Gold *et al*., 1989). Intercropping groundnut with sunhemp did not affect termite abundance or damage to groundnut (Gold and Wightman, 1991).

Groundnut field treated with neem (*Azadirachta indica*) cake at sowing did not reduce isopterans population in the field but slight decreasing in the number of scarified pods (14.3%) at 40 days after crop emergence and increased yield in Andhra Pradesh (Rao *et al.,* 1991). Extracts such as those of the neem tree have been found to be efficacious against termites on groundnut and cassava-maize intercrops (Umeh and Ivbijaro, 1998). Singh and Singh (2003) reported that neem cake @ 2 kg/ tree found most effective against termite in mango orchard. Application of leaf extract of *Chenopoduim album* (7.5 kg leaves in 10 litre of water/ha) through first irrigation was found effective in reducing termite damage in wheat crop (Anon., 2005).

Patel *et al.* (2008) conducted field experiments to determine

the efficacy of plant products against termite in wheat under irrigated conditions in north Gujarat and found that furrow application of neem cake @ 700 kg/ha and leaf extract of *C. album* (7.5 kg leaf in 10 liters of water) through first irrigation were next to the endosulfan in their effectiveness. Leaf extract of *C. album* through irrigation reflected higher ICBR (1:19.07) in tested plant products. Use of dry powder of immature neem kernels and leaves @ 50 kg/ha in the integration of plant nutrients gave significantly higher economic return of wheat by 45.80 q/ha and checked the incidence of termites in Uttar Pradesh (Singh *et al.,* 2010).

Gadhiya (2012) reported that castor cake @ one tonne/ha was significantly superior in reducing termite damage in wheat followed by vermicompost and neem cake @ one tonne/ ha and maximum damage reported in mahua and cotton cake @ one tonne/ha.

2.4 Efficacy of insecticides as seed treatment against termites in groundnut

"Seed treatment refers to give an application of pesticide to a process designed to reduce, control or repel the pests". Among the various methods of insect control, chemical insecticides are more popular in the farming community, due to quicker in action and easy availability. In recent era, the eco-friendly approaches to manage the crop pests are advisable. To reduce the adverse effects on natural enemies, cost of application as well as health hazard, the

approach of seed treatment has been adopted in various field crops. The information available on seed treatment of termite in groundnut are reviewed hereunder for supporting the present study.

Other groups of efficacious insecticides such as organophosphates, carbamates and pyrethroids have been used against soil pests but their low persistence in soils always calls for repeated applications. Recently, controlled-release formulations of some non-persistent insecticides were tried and found to be effective and long lasting against soil pests, particularly termites in groundnut (May 1986 and Logan *et al*., 1992).

Seed treatment with Monocrotophos 36 WSC 17.0 ml, endosulfan 35 EC 17.0 ml and phenthoate 50 EC 12.0 ml/kg seed were found highly effective seed treatment against termites in chickpea crop (Sharma *et al.,* 1989). The seed treated with aldrin 30 EC @ 400 ml/100 kg seed found most suitable and economical for the control of *O. obesus* in wheat grown in Rajasthan (Thakar *et al*., 1991). Bhanot *et al.* (1991) studied the effect of different insecticides as seed treatment on germination, *M. obesi* infestation and yield of wheat in Haryana. Aldrin 30 EC, chlorpyriphos 20 EC and endosulfan 35 EC were effectively reduced termites damage. Grain yield was also increased in formothion 25 EC, aldrin, chlorpyriphos and monocrotophos 36 WSC as well as to a lesser extent by endosulfan and carbaryl 50 WP. Logan *et al.* (1992) found that chlorpyriphos granules increased the yields and reduced the pod damage by termies in groundnut to a lesser extent than

chlorpyriphos controlled release pellets. Misra and Senapati (1997) reported that application of phorat 10 G @ 1.25 kg a.i. /ha in two equal splits to groundnut crop resulted in minimum per cent pod infestation and highest pod yield.

Deol and Sekhon (1998) evaluated different insecticides *viz.* Endosulfan 35 EC @ 7 ml/kg, carbosulfan 25 STD @ 2 g/kg, imidacloprid 70 WS @ 2 and 3 g/kg, cypermethrin 10 EC @ 2, 4 and 6 ml/kg as seed treatment for termite control in wheat. The order of effectiveness of the insecticides starting from most effective to the least effective was Aldrin 30 EC > Moldrin 30 EC > Aldrin 30 EC (BEEKAY) > Aldrex 30 EC > Heptox 20 EC > Dursban 20 EC = Posse 25 STD > Ruban 20 EC =Durmet20 EC = Hostathion 40 EC > Thiotex 35 EC = Coroban 20 EC.

Mishra (1999) revealed that chlorpyriphos 20 EC @ 12.5 ml/kg of as seed dressing recorded the lowest damaged (60.83%) plant, pod infestation (61.17%) and highest (1706-1733kg/ha) pod yield of groundnut. Seed treatment with endosulfan @ 2.4 g a.i./kg seed found most effective in checking termites in wheat crop at Vijapur in Gujarat (Anon., 2001).

Out of the 15 insecticides tested as seed treatment to control *O. obesus* and *M. obesi* in wheat, minimum infestation was observed in chlorpyriphos 20 EC at 4.5 ml kg^{-1} (1%) followed by endosulfan 35 EC at 7.3 ml kg^{-1} (1.9%), lindane 20 EC at 7.5 ml kg^{-1} seeds (2.4%) and pre-sowing soil application of 25 kg ha^{-1} parathion-methyl 2% dust (2.4%), endosulfan 4% dust (3.5%) and quinalphos 1.5% dust

(3.4%). Maximum yield was observed in the plots treated with quinalphos 1.5% dust at 25 kg ha^{-1} (3.48 t ha^{-1}) followed by endosulfan 4% dust at 25 kg ha^{-1} (3.44 t ha^{-1}), endosulfan 35 EC at 7.3 ml kg^{-1} (3.42 t ha^{-1}), parathion-methyl 2% dust at 25 kg ha^{-1} (3.37 t ha^{-1}), chlorpyriphos 20 EC at 4.5 ml kg^{-1} (3.28 t ha^{-1}) and lindane 20 EC at 7.5 ml kg ha^{-1} (3.22 t ha^{-1}). The cost benefit ratio (CBR) was the highest in the seed treatment of chlorpyriphos followed by endosulfan and lindane. Rest of the treatments exhibited high infestation of termites, low yield and low CBR (Kumawat, 2001).

Rana *et al*. (2001) studied the effect of various insecticides as seed treatment for the management of *M. obesi* in wheat under field conditions in Haryana. None of the insecticides was detrimental to seed germination. The termite attack was delayed to the earing stage of the crop (2.7 to 47 damaged tillers/plot). The seeds treated with chlorpyriphos and endosulfan at 0.9 and 2.4 g a.i. /kg seed, respectively were least infested by termites. Singh *et al.* (2004) reported that imidachloprid 600 FS @ 10 ml/ kg seed found most effective with the minimum plant damage (4.18%) and highest pearl millet grain yield (13.45 q/ha). Seed treatment with bifenthrin 10 EC @ 2 ml/kg seeds was found effective and economical followed by endosulfan 35 EC @ 7 ml and chlorpyriphos 20 EC @ 1.5 ml for the management of termites in wheat (Anon., 2006).

A study was conducted to evaluate the effect of insecticides (endosulfan, monocrotophos, chlorpyriphos, imidacloprid, carbaryl,

quinalphos and methyl-parathion) as seed treatments @ 2.5, 2.5, 5.0, 2.0, 4.0, 2.5 and 2.5 ml/kg seeds, respectively for the control of *O. obesus* and *M. obesi* infesting wheat in Uttar Pradesh. Maximum plant stand (77.7 plants/m^2) and minimum infested tillers (5 tillers/plot) due to termites and maximum grain yield (42.2 q/ha) was obtained in imidacloprid @ 2.0 ml/kg followed by chlorpyriphos @ 5 ml/kg seed, whereas carbaryl found least effective (Mishra *et al.,* 2007). Bali *et al.* (2010) studied the efficacy of various pesticides for control of termites in wheat crop and reported that the lowest mean per cent damage of tillers per meter row was with fipronil followed by gradual increase with endosulfan 35 EC, imidacloprid 200 SL, thiamethoxam 70 WS and bifenthrin 10 WP as compared to control. Sundriya and Acharya (2012) studied the eco friendly management of termites in wheat and found that imidacloprid 70 WS @ 10 g/kg seeds as seed treatment gave effective control. Gadhiya (2012) reported that Fipronil 5 SC (5 ml/kg) was significantly superior in reducing termite damage and higher yield (4419.44 kg/ha) in wheat followed by imidacloprid 600 FS (3 ml/kg) and bifenthrin 10 EC (2 ml/kg) and maximum damage reported and yield (3694.44 and 3500.00 kg/ha) in cypermethrin 25 EC (2 ml/kg).

III. MATERIALS AND METHODS

Present investigations were carried out at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during *summer and kharif* 2012 on “Management of termites in groundnut”. The materials used and methods adopted during these studies are described here in this chapter.

3.1 Population dynamics of termites in groundnut

In order to study the population dynamics and impact of weather parameters on the incidence of termites in groundnut, a field experiment was conducted at Agronomy farm, B. A. College of Agriculture, Anand Agricultural University, Anand during the *summer* and *kharif* season 2012 in a Randomized Block Design with three replications (Plate I).

Groundnut variety GG-20 was sown during 23rd February, 2012 as first season and 18th July, 2012 as second season in an area of 25 m x 20 m (500 m^2) with a spacing of 75 cm between two rows and 10 cm within the rows. To record the termites population in field, 25 wooden sticks (about 5 cm diameter, 1 m length) was installed after sowing at the depth of 15 cm. The termite counts were recorded by observing each wooden stick at weekly interval and again reinstalled the sticks. If, whole wooden sticks eaten by termites, the new sticks were installed. The termite population was correlated with meteorological parameters to know the role of abiotic factors on termite fluctuation.

3.2 Screening of groundnut varieties against termites

The field experiment was conducted with ten varieties of groundnut for their susceptibility to termites under field condition during *summer* and *kharif* season of 2012 at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand in a Randomized Block Design with three replications. Different 10 groundnut cultivars (Table 1) were sown during 23rd February, 2012 as first season and 18th July, 2012 as second season in a spacing of 75 cm between two rows and 10 cm within the rows in a gross and net plot area of 4.0 x 3.0 and 3.0 x 1.5 m, respectively.

Different varieties of groundnut were raised by following standard agronomical practices. Plot was kept free from insecticide application. Termite infested and healthy plants were counted at weekly interval from each net plot area in each treatment starting from one week of germination till harvest of the crop. At harvest, 100 mature pods were collected randomly from net plot area and examined for termites damage. Pod as well as haulm yield was recorded plot-wise at harvest.

The eucalyptus sticks were installed @ 3 sticks per plots at a depth of 15 cm in net plot area of all the plots and termites counts were recorded from the sticks at weekly interval and again reinstalled the sticks.

The periodical data on population of termite were subjected to analysis of variance (ANOVA) after transforming them to square root. The data on per cent infestation were analyzed after

transforming them to arcsine. The data are analyzed periodically as well as pooled over periods.

3.2.1 Categorization of groundnut varieties

The different groundnut varieties were also categorized in to resistant, moderately resistant, susceptible and highly susceptible to the termite. For the purpose, mean value of individual cultivar ($\overline{X_i}$) was compared with mean value of all cultivars ($\sum \overline{X}$) and standard deviation (sd) following the modified scale adopted by Patel *et al*. (2002). The retransformed data were used for computation of $\overline{X}$, $\overline{X_i}$ and sd in case of each parameter. The scale used for categorizing different groundnut varieties were as under.

Category of resistance	Scale for resistance
Highly resistant (HR)	$\overline{X_i} < \overline{X}$ - sd
Resistant (R)	$\overline{X_i} > \overline{X}$ - sd < $\overline{X}$
Susceptible (S)	$\overline{X_i} > \overline{X} < (\overline{X} +$ sd)
Highly susceptible (HS)	$\overline{X_i} > (\overline{X}$ + sd) < $\overline{X}$ + 2 sd)

3.3 Effect of organic amendments on the incidence of termites in groundnut

In order to study the effect of various organic amendments on incidence of termites in groundnut, a field experiment was conducted at Agronomy farm, B. A. College of Agriculture, Anand Agricultural University, Anand during the *summer* and *kharif* season of 2012.

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Material and methods

Groundnut variety GG-20 was sown during 23rd February, 2012 as first season and 18th July, 2012 as second season in a spacing of 75 cm between two rows and 10 cm within the rows in a gross and net plot area 3.0 x 1.5 m, respectively. The crop was raised successfully by adopting standard recommended agronomical practices. Different nine organic amendments (Table 2) were evaluated along with control in a Randomized Block Design and replicated three times. The plots were kept free from any chemical insecticide application, except treatments.

Application of organic amendments were made at the time of land preparation for sowing. Termite infested and healthy plants were counted at weekly interval from net plot area in each treatment starting from one week of germination till harvest of the crop. At harvest, 100 mature pods were collected randomly from net plot area and examined for termite damage. Pods and haulm yield was recorded plot-wise at harvest.

The eucalyptus sticks were installed @ 3 sticks per plots at a depth of 15 cm in net plot area of all the plots and termites counts were recorded from the sticks at weekly interval and again reinstalled the sticks.

The periodical data on population of termites were subjected to ANOVA after transforming them to square root. The data on per cent infestation were analyzed after transforming them to arcsine. The data were analyzed periodically as well as pooled over periods.

3.4 Efficacy of insecticides as seed treatments against termites in groundnut

To study the efficacy of various chemical insecticides as seed treatment against termites in groundnut, a field experiment was conducted at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during *summer* and *kharif* season of 2012.

Groundnut variety GG-20 was sown during 23rd February, 2012 as first season and 18th July, 2012 as second season in a spacing of 75 cm between two rows and 10 cm within the rows in a gross and net plot area 3.0 x 1.5 m, respectively. The crop was raised successfully by adopting standard recommended agronomical practices. Different nine insecticides (Table 3) were evaluated along with control in a Randomized Block Design and replicated three times.

The groundnut seeds were treated with respective insecticides at mentioned rates (Table 3) by using 50 ml of water before 12 hours of sowing. For recorded observations, the same methodology was adopted as described under 3.3. The observations were recorded from one week of germination and continued till harvest of the crop.

The periodical data on population of termites were subjected to ANOVA after transforming them to square root. The data on per cent infestation were analyzed after transforming them to arcsine. The data were analyzed periodically as well as pooled over periods.

3.4.1 Increase in yield over control

On the basis of pod and haulm yield harvested from various treatments under study, the per cent increase in pod and haulm yield over control due to infestation of termites was calculated by applying following formula:

$$\text{Increase in yield over control (\%)} = \frac{\text{Yield of treatment} - \text{Yield of control}}{\text{Yield of treatment}} \times 100$$

3.4.2 Estimation of avoidable losses and economics

3.4.2.1 Estimation of avoidable losses

On the basis of yield of various treatments under study, the avoidable losses due to termites infestation in groundnut were calculated by applying the formula of Poul (1976) which is as under:

$$\textbf{Loss (\%) due to termites} = \frac{\textbf{Yield in treatment which gave the highest yield} - \textbf{Yield in respective treatment}}{\textbf{Yield in treatment which gave the highest yield}} \times 100$$

3.4.2.2 Economics and Insecticidal Cost Benefit Ratio

In order to know the economics of different treatments evaluated against termites infesting groundnut, Incremental Cost Benefit Ratio (ICBR) was worked out. For the purpose, total cost of organic amendment/insecticidal treatment per hectare was calculated for each treatment based on prevailing market prices. The increased yield over control was calculated by substracting the

yield obtained in control treatment from the yield obtained in each organic amendment/synthetic insecticidal treatment. Then, the gross realization over control was worked out for each treatment based on the increased yield (kg/ha) over control. The net gain (`/ha) for each treatment was computed by deducting the cost of insecticidal treatment from the values of gross realization over control. The ICBR i.e. net gain in rupees per rupee cost of insecticidal treatment was calculated by dividing net gain with the cost of treatment. This gives values of gross ICBR. To calculate the value of net ICBR (NICBR) *i.e.* additional profit gained per rupee cost of treatment, one rupee was substracted from ICBR obtained in each treatment.

✍.....

Material and methods

Sr. No.	Name of varieties	Characters
1.	GG- 2	Pod yield 1336 kg/ha, Oil content 49.6 %, 98 days to maturity, Early maturing and high yielding
2.	GG- 5	Pod yield 1270 kg/ha, Oil content 49.2%, 100 days to maturity and Bold seeded
3.	GG- 6	Pod yield 2782 kg/ha, Oil content 50.28%, 119 days to maturity and High yielding
4.	GG- 7	Pod yield 2194 kg/ha, Oil content 48.5%, 99 days to maturity and Bold seeded
5.	GG- 11	Pod yield 1430 kg/ha, Oil content 48.6%, 110-114 days to maturity and Suitable for pre- monsoon sowing
6.	GG- 20	Pod yield 1960 kg/ha, Oil content 50.7%, 109 days to maturity, High yield and oil content
7.	GJG- 31	Pod yield 3483 kg/ha, Oil content 49.24%, 117 days to maturity and High yielding
8.	TG- 26	Pod yield 2500 kg/ha, 110-120 days to maturity, Semi dwarf, early maturity, High harvest index, High partitioning efficiency and Fresh seed dormancy
9.	TG- 37	Pod yield 2560 kg/ha, 110-120 days to maturity, Semi dwarf, High harvest index and High partitioning efficiency.
10.	TPG- 41	Pod yield 2450 kg/ha, 120 days to maturity and Large seeded (65 g/100 kernel).

