NUTRIENT MANAGEMENT FOR ORGANIC GROUNDNUT UNDER RAINFED CONDITIONS

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B.Sc. (Ag.)

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(AGRONOMY)

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BY

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B.Sc. (Ag.)

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2016

DECLARATION

I, **Ms. G.D. UMADEVI,** hereby declare that the thesis entitled **"NUTRIENT MANAGEMENT FOR ORGANIC GROUNDNUT UNDER RAINFED CONDITIONS"** submitted to the **Acharya N.G. Ranga Agricultural University** for the degree of **Master of Science in Agriculture** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place : TIRUPATI
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CERTIFICATE

Ms. G.D. UMADEVI has satisfactorily prosecuted the course of research and that thesis entitled **"NUTRIENT MANAGEMENT FOR ORGANIC GROUNDNUT UNDER RAINFED CONDITIONS"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

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CERTIFICATE

This is to certify that the thesis entitled **"NUTRIENT MANAGEMENT FOR ORGANIC GROUNDNUT UNDER RAINFED CONDITIONS"** submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE** of the Acharya N.G. Ranga Agricultural University, Guntur is a record of the bonafide original research work carried out by **Ms. G.D. UMADEVI** under our guidance and supervision.

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

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per cent
@	:	At the rate of
₹ ha^{-1}	:	Rupees per hectare
°C	:	Degree Celsius
CD	:	Critical Difference
cm	:	Centimetre
DAS	:	Days After Sowing
dS m^{-1}	:	Decisiemen per metre
EC	:	Electrical Conductivity
et al.	:	and other people
etc.	:	and so on
Fig.	:	Figure
FYM	:	Farm yard manure
g	:	Gram
ha	:	Hectare
i.e.	:	that is
ICAR	:	Indian Council of Agricultural Research
kg ha^{-1}	:	Kilograms per hectare
l	:	Litre
LAI	:	Leaf Area Index
M ha	:	Million hectare
M t	:	Million tonnes
m	:	Metre
mm	:	Millimetre
N	:	Nitrogen
NS	:	Non-Significant
PGPR	:	Plant Growth Promoting Rhizobacteria
pH	:	Negative logarithm of Hydrogen ion concentration

plant^{-1}	:	per plant
PSB	:	Phosphorus Solubilizing Bacteria
PSM	:	Phosphorus Solubilizing Microorganisms
RBD	:	Randomized Block Design
SEm±	:	Standard error of mean
t	:	Tonne
T_{max}	:	Maximum temperature
T_{min}	:	Minimum temperature
VAM	:	Vasicular arbuscular mycorrhiza
viz.,	:	Namely

ABSTRACT

Name of the Author	:	**G.D. UMADEVI**
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A field experiment entitled "Nutrient management for organic groundnut under rainfed conditions" was carried out during *kharif*, 2015 on sandy loam soils of dryland farm of S.V. Agricultural College, Tirupati, Acharya N.G. Ranga Agricultural University. The experiment was laid out in randomized block design with three replications. There were nine treatments *viz*., control (T_1), 100% RDF (20-40-50 kg N, P_2O_5 & K_2O ha^{-1}) (T_2), 100% N through farm yard manure (FYM) (T_3), 100% N through poultry manure (T_4), 100% N through sheep manure (T_5), 100% N through neem cake (T_6), 50% N through FYM + 50% N through poultry manure (T_7), 50% N through FYM + 50% N through sheep manure (T_8), 50% N through FYM + 50% N through neem cake (T_9). The test variety of groundnut was 'Kadiri-6'.

Various organic sources significantly influenced the growth parameters, yield attributes, yield, economic returns and nutrient uptake of groundnut as well as the post-harvest soil fertility status.

Application of 100% recommended dose of nutrients through fertilizers (T_2) resulted in the tallest plants, largest leaf area index and highest dry matter production, which was significantly superior over rest of the nutrient management practices tried. The next best treatment was supply of 100% N through FYM (T_3), which was however on par with 50% N through FYM + 50% N through sheep manure (T_8). Growth characters were found to be at their lowest with control (T_1), without nutrient application.

Total and effective number of nodules plant^{-1} were noticed to be maximum with 50% N through FYM + 50% N through sheep manure (T_8), which was however comparable with 50% N through FYM + 50% N through neem cake (T_9), 100% N through FYM (T_3), 50% N through FYM + 50% N through poultry manure (T_7). The lowest number of total as well as effective nodules were associated with the control (T_1).

Regarding the yield attributes *viz.,* number of pods plant^{-1}, hundred pod and kernel weight and shelling percentage were the highest with application of 100% recommended dose of nutrients through fertilizers (T_2). Among the various organic sources, application of 100% N through FYM (T_3) resulted in improved stature of yield attributes, which was comparable with 50% N through FYM + 50% N through sheep manure (T_8). Non-supply of nutrients in control (T_1) resulted in the deflated stature of all the above yield attributes.

Supply of 100% recommended dose of nutrients through fertilizers (T_2) recorded the highest pod, kernel and haulm yields in groundnut which was distinctly superior over rest of the treatments. Among the various organic sources, 100% N through FYM (T_3) resulted in higher pod, kernel and haulm yields, which was however in parity with 50% N through FYM + 50% N through sheep manure (T_8). The lowest pod, kernel and haulm yields were recorded with control (T_1).

Nitrogen, phosphorus and potassium uptake were the highest with 100% recommended dose of nutrients through fertilizers (T_2). Among the various organic sources tried, supply of 100% N through FYM (T_3) resulted in higher nutrient uptake and it was comparable with 50% N through FYM + 50% N through sheep manure (T_8). The lowest uptake of nutrient was registered with control (T_1).

The highest post-harvest soil available nitrogen and potassium status was recorded with 100% N through neem cake (T_6), which was however comparable with 100% N through sheep manure (T_5) and poultry manure (T_4). Post-harvest soil available phosphorus status was noticed to be higher with 100% N through poultry manure (T_4), which was however comparable with 100% N through sheep manure (T_5) and neem cake (T_6). The post-harvest soil nutrient status was lower with 100% recommended dose of nutrients through fertilizers (T_2) compared to various organic sources.

The highest gross returns, net returns and benefit cost ratio were realized with 100% recommended dose of nutrients through fertilizers (T_2). Among the various organic sources tried, application 100% N through FYM (T_3) and 50% N through FYM + 50% N through sheep manure (T_8) recorded higher gross returns, net returns and benefit cost ratio which were statistically on par with each other. The lowest economic returns were obtained with 100% N through neem cake (T_6).

In conclusion, the investigation revealed that higher pod yield of groundnut as well as economic returns could be realized with 100% recommended dose of nutrients through fertilizers. Among the various organic sources tried, 100% N through FYM as well as 50% N through FYM + 50% N through sheep manure were proved to be promising organic manurial practices for higher yield and economics of groundnut along with maintenance of soil fertility under rainfed conditions in the present domain of study. However, the economic returns under organic approach could be enhanced with premium price for the organic produce in the market after certification.

Chapter ~ I

Introduction

Chapter I

INTRODUCTION

Groundnut being a premier oil seed crop is also an important food legume and known to be a wonder nut. India is the leader in groundnut farming with 4.19 million hectares of area, 6.68 million tonnes of production and a productivity of 1591 kg ha^{-1} (DGR, 2014-15). Andhra Pradesh shares about an area of 15.5 lakh hectares, 8.8 lakh tonnes of production and 749 kg ha^{-1} productivity (Plant Doctors Diary, 2015).

Groundnut is an exhaustive crop and removes large quantities of nutrients from the soil which cannot be met by single nutrient source. For every one tonne of pods and two tonnes of haulms, it removes about 63 kg N, 11 kg P_2O_5, 46 kg K_2O, 27 kg Ca and 14 kg Mg ha^{-1}. Groundnut depletes the soil nutrients rapidly unless the crop is adequately manured (Nair *et al*, 1982). Though being an oil and protein rich crop, it is mostly grown under energy starved conditions of low soil fertility and rainfed situations. Therefore higher yields of groundnut with sustained production could be obtained with better fertility management practices especially with organic farming approach.

The escalating cost of fertilizers with recent energy crises on the one hand and their deleterious affect on soil health and productivity on the other is necessitating for a fresh look towards the exploitation of various locally available organic sources. With increasing degree of consumer's health concern, organically grown food is fetching premium prices in domestic as well as export market.

Organic agriculture is a holistic food production management system, which promotes and ensures biodiversity and soil biological activity by giving preference to the use of on-farm inputs, which are highly adapted to the production system. It is gaining impetus in recent years due to the realization of inherent advantages in sustaining crop production along with maintenance of soil nutrient status. The holistic analysis showed that the protein (29.6 g/100 g), fat (48 g/100 g) and iron (2.6 mg/100 g) content of organic groundnut were higher compared with their conventional counter parts (Venkatasubramanian, 2011). Use of farmyard manure with other organic amendments like vermicompost, neem cake, poultry manure etc, provide an economic and environment friendly way of applying nutrients to groundnut (Prasad, 2005).

Although many attempts have been made to study the effect of fertilizers on groundnut crop, the information on response of groundnut to various organic sources of nutrients is meager. Keeping these in view, the present experiment entitled "Nutrient management for organic groundnut under rainfed conditions" was conducted during *kharif*, 2015 with the following objectives

1. To study the effect of different organic sources on growth, yield and quality of groundnut
2. To evaluate the effect of combined application of various organic sources on the performance of groundnut
3. To formulate the best organic manurial practice for groundnut with sustenance of soil fertility

Chapter ~ II

Review of Literature

Chapter II

REVIEW OF LITERATURE

The literature related to the present study **"Nutrient management for organic groundnut under rainfed conditions"** is reviewed in this chapter.

2.1 EFFECT OF ORGANIC SOURCES ON GROWTH PARAMETERS OF GROUNDNUT

2.1.1 Plant Height

The highest plant height was recorded with supply of sheep manure @ 6 t ha^{-1}, which was significantly superior to the other lower levels tried (Khaleel, 2004).

Panwar and Munda (2007) revealed that application of pig manure @ 10 t ha^{-1} resulted in taller plant stature of groundnut than control on sandy loam soils of Meghalaya.

The highest plant height of groundnut noticed with application of FYM @ 6 t ha^{-1} was comparable with vermicompost @ 2 t ha^{-1} or castor cake @ 1 t ha^{-1} or 100% recommended dose of nutrients @ 12.5-25-0 kg N, P_2O_5 and K_2O ha^{-1} through fertilizers during *kharif* season on clay soils of Junagadh, Gujarat (Zalate and Padmani, 2009b).

Singh *et al.* (2011) noticed significant increase in plant height of groundnut with the application of FYM @ 10 t ha^{-1} compared to control.

Kumar *et al*. (2012) envisaged that application of FYM @ 7.5 t ha^{-1} + *Rhizobium* and PSB (each @10 kg ha^{-1}) + Panchagavya spray (3% at 30, 60 and 70 DAS) conspicuously increased the plant height of groundnut over FYM alone.

Patra and Sinha (2012) reported that combined application of poultry manure, neem cake, vermicompost and phosphocompost each @ 2.5 t ha^{-1} produced the tallest plants compared to their sole application or chemical fertilizer alone during both the years of study.

Application of FYM @ 5 t ha^{-1} resulted in taller plants in groundnut than unmanured crop (Rahevar *et al*., 2015).

2.1.2 Leaf Area Index

Khaleel (2004) reported that application of sheep manure @ 6 t ha^{-1} produced significantly higher LAI than unmanured treatment in groundnut.