Table 1: Groundnut varieties evaluated against termites

Sr. No.	Name of organic amendments	Dose (tonne/ha)	Source
1.	FYM	10	LRS Farm, Anand Agricultural University, Anand
2.	Vermicompost	1	Agronomy Farm, BACA, AAU, Anand
3.	Neem cake	1	Shree Ambica Oil Cakes Industreis, Khatraj, Taluka: Mahemdabad
4.	Castor cake	1	Shree Ambica Oil Cakes Industreis, Khatraj, Taluka: Mahemdabad
5.	Mahua cake	1	Akshar Traders, Dhanpur road, Opp. Gujarat Vajan kanta, Devgadh Baria, District – Dahod
6.	Cotton cake	1	Shree Ambica Oil Cakes Industreis, Khatraj, Taluka: Mahemdabad
7.	Tobacco dust	1	Bidi Tobacco Research Station, Anand Agricultural University, Anand
8.	Maize cake	1	Shree Ambica Oil Cakes Industreis, Khatraj, Taluka: Mahemdabad
9.	Poultry manure	1	Poultry Farm, Anand Agricultural University, Anand

Table 2: Details of organic amendments on incidence of termites in groundnut

Sr. No.	Name of insecticides	Trade Name	Dose (ml or g/kg of seed)	Source
1.	Deltamethrin 2.8 EC	Decis	2 ml	Bayer Crop Science Ltd., Mumbai
2.	Chlorpyriphos 20 EC	Dursban	4 ml	Dow Agro Science (India) Pvt. Ltd., Mumbai
3.	Bifenthrin 10 EC	Marker	2 ml	Dhanuka Agritech Ltd., Gurgaon
4.	Fipronil 5 SC	Regent	5 ml	Bayer Crop Science Ltd., Mumbai
5.	Imidacloprid 600 FS	Gaucho	3 ml	Rallis India Ltd., Banglore
6.	Quinalphos 25 EC	Ekalux	5 ml	Syngenta Ltd., Pune
7.	Cypermethrin 25 EC	Cybil	2 ml	Bayer Crop Science Ltd., Mumbai
8.	Thiamethoxam 35 FS	Cruiser	3 ml	Syngenta Ltd., Pune
9.	Imidacloprid 17.8	Tatamida	3 ml	Rallis India Ltd.,

	SL			Banglore

Table 3: Details of insecticides used for seed treatment against termites in groundnut

IV. RESULTS AND DISCUSSION

The investigations on population dynamics, screening of different groundnut varieties, effect of organic amendments and seed treatments with insecticides against termite incidence in groundnut were carried out under field conditions during *summer and kharif,* season of 2012 at Agronomy farm, B. A. College of Agriculture, Anand Agricultural University, Anand. The results obtained are presented here in this chapter. The present results are also discussed in relation to the research done earlier elsewhere and as in direct or indirect relation with the present studies.

4.1 Population dynamics of termites in groundnut

To know the effect of weather parameters on occurrence of termites in groundnut crop, a study was carried out during *summer and kharif*, season of 2012. The population of termites was recorded with eucalyptus sticks periodically at weekly interval. The data recorded on the population of termites was also correlated with the various a biotic weather parameters to see the relationship with pest, if any.

4.1.1 *Summer*

The periodical data (Table 4) on termites incidence indicated that the activity of termites was commenced from 1st week of March [10th Standard meteorological week (SMW)] and continued till 2nd week of June (14th SMW) during *summer* in groundnut. The incidence of termite ranged from 5.56 to 101.45 per stick during crop period. On appearance i.e. first week of March (10th SMW), the termite

activity was found negligible in the field when crop age was one week. The pest activity was increased about four times (22.92 termites/stick) in subsequent week i.e. 2nd week of March (11th SMW).

Table: 4

✍.....Results and Discussion

The termite population was gradually increased throughout the season in groundnut crop. It was found 22 to 46 per stick during 2nd to 4th week of March (11th to 13th SMW). The evaporation, bright sunshine, wind speed, minimum temperature, maximum temperature, mean temperature, morning relative humidity, evening relative humidity, mean relative humidity, morning vapour pressure, evening vapour pressure, mean vapour pressure, soil temperature at 5 cm, 10 cm and 15 cm depth during morning and afternoon time were 6.9 to 8.1 mm/day, 8.0 to 9.4 hrs, 3.2 to 3.5 $kmhr^{-1}$, 14.4 to 18.8 ^{0}C, 33.9 to 39.8 ^{0}C, 24.1 to 29.3 ^{0}C, 65.5 to 70.5 %, 20.6 to 21.8%, 43.65 to 45.55%, 10.6 to 12.9 mm of Hg, 8.0 to 10.8 mm of Hg, 9.30 to 11.85 mm of Hg, 20.9 to 25.9 ^{0}C, 25.7 to 29.5 ^{0}C, 27.7 to 31.3 ^{0}C, 41.8 to 46.2 ^{0}C, 32.4 to 36.3 ^{0}C and 29.2 to 32.6 ^{0}C, respectively during this period. The activity of termites (Fig. 2) was noted between 53 and 75 per stick during 1st week of April to 2nd week of May (14th to 19th SMW). When evaporation, bright sunshine hours, wind speed, maximum temperature, minimum temperature, mean temperature, morning relative humidity, evening relative humidity, mean relative humidity, morning vapour pressure, evening vapour pressure, mean vapour pressure, soil temperature at 5 cm, 10 cm and 15 cm depth during morning and afternoon time were 8.3 to 9.9 mm/day, 8.1 to 10.8 hrs, 3.8 to 6.1 $kmhr^{-1}$, 35.7 to 39.6 ^{0}C, 21.8 to 25.9 ^{0}C, 30.5 to 32.4 ^{0}C, 62.4 to 87.1 %, 23.1 to 38.7 %, 46.3 to 57.4 %, 16.2 to 22.6 mm of Hg, 12.3 to 18.9 mm of Hg, 14.85 to 20.50 mm of Hg, 28.4 to 33.1 ^{0}C, 32.1 to 35.8 ^{0}C, 33.0 to 37.0 ^{0}C, 46.3 to 50.5 ^{0}C, 38.3 to 43.0 ^{0}C and 34.7 to

38.3 ^{0}C, respectively. The pest activity (Fig. 1) was observed 76 to 102 termites per stick during 3rd week of May (20th SMW) to 2nd week of June (23rd SMW). During this period the meteorological parameters like evaporation, bright sunshine hours, wind speed, maximum temperature, minimum temperature, mean temperature, morning relative humidity, evening relative humidity, mean relative humidity, morning vapour pressure, evening vapour pressure, mean vapour pressure, soil temperature at 5 cm, 10 cm and 15 cm depth during morning and afternoon time were 9.4 to 9.8 mm/day, 7.7 to 10.8 hrs, 6.1 to 8.6 kmhr^{-1}, 37.7 to 39.9 ^{0}C, 25.3 to 27.8 ^{0}C, 32.2 to 32.9 ^{0}C, 74.4 to 85.2 %, 36.6 to 42.9%, 56.1 to 64.05%, 21.0 to 24.5 mm of Hg, 17.8 to 21.1 mm of Hg, 19.70 to 22.8 mm of Hg, 33.0 to 34.4 ^{0}C, 36.1 to 36.9 ^{0}C, 37.4 to 37.9 ^{0}C, 49.9 to 51.1 ^{0}C, 42.1 to 42.4 ^{0}C and 38.8 to 40.7 ^{0}C, respectively.

4.1.2 *Kharif*

The periodical data (Table 5) on termite incidence showed that the activity of termite was commenced from 4th week of July (30th SMW) and continued till 1st week of November (43rd SMW) during *kharif* 2012. The incidence of termite ranged from 3.05 to 96.75 per stick during crop period. The termite activity (Fig. 4) was found negligible (3.05 to 10.52) in groundnut field during 4th week of July (beginning of the pest) to 2nd week of September (30th to 36th SMW) except 4th week of August (34th SMW) when the termites activity was at higher level (19.96 per stick). The meteorological parameters like evaporation, bright sunshine, wind speed, rain fall, minimum temperature, maximum temperature, mean temperature,

morning relative humidity, evening relative humidity, mean relative humidity, morning vapour pressure, evening vapour pressure, mean vapour pressure, soil temperature at 5 cm, 10 cm and 15 cm depth during morning and afternoon time were 3.9 mm/day, 3.2 hrs, 5.5 $kmhr^{-1}$, 27.6 mm hr^{-1}, 25 ^0C, 32.1 ^0C, 25 ^0C , 95.99%, 70.7 %, 83.3%, 24.5mm of Hg, 23.9 mm of Hg , 24.2 mm of Hg, 27.5 ^0C, 28.4 ^0C, 29.4 ^0C, 36.7 ^0C, 34.0 ^0C and 31.3 ^0C, respectively in this week.

Table: 5

However, from 3rd week of September (37th SMW) to 1st week of October (39th SMW) termite incidence continuously increased and reached to a peak level (96.75 termites per stick)) on 2nd week of October (40th SMW) when crop age was 11 week. The evaporation, bright sunshine, wind speed, rain fall, minimum temperature, maximum temperature, mean temperature, morning relative humidity, evening relative humidity, mean relative humidity, morning vapour pressure, evening vapour pressure, mean vapour pressure, soil temperature at 5 cm, 10 cm and 15 cm depth during morning and afternoon time were 4.4 mm/day, 8 hrs, 2.9 $kmhr^{-1}$, 0 $mm\ hr^{-1}$,25.0 ^0C, 36.2 ^0C, 25.0 ^0C , 89.7%, 58.1 %, 73.9%, 23.6 mm of Hg, 23.3 mm of Hg , 23.5 mm of Hg, 29.2 ^0C, 30.6 ^0C, 31.7 ^0C, 42.7 ^0C, 38.3 ^0C and 34.8 ^0C, respectively during this week. The activity of termite suddenly reduced in subsequent week i.e. 3rd week of October (41st SMW). Again it was increased from 4th week of October (42nd SMW) and 1st week of November (43rd SMW) when crop was at maturity stage. The higher activity of termite (Fig. 3) was noticed during October to removal of the crop when

meteorological parameters like evaporation, bright sunshine, wind speed, rain fall, minimum temperature, maximum temperature, mean temperature, morning relative humidity, evening relative humidity, mean relative humidity, morning vapour pressure, evening vapour pressure, mean vapour pressure, soil temperature at 5 cm, 10 cm and 15 cm depth during morning and afternoon time were recorded 3.7 to 4.7 mm/day, 8 to 9.8 hrs, 1.7 to 3.2 $kmhr^{-1}$, 0 mm hr^{-1},18.8 to 25 ^{0}C, 35.3 to 36.2 ^{0}C, 18.8 to 25.0 ^{0}C , 85.6 to 93.7%, 31 to 59 %, 58.3 to 75.7 %, 16.3 to 23.6 mm of Hg, 12.7 to 23.3 mm of Hg , 14.5 to 23.5 mm of Hg, 25.2 to 29.2 ^{0}C, 28.1 to 30.6 ^{0}C, 29.3 to 31.7 ^{0}C, 38.7 to 42.7 ^{0}C, 34.8 to 38.3 ^{0}C and 32.0 to 34.8 ^{0}C, respectively.

The above results exposed that the temites incidence was low in March (5.56 to 45.56), medium in April to May (53.40 to 78.26) and higher in first fortnight of with peak level on 2nd week of June (101.45) in groundnut during *summer* season. According to Chattopadhyay (2001), termite attack was noticed from the first week of May to the third week of June and maximum infestation was observed in the first week of June (just before the monsoon). Bharpoda (2006) noticed the activity of termite during later part of summer and early part of monsoon in aonla orchard being maximum during second fortnight of June. In *Kharif* season groundnut crop, the pest activity was found low during last week of July (3.05) to 2nd week of September (10.52), mediocre in second forthnight of September to 1st week of October (56.84) and higher

during 2nd week of October (96.75) to end of crop season with peak level on 2nd week of October (96.75). The population of termite workers and pseudo workers were high during October-February (Sen-Sarma, 1986).

4.1.3 Correlation coefficient between abiotic factors and termites in groundnut

In nature, the population of insect pests is never stable. The rise and fall of population density of any organism depends on abiotic factors like temperature, evaporation, humidity, vapour pressure, soil temperature *etc*. To know the effect of various weather parameters on the fluctuation of termite pests in groundnut, simple correlation was worked out between weekly incidence of pest and intensity of different weather parameters.

Summer

Correlation co-efficient analysis (Table 6) between weather parameter and termite populations in groundnut crop during *summer,* 2012 indicated that the evaporation (r=0.946**), maximum (r=0.961**), minimum (r=0.678**) and mean temperature (r=0.949**), soil temperature at 5 cm (r=0.968**), 10 cm (r=0.965**) and 15 cm (r=0.959**) depth at morning and soil temperature at 5 cm (r=0.942**), 10 cm (r=0.943**), 15 cm (0.976**) depth at afternoon hours were highly significant and positively correlated with termite populations (Fig. 1). Wind speed (r=-0.902**), Morning (r=-0.704**), evening (r=-0.715**) and mean (r=-0.711**) vapour pressure had highly significant negative association with population of termites in groundnut (Fig. 2). Morning (r=-0.285*), evening (r=-0.083*) and mean (r=-

0.225*) relative humidity had significant negative association, whereas bright sunshine hours had positive association with population of termites in groundnut field but non-significant.

Kharif

Correlation co-efficient analysis (Table 6) between weather parameters and termite populations in groundnut crop during *kharif* 2012 showed that the evaporation (r=0.706**), bright sunshine hours (r=0.847**) , maximum (r=0.879**), minimum (r=0.684**) and mean (r=0.784**) temperature, soil temperature at 5 cm (r=0.876**), 10 cm (r=0.836**) and 15 cm (r=0.865**) depth at afternoon hours were highly significant and positively correlated with termite populations in groundnut crop (Fig. 3). Bhanot *et al.* (1984) reported that the termite population was positively correlated with maximum and minimum temperature in barley crop. Soil temperature 15 cm (r=0.572*) depth at morning hours had significantly positive relationship with termite incidence in groundnut. Rain fall (r=-0.730**), morning (r=-0.631**), evening (r=-0.863**) and mean (r=-0.864**) relative humidity, morning (r=-0.720**), evening (r=-0.754**) and mean (r=-0.742**) vapour pressure and wind speed (r=-0.660**) had highly significant negative association with population of termite in groundnut (Fig. 4).

Table: 6

Umeh *et al*. (1999) observed that localities in West Africa with less than 800 mm annual rainfall had greater termite infestation and damage in groundnut than those with high rainfall. Low populations of termites were observed whenever there was a heavy rain in the

previous week indications that there was significant negative correlation between rainfall and termites population (Bhanot *et al.* 1984). Soil temperature at 5 cm and 10 cm at morning hours had positive relationship with the occurrence of termites in groundnut but non-significant.

The above correlation coefficient results exposed that evaporation, temperature minimum, maximum and mean, soil temperature (at 5 cm, 10 cm, and 15 cm depth at afternoon hours) and soil temperature (at 15 cm depth at morning hours) had significantly positive relationship with termite activity in groundnut in both the seasons. Wind speed, morning, evening and mean vapour pressure had highly significant negative relationship with termite populations in groundnut during both the seasons. Bright sunshine had positive association with termites activity but non-significant in *summer* and highly significant in *kharif*. In contrast to this, soil temperature at 5 cm and 10 cm depth at morning hours positively correlated with termite incidence in groundnut but significant in *summer* and non-significant in *kharif* season. Morning, evening and mean relative humidity had negative relationship with termite population in groundnut but non-significant in *summer*. Evening and mean relative humidity had highly significant negative and morning relative humidity significant negative relationship with termite populations in groundnut during *kharif* season. Gadhiya (2012) reported that the evaporation and soil temperature (afternoon) at 10 cm depth were highly significant and positively

correlated with termite populations, whereas morning relative humidity had highly significant negative association with population. The wind speed, maximum, minimum and mean temperature, soil temperature at 5 cm, 10 cm and 15 cm depth at morning hours and soil temperature at 5 cm and 15 cm depth during afternoon hours had significantly positive relationship with termite incidence in wheat.

4.2 Screening of groundnut varieties against termites

Considering the economic importance of termites infesting groundnut, different 10 varieties of groundnut selected and screened against the pest under field condition. Termites infested and healthy plants were counted at weekly interval from net plot area of each treatment starting from one week of germination till harvest of the crop. At harvest, 100 mature pods were randomly collected from net plot area and examined for termite damage. Pod as well as haulm yield was recorded at harvest of the crop during *summer* and *kharif,* 2012. The data, thus, obtained are presented in Table 7 -16.

4.2.1 *Summer*

4.2.1.1 Evaluation based on damaged plants by termites

Different 10 varieties of groundnut were screened for their relative susceptibility against termite in a field during *summer,* 2012. Pooled over period results (Table 7) of termite damage in groundnut revealed that significantly the lowest (4.92%) damage was observed in GG-11 than all the evaluated groundnut varieties.

TG-26 (7.54%) and TG-37 (7.94%) were equally susceptible to termites but significantly less damaged than remaining tested varieties. The termites damage was found 9.50 to 12 per cent in groundnut varieties GG-5, GG-20 and GG-7. Groundnut varieties GJG-31 (13.71%), GG-6 (14.23 %) and TPG-41 (14.99 %) were more or less equally damaged by termites (Plate II). Among the evaluated varieties of groundnut (Fig. 5A), the highest (19.29 %) damage of termites was noted in GG-2 followed by TPG-41.

4.2.1.2 Evaluation based on termites population

Termite populations on eucalyptus sticks were recorded after one week of sowing till harvest of the crop. The termite population were found non-significant throughout the study period as well as in pooled over period analysis (Table 8), indicates that different varieties does not affects the population of termites but varieties prevents them to feed on roots/stem.

Pooled over period results (Table 8) revealed that the lower (32.91) termite population was observed in TG-26, whereas it was higher (52.35) in the GG-2. Remaining varieties of groundnut had termite population between 36.34 and 46.97 per stick.

Table: 7

Table: 8

4.2.1.3 Evaluation based on pod damage by termites

The same groundnut varieties were screened for their relative susceptibility against termites by counting damaged and healthy pods during *summer* 2012. Pooled over period results (Table 9) of pod damage caused by termite in groundnut revealed that significantly the lowest (2.77%) damage exhibited in GG-11 than all the evaluated varieties. Groundnut varieties TG-26 and TG-37 were equally susceptible to termites by registering 5.32 and 7.32 per cent pod damage, respectively. Groundnut varieties GG-5, GG-20, GG-7 and GJG-31 were found at par with each other in preventing the pod damage caused by termites (Plate II). Among the evaluated varieties of groundnut (Fig. 5A), the highest (22.62 %) pod damage was observed in GG-2 and it was at par with TPG-41 (20.48 %).

4.2.1.4 Categorization of groundnut varieties

Different 10 varieties of groundnut were also grouped in to four category of resistance *viz.*, highly resistant (HR), resistant (R), susceptible (S) and highly susceptible (HS) based on per cent damage plants due to termite by comparing the mean incidence of individual varieties ($\overline{X_i}$) with mean incidence of all varieties ($\overline{X}$) and standard deviation (sd). The categorization of different groundnut varieties is presented in Table 10.

Based on per cent damage, GG-11 variety of groundnut recorded less than 6.66 per cent damage by termites and categorized in to group of highly resistant (Table 10). Groundnut varieties TG-26, TG-37, GG-5 and GG-20 noticed less than 11.49 but more than 6.66 per cent damage and categorized under the resistant. Varieties GG-7, GJG-31, GG-6 and TPG-41 recorded less than 16.32 but more than 11.49 per cent damage was considered as susceptible varieties of groundnut. Groundnut variety GG-2 registered more than 16.32 per cent damage and categorized as highly susceptible.

Table: 9

Table: 10

4.2.1.5 Yield

(A) Pod

The different varieties of groundnut tested against termites for their susceptibility showed that the highest (2129 kg/ha) pod yield was harvested from GG-11 (Table 11) and it was statistically at par with TG-26 (2022 kg/ha), TG-37 (1926 kg/ha) and GG-5 (1863 kg/ha). The GG-20, GG-7, GJG-31 and GG-6 produced 1781, 1778, 1685 and 1619 kg/ha pod, respectively (Fig. 5A). Among the tested varieties, the lowest (1285 kg/ha) pod yield was recorded in GG-2 and it was at par with TPG-41 (1232 kg/ha).

(B) Haulm

The highest (3963 kg/ha) groundnut haulm yield (Table 11) was harvested from GG-11 variety and it was at par with TG-26 (3718.90 kg/ha) and TG-37 (3490.76 kg/ha during *summer,* 2012. The groundnut haulm yield was between 2625 and 3317 kg/ha in GG-6, GJG-31, GG-7, GG-20 and GG-5. The lowest (2383 kg/ha)

haulm yield (Fig. 5A) was noticed in GG-2 and it was at par with TPG-41(2450 kg/ha), GG-6 (2625 kg/ha) and GJG-31 (2809 kg/ha).

Table: 11

4.2.2 *Kharif*

4.2.2.1 Evaluation based on damaged plants by termites

The varieties of groundnut screened for their relative susceptibility against termites in summer were further evaluated during *kharif,* 2012. Pooled over period results (Table 12) of termite damage in groundnut showed significantly the lowest (3.33%) incidence in GG-11 than all the tested varieties. Groundnut varieties TG-26, TG-37 and GG-5 were equally susceptible to termites which registered damaged plants between 5.37 and 7.12 per cent. GG-20 and GG-7 were equally susceptible to termites damage. Of the evaluated varieties of groundnut (Fig. 5B), the highest (15.14 %) damage was found in GG-2 and it was at par with TPG-41(13.49%), GG-6 (13.08 %) and GJG-31 (12.85%).

4.2.2.2 Evaluation based on termites population

Pooled over period results (Table 13) exhibited that the lower (21.59) termites population was niticed in TG-26, whereas it was

higher (30.97) in the GG-2. Remaining varieties of groundnut had termite population between 23.02 and 31.65 per stick.

4.2.2.3 Evaluation based on pod damage by termites

Pooled over period results (Table 14) of *kharif,* 2012 on pod damage caused by termites in groundnut showed significantly the lowest (2.59%) damage in GG-11 than all the varieties. TG-26 and TG-37 noticed 4.86 and 6.8 per cent pod damage, respectively. Groundnut varieties GG-5 (9.64 %), GG-20 (9.73%), GG-7 (11.49 %) and GJG-31 (12.16%) were equally susceptible to termites but significantly superior to remaining varieties (Fig. 5B). Among the screened varieties of groundnut, the highest (22.58 %) pod damage exhibited in GG-2 and it was at par with TPG-41 (21.08 %). Mohapatra *at al*. (1995) reported that the termite infestation in groundnut was more serious during dry season and pod damage was higher in winter (11 to 28 %) than rainy season.

Table: 12

Table: 13

Table: 14

4.2.2.4 Categorization of groundnut varieties

Based on per cent damage due to termite, the groundnut varieties GG-11 and TG-26 recorded less than 5.38 per cent damage due to termites and categorized in to group of highly resistant (Table 15). Groundnut varieties TG-37, GG-5 and GG-20 registered less than 9.46 but more than 5.38 per cent damage and categorized under the resistant, whereas varieties GG-7, GJG-31, GG-6 and TPG-41 recorded less than 13.54 but more than 9.46 per cent damage was considered as susceptible. Groundnut variety GG-2 registered more than 13.54 per cent damage are categorized as highly susceptible (Table 15).

4.2.2.5 Yield

(A) Pod

The higher (2537 kg/ha) pod yield was harvested from groundnut variety GG-11 (Table 16) and it was statistically at par with TG-26 (2519 kg/ha) and TG-37 (2233 kg/ha) during *kharif* season of 2012. The GG-5, GG-20, GG-7, GJG-31 and GG-6 produced 2111, 1974, 1929, 1915, 1889, 1544, 1889 kg/ha pod, respectively (Fig. 5B). Of the tested varieties, the lower (1204 kg/ha) pod yield was recorded in GG-2 and it was at par with TPG-41 (1544 kg/ha).

(B) Haulm

The higher (4008 kg/ha) haulm yield (Table 16) was harvested from GG-11 variety and it was at par with TG-26 (3719 kg/ha). Groundnut varieties TG-37, GG-5, GG-20 and GG-7 were produced between 2500 and 3300 kg/ha haulm. The haulm yield between 2150 and 2400 kg/ha in TPG-41, GG-6 and GJG-31 (Fig. 5B). Of the evaluated varieties, the lowest (1867 kg/ha) haulm yield was noticed in GG-2 and it was at par with TPG-41 (2167 kg/ha).

Table: 15

From the above results it can be concluded that the varieties GG-11, TG-26 and TG-37 were found superior for suppressing the termites damage and produced higher pod and haulm of groundnut (Plate III). These varieties categorized into resistant to highly resistant groups. The groundnut varieties GG-5, GG-20, GG-7 and GJG-31 were observed susceptible to termites. These varieties falls in to susceptible to resistant category group. In contrast to this, the groundnut varieties GG-6, TPG-41 and GG-2 gave poor performance against termites. This poor performance reflected on pod and haulm

yield too. These varieties grouped in to highly susceptible to susceptible categories.

4.3 Effect of organic amendments on incidence of termites in groundnut

Considering the economic importance of termites infesting groundnut, different nine organic amendments were tested to know their effects for managing the termites in groundnut as soil application at the time of land preparation before sowing. Termites infested and healthy plants were counted at weekly interval from net plot area of each treatment starting from one week of germination till harvest of the crop. At harvest, 100 mature pods were randomly collected from net plot area and examined for termite damage. Pod as well as haulm yield was recorded at harvest of the crop during *summer*, 2012. The data, thus, obtained are presented in Table 17-26.

Table: 16

4.3.1 *Summer*

4.3.1.1 Evaluation based on damaged plants by termites

All the organic amendment treatments were found significantly superior to control till fourteen week of sowing as well

as in pooled over period results of summer groundnut except 5th, 6th and 7th week after sowing. There was no pest incidence up to four week of crop age. After five week of sowing, the lowest (0.22 %) termite damage was found in plots treated with neem cake than all the evaluated amendments. Castor cake (1.00 %) and vermicompost (1.16 %) were equally effective to termites but significantly less damaged than remaining amendments. Poultry manure (2.07 %), tobacco dust (2.16 %) and maize cake (2.65 %) were equally effective against termites in groundnut and they were significantly more effective than remaining amendments. Among the tested organic amendments, the highest (4.16 %) damaged plants was observed in plots treated with mahua cake and it was at par with cotton cake (3.56%), FYM (3.00%) and Maize cake (2.65 %).

Application of neem cake showed the lower (0.65%) termite damage in groudnut than all the tested amendments after 6th week of sowing. Castor cake (1.41 %) and vermicompost (1.76 %) were equally effective against termite in groundnut. Poultry manure, tobacco dust and maize cake applied plots noticed 2.45 to 2.80 per cent damage of termites, respectively and they were statistically at par with each other. However, prior and later amendments were at par with poultry manure (2.80 %) and FYM (3.35 %). The highest (4.74 %) damaged plants was observed in the treatment of mahua cake and it was at par with cotton cake (3.83 %).

After seven week of sowing, significantly the lowest (1.08%) termites damage was recorded in plots received neem cake than all

the evaluated amendments. Castor cake (1.82 %) and vermicompost (2.06 %) were equally effective in cheking the termites in groundnut. The treatments of poultry manure, tobacco dust, maize cake and FYM were exhibited termite damage between 2.79 and 3.52 per cent and they were at par with each other in reducing the termites damage (Table 17). Among the tested organic amendments, the highest (5.26 %) damaged plants was observed in plots treated with mahua cake and it was at par with cotton cake (3.46%).

The minimum (1.36 %) damage was observed in the treatment of neem cake and it was at par with castor cake (2.09 %) after eight week of sowing. Vermicompost (2.31%), poultry manure (3.16 %) and tobacco dust (3.36 %) were at par with each other in controlling the damage caused by termites prior amendment was as effective as castor cake (2.09). Of the evaluated amendments, the higher (5.47%) incidence was recorded in plots received mahua cake following by cotton cake (4.47 %), FYM (4.08 %), maize cake (4.00 %).

After nine week of sowing, the lowest (1.76%) damage exhibited in the treatment of neem cake and it was at par with castor cake (2.36 %) and vermicompost (2.74 %). Poultry manure (3.49 %) and tobacco dust (3.58 %) treated plots were equally effective as vermicompost (2.74 %) in controlling the termites in groundnut (Table 17). Maize cake and FYM treated plotes noticed 4.23 and 4.31 per cent damaged plants, respectively. Among the

evaluated organic amendments, the highest (5.74 %) damage was recorded in plots treated with mahua cake and it was at par with cotton cake (4.77%).

After ten week of sowing, the lowest (2.29%) damage was observed in the treatment of neem cake and it was at par with castor cake (2.65 %) and vermicompost (3.11 %). Poultry manure (3.79 %) and tobacco dust (3.83 %) treated plots were as effective as vermicompost (3.11 %) in controlling the termites in groundnut. Maize cake and FYM applied plots recorded 4.49 and 4.64 per cent termites damage, respectively. Among the evaluated organic amendments, the highest (6.95 %) damage was noticed in plots treated with mahua cake and it was at par with cotton cake (5.09 %).

After eleven and twelve week of sowing, the lowest (3.72 and 4.20 %) termites damage was noted in plots treated with neem cake and it was at par with castor cake (4.09-5.16 %) and vermicompost (5.03-5.43 %). Poultry manure (6.18-8.12 %) and tobacco dust (6.49-8.35 %) treated plots were equally effective as vermicompost and castor cake in controlling the termites in groundnut (Table 11). Of the tested organic amendments, the highest (10.16-18.74 %) damage exhibited in plots treated with mahua cake and it was at par with cotton cake (9.16-15.07 %).

More or less similar trend of effectiveness was observed after thirteen week of sowing as noticed in previous weeks in suppression of termites in groundnut. In which, the lowest (5.56 %) damage was

noted in neem cake and it was at par with castor cake (6.24 %) and vermicompost (7.17 %). The treatments of poultry manure (10.49 %), tobacco dust (12.45%) and maize cake (10.49 %) were found equally effective in suppressing the damage caused by termites. Among the tested organic amendments, the highest (20.81 %) damaged plants was observed in plots treated with mahua cake and it was at par with cotton cake (18.29 %) followed by FYM (15.67 %).

Organic amendment treatments of neem cake exhibited significantly the lowest (6.66 %) damaged plants than all the evaluated amendments, except castor cake (8.16 %) and vermicompost (10.45 %) after fourteen week of sowing. Poultry manure, tobacco dust, maize cake and FYM treatments of organic amendments recorded 14.95, 15.32, 17.24 and 20.19 per cent damage of termites and they wete at par with each other. Prior amendment was as effective as vermicompost. Of the tested organic amendments, the highest (22.16 %) damaged plants was observed in plots treated with mahua cake and it was at par with cotton cake (21.59 %).

Pooled over period results (Table 17) of summer groundnut revealed that the application of neem cake (2.33 %) significantly superior in managing the termites infestation and it was at par with castor cake (3.18 %) and vermicompost (3.73 %). Poultry manure (5.18 %), tobacco dust (5.35 %) and maize cake (6.24 %) treatments were at par with each other in checking the damage caused by termite in groundnut. Prior amendment was as effective as

vermicompost (3.73 %). Of the the tested organic amendments, the highest (9.52 %) damaged plants (Fig. 6A) was observed in plots treated with mahua cake and it was at par with cotton cake (8.08 %).

Table: 17

4.3.1.2 Evaluation based on Termites population

All the organic amendment treatments were found significantly superior to control termite till fourteen week after sowing (Table 18). Pooled over period results of summer season crop exposed that significantly the lowest (6.10) termites population was observed in plots treated with neem cake than among all the tested amendments. Castor cake (9.11) and vermicompost (11.82) were found equally effective in reducing the termites population in groundnut crop. The treatment of poultry manure, tobacco dust and maize cake treated plots registered 14.94, 16.89 and 18.16 termites per stick, respectively but they were statistically more effective than remaining amendments. Of the evaluated organic amendments, the highest (38.44) termite count was observed in plots treated with mahua cake followed by cotton cake (33.96) and FYM (30.52). However, they were significantly low than control (51.20).

4.3.1.3 Evaluation based on pod damage by termites

Effect of organic amendments was also assessed at crop maturity. The pod damage caused by termite were significantly lower in all the tested organic amendments except, mahua cake (22.34 %) (Table 19). The lowest (2.44%) pod damage was exhibited in the plot treated with neem cake and which was statistically at par with castor cake (6.92 %). The treatment of vermicompost (4.26 %) was as effective as castor cake in reducing the pod damage but it was significantly superior to remaining organic amendments. The treatments of poultry manure, tobacco dust, maize cake and FYM were equally effective to termites by registering 11.95, 12.33, 13.03 and 14.31 per cent pod damage, respectively and they were at par with each other. Among the tested organic amendments, the highest (22.34 %) damaged pod (Fig. 6A) were observed in plots treated with mahua cake followed by cotton cake (17.41 %).

Table: 18

Table: 19

4.3.1.4 Seed germination

To know the detrimental effect on seed germination, the germination was also recorded at 10 days after sowing and presented in Table 20. There was no adverse effect of soil application of organic amendments on germination of groundnut seed as the result was non- significant. The seed germination in all the evaluated organic amendments was observed between 84 and 91 per cent. The plots treated with cotton cake and maize cake showed 84 per cent germination. The germination was founded 85 to 89 per cent in plots treated with mahua cake, castor cake, FYM,

tobacco dust, neem cake and vermicompost. The highest (90.33%) seed germination was noticed in the treatment of poultry manure.

4.3.1.5 Yield, Increase in yield, Avoidable losses and Economics

Yield

(A) Pod

The organic amendment applied plots produced significantly higher pod yield than control (Table 20). The maximum (2283 kg/ha) pod yield was obtained from the plots treated with neem cake and it was statistically at par with castor cake (2118 kg/ha). The pod yield rangedbetween 1800 and 1878 kg/ha from the plots treated with vermicompost, poultry manure and tobacco dust. Among the evaluated organic amendments, minimum (1500 kg/ha) pod yield (Fig.6A) was obtained from the plots treated with mahua cake and it was at par with maize cake (1750 kg/ha), FYM (1715 kg/ha) and cotton cake (1525 kg/ha).

Increase in yield

The per cent increase in yield over control in groundnut pod was also worked out and presented in Table 20. Maximum (50.55%) yield increased in the plots treated with neem cake followed by castor cake (46.70%) and vermicompost (39.88 %). It was between 35.49 and 37.90 per cent in poultry manure, tobacco dust and maize cake. The increase in yield over control was 34.17 to 35.00 per cent in plots treated with FYM, cotton cake and mahua cake.

Avoidable losses

The avoidable losses (Table 20) in pod yield of groundnut was varied from 7.22 to 50.55 per cent in different treatments, considering the maximum (2283 kg/ha) yield of neem cake taken as base. The avoidable loss was 7.22 and 17.73 per cent in the treatments of castor cake and vermicompost, respectively. It was 20.37 to 24.87 per cent in poultry manure, tobacco dust, maize cake and FYM. The avoidable losses comparatively higher (33.20-36.19 %) in the treatments of cotton cake and mahua cake.