Experiment conducted in farmer's field at Chinthamani, Karnataka revealed that application of FYM @ 7.5 t ha^{-1} + *Rhizobium* and PSB (each @ 10 kg ha^{-1}) + Panchagavya spray (3% at 30, 60 and 70 DAS) recorded significantly higher leaf area index in groundnut over FYM alone (Kumar *et al*., 2012).

Combined application of poultry manure, neem cake, vermicompost and phosphocompost each @ 2.5 t ha^{-1} produced higher leaf area index of groundnut than sole application of each of these organic sources @ 5 t ha^{-1}, whereas comparable with 100% recommended dose of nutrients (20-60-60 kg N, P_2O_5 & K_2O ha^{-1}) supplied through fertilizers (Patra and Sinha, 2014).

2.1.3 Dry Matter Production

Devi *et al.* (2003) reported that application of farm yard manure @ 8 t ha^{-1} or neem cake @ 0.7 t ha^{-1} resulted in higher dry matter production compared to poultry manure @ 8 t ha^{-1}.

Application of sheep manure @ 6 t ha^{-1} recorded significantly higher dry matter production in groundnut than non application of sheep manure (Khaleel, 2004).

Application of farm yard manure @ 10 t ha^{-1} recorded higher dry matter accumulation $plant^{-1}$ compared to FYM @ 5 t ha^{-1} in the clay soils of Navsari, Gujarat (Kausale *et al*., 2009).

Seran and Suthamathy (2013) noticed that the application of cattle manure @ 15 t ha^{-1} along with effective microorganisms through soil application had markedly produced higher dry matter accumulation of groundnut over control.

Combined application of poultry manure, neem cake, vermicompost and phosphocompost each @ 2.5 t ha^{-1} produced higher drymatter accumulation of groundnut than sole application of each of these organic sources @ 5 t ha^{-1}, whereas comparable with 100% recommended dose of nutrients (20-60-60 kg N, P_2O_5 and K_2O ha^{-1}) supplied through fertilizers (Patra and Sinha, 2014).

Rahevar *et al*. (2015) observed that application of FYM @ 5 t ha^{-1} resulted in significantly higher dry matter production than no FYM.

2.1.4 Number of Total and Effective Nodules $Plant^{-1}$

Application of FYM @ 10 t ha^{-1} significantly enhanced the number of root nodules $plant^{-1}$ in the clay soils of Navsari, Gujarat (Kausale *et al*., 2009).

Zalate and Padmani (2009b) reported that the number of nodules $plant^{-1}$ of groundnut recorded with application of FYM @ 6 t ha^{-1} was comparable with vermicompost @ 2 t ha^{-1} or castor cake @ 1 t ha^{-1} or 100% recommended dose of nutrients @ 12.5-25-0 kg N, P_2O_5 and K_2O ha^{-1} through fertilizers during *kharif* season on clay soils of Junagadh, Gujarat.

Gunri and Nath (2012) revealed that the number of nodules $plant^{-1}$ of groundnut registered with application of FYM @ 10 t ha^{-1} was comparable with poultry manure @ 5 t ha^{-1} as well as with recommended dose of nutrients @ 20-60-40 kg N, P_2O_5 and K_2O ha^{-1}.

2.2 EFFECT OF ORGANIC SOURCES ON YIELD ATTRIBUTES OF GROUNDNUT

2.2.1 Number of Pods Plant^{-1}

Devi *et al*. (2003) observed that number of pods plant^{-1} produced with poultry manure @ 8 t ha^{-1} was in parity with neem cake @ 0.7 t ha^{-1}, however both were significantly lower than recommended dose of nutrients (40-50-50 kg N, P_2O_5 and K_2O ha^{-1}).

Khaleel (2004) found that application of sheep manure @ 6 t ha^{-1} produced the highest number of filled pods plant^{-1} than unmanured crop.

Laxminarayana and Patiram (2005) reported that application of FYM @ 15 t ha^{-1} or poultry manure @ 5 t ha^{-1} produced comparable number of pods plant^{-1} with 100% RDF @ 40-26-30 kg NPK ha^{-1}.

Zalate and Padmani (2009b) observed that the number of pods plant^{-1} of groundnut increased with application of FYM @ 6 t ha^{-1}, which was however comparable with vermicompost @ 2 t or castor cake @ 1 t ha^{-1} or 100% recommended dose of nutrients @ 12.5-25-0 kg N, P_2O_5 and K_2O ha^{-1} through fertilizers during *kharif* season on clay soils of Junagadh, Gujarat.

Singh *et al.* (2011) noticed that the application of lime @ 500 kg ha^{-1} + FYM @ 10 t ha^{-1} and recommended dose of fertilizers (20-60-40 kg N, P_2O_5 and K_2O ha^{-1}) recorded the highest number of pods plant^{-1}.

Gunri and Nath (2012) observed higher number of pods plant^{-1} in groundnut with application of FYM @ 10 t ha^{-1} + Biofertilizers (*Rhizobium*, PSB and PGPR) than application of FYM alone @ 10 t ha^{-1}.

Kumar *et al.* (2012) envisaged that application of FYM @ 7.5 t ha^{-1} + *Rhizobium* and PSB (each 10 @ kg ha^{-1}) + Panchagavya spray (3% at 30, 60 and 70 DAS) conspicuously recorded the highest number of pods plant^{-1} in groundnut.

Patra and Sinha (2012) reported that combined application of poultry manure, neem cake, vermicompost and phosphocompost each @ 2.5 t ha^{-1} produced significantly the highest number of pods $plant^{-1}$ in groundnut compared to their single or chemical fertilizer alone during both the years of study.

Seran and Suthamathy (2013) reported that application of cattle manure @ 15 t ha^{-1} along with effective microorganisms through soil application had markedly produced higher number of pods $plant^{-1}$ in groundnut over control.

2.2.2 Hundred Pod Weight

Devi *et al*. (2003) observed higher hundred pod weight in groundnut with application of vermicompost @ 4 t ha^{-1}, which was however comparable with application of neem cake @ 0.7 t ha^{-1}.

2.2.3 Hundred Kernel Weight

Groundnut crop supplied with sheep manure @ 6 t ha^{-1} recorded the highest hundred kernel weight, which was significantly superior to all other lower levels tried (Khaleel, 2004).

Reddy *et al.* (2005) revealed that the application of recommended dose of nitrogen @ 25 kg ha^{-1} through composted poultry manure recorded significantly higher hundred kernel weight than control.

2.2.4 Shelling Percentage

Application of sheep manure @ 6 t ha^{-1} recorded higher shelling percentage in groundnut compared to lower levels tried (Khaleel, 2004).

Application of FYM @ 7.5 t ha^{-1} + *Rhizobium* and PSB (each @ 10 kg ha^{-1}) + Panchagavya spray (3% at 30, 60 and 70 DAS) recorded higher shelling percentage in groundnut than FYM alone (Kumar *et al*., 2012).

Kumar *et al*. (2013) reported that application of enriched FYM @ 7.5 t ha^{-1} + seed treatment with PSB and foliar spray of 5% NSKE resulted in the highest shelling percentage in groundnut.

Seran and Suthamathy (2013) stated that application of cattle manure @ 15 t ha^{-1} along with effective microorganisms through soil application recorded higher shelling percentage of groundnut compared to no manure.

2.3 EFFECT OF ORGANIC SOURCES ON POD AND HAULM YIELDS OF GROUNDNUT

2.3.1 Pod Yield

Higher pod yield was obtained with the application of FYM @ 12.5 t ha^{-1} than no FYM (Balasubramaniyan, 1997).

Dosani *et al.* (1999) observed increase in pod yield in groundnut with the application of poultry manure @ 3 t ha^{-1} over control.

Subrahmaniyan *et al.* (1999) revealed that the application of 50 per cent RDF + crop residue (groundnut haulms) @ 10 t ha^{-1} recorded significantly higher pod yield over the farmer's practice (DAP @ 125 kg ha^{-1}).

Malligawad *et al.* (2000) stated that application of FYM @ 4 t ha^{-1} + 50 per cent RDF (12.5- 30-12.5 kg N, P_2O_5 K_2O ha^{-1}) recorded significantly higher dry pod yield (3232 kg ha^{-1}) of groundnut compared to 100 per cent RDF alone.

Combined application of FYM @ 20 t ha^{-1} + 100 per cent RDF along with *Azotobacter* and *Pseudomonas striata* resulted in 48 per cent higher pod yield in groundnut over control (Kachot *et al.,* 2001).

Dikshit and Khatik (2002) found that the application of compost @ 10 t ha^{-1} recorded higher seed yield of soybean compared to control.

Devi *et al*. (2003) reported that application of neem cake @ 0.7 t ha^{-1} recorded significantly higher pod yield (2702 kg ha^{-1}) of groundnut than control.

Application of sheep manure @ 6 t ha^{-1} resulted in 43 per cent higher pod yield over no sheep manure (Khaleel, 2004).

Laxminarayana and Patiram (2005) stated that application of FYM @ 15 t ha^{-1} produced higher pod yield in groundnut than application of either poultry manure or pig manure alone @ 5 t ha^{-1}.

Application of FYM @ 10 t ha^{-1} as well as poultry manure @ 5 t ha^{-1} recorded comparable pod yields of groundnut on sandy clay loam soils of Udaipur, Rajasthan (Rao and Shaktawat, 2005).

Reddy *et al.* (2005) revealed that application of composted poultry manure resulted in significantly higher pod yield of groundnut over the control.

Solanki *et al*. (2006) reported that application of FYM @ 10 t ha^{-1} recorded significantly higher pod yield of groundnut over 100 per cent recommended dose of fertilizer @ 12.5-25-0 kg NPK ha^{-1}.

Panwar and Munda (2007) revealed that application of FYM @ 10 t ha^{-1} resulted in significantly higher pod yield of groundnut on sandy loam soils of Meghalaya.

Kausale *et al.* (2009) obtained the highest pod yield of groundnut with application of FYM @ 10 t ha^{-1}.

The pod yield of groundnut recorded with application of FYM @ 6 t ha^{-1} was comparable with vermicompost @ 2 t ha^{-1} or castor cake @ 1 t ha^{-1} or 100% recommended dose of nutrients @ 12.5-25-0 kg N, P_2O_5 and K_2O ha^{-1} through fertilizers during *kharif* season on clay soils of Junagadh, Gujarat (Zalate and Padmani, 2009b).

Choudhary *et al.* (2011) revealed that application of vermicompost and poultry manure each @ 1.25 t ha^{-1} + biofertilizers (*Rhizobium* + VAM + PSB) recorded significantly higher pod yield of groundnut than application of either manures or fertilizers alone.

Singh *et al.* (2011) opined that application of FYM @ 10 t ha^{-1} produced higher pod yield of groundnut over control.

Gunri and Nath (2012) revealed that application of FYM @ 10 t ha^{-1} + poultry manure @ 5 t ha^{-1} along with bio pesticides recorded significantly higher pod yield of groundnut than sole application of FYM or poultry manure or recommended dose of fertilizers.

Experiment conducted in farmer's field at Chinthamani, Karnataka revealed that application of FYM @ 7.5 t ha^{-1} + *Rhizobium* and PSB (each @ 10 kg ha^{-1}) + Panchagavya spray (3% at 30, 60 and 70 DAS) recorded significantly higher pod yield of groundnut over FYM alone (Kumar *et al.*, 2012).