(B) Haulm

The organic amendment treated plots produced significantly higher haulm yield than control (Table 20). Significantly the highest (4282 kg/ha) haulm yield was obtained from the plots treated with neem cake than all the tested organic amendments, except castor cake (4133 kg/ha) and vermicompost (3967 kg/ha). The plots treated with poultry manure, tobacco dust and maize cake produced 3683, 3667 and 3417 kg/ha haulm, respectively. Among the tested organic amendments, minimum (3000 kg/ha) haulm (Fig. 6A) was produced in plots treated with mahua cake and it was statistically at par with maize cake (3417 kg/ha), FYM (3316 kg/ha) and cotton cake (3266 kg/ha).

Table: 20

Increase in yield

The per cent increases in yield over control of groundnut haulm was also worked out and presented in Table 20. Maximum (51.33%) haulm yield was increased in the plot treated with neem cake followed by castor cake (49.58 %) and vermicompost (47.46 %). It was between 40.77 and 44.72 per cent in poultry manure, tobacco dust and maize cake. The increase in yield over control was 36.19 to 43.17 per cent in plots treated with FYM, cotton cake and mahua cake.

Avoidable losses

The avoidable losses (Table 20) in haulm yield of groundnut was varied from 7.22 to 50.55 per cent in different treatments, considering the maximum (4282 kg/ha) yield of neem cake taken as base. The avoidable loss was 3.48 and 7.36 per cent in the treatment of castor cake and vermicompost, respectively. It was 20 to 24.87 per cent in poultry manure, tobacco dust, maize cake and FYM. Among the tested organic amendments, the highest (29.94 %) avoidable losses was found in mahua cake followed by cotton cake (23.73 %).

Economics

Economics of different organic amendments used for managing termite incidence in groundnut are presented in Table 21. Maximum (68965 `/ha) net realization was calculated in the treatment of neem cake. It was 59517 and 45903 `/ha in castor cake and vermicompost, respectively. Poultry manure, tobacco dust and maize cake treated plots exhibited net realization between 37488

and 41893 `/ha, whereas remaining three amendments (cotton cake, mahua cake, FYM) registered 22695 to 35310 `/ha. Looking to the NICBR, the highest (1:43.38) return was obtained with the treatment of poultry manure.

Table: 21

The NICBR of FYM, neem cake and tobacco dust was1:4.87, 1:1.59 and 1:4.56, respectively. The treatments of vermicompost, castor cake, mahua cake and maize cake gave 1:2.12 to 1:3.44 NICBR. The NICBR was poor 1:1.00 in the treatment of cotton cake.

4.3.2 *Kharif*

4.3.2.1 Evaluation based on damaged plants by termites

All the organic amendment treatments were found significantly superior to control till fourteen week of sowing as well as in pooled over period results of *kharif* groundnut, except nine week of sowing. There was no pest incidence up to one month of crop age.

After five and six week of sowing more or less similar trend of effectiveness was observed in suppression of termite in groundnut. In which, the lowest (0.65 and 0.68 %) damage was observed in neem cake and it was at par with castor cake (0.82 and 0.89%) and vermicompost (0.93 and 0.97 %). The treatments of poultry manure (1.17 and 1.24 %) and tobacco dust (1.22 and 1.37 %) were as effective as vermicompost and castor cake. However, these treatments were significantly superior to remaining amendments in controlling the pest damage caused by termites. Maize cake and FYM treated plotes recorded 2.16 to 2.36 and 2.66 to 2.80 per cent damage during fifth and sixth week of sowing, respectively.

Among the tested amendments, the higher (3.29 and 3.51 %) damaged plants were observed in plots treated with mahua cake and it was at par with FYM (2.66 and 15.66 %) and cotton cake (3.05 and 21.61 %).

After seven week of sowing, significantly the lowest (0.75 %) damaged plants were observed in plots applied neem cake than all the organic amendments except castor cake (0.91 %) and vermicompost (1.06 %). Poultry manure (1.17 %) and tobacco dust (1.74 %) as well as maize cake (2.58 %) and FYM (3.02 %) were found equally effective in controlling the damage of termites in groundnut and they were differe significantly to each group. Of the tested amendments, the highest (3.97 %) damage was noticed in plots treated with mahua cake and it was at par with cotton cake (3.63 %).

Termites damaged groundnut plants was found minimum (0.86 %) in plots treated with neem cake and it was at par with castor cake (1.09%) and vermicompost (1.24 %) after eight week of sowing. Poultry manure (1.82 %) and tobacco dust (1.83 %) treated plots were equally effective as vermicompost and significantly superior to remaining organic amendments. Maize cake and FYM recorded 2.72 and 1.72 per cent damage in groundnut, respectively. Among the evaluated organic amedmedments, the highest (4.13%) damage was observed in treatments of mahua cake and it was at par with cotton cake (3.80 %) and FYM (3.12 %).

✍.....Results and Discussion

After nine and ten week of sowing, the lowest (0.96 and 1.22 %) damage was recorded in plots treated with neem cake and it was at par with castor cake (1.26 and 1.68 %) and vermicompost (1.51and 1.72 %). Poultry manure (2.05-2.87 %) and tobacco dust (2.15-2.29 %) treatments were as effective as vermicompost and castor cake in checking the termite damage in groundnut. Of the tested organic amendments, the highest (4.59-4.62 %) damaged plants were exhibited in treatments of mahua cake followed by cotton cake (4.02 %) and FYM (3.18-3.20 %).

Among the tested organic amendments, the lowest (1.37%) damaged groundnut plants exhibited in plots treated with neem cake and it was at par with castor cake (1.76 %) and vermicompost (1.77%) after eleven week of sowing. Poultry manure, tobacco dust and maize cake treatments recorded damaged plants between 2.36 and 3.14 per cent and they were as effective as vermicompost. The highest (4.68 %) damaged plants were exhibited in treatments of mahua cake followed by cotton cake (4.20 %) and FYM (3.21 %).

After twelve week of sowing, significantly the lowest (1.45 %) termites damage was found in plots enriched with neem cake than all the evaluated amendments except castor cake (1.93 %) and vermicompost (1.45 %). Poultry manure, tobacco dust and maize cake treated plots recorded 2.45, 2.52 and 3.04 per cent damaged plants of groundnut, respectively and they were significantly more effective than remaining organic amendments. Of the evaluated organic amendments, the highest (4.98 %) damaged plants was

noticed in plots treated with mahua cake followed by cotton cake (4.35 %) and FYM (3.31 %).

Among the evaluated organic amendments, the lowest (2.02 and 4.06) damage was noticed in plots received neem cake and it was wt par with castor cake (3.03 and 5.34%) and vermicompost (3.27 and 7.09 %) after thirteen and fourteen week of sowing. Poultry manure and tobacco dust were as effective as vermicompost. The the highest (21.05 and 22.29 %) damaged plants exhibited in plots treated with mahua cake followed by cotton cake (20.09 and 21.61 %) and FYM (11.37 and 15.66 %).

Pooled over period results (Table 22) of *kharif* groundnut indicated that the application of neem cake (1.28 %) was significantly superior in managing the termite infestation in groundnut than all the tested organic amendments except castor cake (1.70 %). Vermicompost (1.92 %) was as effective as castor cake in controlling the termite and significantly superior to remaining organic amendments. Poultry manure (2.90 %), tobacco dust (3.00 %) and maize cake (3.97 %) enriched plotes noticed 2.90 to 3.97 per cent damage and they were at par with each other. Among the tested organic amendments, the highest (6.71 %) damaged plants (Fig. 6B) was observed in plots treated with mahua cake followed by cotton cake (6.21 %) and FYM (4.57 %).

4.3.2.2 Evaluation based on termites population

All the organic amendment treatments were found significantly superior to control in reducing the termite population

till fourteen week after sowing. Pooled over period results (Table 23) showed significantly the lowest (2.09) termite population in plots treated with neem cake than all the tested organic amendments except castor cake (2.26 %). The treatments of vermicompost (5.50 %), poultry manure (8.44) and tobacco dust differed significantly to each other in their descending order. Among the tested organic amendments, the highest (22.54) damaged plants was observed in plots treated with mahua cake followed by cotton cake (20.29) and FYM (4.57).

Table: 22

Table: 23

4.3.2.3 Evaluation based on pod damage by termites

The organic amendments tested against termies in groundnut during *summer* were further evaluated in *kharif* season. To assess the effect of organic amendments, pod damage was counted at harvest. The data recorded on pod damage in various organic amendments differed significantly to control except mahua cake (Table 24). Significantly the lowest (2.03 %) pod damage was noted

in plots enriched with neem cake than all the organic amendments except castor cake (3.21 %). Vermicompost (4.28 %) was as effective as castor cake in suppressing the pod damage caused by termites and differed significant to remaining organic amendments. Poultry manure, tobacco dust, maize cake and FYM treated plots exhibited pod damage between 8.19 and 13.05 per cent, respectively (Fig. 6B). Among the tested organic amendments, the highest (20.16 %) pod damaged was observed in plots treated with mahua cake followed by castor cake.

4.3.2.4 Seed germination

To know the detrimental effect if any of organic amendments on seed germination, the observations on germination was also recorded at 10 days after sowing and are presented in Table 25. There was no adverse effect of soil application of organic amendments on germination of groundnut seed as the result was non- significant. The seed germination in all the tested organic amendments was observed between 82 and 88 per cent. The plots treated with mahua cake and cotton cake showed 83.67 and 85.00 per cent germination, respectively. The germination was recorded 86.00 to 88.00 per cent in the plots treated with castor cake, neem cake, FYM and tobacco dust. The highest (88.00%) seed germination was noticed in the treatment of vermicompost followed by maize cake and poultry manure.

Table: 24

4.3.2.5 Yield, Increase in yield, Avoidable losses and Economics

Yield

(A) Pod

The organic amendment applied plots produced significantly higher pod yield than control (Table 25). maximum (2411 kg/ha) pod yield was obtained from the plots treated with neem cake and it was statistically at par with castor cake (2223 kg/ha) and vermicompost (2141 kg/ha). The pod yield harvested between 1863 and 2019 kg/ha from the plots treated with poultry manur, tobacco dust, maize cake and FYM. Among the evaluated organic amendments, the minimum (1470 kg/ha) yield (Fig. 6B) was obtained from the plots treated with mahua cake and it was at par with cotton cake (1700 kg/ha).

Increase in yield

The per cent increase in yield over control in groundnut pod was also worked out and presented in Table 25. Maximum 54.54 per cent yield was increased in the plots treated with neem cake followed by castor cake (50.70%) and vermicompost (48.80 %). It was between 41.64 and 45.72 per cent in poultry manure, tobacco dust and maize cake. The increase in yield over control was 41.17 to 35.53 per cent in plots treated with FYM, cotton cake and mahua cake.

Avoidable losses

The avoidable losses (Table 25) in pod yield of groundnut was varied from 7.80 to 54.42 per cent in different treatments, considering the maximum (2223 kg/ha) yield of neem cake taken as base. The avoidable loss was 7.80 and 11.20 per cent in the treatment of castor cake and vermicompost, respectively. It was

16.26 to 22.73 per cent in poultry manure, tobacco dust, maize cake and FYM. The avoidable losses comparatively higher (29.49-39.03 %) in the treatments of cotton cake and mahua cake.

(B) Haulm

The organic amendment treated plots produced significantly higher haulm yield than control (Table 25). The highest (4227 kg/ha) haulm yield was obtained from the plots treated with neem cake and it was at par with castor cake (3929 kg/ha) and vermicompost (3693 kg/ha). The plots treated with poultry manure, tobacco dust and maize cake enriched plotes produced haulm yield 3433, 3400 and 3384 kg/ha, respectively. Of the tested organic amendments, minimum (2887 kg/ha) haulm yield (Fig. 6B) was produced in plots treated with mahua cake followed by cotton cake (3229 kg/ha) and FYM (3367 kg/ha).

Increase in yield

The per cent increase in yield over control of groundnut haulm was also worked out and presented in Table 25. Maximum (52.99 %) haulm yield was increased in the plot treated with neem cake followed by castor cake (49.43 %) and vermicompost (46.62 %). It was between 41.28 and 45.72 per cent in poultry manure, tobacco dust and maize cake. The increase in yield over control was 31.17 to 43.96 per cent in plots treated with FYM, cotton cake and mahua cake.

Table: 25

Avoidable losses

The avoidable losses (Table 25) in haulm yield of groundnut was varied from 7.04 to 53.00 per cent in different treatments, considering the maximum (3929 kg/ha) yield of neem cake taken as base. The avoidable loss was 7.04 and 12.63 per cent in the treatment of castor cake and vermicompost, respectively. It was 18.78 to 20.36 per cent in poultry manure, tobacco dust, maize cake and FYM. The avoidable losses comparatively higher in the treatments of cotton cake (23.61 %) and mahua cake (31.70 %).

Economics

Economics of different organic amendments used for managing termites incidence in groundnut are presented in Table 26. Maximum (75867 `/ha) net realization was calculated in the treatment of neem cake. It was 64783 and 59682 `/ha in castor cake and vermicompost, respectively. poultry manure, tobacco dust and maize cake treated plots exhibited net realization between 44445 and 52322 `/ha, whereas remaining three amendments (cotton cake, mahua cake, FYM) registered 20762 to 43577 `/ha. Looking to the NICBR, the highest (1:56.61) return was obtained with the treatment of poultry manure. The NICBR of FYM, neem cake and tobacco dust was 1:6.59, 1:5.31 and 1:5.94, respectively. The treatments of vermicompost and castor cake gave 1:3.09 and 1:4.97 NICBR, respectively. The NICBR was poor (1:1.94 to 1:2.88) in the treatment of tobacco dust, mahua cake and cotton cake.

From the above results, it can be extracted that the application of neem cake @ 1 tonne, castor cake @ 1 tonne and

vermicompost @ 1 tonne were found to be More effective against termite in groundnut which reflected on yield of pod and haulm as well as avoidable losses (Plate IV). Application of neem cake at sowing and 40 days after emergence increased groundnut pod yield (Rao *et al.,* 1991).

Table: 26

Application of neem cake @ 2 kg/ tree found most effective against termite in mango orchard (Singh and Singh, 2003). Furrow application of neem cake at 700 kg/ha was next to the endosulfan in their effectiveness (Patel *et al.,* 2008). Singh *et al.* (2010) reported that use of dry powder of immature neem kernels and leaves effectively control the termite and increase the yield of wheat with economic return. Gadhiya, (2012) reported that the soil application of castor cake, vermicompost and neem cake @ 1 tonne/ha at the time of land preparation before sowing was more effective in suppressing the termite population in wheat. The treatments of poultry manure, tobacco dust, maize cake were found mediocre in their effectiveness. These treatments produced comparatively less pod as well as haulm yield and higher avoidable losses. In contrast to this, the application of mahua cake, cotton cake and FYM was found poor in controlling the termite in groundnut. These poor effects also reflected on pod and haulm yield as well as in avoidable losses too.

4.4 Efficacy of insecticides as seed treatments against termites in groundnut

4.4.1 *Summer*

✍.....Results and Discussion

Nine different insecticides (Table 27) were evaluated for their efficacy as a seed treatment against termites in groundnut during *summer,* 2012.

4.4.1.1 Evaluation based on damaged plants by Termites

All the insecticidal treatments were significantly superior to control till fourteen week after sowing as well as in pooled over period analysis except ninth and tenth week after sowing (Table 27). There was no pest incidence up to four week of crop age. After five week of sowing, the lowest (0.53 %) termite damage was found in plots treated with fipronil 5 SC and it was at par with chlorpyriphos 20 EC (0.55 %). Imidacloprid 600 FS (1.00 %), bifenthrin 10 EC (1.04 %) and imidacloprid 17.8 SL (1.22 %) were equally effective in cheking the termites damage in groundnut. The highest (2.08 %) damaged plants observed in seed treated with cypermethrin 25 EC and it was at par with thiamethoxam 35 FS (1.68 %) and deltamethrin 2.8 EC (1.80 %).

After six week of sowing, the lowest (0.79 %) termite damage was recorded in plots treated with fipronil 5 SC and it was at par with chlorpyriphos 20 EC (1.21 %). Imidacloprid 600 FS (1.50 %), bifenthrin (1.50 %), imidacloprid 17.8 SL (1.86 %) and quinalphos 25 EC (2.09 %) were at par with each other in controlling the damage in groundnut. Of the evaluated insecticides as seed treatments, the highest (2.80 %) damaged plants observed in seed treated with cypermethrin and it was at par with deltamethrin (2.46 %), thiamethoxam (2.29 %) and quinalphos 25 EC (2.09 %).

✍.....Results and Discussion

After seven week of sowing, the lowest (1.14 %) termite damage was noticed in plots treated with fipronil 5 SC and it was at par with chlorpyriphos 20 EC (1.35%), imidacloprid 600 FS (1.62 %) and bifenthrin (1.73%). Imidacloprid 17.8 SL and and quinalphos exhibited 2.18 and 2.19 per cent damaged plants and they were as effective as bifenthrin (1.73%) and imidacloprid 600 FS (1.62%). The highest (3.02 %) damaged plants registered in seed treated with cypermethrin and it was at par with deltamethrin (2.62 %), thiamethoxam (2.45 %) and quinalphos (2.19 %).

The seed treatment of fipronil, chlorpyriphos, imidacloprid 600 FS (1.62 %) and bifenthrin (1.73%) found significantly higher effective by registerering 1.40 to 2.17 per cent damaged plants of groundnut than all the evaluated insecticides after eighth week of sowing. The highest (4.32%) damaged plants was recorded in seed treated with cypermethrin and it was at par with thiamethoxam (3.86 %) followed by quinalphos (3.49 %).

After nine week of sowing, the lowest (1.73 %) termite damage was recorded in plots treated with fipronil and it was at par with imidacloprid 600 FS (2.48 %) and chlorpyriphos (2.50 %). The treatments of bifenthrin (3.03%), imidacloprid 17.8 SL (3.51 %) and quinalphos (4.00 %) were found equally effective in controlling the termites damage. Of the tested insecticides as seed treatment, the highest (5.65 %) damaged plants exhibited in seed treated with cypermethrin and it was at par with thiamethoxam (4.51 %) and deltamethrin (5.27 %).

After ten week of sowing, the lowest (1.40 %) termite damage was observed in plots treated with fipronil and it was at par with chlorpyriphos (1.63 %). The treatments of imidacloprid 600 FS (2.11%), bifenthrin (2.17%) and imidacloprid 17.8 SL (3.16 %) were equally effective in checking the damage caused by termites in groundnut. The highest (3.16 %) damaged plants registered in seed treated with cypermethrin 25 EC (4.32 %) and it was at par with deltamethrin (3.86 %), thiamethoxam (3.49 %) and quinalphos (3.86 %).

After eleven week of sowing, more or less similar trend of effectiveness was observed in suppression of termites as noticed in previous weeks. In which, the lowest (3.17%) damage was registered in fipronil and it was at par with chlorpyriphos (3.42 %) and bifenthrin (4.34 %). The treatments of quinalphos (4.93 %), imidacloprid 17.8 SL (5.09 %) and imidacloprid 600 FS recorded 4.93, 5.09 and 5.39 per cent damaged plants, respectively. Among the evaluated insecticides as seed treatments, the highest (7.79 %) damaged plants observed in seed treated with cypermethrin and it was at par with deltamethrin (7.50 %) and thiamethoxam (7.14 %).

Of the tested insecticides as seed treatment, the lowest (4.04 %) termites damaged plants was found in fipronil and it was at par with chlorpyriphos (4.51%) after twelve week of sowing (Table 27). Imidacloprid 600 FS, bifenthrin and imidacloprid 17.8 SL (5.09 %) used as seed treatments were registered 5.98, 6.59, and 6.90 per cent damaged plants and they were at par with each other in

controlling the termites damage in groundnut. The highest (13.10 %) damaged plants noticed in seed treated with cypermethrin followed by deltamethrin (8.49 %) and thiamethoxam (8.20 %).

After thirteen week of sowing, the lowest (5.13 %) plant damage was found in seed treated with fipronol followed by chlorpyriphos (6.09%) and imidacloprid 600 FS (6.27 %). Bifenthrin, imidacloprid 17.8 SL and quinalphos exhibited 10.28 to 16.95 per cent damage. Of the evaluated insecticides as seed treatment, the highest (23.09 %) damaged plants recorded in seed treated with cypermethrin and it was at par with deltamethrin (16.23 %) and thiamethoxam (11.08 %).

Table: 27

Insecticides seed treatment of with fipronil, chlorpyriphos and imidacloprid 600 FS recored 6.09 to 8.36 per cent damage and they were significantly lower than all evaluated insecticides as seed treatment after fourteen week of sowing. Bifenthrin, imidacloprid 17.8 SL and quinalphos were equally effective against termites by

registering damaged plants between 10.28 and 16.95 per cent but significantly more effective than remaining insecticides. The highest (27.71 %) damaged plants exhibited in plots received the seed treated with cypermethrin and it was at par with deltamethrin (25.61 %) and thiamethoxam (21.81 %).

Pooled over period results (Table 27) of *summer* season revealed that the seed treatment of fipronil (2.31%) stood first in cheking the termites damage in groundnut and it was at par with chlorpyriphos (2.84 %). Imidacloprid 600 FS (3.45 %), bifenthrin (3.78 %), and Imidacloprid 17.8 SL (4.63 %) and quinalphos (5.01 %) were at par with each other in restricting the termites damage in groundnut crop. Among the evaluated insecticides as seed treatments, the highest (8.02 %) damage (Fig. 7A) was noticed in cypermethrin and it was at par with thiamethoxam (6.03 %) and deltamethrin (8.02 %).

4.4.1.2 Evaluation based on termites population

Termite population on eucalyptus stick (Plate V) was also recorded throughout the cropping season. All the insecticidal seed treatments were found significantly superior to control till fourteen week after sowing as well as in pooled over period analysis (Table 28)**.** Pooled over period results of termite incidence showed significantly the lowest (6.74) number of termites in fipronil than all the evaluated insecticides. Plots receved seeds treated with chlorpyriphos and imidacloprid 600 FS recorded 12.53 and 13.71 termites per stick, respectively and significantly superior to rest of the insecticides.

Table: 28

The plots treated with bifenthrin (18.42), imidacloprid 17.8 SL (19.04) and quinalphos (20.84) were at par with each other in harbouring the termites population and they were significantly less than remaining insecticides. Among the tested insecticides, the highest (26.02) termites population was noticed in the treatment of cypermethrin followed by thiamethoxam (23.12) and deltamethrin (24.00).

4.4.1.3 Evaluation based on pod damage by termites

All the tested insecticides as seed treatments had significantly less pod damage than control except the cypermethrin (Table 29). The lowest (3.30%) pod damage exhibited in fipronil and it was at par with chlorpyriphos (3.93 %) and imidacloprid 600 FS (4.28 %). These thre treatments were found significantly superior to rest of the insecticides. Bifenthrin (7.28 %) and imidacloprid 17.8 SL (10.62 %) were equally effective in checking the pod damage by pest. Among the evaluated insecticides as seed treatments, the highest (18.82 %) pod damage (Fig. 7A) was observed in cypermethrin followed by deltamethrin (14.96%).

4.4.1.4 Seed germination

Seeds treated with various insecticides were evaluated to check the adverse effect on seed germination (Table 30). There was no adverse effect of insecticidal seed treatments on seed germination as the results were non-significant. The seed germination recorded between 84 and 91 per cent in the evaluated insecticides. The less (84.26%) germination exhibited in quinalphos @ 5 ml/kg seed. The germination was between 85 and 87 per cent in the treatments of imidacloprid 600 FS (3 ml), cypermethrin 25 EC

(2 ml), thiamethoxam (3 ml) and deltamethrin (2 ml). The highest (90.45%) seed germination was observed in treatment of imidacloprid 17.8 SL (3 ml) followed by bifenthrin (2 ml), chlorpyriphos (4 ml) and fipronil (5 ml).

Table: 29

4.4.1.5 Yield, Increase in yield, Avoidable losses and Economics

The main goal of the pest management is to suppress the target pests by using different components and its ultimate effect on yield and economics. Therefore, to determine the effects of various insecticides on produce, the yield data were recorded. On the basis of pod and haulm yield, increase in yield over control and avoidable losses were calculated, whereas by using costs of treatments, Net Incremental Cost Benefit Ratio (NICBR) was calculated. The results on pod and haulm yield, avoidable losses and economics are presented in Table 30 and 33.

Yield

(A) Pod

The insecticidal seed treatments produced significantly higher yield (Table 30) than control during *summer,* 2012. Significantly the highest (2487 kg/ha) pod yield was obtained from insecticidal seed treatment with fipronil and it was at par with chlorpyriphos (2300 kg/ha) and imidacloprid 600 FS (2205 kg/ha). The plots treated with bifenthrin produced 2114 kg/ha pods and it was statistically equal to imidacloprid 17.8 SL (2016 kg/ha). Among the evaluated insecticidal seed treatments, the lower (1375 kg/ha)

yield (Fig. 7A)was recorded in cypermethrin and it was at par with quinalphos (1673 kg/ha), thiamethoxam (1604 kg/ha) and deltamethrin (1496 kg/ha).

Increase in yield

The per cent increase in yield over control in groundnut pods was also worked out and presented in Table 30. Maximum (55.93 %) yield was increased in the plots treated with fipronil. It was between 34.49 and 52.35 per cent in chlorpyriphos, imidacloprid 600 FS, bifenthrin, imidacloprid 17.8 SL and quinalphos. The increase in yield over control was 20.29 to 31.67 per cent in plots treated with cypermethrin, deltamethrin and thiamethoxam.

Avoidable losses

The avoidable losses (Table 30) in pod yield of groundnut was varied from 7.52 to 55.93 per cent in different treatments, considering the maximum (2487 kg/ha) yield of fipronil taken as base. The avoidable loss was the lowest (7.52%) in the treatment of chlorpyriphos followed by imidacloprid 600 FS (11.26%). It was 15.00 to 39.84 per cent in bifenthrin, imidacloprid 17.8 SL, quinalphos and thiamethoxam. The less effective insecticide cypermethrin recorded 44.71 per cent loss in pod yield of groundnut followed by deltamethrin (39 %).

(B) Haulm

The insecticidal seed treated plots produced significantly higher haulm yield (Table 30) than control during *summer,* 2012. The significantly highest (4373 kg/ha) haulm yield was obtained from

insecticidal seed treated with fipronil and it was at par with chlorpyriphos (4217 kg/ha) and imidacloprid 600 FS (4066 kg/ha). The plots treated with bifenthrin produced 3700 kg/ha haulm and it was statistically equal to imidacloprid 17.8 SL (3604 kg/ha). Among the evaluated insecticidal seed treatments the lower (2766 kg/ha) yield (Fig. 7A) was recorded in cypermethrin and it was at par with quinalphos 25 EC (3106 kg/ha), thiamethoxam (3093 kg/ha) and deltamethrin (2766 kg/ha).

Table: 30

Increase in yield

The per cent increase in yield over control in groundnut haulm was also worked out and presented in Table 30. Maximum (55.01 %) per cent yield was increased in the plots treated with fipronil. It was between 36.67 and 53.34 per cent in chlorpyriphos, imidacloprid 600 FS, bifenthrin, imidacloprid 17.8 SL and quinalphos. The increase in yield over control was 28.89 to 36.40 per cent in plots treated with cypermethrin, deltamethrin and thiamethoxam.

Avoidable losses

The avoidable losses (Table 30) in haulm yield of groundnut was varied from 3.57 to 36.75 per cent in different treatments, considering the maximum (4373 kg/ha) yield of fipronil taken as base. The avoidable loss was the lowest (3.57%) in the treatment of chlorpyriphos followed by imidacloprid 600 FS (7.02 %). It was 15.39 to 29.27 per cent in bifenthrin, imidacloprid 17.8 SL,

quinalphos and thiamethoxam. The less effective insecticide cypermethrin recorded 33.41 per cent loss in haulm yield of groundnut followed by deltamethrin (30.75 %). Gadhiya (2012) recorded minimum avodable losses of wheat straw in plots treated with fipronil @ 5ml /kg seed.

Economics

Economics of various insecticidal seed treatments against termites infesting groundnut are presented in Table 31. Maximum (82520 `/ha) net realization was found in the treatment of fipronil. It was 60322 and 71845 `/ha in chlorpyriphos, imidacloprid 600 FS and bifenthrin treatments, respectively. Imidacloprid 17.8 SL and quinalphos treated plots exhibited net realization of 54692 and 34582 `/ha, respectively whereas remaining three insecticides (cypermethrin, thiamethoxam and deltamethrin) registered 17342 to 30755 `/ha. Looking to the NICBR, the highest (1:148.68) return was obtained with the treatment of chlorpyriphos.

Table: 31

The NICBR of bifenthrin and quinalphos treated seed gave 1:127.19 and 1:79.86, respectively. However, imidacloprid 17.8 SL (1:68.44) and cypermethrin (1:62.46) were found mediocre, whereas cypermethrin was poor against termite in groundnut crop. The treatment of imidacloprid 600 FS, deltamethrin and thiamethoxam recorded 1:59.87, 1:51.85 and 1:7.56 NICBR, respectively. Of these seed treatments, fipronil, chlorpyriphos and imidacloprid 600 FS were highly effective against termites in groundnut.

4.4.2 *Kharif*

Nine different insecticides (Table 32) were evaluated for their efficacy as a seed treatment against termites in groundnut during *Kharif,* 2012.

4.4.2.1 Evaluation based on damaged Plants by termites

All the insecticidal treatments were found significantly superior to control till fourteen week after sowing as well as in pooled over period analysis except sixth week after sowing (Table 32). There was no pest incidence up to four week of crop age. After five week of sowing, the lowest (0.35%) damage registered in fipronil 5 SC aand it was at par with chlorpyriphos 20 EC (0.50 %). The treatments of imidacloprid 600 FS (0.67 %) and bifenthrin 10 EC (0.90 %), bifenthrin and imidacloprid 17.8 SL (1.09 %) as well as imidacloprid 17.8 SL (1.09 %) and quinalphos 25 EC were at par with each other in their decscending order in checking the plant damage by termites. The highest (2.00 %) damaged plants observed in seed treated with cypermethrin 25 EC followed by deltamethrin 2.8 EC (1.72 %) and thiamethoxam 35 FS (1.68 %).

Table: 32

✍.....Results and Discussion

After six week of sowing, the lowest (0.43-0.51%) damage was observed in fipronil and it was at par with chlorpyriphos (0.56 %). The treatment of imidacloprid 600 FS (0.83 %) was equally effective as chlorpyriphos (0.56 %). Plots received seeds treated with bifenthrin (0.90 %), imidacloprid 17.8 SL and quinalphos were recorded 1.90, 1.53 an 1.58 per cent damaged plants, respectively. Of the tested insecticides as seed treatment, the higher (2.36 %) damaged plants observed in seed treated with cypermethrin and it was at par with deltamethrin (1.75 %) and thiamethoxam (1.69 %).

Groundnut seeds treated with fipronil were found the highest effective in checking the plant damage by termites and it was at par with chlorpyriphos (0.69 %) after seven week of sowing. Imidacloprid 600 FS, bifenthrin (0.90 %) and imidacloprid 17.8 SL insecticidal seed treatments were equally effective against termites by observing 1.13 to1.57 per cent damage plants. Seed treatments with quinalphos (1.79 %) and thiamethoxam (1.84 %) were as effective as imidacloprid 17.8 SL in controlling the pest. Of the evaluated insecticides as seed treatments, the highest (2.68 %) damaged plants exhibited in cypermethrin and it was at par with deltamethrin (2.65%).

After eight week of sowing, the lowest (0.86 %) damage was noticed in fipronil and it was at par with chlorpyriphos (1.19 %), bifenthrin (1.33%) and imidacloprid 600 FS (1.36 %). The treatments of imidacloprid 17.8 SL, quinalphos and thiamethoxam were at par with each other by observing plant damage between 1.66 and 2.30

per cent. The highest (3.61%) damaged plants observed in seed treated with cypermethrin and it was at par with deltamethrin (3.21 %).

After nine week of sowing, the lowest (1.07 %) damaged plants was registered in fipronil and it was at par with chlorpyriphos 20 EC (3.42 %) and imidacloprid 600 FS (1.80 %). Bifenthrin (2.19 %) seed treatments were as effective as chlorpyriphos. The remaining insecticidal seed treatments were at par in checking the plant damage caused by termites, of these plots received seeds treated with cypermethrin recorded the highest (4.04 %) damage by termites.

The plots received seeds treated with fipronil was found the highest (1.82 and 2.25 %) effectiveness against termites damage and it was at par with chlorpyriphos (2.11 and 2.93 %) and imidacloprid 600 FS (2.76 and 3.52 %) after ten and eleven week of sowing. Bifenthrin, imidacloprid 600 FS, quinalphos and thiamethoxam treated seeds were exhibited plant damage between 3.10 and 5.10 per cent. Among the evaluated insecticides as seed treatments, the highest (4.89 and 5.28 %) damaged plants recorded in deltamethrin and thiamethoxam (4.42 and 5.10 %).

After twelve and thirteen week of sowing, the lowest (3.00-4.15 %) damage was registered in fipronil and it was at par with chlorpyriphos (3.80 and 5.03 %), imidacloprid 600 FS (4.20 and 5.99 %) and bifenthrin (4.68 and 6.79 %). The treatments of imidacloprid 17.8 SL, quinalphos and thiamethoxam observed plant damage

between 4.68 and 10.96 per cent. The highest (11.98 and 16.96 %) damaged plants observed in seed treated with cypermethrin and it was at par with deltamethrin (10.14 and 12.82 %).

Seed treatments of fipronil exhibited the lowest (4.15 and 5.10 %) damage plants and it was at par with chlorpyriphos (5.03 and 7.03%) after fourteen week of sowing. The treatments of imidacloprid 600 FS (5.99 and 9.61 %), bifenthrin (6.79 and 11.21%) and imidacloprid 17.8 SL (7.19 and 13.25 %) were equally effective in controlling the damage caused by termites. The highest (16.96 and 24.20 %) damaged plants observed in seed treated with cypermethrin and it was at par with thiamethoxam (10.96 and 18.05 %) and deltamethrin (12.82 and 19.98 %).

Pooled over period results (Table 32) of *kharif* season revealed that the seed treatment of fipronil (1.64%) stood first in restricting the plant damage caused by termites in groundnut and it was at par with chlorpyriphos (2.18 %). The treatments of imidacloprid 600 FS (2.76 %), bifenthrin (3.15 %) and imidacloprid 17.8 SL (3.65 %) were equally effective in checking the damage caused by termites. Imidacloprid 17.8 SL and quinalphos, quinalphos and thiamethoxam as well as thiamethoxam and deltamethrin were at par in reducing the damage caused by termites in their descending order. Among the evaluated insecticides as seed treatments, the highest (6.61 %) damage (Fig. 7B) was noticed in cypermethrin and it was at par with deltamethrin (5.71 %).