Combined application of poultry manure, neem cake, vermicompost and phosphocompost each @ 2.5 t ha^{-1} produced higher pod yield of groundnut than application of each of these organic sources @ 5 t ha^{-1} alone, which was comparable with 100% recommended dose of nutrients (20-60-60 kg N, P_2O_5 and K_2O ha^{-1}) supplied through fertilizers (Patra and Sinha, 2012).

Kumar *et al*. (2013) reported that application of enriched FYM @ 7.5 t ha^{-1} + seed treatment with PSB and foliar spray of 5% neem seed kernel extract recorded the highest pod yield of groundnut among the different organic sources tried.

Seran and Suthamathy (2013) stated that application of cattle manure @ 15 t ha^{-1} along with soil application of effective microorganisms markedly improved the pod yield of groundnut over control.

Datta *et al*. (2014) found that application of FYM @ 10 t ha^{-1} recorded 67 per cent higher pod yield of groundnut over the control.

Mukhtar *et al*. (2014) reported that application of poultry manure @ 2 t ha^{-1} resulted in significantly higher pod yield in groundnut compared to control.

Application of FYM @ 2.5 t ha^{-1} recorded significantly higher pod yield of groundnut over the recommended dose of fertilizer 12.5-25-0 kg N, P_2O_5 and K_2O ha^{-1} (Mathukia *et al*., 2015).

Rahevar *et al*. (2015) observed that application of FYM @ 5 t ha^{-1} resulted in higher pod yield of groundnut than no FYM.

Jeyamangalam and Franciya (2016) opined that combined application of FYM + tank silt (1:1) @ 12.5 t ha^{-1} recorded higher pod yield (4300 kg ha^{-1}) of groundnut over control.

2.3.2 Haulm Yield

Higher haulm yield was obtained with the application of FYM @ 12.5 t ha^{-1} than no FYM (Balasubramaniyan, 1997).

Application of poultry manure @ 3 t ha^{-1} recorded significantly higher haulm yield in groundnut over control (Dosani *et al*., 1999).

Application of sheep manure @ 6 t ha^{-1} recorded significantly higher haulm yield than rest of the manurial levels tried (khaleel, 2004).

Laxminarayana and Patiram (2005) observed that application of pig manure @ 5 t ha^{-1} recorded comparable haulm yield with FYM @ 15 t ha^{-1}, however both were superior to control.

Application of recommended dose of nitrogen @ 25 kg N ha^{-1} through composted poultry manure markedly improved the haulm yield of groundnut compared to farm yard manure (Reddy *et al*., 2005).

Application of FYM @ 10 t ha^{-1} resulted in significantly higher haulm yield of groundnut over control on sandy loam soils at Meghalaya (Panwar and Munda, 2007).

Zalate and Padmani (2009b) envisaged that the haulm yield recorded with application of FYM @ 6 t ha^{-1} was comparable with vermicompost @ 2 t ha^{-1} or castor cake @ 1 t ha^{-1} or 100% recommended dose of nutrients @ 12.5-25-0 kg N, P_2O_5 and K_2O ha^{-1} through fertilizers during *kharif* season on clay soils of Junagadh, Gujarat.

Choudhary *et al.* (2011) revealed that application of vermicompost and poultry manure each @ 1.25 t ha^{-1} + biofertilizers (*Rhizobium* + VAM + PSB) conspicuously increased the haulm yield of groundnut than sole application of manures or fertilizers.

Application of FYM @ 10 t ha^{-1} produced higher haulm yield of groundnut over control (Singh *et al.* 2011).

Gunri and Nath (2012) revealed that application of FYM @ 10 t ha^{-1} + poultry manure @ 5 t ha^{-1} along with bio pesticide application considerably enhanced the haulm yield of groundnut than sole application of FYM or poultry manure or recommended dose of fertilizers.

Kumar *et al*. (2012) envisaged that application of FYM @ 7.5 t ha^{-1} + *Rhizobium* and PSB (10 kg each ha^{-1}) + Panchagavya spray (3% at 30, 60 and 70 DAS) recorded the highest haulm yield of groundnut.

Combined application of poultry manure, neem cake, vermicompost and phosphocompost each @ 2.5 t ha^{-1} produced higher haulm yield of groundnut than application of each of these organic sources alone @ 5 t ha^{-1}, however which was comparable with 100% recommended dose of nutrients (20-60-60 kg N, P_2O_5 & K_2O ha^{-1}) supplied through fertilizers (Patra and Sinha, 2012).

2.3.3 Kernel Yield

Application of vermicompost @ 1.25 t ha^{-1} + poultry manure @ 1.25 t ha^{-1} along with bio fertilizers (*Rhizobium* + VAM + PSB) resulted in higher kernel yield of groundnut than sole application of manures or fertilizers (Choudhary *et al*., 2011).

Gunri and Nath (2012) revealed that application of FYM @ 10 t ha^{-1} + poultry manure @ 5 t ha^{-1} + bio pesticide (neem cake 500 kg ha^{-1} + trichoderma seed treatment @ 5 g kg^{-1} of seed + foliar application of 2% NSKE) resulted in conspicuous increase in kernel yield of groundnut than sole application of FYM or poultry manure or recommended dose of fertilizers.

Experiment conducted in farmer's field at Chinthamani, Karnataka revealed that application of FYM @ 7.5 t ha^{-1} + *Rhizobium* and PSB (each @ 10 kg ha^{-1}) + Panchagavya spray (3% at 30, 60 and 70 DAS) produced higher kernel yield of groundnut than FYM alone (Kumar *et al*., 2012).

Seran and Suthamathy (2013) noticed that application of cattle manure @ 15 t ha^{-1} along with soil application effective microorganisms markedly produced higher kernel yield of groundnut than control.

2.4 EFFECT OF ORGANIC SOURCES ON QUALITY OF GROUNDNUT

2.4.1 Oil Content

Dosani *et al.* (1999) observed marked increase in oil content in groundnut with application of poultry manure @ 3 t ha^{-1} over control.

Application of graded levels sheep manure failed to exert significant influence on the oil content in groundnut (Khaleel, 2004).

Reddy *et al.* (2005) revealed that application of composted poultry manure resulted in significantly higher oil yield of groundnut over the control.

Solanki *et al.* (2006) obtained higher oil content in groundnut with application of FYM @ 10 t ha^{-1} compared to control.

Panwar and Munda (2007) reported that oil content in groundnut was not significantly influenced by the application of various organic sources and fertilizers.

2.4.2 Protein Content

Dosani *et al.* (1999) observed conspicuous increase in protein content in groundnut with application of poultry manure @ 3 t ha^{-1} than non application of poultry manure.

Application of composted poultry manure recorded significantly higher protein yield in groundnut over control (Reddy *et al.*, 2005).

2.5 EFFECT OF ORGANIC SOURCES ON UPTAKE OF NUTRIENTS BY GROUNDNUT

Balasubramaniyan (1997) recorded significantly higher nutrient (NPK) uptake in groundnut with application of FYM @ 12.5 t ha^{-1} compared to non supply of FYM.

Dosani *et al.* (1999) observed increase in uptake of N, P and K with application of poultry manure @ 3 t ha^{-1} than control.

Kachot *et al.* (2001) revealed that N, P and K content in groundnut were significantly higher with application of FYM @ 20 t ha^{-1} compared to control.

Dikshit and Khatik (2002) found that application of compost @ 10 t ha^{-1} recorded increased uptake of N and P in soybean over control.

Devi *et al.* (2003) reported that application of neem cake @ 0.7 t ha^{-1} resulted in significantly higher the N, P and K uptake by pods and haulms at harvest over control.

Reddy *et al.* (2004) revealed that supply of N through composted poultry manure on equal N basis resulted in significantly higher nitrogen uptake than FYM alone.

The highest N, P and K uptake in pod and haulms in groundnut was noticed with application of FYM @ 15 t ha^{-1} followed by pig manure @ 5 t ha^{-1} (Laxminarayana and Patiram, 2005).

Rao and Shaktawat (2005) envisaged that application of FYM @ 10 t ha^{-1} and poultry manure @ 5 t ha^{-1} brought significant improvement in total uptake of nutrients.

Panwar and Munda (2007) reported that application of FYM @ 10 t ha^{-1} resulted in increased uptake of N, P and K over control in sandy loam soils at Meghalaya.

Application of FYM @ 6 t ha^{-1} along with seed treatment of *rhizobium* and PSM increased the N, P and K uptake than control (Zalate and Padmani, 2009a).

Application of vermicompost @ 0.625 t ha^{-1} resulted in improved nitrogen and potassium uptake by groundnut compared to recommended dose of fertilizer *i.e.* 12.5-25-0 kg N, P_2O_5 and K_2O ha^{-1} (Mathukia *et al*., 2015).

2.6 EFFECT OF ORGANIC SOURCES ON SOIL FERTILITY STATUS

Kachot *et al.* (2001) revealed that available N, P and K in soil after harvest of groundnut were significantly increased with application of FYM @ 20 t ha^{-1} over control.

Dikshit and Khatik (2002) found that application of compost @ 10 t ha^{-1} enhanced the available nitrogen in soil over control.

Khaleel (2004) observed the highest post-harvest available nitrogen, phosphorus and potassium in soil with application of 6 t ha^{-1} of sheep manure in groundnut.

Laxminarayana and Patiram (2005) found increase in soil organic carbon, available nitrogen and total nitrogen status in the soil with application of different organic manures.

Rao and Shaktawat (2005) reported that application of FYM @ 10 t ha^{-1} and poultry manure @ 5 t ha^{-1} brought significant improvement in available nitrogen in the soil after harvest of groundnut over control.

Solanki *et al*. (2006) noticed significant increase in the available N, P and K with application of FYM @ 10 t ha^{-1} as compared to 100 per cent recommended dose of nutrients @ 12.5-25-0 kg NPK ha^{-1} through fertilizers.

The available N, P and K were maximum with application of lime @ 500 kg ha^{-1} + FYM @ 10 t ha^{-1} and 50% NPK compared to control (Singh *et al*., 2011).

Mathukia *et al*. (2015) envisaged that application of FYM @ 2.5 t ha^{-1} improved the available nutrient status of the soil after harvest of groundnut.

The maximum nitrogen availability was found in FYM + tanksilt (1:1) @ 7.5 t ha^{-1} applied to soil over control (Jeyamangalam and Franciya, 2016).

2.7 EFFECT OF ORGANIC SOURCES ON ECONOMICS OF GROUNDNUT

The highest net returns and benefit - cost ratio was recorded with application sheep manure @ 6 t ha^{-1}, which was significantly higher than any other lower level of manure tried (Khaleel. 2004).

Reddy *et al.* (2005) realized higher net returns and benefit cost ratio with application of composted poultry manure in groundnut.

Application of FYM @ 6 t ha^{-1} along with *Rhizobium* + PSM recorded significantly higher B:C ratio than the rest of the organic sources tried (Zalate and Padmani, 2009a).

Kumar *et al*. (2012) envisaged that application of FYM @ 7.5 t ha^{-1} + *Rhizobium* and PSB (each @ 10 kg ha^{-1}) + Panchagavya spray (3% at 30, 60 and 70 DAS) resulted in higher net returns and B:C ratio in groundnut.

Maximum net returns and B:C ratio were obtained with application of FYM @ 2.5 t ha^{-1} compared to recommended dose of fertilizer *i.e.* 12.5-25-0 kg N, P_2O_5 and K_2O ha^{-1} (Mathukia *et al*., 2015).

Chapter ~ III

Material and Methods

Chapter III

MATERIAL AND METHODS

The experiment entitled **"Nutrient management for organic groundnut under rainfed conditions"** was conducted during *kharif*, 2015. The material used and the methods employed during the course of investigation are presented in this chapter.

3.1 LOCATION OF THE EXPERIMENTAL SITE

The field experiment was conducted in field No. 104 of S.V. Agricultural College Dryland Farm, Tirupati campus of Acharya N.G. Ranga Agricultural University, which is geographically situated at 13.5°N latitude and 79.5°E longitude, with an altitude of 182.9 m above the mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh.

3.2 WEATHER DURING THE CROP GROWTH PERIOD

Weather data during the crop growth period (15-07-2015 to 03-11-2015) recorded at meteorological observatory, S.V. Agricultural College Farm, Tirupati is presented in Table 3.1 and depicted in Fig. 3.1.

The weekly mean maximum temperature during the crop period ranged from 30.9°C to 38.2°C with an average of 34.1°C while the decennial mean maximum temperature for the corresponding period ranged from 30.3°C to 35.3°C with an average of 32.5°C.

The weekly mean minimum temperature during the crop growth period ranged from 18.6°C to 26.7°C with an average of 23.3°C whereas the decennial mean minimum temperature for the corresponding period ranged from 21.7°C to 26.2°C with an average of 24.3°C.

Table 3.1. Standard week wise mean meteorological data during the crop growth period of groundnut (15-07-2015 to 03-11-2015)

Standard week	Date and Month	Temperature (°C)				Mean relative humidity (%)		Rainfall (mm)		Number of rainy days		Mean evaporation (mm day^{-1})		Mean bright sunshine (hours day^{-1})	
		Maximum		Minimum											
		A	DN	A	DN	A	DN	A	DN	A	DN	A	DN	A	DN
28	09 July - 15 July	38.2	2.9	26.3	0.11	55.7	0.8	7.0	-18.1	1	-0.4	7.5	0.289	6.3	2.1
29	16 July - 22 July	36.7	1.8	25.7	-0.17	59.5	1.3	12.0	-20.8	1	-0.6	7.4	0.956	4.6	1.07
30	23 July - 29 July	34.6	0.3	25.1	-0.38	59.4	0.1	14.2	-0.7	2	0.2	6.5	0.51	4.2	0.94
31	30 July - 05 Aug.	35.9	1.6	25.1	-0.82	65.9	9.4	10.2	-3.2	2	1.3	5.9	-0.57	5.0	2.05
32	06 Aug. - 12 Aug.	35.5	0.3	26.7	1.11	58.5	2.1	0.0	-19.5	0	-1.3	7.9	0.68	5.7	1.7
33	13 Aug. - 19 Aug.	36.3	2.2	25.0	0.19	61.8	0.0	37.0	-6.1	1	-1.8	7.1	1.26	4.6	0.15
34	20 Aug. - 26 Aug.	35.2	1.5	26.1	1.63	61.4	-3.2	39.2	-4.1	3	0.8	6.3	1.01	4.7	-0.59
35	27 Aug. - 02 Sept.	34.5	1.4	23.5	-0.81	56.1	-9.0	9.0	-26.2	1	-0.7	5.7	0.65	4.5	0.17
36	03 Sept. - 09 Sept.	31.9	-1.6	22.1	-2.37	65.6	0.3	97.0	62.6	3	1.1	4.7	-0.07	3.9	-0.22
37	10 Sept. - 16 Sept.	31.3	-2.2	22.5	-1.63	73.7	7.6	0.0	-31.1	0	-2	4.4	-0.81	4.4	-0.47
38	17 Sept. - 23 Sept.	33.9	0.6	21.3	-3.01	64.6	1.1	32.0	16.5	2	1	4.3	-1.16	4.7	-0.11
39	24 Sept. - 30 Sept.	34.0	0.0	20.7	-3.60	67.9	3.3	69.0	44.2	3	1.6	5.1	-0.09	6.3	0.33
40	01 Oct. - 07 Oct.	30.9	-2.8	18.6	-5.59	68.5	3.5	51.0	33.4	4	3.1	4.2	-0.49	5.0	-0.58
41	08 Oct. - 14 Oct.	33.0	-0.4	20.7	-2.36	71.8	4.7	114.2	88.6	4	2.4	4.1	-0.31	3.4	-2.11
42	15 Oct. - 21 Oct.	33.9	1.1	23.2	0.68	65.0	-6.2	0.0	-31.9	0	-2	5.0	0.78	8.1	2.56
43	22 Oct. - 28 Oct.	32.5	1.6	21.0	-1.15	71.5	-3.3	0.0	-67.9	0	-3.5	4.7	1.16	7.2	3.21
44	29 Oct. - 03 Nov.	31.6	1.3	23.1	1.39	80.0	3.6	83.0	24.5	3	0.1	4.4	1.15	3.9	-0.58
							Total	574.8		30					

A: Actual; DN: Deviation from decennial mean

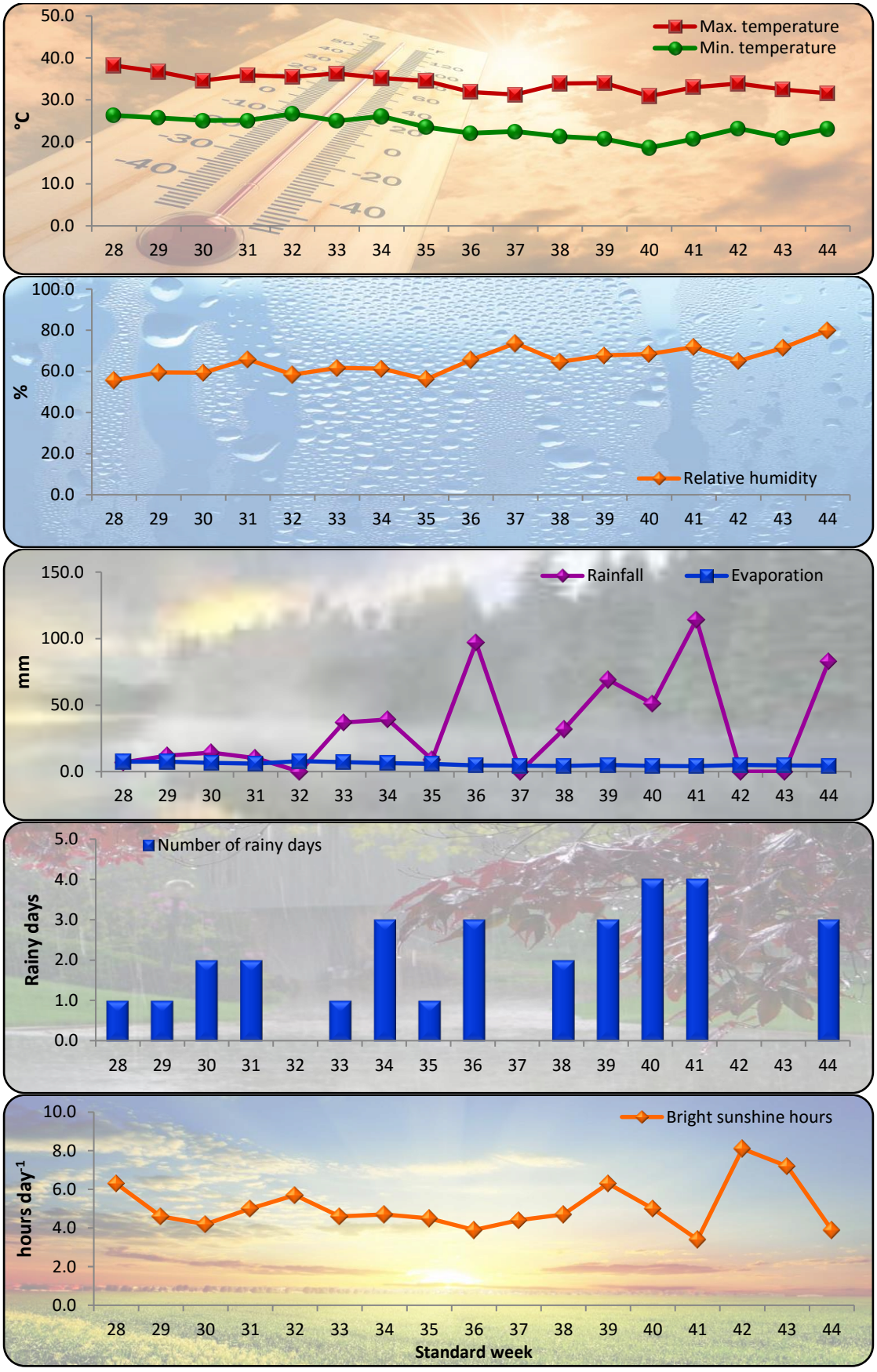


Fig 3.1. Standard week wise meteorological data during the crop growth period (15-07-2015 to 03-11-2015).

The weekly mean relative humidity during the crop growth period ranged from 55.7 to 80.0 per cent with an average of 65.1 per cent while the decennial mean for the corresponding period varied from 54.9 to 76.3 per cent with an average of 64.1 per cent.

The weekly mean bright sunshine hours day^{-1} during the crop growth period ranged from 3.4 to 8.1 with an average of 5.0 while the decennial mean for the corresponding period ranged from 3.0 to 6.0 with an average of 4.5 hours day^{-1}.

During the crop period, the weekly mean evaporation (USWB Class-A open pan evaporimeter) ranged from 4.1 to 7.9 mm day^{-1} with an average of 5.6 mm day^{-1} whereas the decennial mean for the corresponding period ranged from 3.3 to 7.2 mm day^{-1}, with an average of 5.3 mm day^{-1}.

A total rainfall of 574.8 mm had been received during the crop period in 30 rainy days, whereas the decennial average for the corresponding period was 534.4 mm in 31 rainy days.

3.3 SOIL CHARACTERISTICS OF THE EXPERIMENTAL SITE

Soil samples were drawn at random from 0-30 cm depth of the field before the experimentation and analysed for physico-chemical properties by adopting the standard procedures and the results are presented in Table 3.2.

Perusal of the data indicated that the soil was sandy loam in texture, neutral in soil reaction, low in organic carbon and available nitrogen, high in phosphorus and medium in potassium.