4.4.2.2 Evaluation based on population of termites

Termites population on eucalyptus stick was also recorded throughout the cropping season. All the insecticidal seed treatments were found significantly superior to control till fourteen week of sowing as well as in pooled over period analysis (Table 33). Pooled over period results showed significantly the lowest (3.30) termites incidence in fipronil than all the evaluated insecticides. Chlorpyriphos and imidacloprid 600 FS exhibited 5.40 and 6.42 termites per stick, respectively and that were significantly superior to rest of the insecticides. The plots treated with bifenthrin (7.85) and imidacloprid 17.8 SL (8.24) were found significantly superior to remaining insecticides. Among the tested insecticides, the highest (26.33) termites population was noticed in the treatment of cypermethrin followed by deltamethrin 2.8 EC (17.14) and thiamethoxam 35 FS (16.06)

4.4.2.3 Evaluation based on pod damage by termites

All the insecticidal seed treatments were found significantly superior to control except cypermethrin (Table 34). Pod damage caused by termites in groundnut revealed that significantly the lowest (2.45%) damage exhibited in fipronil than all the insecticides except chlorpyriphos (3.00 %). Imidacloprid 600 FS (4.65 %) and bifenthrin (6.6 %) were equally effective in checking the pod damage by termites and to found significantly superior to rest of the insecticides. Imidacloprid 17.8 SL (9.81 %), quinalphos (10.65 %) and thiamethoxam (10.78%) were at par with each other in restricting the pod damage by termites. Among the evaluated

insecticides as seed treatments, the highest (16.05 %) pod damage (Fig. 7B) was noticed in cypermethrin and it was at par with deltamethrin (13.96%).

Table: 33

Table: 34

From the above results, it can be concluded that the insecticidal seed treatment of fipronil 5 SC @ 5 ml/kg, chlorpyriphos 20 EC @ 4 ml/kg and imidacloprid 600 FS @ 3 ml/kg were found highly effective in suppressionof termites damage in groundnut (Plate VI). The seed treated with chlorpyriphos 20 EC @ 0.9 g. a. i./ha were less infested by termites (Rana *et al*., 2001). Singh *et al.* (2004) reported that imidacloprid 600 FS @ 10 ml/kg seed was most effective with the minimum plant damage (4.18%) in pearl millet. Seed treatments with bifenthrin 10 EC @ 2 ml/kg and chlorpyriphos 20 EC @ 1.5 ml/kg seeds were effective and economical for the management of termites in wheat (Anon., 2006). The lowest damage (0.41 %) of tillers per meter row was with fipronil 5 FS @ 0.3 ml/kg seed (Bali *et al.,* 2010). Sundriya and Acharya (2012) mentioned that imidacloprid 70 WS @ 10 g/kg as seed treatment gave effective control of termite in wheat. These reports strongly support the present conclusion. Seed treatments of bifenthrin 10 EC @ 2 ml/kg, imidacloprid 17.8 SL @ 3 ml/kg, quinalphos 25 EC @ 5 ml/kg and thiamethoxam 35 FS @ 3 ml/kg seed were moderately effective against termites in groundnut. Gadhiya (2012) reported that insecticidal seed treatments of fipronil 5 SC @ 5 ml/kg, imidacloprid 600 FS @ 3 ml/kg and bifenthrin 10 EC @ 2 ml/kg seeds were found highly effective in suppression of termites damage in wheat. Deltamethrin 2.8 EC @ 2 ml/kg, cypermethrin 25 EC @ 2 ml/kg seed were less effective in controlling the termite in groundnut. Seed treatments of quinalphos 25 EC @ 5 ml/kg,

thiamethoxam 35 FS @ 3 ml/kg and cypermethrin 25 EC @ 2 ml/kg seed were less effective in controlling the termites in wheat.

4.4.2.4 Seed germination

Seeds treated with various insecticides were evaluated to check the adverse effect on seed germination (Table 35). There was no adverse effect of insecticidal seed treatments on seed germination as the results were non-significant. The seed germination was between 83 and 90 per cent in the evaluated insecticides. The less (83.67%) germination noticed in deltamethrin. The germination was between 84 and 88 per cent in the treatments of imidacloprid 600 FS, cypermethrin, thiamethoxam and quinalphos. The higher (90.00%) seed germination was observed the treatment of chlorpyriphos followed by imidacloprid 17.8 SL and fipronil. Seed treatment with chlorpyriphos 20 EC (1.5-4.5 ml/kg seed) had no adverse effect on seed germination of wheat (Anon., 1990 and Bhanot *et al.,* 1991). The difference in the plant population per metre row length in the treatments of chlorpyriphos 20 EC, imidacloprid 70 WS and cypermethrin 10 EC were non-significant, which shows that none of the insecticides affects the germination of the seed (Deol and Sekhon, 1998). Rana *et al*. (2001) mentioned that the cypermethrin, imidacloprid and chlorpyriphos as seed treatment were not detrimental to seed germination. The pearl millet seed treated with imidacloprid 70 WS and imidacloprid 600 FS had no adverse effect on the germination (Singh *et al.,* 2004). Seed

treatment with fipronil 5 FS, imidacloprid 200 SL, bifenthrin 10 WP and thiamethoxam 70 WS were not affected seed germination (Bali *et al.,* 2010). Gadhiya (2012) reported that fipronil 5 SC, imidacloprid and bifenthrin 10 were not affected seed germination in wheat. These reports are in accordance with the present conclusion.

4.4.2.5 Yield, Increase in yield, Avoidable losses and Economics

Yield

(A) Pod

The insecticidal seed treated plots produced significantly higher yield (Table 35) than control during *kharif,* 2012. Significantly the highest (2500 kg/ha) pod yield was obtained from insecticidal seed treated with fipronil and it was at par with chlorpyriphos 20 EC (2371 kg/ha) and imidacloprid 600 FS (2207 kg/ha). The plots treated with bifenthrin 10 EC and imidacloprid 17.8 SL produced 2081 and 1985 kg/ha pods and it was statistically superior than remaining insecticides. Among the evaluated insecticidal seed treatments, the lower (1421 kg/ha) yield (Fig. 7B) was recorded in cypermethrin and it was at par with quinalphos 25 EC (1702 kg/ha), thiamethoxam (1602 kg/ha) and deltamethrin 2.8 EC (1463 kg/ha). As per the report of Singh *et al.* (2004), maximum yield was recorded in imidacloprid 600 FS followed by imidacloprid 70 WS. Gadhiya (2012) reported that seed treatment of fipronil 5 SC @ 5 ml/kg, imidacloprid 600 FS @ 3 ml/kg and bifenthrin 10 EC @ 2 ml/kg seed were found highly effective produced higher (3500 to

4420 kg/ha) grain yield of wheat. Treatments of quinalphos 25 EC @ 5 ml/kg, thiamethoxam 35 FS @ 3 ml/kg and cypermethrin 25 EC @ 2 ml/kg seed were comparatively less effective and produced 2177 to 2250 kg/ha grain yield of wheat.

Increase in yield

The per cent increase in yield over control in groundnut pods was also worked out and presented in Table 35. Maximum 56.84 per cent yield was increased in the plots treated with fipronil. It was between 45.64 and 54.49 per cent in chlorpyriphos, imidacloprid 600 FS, bifenthrin and imidacloprid 17.8 SL. The increase in yield over control was 24.06 to 32.65 per cent in plots treated with quinalphos, cypermethrin, deltamethrin and thiamethoxam. The per cent increase in wheat grain yield over control was maximum with fipronil (Bali *et al.,* 2010). Gadhiya (2012) reported that insecticidal seed treatments of fipronil 5 SC @ 5 ml/kg, imidacloprid 600 FS @ 3 ml/kg and bifenthrin 10 EC @ 2 ml/kg seed were increased 59 to 61 per cent grain yield. Treatments of quinalphos 25 EC @ 5 ml/kg, thiamethoxam 35 FS @ 3 ml/kg and cypermethrin 25 EC @ 2 ml/kg seed were comparatively less effective and increased 45 to 47.50 per cent grain in wheat.

Avoidable losses

The avoidable losses (Table 35) in pod yield of groundnut varied from 5.16 to 56.84 per cent in different treatments, considering the maximum (2500 kg/ha) yield of fipronil taken as base. The minimum per cent avoidable loss was recorded in plots

treated with fipronil (Bali *et al.,* 2010). Gadhiya (2012) recorded minimum avoidable loss in plots treated with fipronil 5 SC @ 5ml /kg seed. The avoidable loss was the lowest (5.16%) in the treatment of chlorpyriphos followed by imidacloprid 600 FS (11.72%). It was 16.76 to 45.64 per cent in bifenthrin, imidacloprid 17.8 SL, quinalphos and thiamethoxam. The less effective insecticide cypermethrin recorded 43 per cent loss in pod yield yield of groundnut followed by deltamethrin (41.48 %).

(B) Haulm

The insecticidal seed treated plots produced significantly higher haulm yield (Table 35) than control during *kharif,* 2012. The significantly highest (4459 kg/ha) haulm yield was obtained from insecticidal seed treated with fipronil and it was at par with chlorpyriphos (4287 kg/ha) and imidacloprid 600 FS (4108 kg/ha). The plots treated with bifenthrin 10 EC produced 3820 kg/ha haulm and it was statistically equal to imidacloprid 17.8 SL (3700 kg/ha). Among the evaluated insecticidal seed treatments, the lower (2900 kg/ha) yield (Fig. 7B) was recorded in cypermethrin and it was at par with quinalphos 25 EC (3455 kg/ha), thiamethoxam (3240 kg/ha) and deltamethrin 2.8 EC (3088 kg/ha). Gadhiya (2012) reported that insecticidal seed treatments of fipronil 5 SC @ 5 ml/kg, imidacloprid 600 FS @ 3 ml/kg and bifenthrin 10 EC @ 2 ml/kg seed were produced higher haulm yield, whereas cypermethrin 25 EC @ 2 ml/kg seed was poor in yield of wheat.

Increase in yield

The per cent increase in yield over control of groundnut haulm was also worked out and presented in Table 35. Maximum (52.30 %) yield was increased in plots treated with fipronil. It was between 45.61 and 50.38 per cent in chlorpyriphos, imidacloprid 600 FS, bifenthrin, imidacloprid 17.8 SL and quinalphos. The increase in yield over control was 26.66 to 38.44 per cent in plots treated with cypermethrin, deltamethrin and thiamethoxam.

Avoidable losses

The avoidable losses (Table 35) in haulm yield of groundnut varied from 3.86 to 52.30 per cent in different treatments, considering the maximum (4459 kg/ha) yield of fipronil taken as base. The avoidable loss was the lowest (3.86 %) in the treatment of chlorpyriphos followed by imidacloprid 600 FS (7.87 %). It was 14.33 to 27.34 per cent in bifenthrin, imidacloprid 17.8 SL, quinalphos and thiamethoxam. The less effective insecticide cypermethrin recorded 34.96 per cent loss in haulm yield of groundnut followed by deltamethrin (30.75 %). Gadhiya (2012) recorded minimum avodable losses of haulm in plots treated with fipronil 5 SC @ 5ml /kg seed.

Table: 35

Economics

Economics of different insecticides used for managing termites incidence in groundnut are presented in Table 36. Maximum (83985 `/ha) net realization was calculated in the treatment of fipronil. It was 76460 and 66992 `/ha in chlorpyriphos and imidacloprid 600 FS, respectively. Bifenthrin, imidacloprid 17.8 SL and quinalphos treated plots exhibited net realization between

37585 and 59042 `/ha, whereas remaining insecticide (cypermethrin, deltamethrin and thiamethoxam ) registered 20742 to 31547 `/ha. Looking to the NICBR, the highest (1:158.71) return was obtained with the treatment of fipronil 5 SC. The NICBR of bifenthrin, fipronil and quinalphos was 1:86.90 and 1:124.47, respectively. The treatments of cypermethrin, imidacloprid 17.8 SL and imidacloprid 600 FS gave 1:60.46 and 1:74.90 NICBR. The NICBR was lowest (1:7.75) return in the treatment of thiamethoxam , respectively. Gadhiya (2012) reported that NICBR of fipronil 5 SC, imidacloprid 600 FS and bifenthrin 10 EC were 1:62.97, 1:108.03 and 1:35.37, respectively.

Table: 36

V SUMMARY AND CONCLUSION

The investigations on population dynamics, screening of different groundnut varieties, effect of organic amendments and seed treatments of insecticides on termite incidence in groundnut were carried out under field conditions during *summer and kharif* season of 2012 at Agronomy farm, B. A. College of Agriculture, Anand Agricultural University, Anand. The important conclusions obtained from the research studies are summarized here under.

5.1 Population dynamics of termites in groundnut

The activity of termites commenced from 1st week of March [10th standard meteorological week (SMW)] and continued till 2nd week of June (14th SMW) during *summer,* whereas 4th week of July (30th SMW) and continued till 1st week of November (43rd SMW) during *kharif.* The incidence of termites ranged from 5.56 to 101.45 per stick during crop period in *summer,* whereas it was 3.05 to 96.75 per stick during *kharif* season. On appearance i.e. 1st week of March (10th SMW), the termites activity was found negligible in the groundnut field, when crop age was one week. It was found 22 to 46 per stick during 2nd to 4th week of March (11th to 13th SMW). The activity of termites was found between 53 and 75 per stick during 1st week of April to 2nd week of May (14th to 19th SMW) in *summer* season, whereas The termites activity was found negligible (3.05 to 10.52) in groundnut field during begining to 4th week of July to 1st week of September (30th to 35th SMW) except 4rd week of August (34rd SMW), when the termites activity was at higher level (19.96

per stick). The termites incidence was gradually increased from 3rd week of September to 1st week of October. The activity of termites suddenly reduced in subsequent week i.e. 3rd week of October (41st SMW). Again it was increased from 4th week of October (42nd SMW) and 1st week of November (43rd SMW) during *kharif* season. The higher activity of termites was observed (76 to 102 termites per stick) during 3rd week of May (20th SMW) to 2ndweek of June (23rdSMW) with peak level on 2nd week of June, in *summer,* while it higher in October to 1st week of November in groundnut with peak level on 2nd week of October during *kharif* season.

Correlation coefficient between abiotic factors and termites

The correlation coefficient results indicated that the evaporation, minimum, maximum and mean temperature, soil temperature at 5 cm, 10 cm, and 15 cm depth at afternoon hours and soil temperature at 15 cm depth at morning hours had significantly positive relationship with termites activity in groundnut in both seasons, Bright sunshine had positive association with termites activity but non-significant in *summer* and significant in *kharif*. In contrast to this, soil temperature at 5 cm and 10 cm depth at morning hours positively correlated with termites incidence in groundnut but significant in *summer* and non-significant in *kharif* season. Morning, evening and mean vapour pressure had highly significant negative relationship, whereas wind speed had significant negative association with termites population in groundnut in both seasons. Morning, evening and mean relative humidity had negative

correlation with termites population but non-significant in *summer* and significant in *kharif* season.

5.2 Screening of groundnut varieties against termite

Summer

Of the 10 varieties of groundnut screened for their relative susceptibility against termites, varieties GG-11, TG-26 and TG-37 were found superior in suppressing the termites damage and produced higher yield of pod (1926 to 2130 kg/ha) and haulm (3491 to 3963 kg/ha). The groundnut varieties GG-5, GG-20, GG-7 and GJG-31 were found less susceptible against termites and recorded 1685 to 1862 kg/ha pods and 2809 to 3317 kg/ha haulm, whereas groundnut varieties GG-6, TPG-41 and GG-2 gave poor performance against termites. This poor performance reflected on the pod and haulm yield too.

Kharif

Of the 10 varieties of groundnut screened for their relative susceptibility against termites, varieties GG-11, TG-26 and TG-37 were found superior in suppressing the termites damage and produced higher yield of pod (2233 to 2537 kg/ha) and haulm (3292 to 4000 kg/ha). The groundnut varieties GG-5, GG-20, GG-7 and GJG-31 were found less susceptible against termites and recorded 1915 to 2111 kg/ha pods and 2406 to 3013 kg/ha haulm, whereas groundnut varieties GG-6, TPG-41 and GG-2 gave poor performance against termites. This poor performance reflected on the pod and haulm yield too.

5.3 Effect of amendments on incidence of termites in groundnut

Summer

The soil application of neem cake, castor cake and vermicompost @ 1 tonne/ha at the time of land preparation before sowing was more effective in suppressing the termites population in groundnut and produced 1878 to 2283 kg/ha yield of pod and 3967 to 4282 kg/ha haulm during *summer* 2012. These treatments increased 39.88 to 50.55 per cent pod and 47 to 51.33 per cent haulm yield over control, whereas avoidable loss in pod was up to 8.00 per cent and in haulm yield it was up to 4.00 per cent. The NICBR of these amendments were 1:4.59, 1:2.64 and 1:2.44, respectively. The treatments of poultry manure, tobacco dust and maize cake @ 1 tonne/ha were found moderately effective against termites in groundnut. These treatments recorded 1750 to 1818 kg/ha yield of pod and 3417 to 3683 kg/ha haulm. Yield due to these treatments increased from 35.49 to 37.90 per cent pod and 40.77 to 44.72 per cent haulm yield over control, whereas loss in pod yield was 20.37 to 23.35 per cent and 13.99 to 20.20 per cent in case of haulm. The NICBR of these amendments was 1:43.38, 1:4.56 and 1:2.12 respectively. The application of mahua cake, cotton cake and FYM @ 1 tonne/ha was found poor in controlling the termites in groundnut. These poor effects also reflected on pod and haulm yield as well as in avoidable losses and NICBR too.

Kharif

The soil application of neem cake, castor cake and vermicompost @ 1 tonne/ha at the time of land preparation before sowing was more effective in suppressing the termites population in groundnut during *kharif* 2012 and produced 2141 to 2411 kg/ha yield of pod and 3693 to 4227 kg/ha haulm. These treatments increased 48.80 to 54.54 per cent pod and 46.62 to 52.99 per cent haulm yield over control, whereas loss in pod was up to 8.00 per cent and in haulm yield it was up to 7.00 per cent. The NICBR of these amendments was 1:5.31, 1:3.09 and 1:4.97, respectively. The treatments of poultry manure, tobacco dust and maize cake @ 1 tonne/ha were moderately effective against termites in groundnut. These treatments gave 1878 to 2019 kg/ha yield of pod and 3384 to 3433 kg/ha haulm. These effective treatments increased 41.64 to 45.72 per cent pod and 41.28 to 42.12 per cent haulm yield over control, whereas loss in pod yield was 16.26 to 22.11 per cent and 18.78 to 19.94 per cent in case of haulm. The NICBR of these amendments was 1: 56.61, 1:5.94 and 1:2.88, respectively. The application of mahua cake, cotton cake and FYM @ 1 tonne/ha was found poor in controlling the termites in groundnut. These poor effects also reflected on pod and haulm yield as well as in avoidable losses and NICBR too.