Table 3.2. Physico-chemical properties of the experimental field

Particulars	Value	Method adopted
I. Physical characteristics		
Coarse sand (%)	40.1	Bouyoucos hydrometer method (Piper, 1950)
Fine sand (%)	28.1	
Silt (%)	6.5	
Clay (%)	25.3	
Soil texture	Sandy loam	
II. Chemical characteristics		
Soil pH (1: 2.5 soil : water suspension)	6.9	Glass electrode pH meter (Jackson, 1973)
Electrical conductivity (dS m^{-1})	0.16	Conductivity bridge (Jackson, 1973)
Organic carbon (%)	0.43	Wet digestion method (Walkley and Black, 1934)
Available N (kg ha^{-1})	138	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	40	Olsen's method (Olsen *et. al*., 1954)
Available K_2O (kg ha^{-1})	176	Flame photometry method (Jackson, 1973)

3.4 CROPPING HISTORY OF THE EXPERIMENTAL FIELD

Cropping history of the experimental field during the three years preceding the present investigation are given below

Year	*Kharif*	*Rabi*	Summer
2011-12	Redgram	Redgram	Fallow
2012-13	Bajra	Sunhemp	Fallow
2013-14	Redgram	Redgram	Fallow
2014-15	**(Present experiment)**	-	-

3.5 EXPERIMENTAL DETAILS

3.5.1 Design and Layout

The experiment was laid out in randomized block design with nine treatments replicated thrice. The layout plan of the experiment is furnished in Fig. 3.2

3.5.2 Treatments

T_1 : Control

T_2 : 100% RDF (20-40-50 kg N, P_2O_5 and K_2O ha^{-1})

T_3 : 100% N through farm yard manure (FYM)

T_4 : 100% N through poultry manure

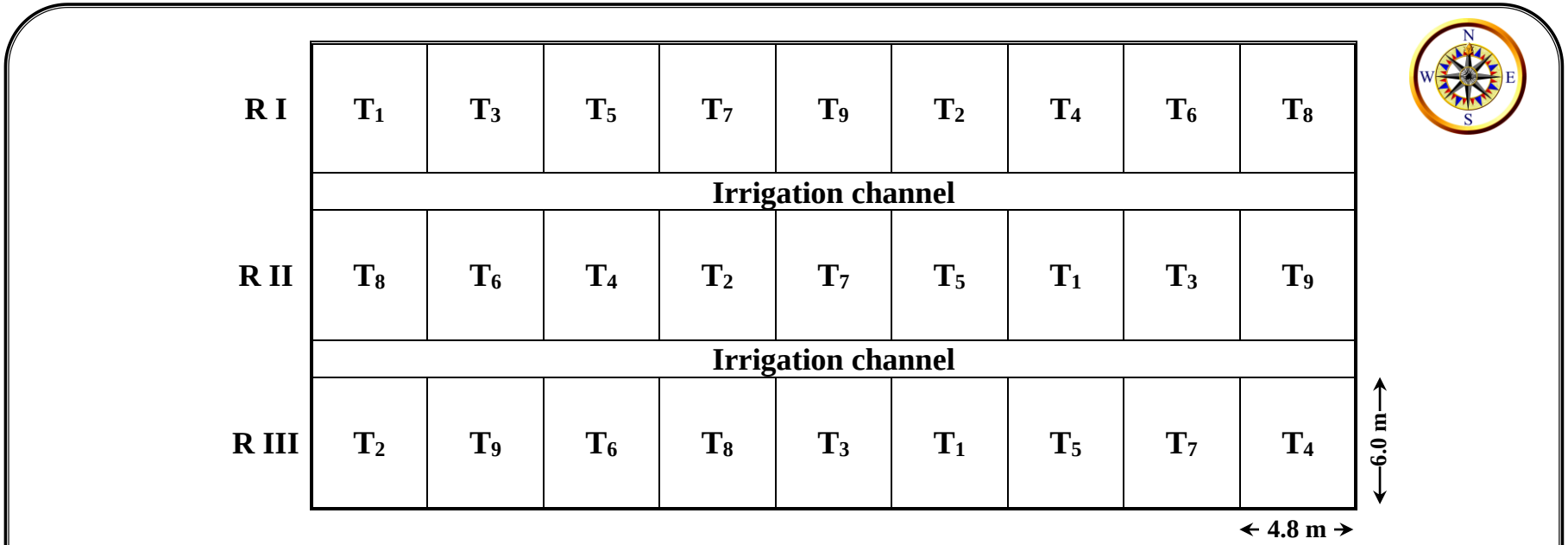
T_5 : 100% N through sheep manure

T_6 : 100% N through neem cake

T_7 : 50% N through FYM + 50% N through poultry manure

T_8 : 50% N through FYM + 50% N through sheep manure

T_9 : 50% N through FYM + 50% N through neem cake



Design : Randomized block design (RBD)
Gross plot: 6.0 m × 4.8 m
Net plot : 4.8 m × 4.4 m

Replications : Three
Spacing : 30 cm × 10 cm

Treatments:

T_1 : Control
T_2 : 100% RDF (20-40-50 kg N, P_2O_5 & K_2O ha^{-1})
T_3 : 100% N through farm yard manure (FYM)
T_4 : 100% N through poultry manure
T_5 : 100% N through sheep manure
T_6 : 100% N through neem cake
T_7 : 50% N through FYM + 50% N through poultry manure
T_8 : 50% N through FYM + 50% N through sheep manure
T_9 : 50% N through FYM + 50% N through neem cake

Fig. 3.2. Layout plan of the experimental field.

3.5.3 Plot Size

Gross : 6.0 m × 4.8 m

Net : 4.8 m × 4.4 m

3.5.4 Cultivar Description

The test variety used in the present experiment was Kadiri-6, developed at Agricultural Research Station (ARS), Kadiri, Andhra Pradesh. It is a spanish bunch variety, which matures in 100-105 days. It is a short stature, erect type with an yield potential of 2000 to 2200 kg during *kharif* and 4000 to 4250 kg ha^{-1} during *rabi.* The average oil content is about 48 per cent.

3.6 CULTIVATION DETAILS

3.6.1 Field Preparation

The experimental field was prepared by working twice with a tractor drawn cultivator followed by harrowing with bullock drawn blade harrow. The field was finally levelled with wooden plank and the plots were laid out according to the layout plan.

3.6.2 Manures and Fertilizers

3.6.2.1 Manures

Organic manures *i.e.* farm yard manure, poultry manure, sheep manure and neem cake were analysed for their nutrient (NPK) content and applied on equal nitrogen basis. All the above organic manures were thoroughly incorporated in to the soil 15 days prior to sowing of crop. Nutrient content and required quantities of different organic manures on equal nitrogen basis to supply recommended dose of nitrogen is furnished in Table 3.3. The corresponding quantity of phosphorus and potassium added due to application of different organic manures are furnished in Table 3.4.

Table 3.3. Nutrient content of different organic sources

Organic sources	Nutrient content (%)			Quantity of organic manures required (t ha^{-1}) to supply recommended dose of nitrogen *i.e.* 20 kg ha^{-1}
	N	P	K	
Farm yard manure	0.5	0.2	0.5	4.0
Poultry manure	1.1	1.7	1.4	1.8
Sheep manure	1.2	0.4	1.7	1.6
Neem cake	1.9	0.9	1.1	1.0

Table 3.4. Quantity of P_2O_5 and K_2O (kg ha^{-1}) added through different organic sources

Organic sources	P_2O_5	K_2O
Farm yard manure	8.0	20.0
Poultry manure	10.0	25.4
Sheep manure	6.6	28.3
Neem cake	9.4	11.5

The quantities of P_2O_5 and K_2O supplied through the respective organic manures were quantified and balance amount were supplemented through Biophos (20% P_2O_5) and Biopotash (14% K_2O) to meet their respective recommended doses.

Biophos and Biopotash were certified organic agri-inputs manufactured through fermentation process with the help of bacteria and fungi which were procured from Prathista industries limited, Nalagonda district, Telangana.

3.6.2.1.1 *Farm yard manure*

Well rotten farm yard manure collected from the dairy farm, College of Veterinary Science, Tirupati is used in the study.

3.6.2.1.2 *Poultry manure*

Poultry manure collected from the poultry farm, College of Veterinary Science, Tirupati is used in the study.

3.6.2.1.3 *Sheep manure*

Sheep manure collected from the sheep farm, College of Veterinary Science, Tirupati is used in the study.

3.6.2.1.4 *Neem cake*

Neem cake purchased from the local oil mill is used in the study.

3.6.2.2 Fertilizers

The recommended dose of nutrients 20-40-50 kg N, P_2O_5 and K_2O ha^{-1} were supplied through chemical fertilizers in T_2 treatment. The entire quantity of nitrogen, phosphorus and potassium were applied as basal at the time of sowing through urea, single super phosphate and muriate of potash, respectively.

3.6.3 Seeds and Sowing

Healthy and matured seeds of groundnut @ 120 kg ha^{-1} were used for sowing. Seeds were sown by hand dibbling @ one seed $hill^{-1}$ at a depth of 5 cm, with the spacing of 30 cm between the rows and 10 cm between the plants with in the row.

3.6.4 Weeding

Two hand weedings were done at 20 and 35 days after sowing to keep the crop free from weeds. One intercultivation was done with star weeder at 15 DAS to loosen the soil and to reduce evaporation losess.

3.6.5 Irrigation

Two irrigations were scheduled during the crop growth period due to insufficient soil moisture. Light irrigation was given immediately after sowing for better germination and establishment. Second irrigation was given at 40 DAS to save the crop from the effect of continuous dry spell for 15 days.

3.6.6 Plant Protection

Plant protection measures were taken with organic sources namely neemastram (3 foliar sprays) and bramhastram (2 foliar sprays) at regular intervals to control sucking pests and red hairy caterpillar and spodoptera (Appendix-A).

3.6.7 Harvesting and Stripping

The crop was harvested, when more than 75 per cent of the pods of randomly selected plants shown dark streaks inside the pods and the testa turned to rose colour. The plants in the gross and net plot area were harvested separately by pulling. Pods were stripped and dried under the sun to a constant weight. The haulms were dried under the sun for a week and weight was recorded.

3.7 OBSERVATIONS

3.7.1 Pre-Harvest Observations

Five plants at random were tagged in the net plot area in each treatment for recording periodical observations on growth and yield attributes during the crop growth period.

3.7.1.1 Plant height

Plant height was measured from the base of the plant to the tip of the terminal bud at 25, 50, 75 DAS and at harvest and the mean value was expressed in centimeters (cm)

3.7.1.2 Leaf area index

Leaf area from the five destructively sampled plants was measured at 25, 50, 75 DAS and at harvest using LI-COR Model, LI-3100C leaf area meter with transparent conveyer belt having electronic digital display and

expressed in cm^2. Leaf area index was calculated by dividing leaf area with the corresponding land area as suggested by Watson (1952).

$$LAI = \frac{\text{Leaf area } (cm^2)}{\text{Unit land area } (cm^2)}$$

3.7.1.3 Dry matter production

Five plants at random from the border rows leaving the extreme row were destructively sampled at 25, 50, 75 DAS and at the time of harvesting. The plant samples were dried under sun initially and later dried in hot air oven at 60°C to a constant weight and expressed as kg ha^{-1}.

3.7.1.4 Total and effective nodules $plant^{-1}$

The roots of five plants used for destructive sampling were excavated gently without damaging the roots and washed under gentle stream of water so as to remove the adhering soil at 25, 50 and 75 DAS. Then the effective and total number of nodules were removed from the roots carefully and counted. The effective and ineffective nodules were differentiated by cutting the nodule and observing the presence of absence of pink colour. Those with pink colour are classified as effective nodules.

3.7.2 Post-Harvest Observations

3.7.2.1 Number of pods $plant^{-1}$

The number of pods from five randomly selected labelled plants at harvest were counted, averaged and expressed as number of pods $plant^{-1}$.

3.7.2.2 Hundred pod weight

After thorough sun drying of pods to a constant weight, five lots of 100 pods were randomly selected and weight was recorded and the average weight of 100 pods was expressed in g.

3.7.2.3 Hundred kernel weight

Weight of 100 randomly selected kernels (obtained from shelled pods of net plot area) was recorded and expressed in g.

3.7.2.4 Shelling percentage

One kilogram of sun dried pods were collected from composite sample from each net plot area, which were shelled and weight of those kernels was recorded. The shelling percentage was calculated by dividing the weight of the kernels with known weight of pods and expressed in percentage.

3.7.2.5 Pod yield

Pods from the net plot area were cleaned thoroughly, sun dried until a constant weight and expressed in kg ha^{-1}.

3.7.2.6 Haulm yield

The plants in the net plot area after removal of the pods from haulms were thoroughly sun dried till constant weight was attained and haulm yield was recorded and expressed in kg ha^{-1}.

3.7.2.7 Oil content

The oil content of the kernel was estimated by Nuclear Magnetic Resonance (NMR) spectroscope technique as per the procedure laid down by Tiwary *et al*. (1984) and expressed in percentage.

3.7.2.8 Protein content

The protein content of the kernel was estimated by Nuclear Magnetic Resonance (NMR) spectroscope technique as per the procedure laid down by Tiwary *et al*. (1984) and expressed in percentage.

3.8 PLANT ANALYSIS

For estimating nitrogen, phosphorus and potassium content in plants, well dried plant samples collected for dry matter production were powdered and used for chemical analysis.

3.8.1 Nitrogen Uptake

Nitrogen content in dry matter was estimated by microkjeldahl method (AOAC, 1960). The nitrogen uptake was calculated by multiplying the nitrogen content (%) with respective dry matter production and expressed in kg ha^{-1}.

3.8.2 Phosphorus Uptake

The tri-acid digested plant samples were analysed for phosphorus content by vanado - molybdo phosphoric acid method (Jackson, 1973). The intensity of yellow colour developed was measured by using spectrophotometer. The uptake of phosphorus was calculated by multiplying the phosphorus content with the respective dry matter production and expressed in kg ha^{-1}.

3.8.3 Potassium Uptake

Potassium content of the extract of tri-acid digested material was determined by using flame photometer and uptake of potassium was estimated by multiplying the potassium content with the respective dry matter production and presented in kg ha^{-1}.

3.9 POST HARVEST SOIL NUTRIENT ANALYSIS

After harvesting of groundnut crop, soil samples were collected from each plot and analysed to find out the post-harvest nutrient status of the soil, as detailed below:

3.9.1 Available Nitrogen

The available nitrogen in soil was analysed by alkaline permanganate method as detailed by Subbiah and Asija (1956).

3.9.2 Available Phosphorus

The available phosphorus status in soil was analysed by Olsen's method (Olsen *et al.*, 1954).

3.9.3 Available Potassium

The available potassium content in soil was analysed by Flame Photometry method (Jackson, 1973).

3.10 ECONOMICS

The total cost of cultivation of groundnut ha^{-1} was calculated for treatment on the basis of inputs used. Gross returns ha^{-1} were computed by considering the prevailing market price of the output. Net returns ha^{-1} were arrived at by deducting the cost of cultivation of respective treatments from gross returns for the corresponding treatments. Benefit-cost ratio was calculated by using the following formula.

$$\text{Benefit : Cost ratio} = \frac{\text{Gross returns } (₹\ ha^{-1})}{\text{Cost of cultivation } (₹\ ha^{-1})}$$

3.11 STATISTICAL ANALYSIS

The data recorded on various parameters of crop during the course of investigation was statistically analyzed following the analysis of variance for randomized block design as suggested by Panse and Sukhatme (1985). Statistical significance was tested with 'F' value at 5 per cent level of probability and compared the treatment means with critical difference (CD).

Chapter ~ IV

Results & Discussion

Chapter IV

RESULTS AND DISCUSSION

A field experiment entitled **"Nutrient management for organic groundnut under rainfed conditions"** was carried out during *kharif* 2015, on sandy loam soils of dryland farm of S.V. Agricultural College, Tirupati. The experimental results pertaining to growth parameters, yield attributes, yield, nutrient uptake, economics of groundnut and post-harvest soil nutrient status as influenced by various organic sources are presented in this chapter with scientific reasoning under the following heading.

4.1 WEATHER

Weather during the crop growth period (15-07-2015 to 03-11-2015) did not deviate much from the decennial mean of the location of the study. Thus, the crop enjoyed favourable weather during different phenophases and expressed its optimal performance.

4.2 GROWTH PARAMETERS

4.2.1 Plant Height

Plant height of groundnut measured at 25, 50, 75 DAS and at the time of harvesting was significantly influenced by various organic sources (Table 4.1 and Fig. 4.1). Plant height of groundnut inclined to increase steadily with advance in the age of the crop up to harvest. The trend of plant height in response to nutrient management practices was similar at all the stages of observations.

The highest plant height was noticed with 100% recommended dose of nutrients through fertilizers (T_2), which was significantly superior to the organic sources tested. The next best treatment was 100% N through FYM (T_3), which was however, comparable with 50% N through FYM + 50% N

Table 4.1. Plant height (cm) of groundnut at different growth stages as influenced by various organic sources

Treatments	25 DAS	50 DAS	75 DAS	At harvest
T_1 : Control	8.4	18.0	26.0	36.0
T_2 : 100% RDF (20-40-50 kg N, P_2O_5 and K_2O ha^{-1})	14.5	26.6	36.7	47.3
T_3 : 100% N through farm yard manure (FYM)	12.6	24.3	34.7	44.9
T_4 : 100% N through poultry manure	9.8	20.7	29.1	39.1
T_5 : 100% N through sheep manure	9.9	20.8	29.2	39.2
T_6 : 100% N through neem cake	9.7	20.5	29.0	39.0
T_7 : 50% N through FYM + 50% N through poultry manure	10.9	22.3	32.1	42.2
T_8 : 50% N through FYM + 50% N through sheep manure	12.5	24.2	34.6	44.7
T_9 : 50% N through FYM + 50% N through neem cake	10.8	22.1	32.0	42.0
SEm±	0.18	0.36	0.52	0.49
CD (P=0.05)	0.5	1.0	1.5	1.4

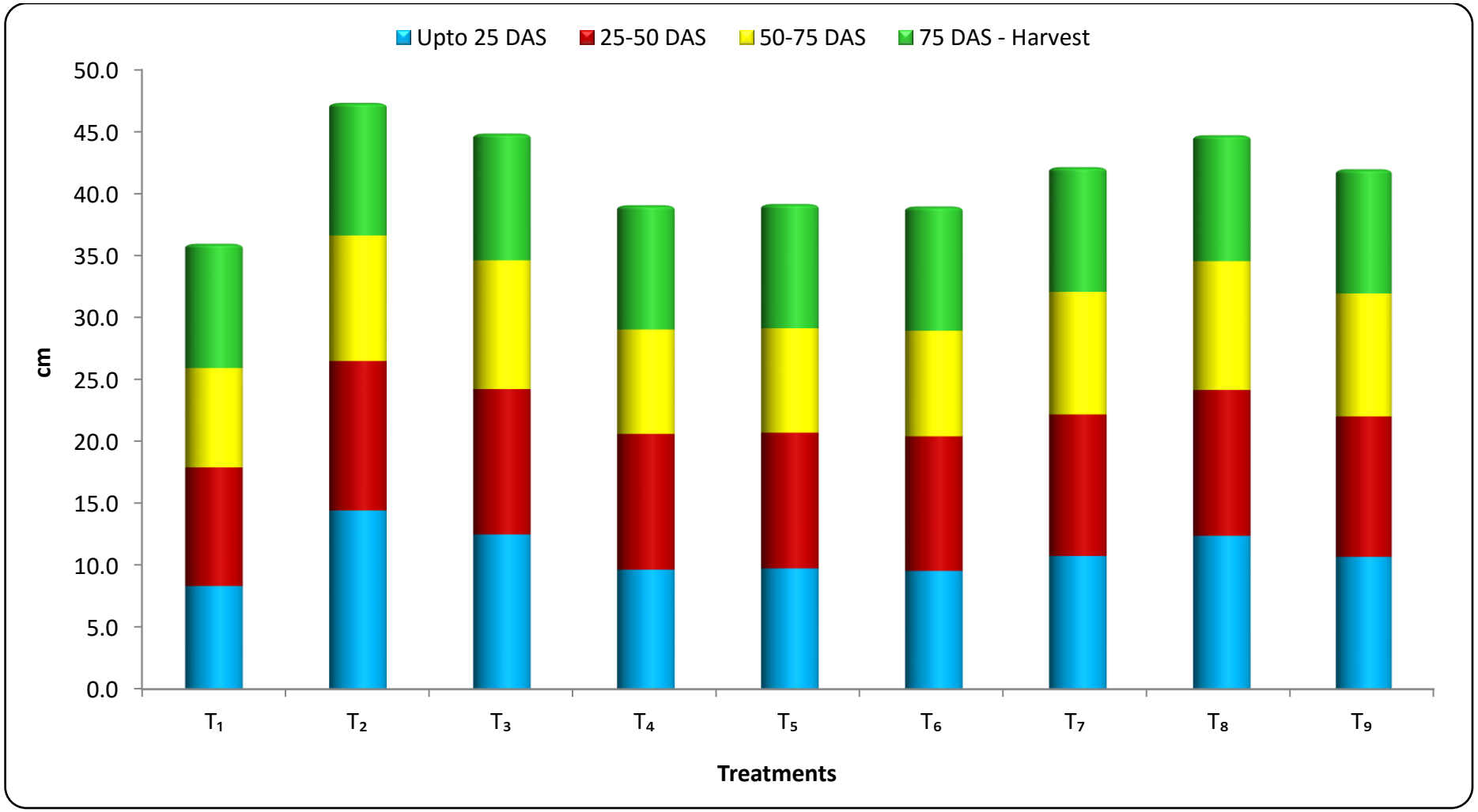


Fig. 4.1. Plant height (cm) of groundnut at different growth stages as influenced by various organic sources.

through sheep manure (T_8). Supply of 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9) were statistically on par with each other, followed by 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6), which were in turn comparable among them. The shortest plants were noticed with control (T_1).

The tallest plant stature produced with 100% recommended dose of nutrients through fertilizers (T_2) over organic manural treatments might be due to quick release and availability of nutrients and especially nitrogen, which is an important constituent of protoplasm playing a positive role in cell multiplication. Among the various organic sources tried for the study, the taller plants were noticed with the application of 100% N through FYM (T_3). Though all the organic manures were applied on equal nitrogen basis, the better performance of the crop under 100% N through FYM could be attributed to the stimulated activities of microorganisms and synchronized release of nitrogen, which might have stimulated the cellular activity, useful for the process of cell division. The shortest plants observed with control might be due to non-availability of sufficient quantity of nutrients for crop growth. The results are in close confirmity with the findings of Marimuthu *et al.* (2002), Verma and Munshi (2003) and Zalate and Padmani (2009b).

4.2.2 Leaf Area Index

Leaf area index of groundnut tended to increase steadily with advance in the age of the crop up to 75 DAS and then found declined towards harvest due to senescence of lower leaves. Various organic sources exerted distinct influence on the leaf area index of groundnut measured at 25, 50, 75 DAS and at the time of harvesting (Table 4.2 and Fig. 4.2).