5.4 Efficacy of insecticides as seed treatments against termites in groundnut

Summer

Of the insecticides tested as seed treatment, the insecticidal seed treatment of fipronil 5 SC @ 5 ml/kg, chlorpyriphos 20 EC @ 4 ml/kg and imidacloprid 600 FS @ 3 ml/kg seed were found highly effective in suppression of the termites population in groundnut during *summer*, 2012. These treatments produced 2207 to 2487 kg/ha yield of pod and 4066 to 4373 kg/ha haulm. These effective treatments increased 50.34 to 55.93 per cent pod and 51.62 to 55.01 per cent haulm yield over control, whereas loss in pod yield was up to 11.26 per cent and up to 7.02 per cent in case of haulm. The NICBR of these insecticides was 1: 87.35, 1: 148.68 and 1: 59.87, respectively. Treatment with bifenthrin 10 EC @ 2ml/kg, imidacloprid 17.8 SL @ 3 ml/kg and quinalphos 25 EC 5 ml/kg seed were moderately effective against termites population. These treatments of harvested 1673 to 2114 kg/ha pod and 3106 to 3700 kg/ha haulm. These treatments increased 34.49 to 45.63 per cent pod and 36.67 to 45.42 per cent haulm yield over control, whereas loss in pod was up to 32.73 per cent and up to 28 per cent in case of haulm. The NICBR of these insecticides was 127.19, 68.44 and 79.86, respectively. Treatments of thiamethoxam 35 FS @ 3 ml/kg, deltamethrin 2.8 EC 2 ml/kg and cypermethrin 25 EC @ 2 ml/kg seed were comparatively less effective in managing the termites population. These poor effects reflected on yield, increase in yield over control and avoidable losses too. NICBR of these insecticides was 1:7.56, 1:51.85 and 1:62.46, respectively. The evaluated insecticides had no adverse effect on seed germination in groundnut.

Kharif

✍.....Summary and Conclusion

Of the insecticides tested as seed treatment, the insecticidal seed treatment of fipronil 5 SC @ 5 ml/kg, chlorpyriphos 20 EC @ 4 ml/kg and imidacloprid 600 FS @ 3 ml/kg and seed were found highly effective in suppression of the termites population in groundnut during *kharif*, 2012. These treatments produced 2207 to 2500 kg/ha pod and 4108 to 44459 kg/ha haulm yield. These effective treatments increased 51.11 to 56.84 per cent pod and 48.22 to 52.30 per cent haulm yield over control, whereas loss in pod was up to 11.72 per cent and up to 7.87 per cent in case of haulm yield. The NICBR of these insecticides were 1:88.92, 1:158.71 and 1:60.46, respectively. Treatments of bifenthrin 10 EC @ 2ml/kg, imidacloprid 17.8 SL @ 3 ml/kg and quinalphos 25 EC 5 ml/kg seed were moderately effective against termites population. These insecticides recorded 1702 to 2081 kg/ha pod and 3455 to 3820 kg/ha haulm yield. These treatments increased 28.23 to 48.15 per cent pod and 38.44 to 48.04 per cent haulm yield over control, whereas avoidable loss in pod was up to 31.92 per cent and up to 22.52 per cent in case of haulm yield. The NICBR of these insecticides was 1:124.47, 1:67.64 and 1:86.90, respectively. Treatments of thiamethoxam 35 FS @ 3 ml/kg, deltamethrin 2.8 EC 2 ml/kg and cypermethrin 25 EC @ 2 ml/kg seed were comparatively less effective in managing the termites population. The poor performance also reflected on yield, increase in yield over control and avoidable losses. However, NICBR of these insecticides was 1:7.78, 1:50.02 and1:74.90, respectively. The evaluated insecticides had no adverse effect on seed germination in groundnut.

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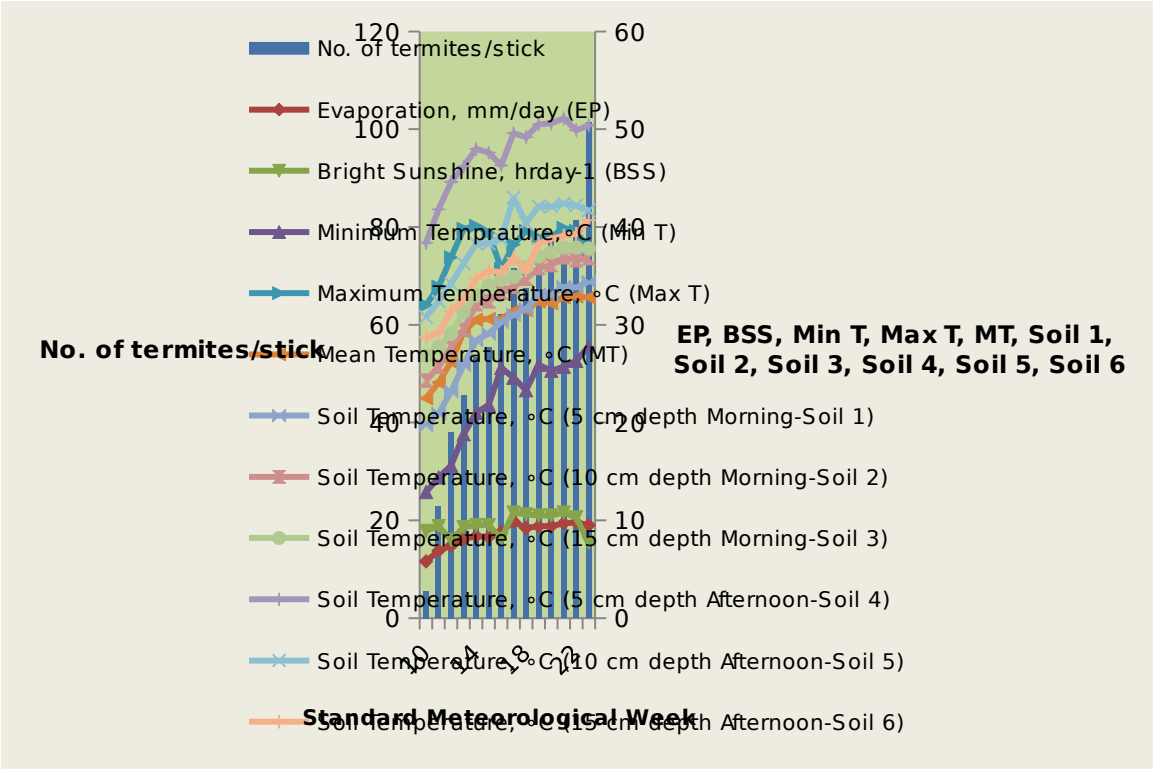


Fig. 1: Positive relationship between termites activity and abiotic factors in *summer* season

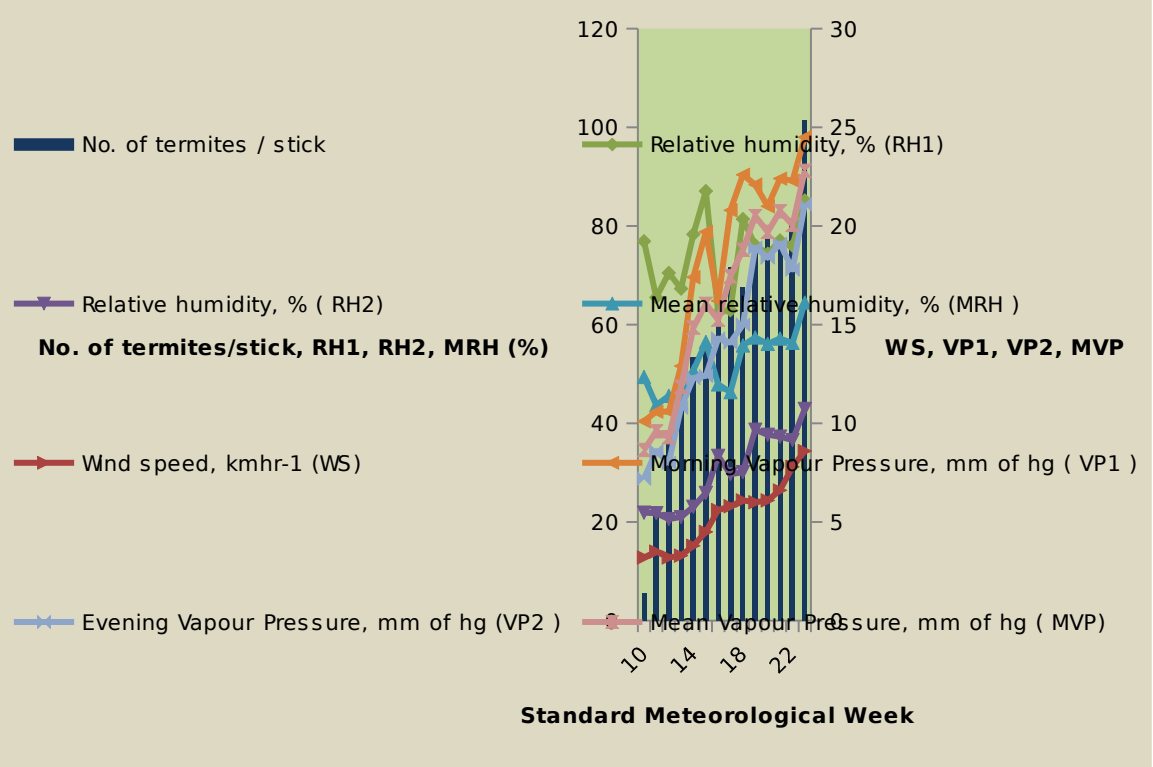


Fig. 2: Negative relationship between termites activity and abiotic factors in *summer* season

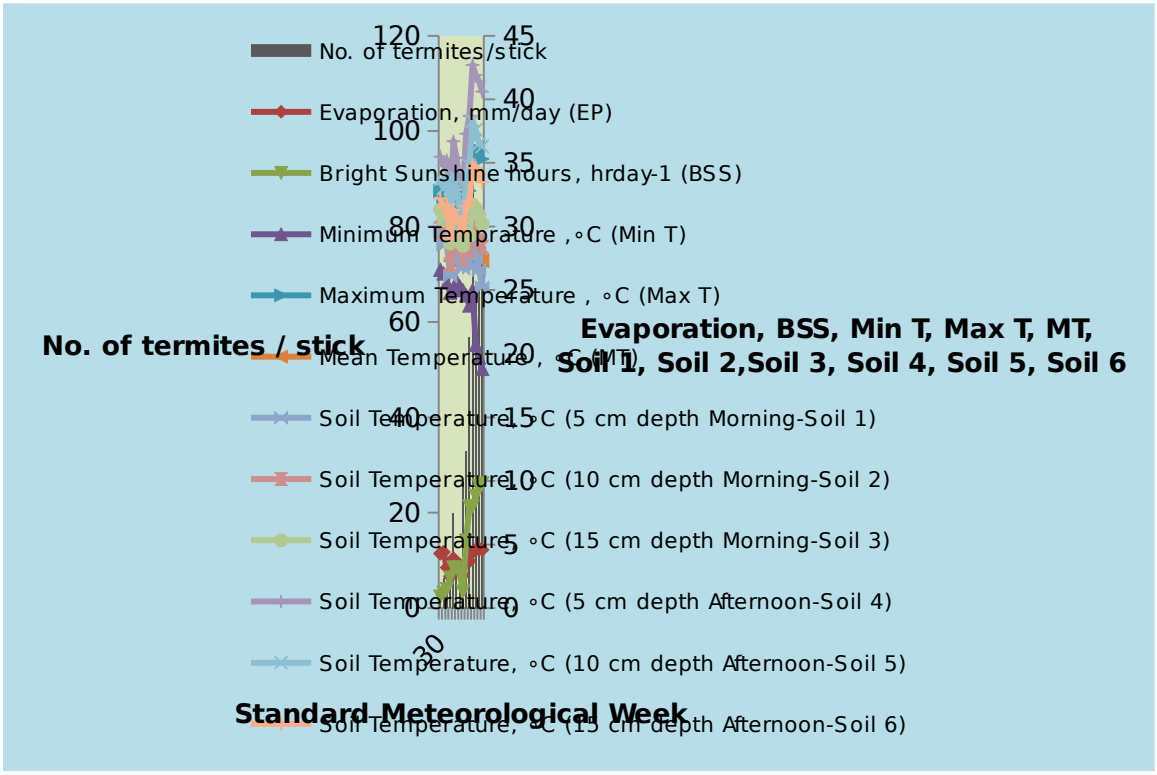


Fig. 3: Positive relationship between population of termites and abiotic factors in *kharif* season

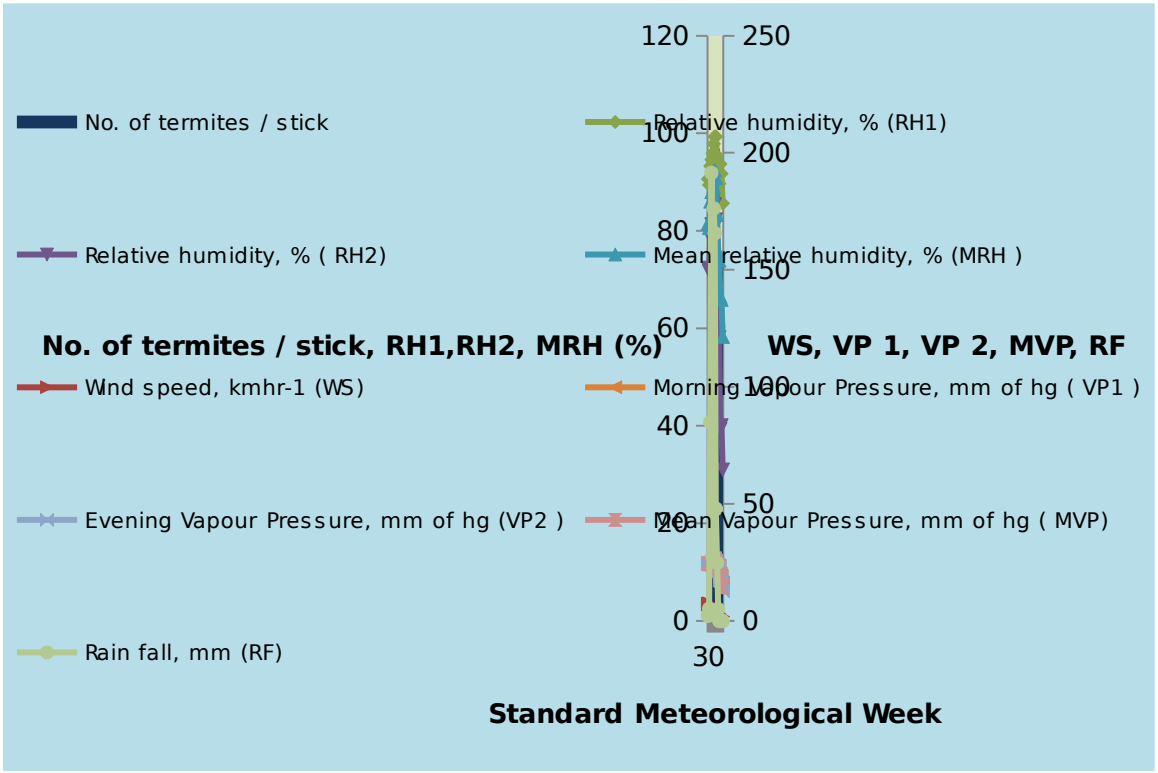
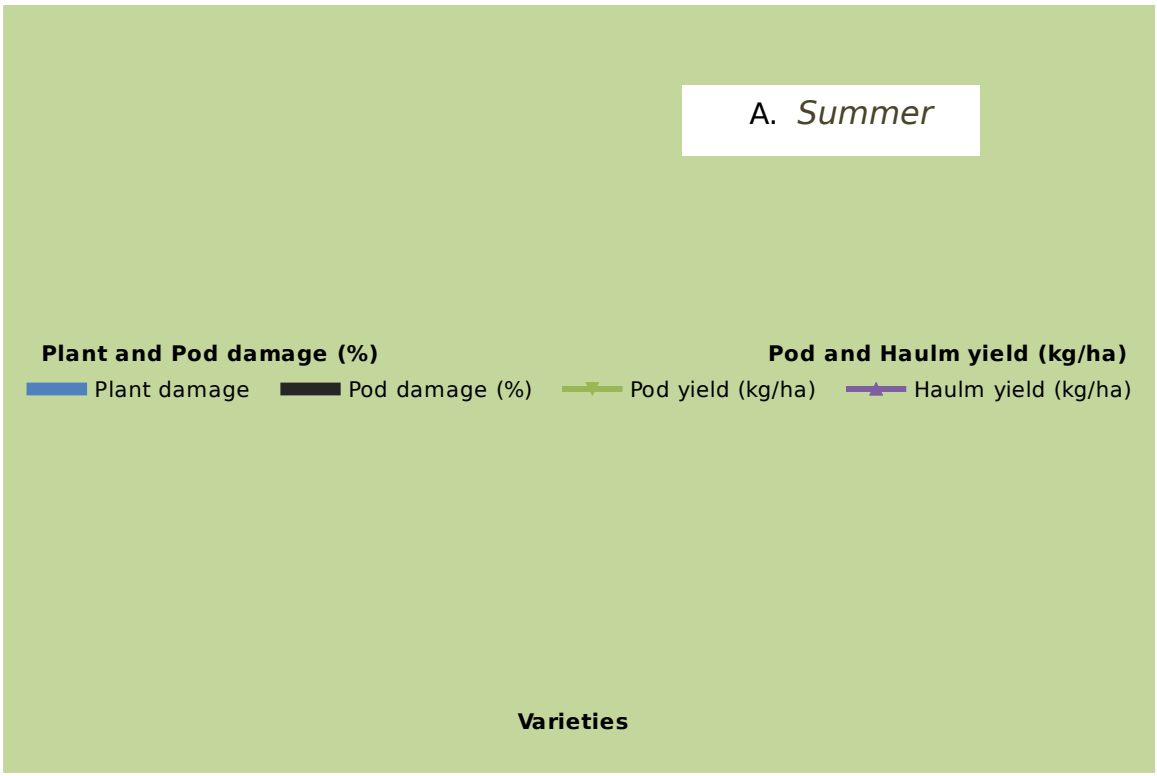