At all the stages of observation, the highest leaf area index was associated with 100% recommended dose of nutrients through fertilizers

Table 4.2. Leaf area index of groundnut at different growth stages as influenced by various organic sources

Treatments	25 DAS	50 DAS	75 DAS	At harvest
T_1 : Control	0.33	1.73	2.47	1.45
T_2 : 100% RDF (20-40-50 kg N, P_2O_5 and K_2O ha^{-1})	1.04	2.87	3.67	2.62
T_3 : 100% N through farm yard manure (FYM)	0.85	2.68	3.35	2.34
T_4 : 100% N through poultry manure	0.47	2.01	2.75	1.72
T_5 : 100% N through sheep manure	0.47	2.02	2.78	1.73
T_6 : 100% N through neem cake	0.45	2.00	2.71	1.70
T_7 : 50% N through FYM + 50% N through poultry manure	0.68	2.28	3.04	2.09
T_8 : 50% N through FYM + 50% N through sheep manure	0.83	2.62	3.31	2.29
T_9 : 50% N through FYM + 50% N through neem cake	0.68	2.27	3.03	1.99
SEm±	0.04	0.05	0.07	0.05
CD (P=0.05)	0.11	0.16	0.20	0.14

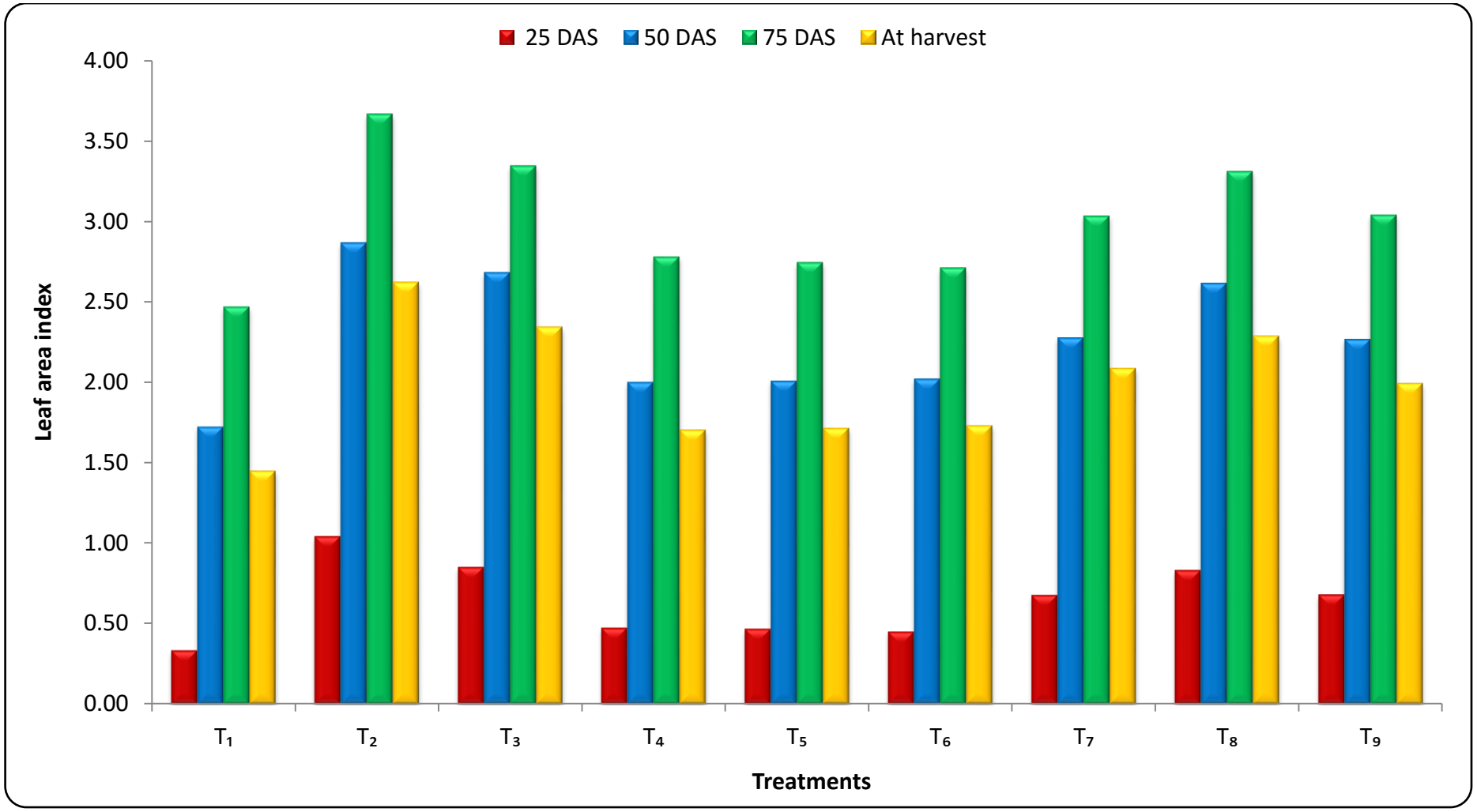


Fig. 4.2. Leaf area index of groundnut at different growth stages as influenced by various organic sources.

(T_2), which was significantly superior to the remaining treatments. Among the various organic sources tried, application of 100% N through FYM (T_3) recorded higher leaf area index, which was however comparable with 50% N through FYM + 50% N through sheep manure (T_8). The next best treatments were 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9) which were statistically on par with each other. However, these treatments produced significant higher leaf area index than application of 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) which did not differ among them. The lowest leaf area index was registered with control (T_1).

Better nutrient availability with 100% recommended dose of nutrients through fertilizers (T_2) might have triggered the production of higher number of leaves as well as leaf expansion which in turn resulted in the highest leaf area index. The next higher values of leaf area index noticed with the application of 100% N through FYM (T_3) and 50% N through FYM + 50% N through sheep manure (T_8) might be due to the faster release of nutrients and their favorable effect on producing of more number of larger leaves.

4.2.3 Dry Matter Production

Dry matter Production of groundnut recorded at 25, 50, 75 DAS and at the time of harvest was significantly influenced by various organic sources. Dry matter production increased progressively with advance in age of the crop up to harvest (Table 4.3 and Fig. 4.3).

At all the stages of observation, application of 100% recommended dose of nutrients through fertilizers (T_2) recorded the highest dry matter production, which was significantly superior to the organic sources. The next best treatment was 100% N through FYM (T_3) which was however comparable with 50% N through FYM + 50% N through sheep manure (T_8),

Table 4.3. Dry matter production (kg ha^{-1}) of groundnut at different growth stages as influenced by various organic sources

Treatments	25 DAS	50 DAS	75 DAS	At harvest
T_1 : Control	497	1195	2733	3763
T_2 : 100% RDF (20-40-50 kg N, P_2O_5 and K_2O ha^{-1})	908	1997	3987	6917
T_3 : 100% N through farm yard manure (FYM)	798	1798	3693	6337
T_4 : 100% N through poultry manure	596	1395	3093	5193
T_5 : 100% N through sheep manure	598	1397	3097	5194
T_6 : 100% N through neem cake	592	1383	3092	5190
T_7 : 50% N through FYM + 50% N through poultry manure	699	1598	3360	5733
T_8 : 50% N through FYM + 50% N through sheep manure	794	1795	3670	6310
T_9 : 50% N through FYM + 50% N through neem cake	682	1596	3353	5707
SEm±	23.7	36.0	85.2	153.0
CD (P=0.05)	71	107	255	458

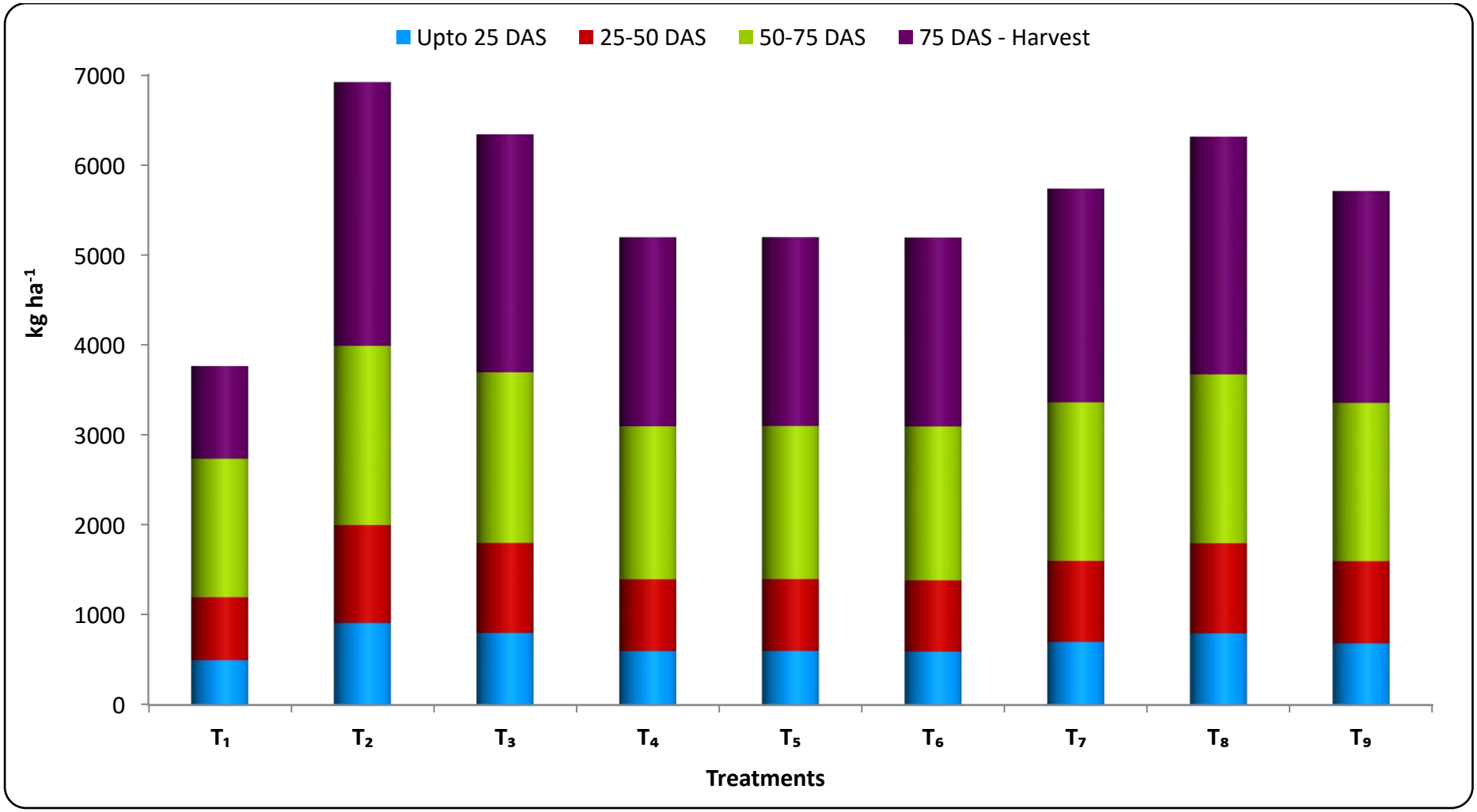


Fig. 4.3. Dry matter production (kg ha^{-1}) of groundnut at different growth stages as influenced by various organic sources.

and these two were found to be distinctly superior over 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9), which were statistically on par with each other. Application of 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) were comparable among them. The control (T_1) found to exhibit the lowest dry matter production.

Dry matter accumulation is the prerequisite for higher yields, which is an indication of the biosynthetic process associated with the crop growth and development. Significantly higher dry matter accumulation with 100% recommended dose of nutrients through fertilizers (T_2) might be due to the immediate availability of adequate quantity of nutrients, which in turn resulted in vigorous crop growth with effective interception of light and higher rate of photosynthesis. These findings are in support of Reddy and Moorthy (1984) and Devi *et al*. (2003). Among the organic manures tried, the higher dry matter accrual noticed with 100% N through FYM (T_3) is ascribed due to its better release of macro and micro nutrients and improved extraction by the groundnut crop, resulting in more photosynthesis. Organic matter added through FYM being more might have beneficial effect on soil physical properties which is more importance for groundnut. Similar results were perceived by Dosani *et al*. (1999).