Fig. 4: Negative relationship between population of termites and abiotic factors in *Kharif* season


A. Summer
Plant and Pod damage (%)
Pod and Haulm yield (kg/ha)
Plant damage
Pod damage (%)
Pod yield (kg/ha)
Haulm yield (kg/ha)
Varieties

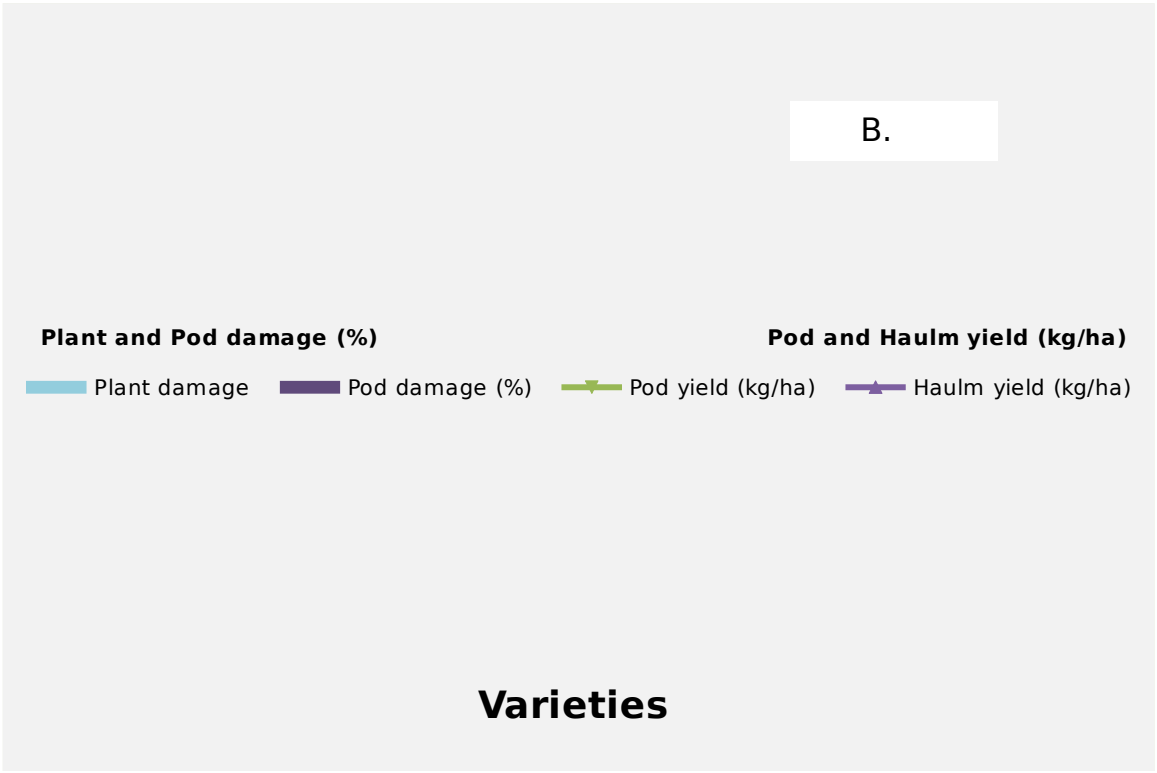
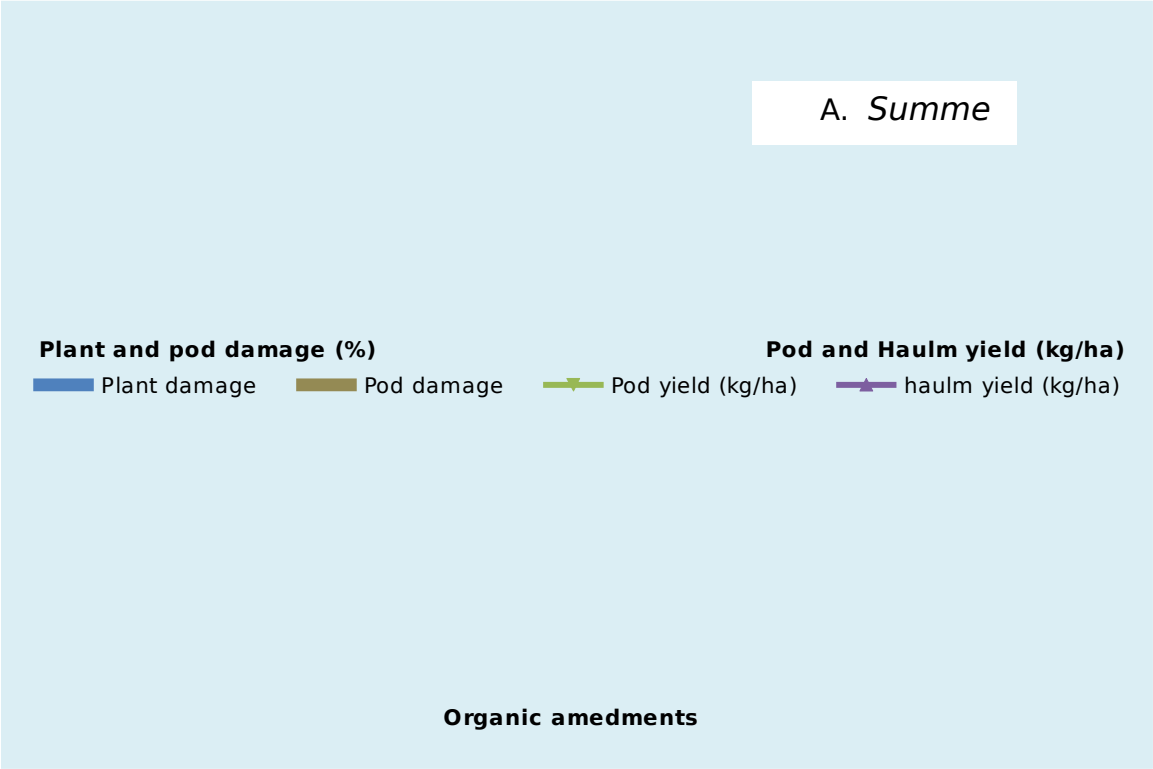

B.
Plant and Pod damage (%)
Pod and Haulm yield (kg/ha)
Plant damage
Pod damage (%)
Pod yield (kg/ha)
Haulm yield (kg/ha)
Varieties

Fig. 5: Susceptibility of groundnut varieties against termites



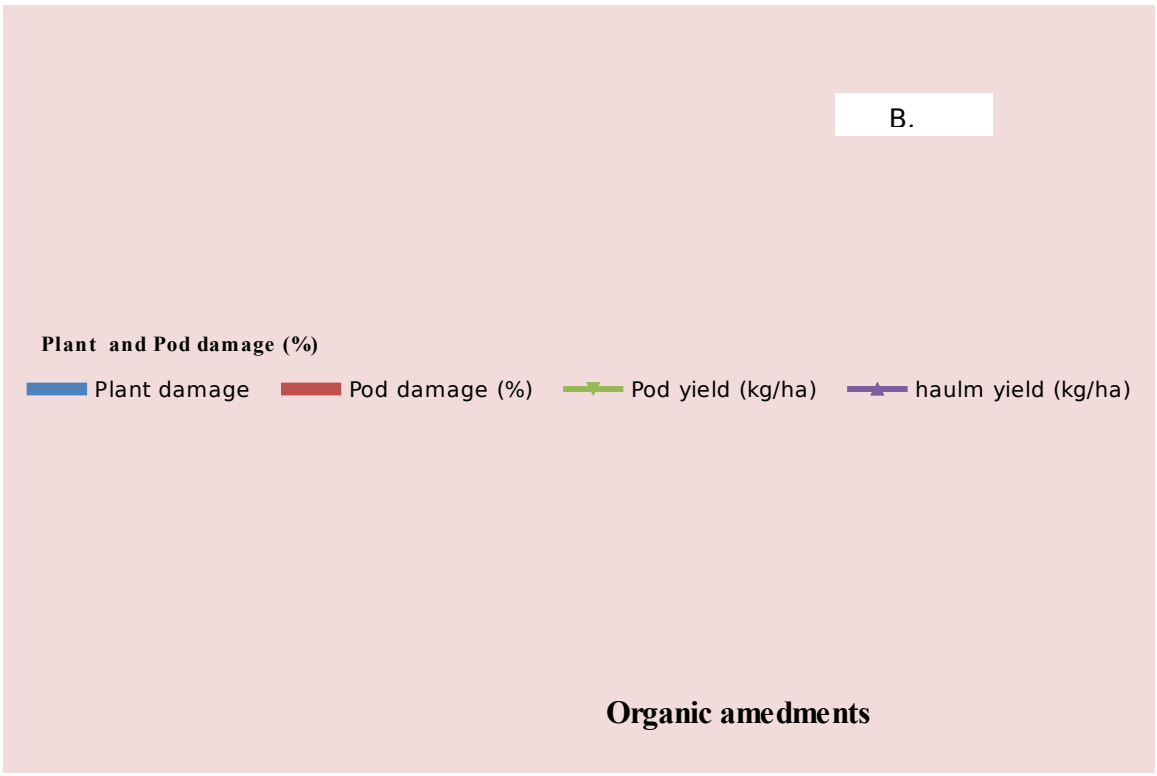
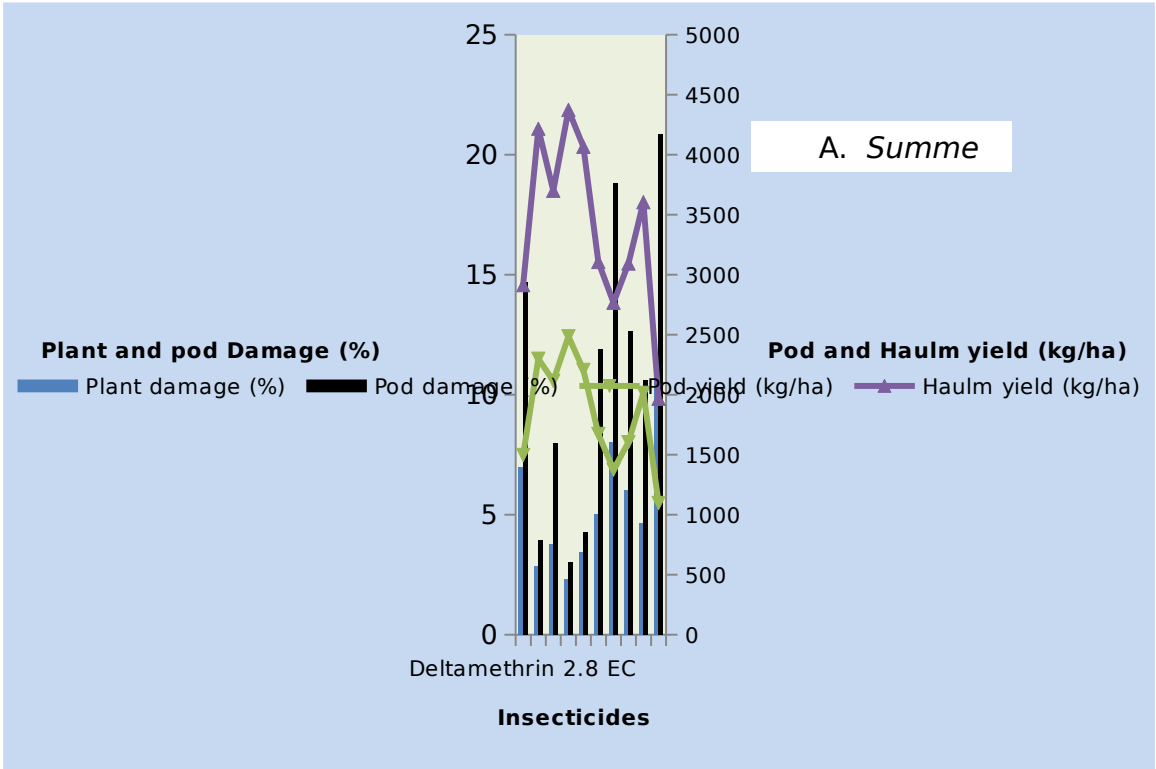


Fig. 6: Effect of organic amendments on termites incidence and yield of groundnut



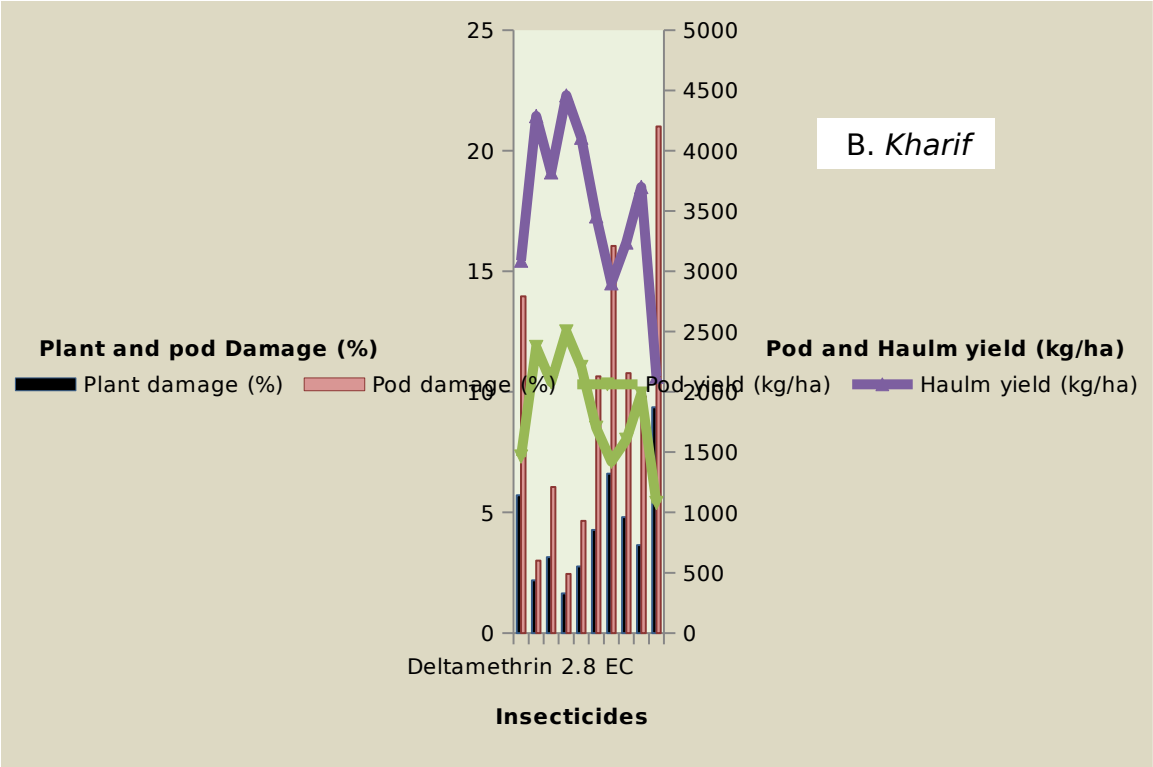


Fig. 7: Effect of insecticidal seed treatments against termites in groundnut

Healthy groundnut plants

Termites

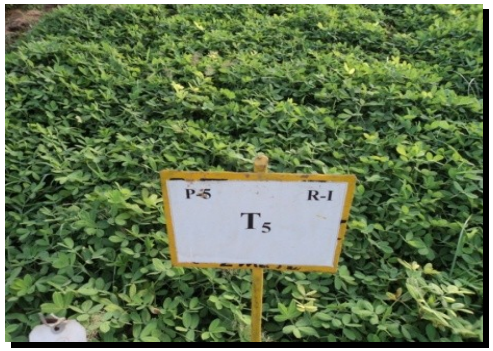
damaged plants

Termites damaged stems

Termites feed on root

Termites damaged pods

Plate II. Damage symptoms due to termites (*Microtermes obesi* and *Odontotermes obesus*) in groundnut



GG-11

TG-26

TG-37

Resistant varieties of groundnut

GG-2

Susceptible variety of groundnut

Plate III. Susceptibility of groundnut varieties against termites

Vermicompost

Neem cake

Castor cake

Organic amendment treated plot

Untreated plot

Plate IV. Groundnut plots with effective organic amendments against termites

Fipronil 5 SC **Chlorpyriphos 20 EC**
Imidacloprid 600 FS

Insecticidal seed treated plots

Untreated plot

Plate VI. Groundnut plots with effective insecticides against termites

Eucalyptus stick at the time of installation **Eucalyptus stick covered with mud gallery**

Termites feed on stick **Stick after termites feeding**

Plate V: Termites on eucalyptus sticks installed in groundnut field