4.2.4 Number of Nodules Plant^{-1}

Number of nodules plant^{-1} in groundnut recorded at 25, 50 and 75 DAS was significantly influenced by various organic sources. Number of nodules plant^{-1} of groundnut tended to increase steadily with advance in the age of the crop up to 75 DAS (Table 4.4).

The height number of nodules plant^{-1} was recorded with application of 50% N through FYM + 50% N through sheep manure (T_8), which was however comparable with 50% N through FYM + 50% N through neem cake (T_9), 100% N through FYM (T_3), 50% N through FYM + 50% N through poultry manure (T_7). Application of 100% N through poultry

Table 4.4. Total number of nodules plant^{-1} of groundnut at different growth stages as influenced by various organic sources

Treatments	25 DAS	50 DAS	75 DAS
T_1 : Control	11.0	26.1	44.8
T_2 : 100% RDF (20-40-50 kg N, P_2O_5 and K_2O ha^{-1})	16.3	35.2	55.6
T_3 : 100% N through farm yard manure (FYM)	25.6	52.4	72.1
T_4 : 100% N through poultry manure	21.1	45.2	64.1
T_5 : 100% N through sheep manure	20.2	44.3	63.0
T_6 : 100% N through neem cake	19.5	41.1	62.1
T_7 : 50% N through FYM + 50% N through poultry manure	24.8	51.6	70.3
T_8 : 50% N through FYM + 50% N through sheep manure	26.5	54.0	74.2
T_9 : 50% N through FYM + 50% N through neem cake	26.0	53.5	73.3
SEm±	0.59	1.35	1.65
CD (P=0.05)	1.8	4.1	4.9

manure (T_4), sheep manure (T_5) and neem cake (T_6) recorded comparable number of nodules and were significantly superior to 100% recommended dose of nutrients through fertilizers (T_2). The lowest number of nodules plant^{-1} was registered with control (T_1).

4.2.5 Number of Effective Nodules Plant^{-1}

The number of effective nodules plant^{-1} were significantly influenced by various organic sources and followed the similar trend as that of total number of nodules plant^{-1} of groundnut at 25, 50 and 75 DAS (Table 4.5 and Fig. 4.4).

Total number of nodules as well as effective nodules plant^{-1} with the treatments involving various sources of organic manure was significantly higher compared to 100% recommended dose of nutrients through fertilizers (T_2). Organic manures favour root development which might have resulted in increasing of root nodule number. This was in close agreement with the findings of Patel (1994) and Kausale *et al.* (2009).

4.3 YIELD ATTRIBUTES

4.3.1 Number of Pods Plant^{-1}

Number of pods plant^{-1} of groundnut was found to be significantly influenced by various organic sources (Table 4.6 and Fig. 4.5).

The highest number of pods plant^{-1} of groundnut was recorded with 100% recommended dose of nutrients through fertilizers (T_2), which was significantly higher than rest of the treatments. The next best treatment was 100% N through FYM (T_3), which was however, comparable with 50% N through FYM + 50% N through sheep manure (T_8) and these two were distinctly superior to 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9), which were statistically on par with each other. Application of 100% N through

Table 4.5. Number of effective nodules plant^{-1} of groundnut at different growth stages as influenced by various organic sources

Treatments	25 DAS	50 DAS	75 DAS
T_1 : Control	8.7	24.2	39.2
T_2 : 100% RDF (20-40-50 kg N, P_2O_5 and K_2O ha^{-1})	13.5	33.9	49.4
T_3 : 100% N through farm yard manure (FYM)	20.4	46.4	65.7
T_4 : 100% N through poultry manure	17.1	40.1	59.2
T_5 : 100% N through sheep manure	16.9	39.7	58.1
T_6 : 100% N through neem cake	15.8	38.5	56.3
T_7 : 50% N through FYM + 50% N through poultry manure	19.5	45.1	64.5
T_8 : 50% N through FYM + 50% N through sheep manure	22.4	48.2	67.9
T_9 : 50% N through FYM + 50% N through neem cake	21.3	47.3	66.8
SEm±	0.49	1.15	1.45
CD (P=0.05)	1.5	3.4	4.3

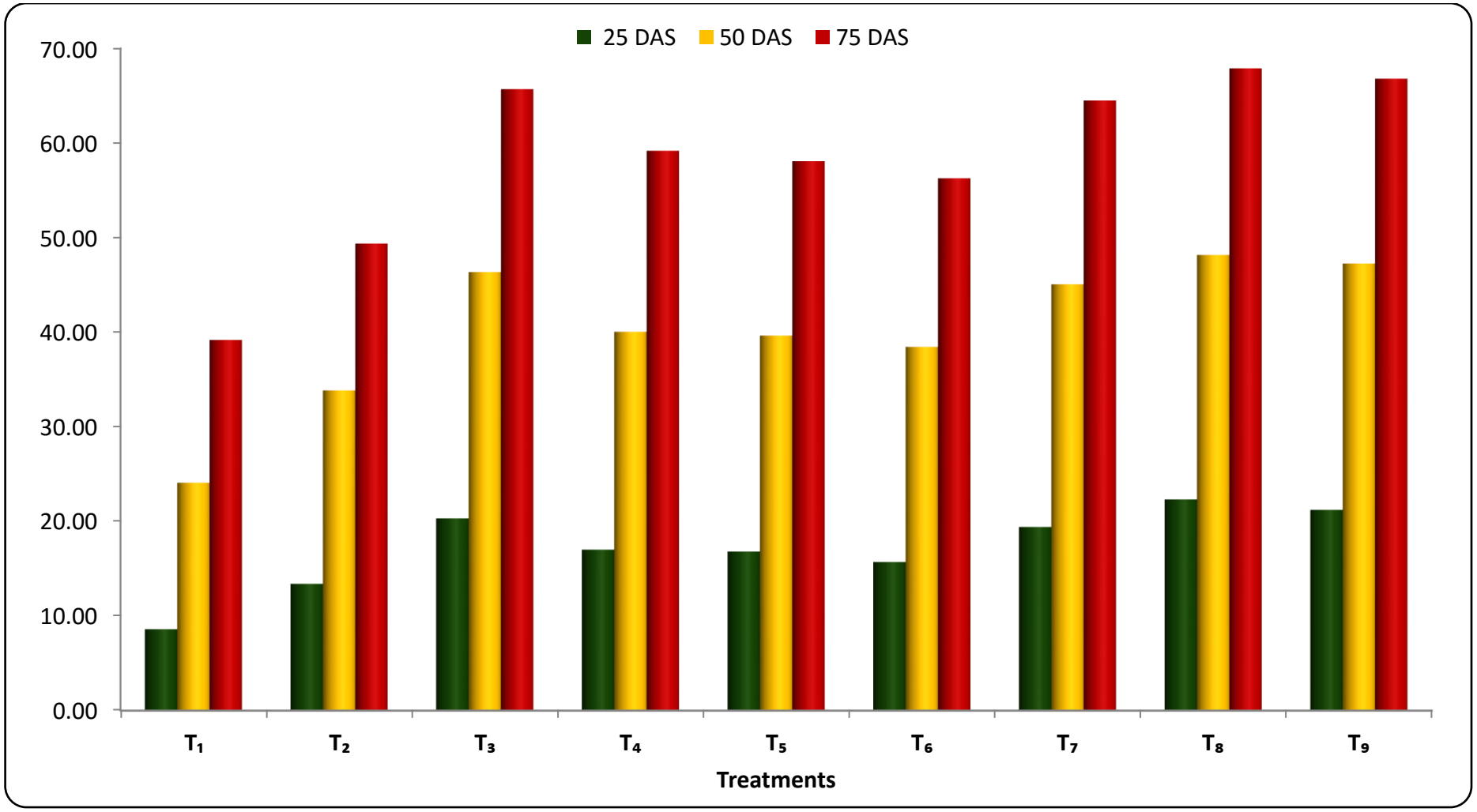


Fig. 4.4. Number of effective nodules plant^{-1} of groundnut at different growth stages as influenced by various organic sources.

sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) were comparable among them. Control (T_1) resulted in the lowest number of pods plant^{-1}.

4.3.2 Hundred Pod Weight

Different organic sources exerted significant influence on hundred pod weight of groundnut (Table 4.6 and Fig. 4.6).

Application of 100% recommended dose of nutrients through fertilizers (T_2) recorded the highest hundred pod weight, which was significantly superior to all the other treatments. The next best treatment was 100% N through FYM (T_3), which was however, comparable with 50% N through FYM + 50% N through sheep manure (T_8). These treatments were followed by 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9), which were statistically on par with each other. Application of 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) did not differ among them. The lowest hundred pod weight was registered with control (T_1).

4.3.3 Hundred Kernel Weight

Hundred kernel weight of groundnut differed distinctly due to various organic sources (Table 4.6).

The highest hundred kernel weight was recorded with 100% recommended dose of nutrients through fertilizers (T_2), which was significantly superior to rest of the treatments. Application of 100% N through FYM (T_3) was the next best treatment with higher hundred kernel weight, which was however comparable with 50% N through FYM + 50% N through sheep manure (T_8), but were distinctly superior to 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9), which were statistically on par with each

other. Application of 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) were comparable among them. The lowest hundred kernel weight was recorded with control (T_1).

4.3.4 Shelling Percentage

The shelling percentage of groundnut was significantly influenced by the various organic sources (Table 4.6).

The highest shelling percentage of groundnut was recorded with 100% recommended dose of nutrients through fertilizers (T_2), which was distinctly superior to the other organic sources. Application of 100% N through FYM (T_3) resulted in higher shelling percentage which was however, comparable with 50% N through FYM + 50% N through sheep manure (T_8). The next best treatments were 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9), which were statistically on par with each other. However, application of 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) were comparable among them. The control (T_1) exhibited the lowest shelling percentage.

The pod formation is the complex process and governed by complementary interaction between source and sink. Thus the favorable effect of readily available nutrients with 100% recommended dose of nutrients through fertilizers (T_2) is evident with higher dry matter accumulation and effective translocation of photosynthates to the sink which resulted in improved stature of yield attributes *i.e*. number of pods plant^{-1}, hundred pod weight, hundred kernel weight and shelling percentage. These results were found in confirmity with the findings of Sagare *et al.* (1992) and Devi *et al.* (2003).

Table 4.6. Number of pods plant^{-1}, hundred pod weight, hundred kernel weight (g) and shelling percentage of groundnut as influenced by various organic sources

Treatments	Number of pods plant^{-1}	Hundred pod weight	Hundred kernel weight	Shelling percentage
T_1 : Control	14.7	80.3	28.5	65.3
T_2 : 100% RDF (20-40-50 kg N, P_2O_5 and K_2O ha^{-1})	26.7	97.4	41.0	73.3
T_3 : 100% N through farm yard manure (FYM)	24.0	93.4	37.3	71.8
T_4 : 100% N through poultry manure	17.3	84.5	31.4	67.6
T_5 : 100% N through sheep manure	17.6	84.9	31.6	67.1
T_6 : 100% N through neem cake	17.0	84.3	31.2	67.4
T_7 : 50% N through FYM + 50% N through poultry manure	20.3	89.3	34.3	69.8
T_8 : 50% N through FYM + 50% N through sheep manure	23.5	93.0	37.0	71.8
T_9 : 50% N through FYM + 50% N through neem cake	20.0	89.0	34.0	69.8
SEm±	0.54	1.04	0.78	0.37
CD (P=0.05)	1.6	3.1	2.3	1.1

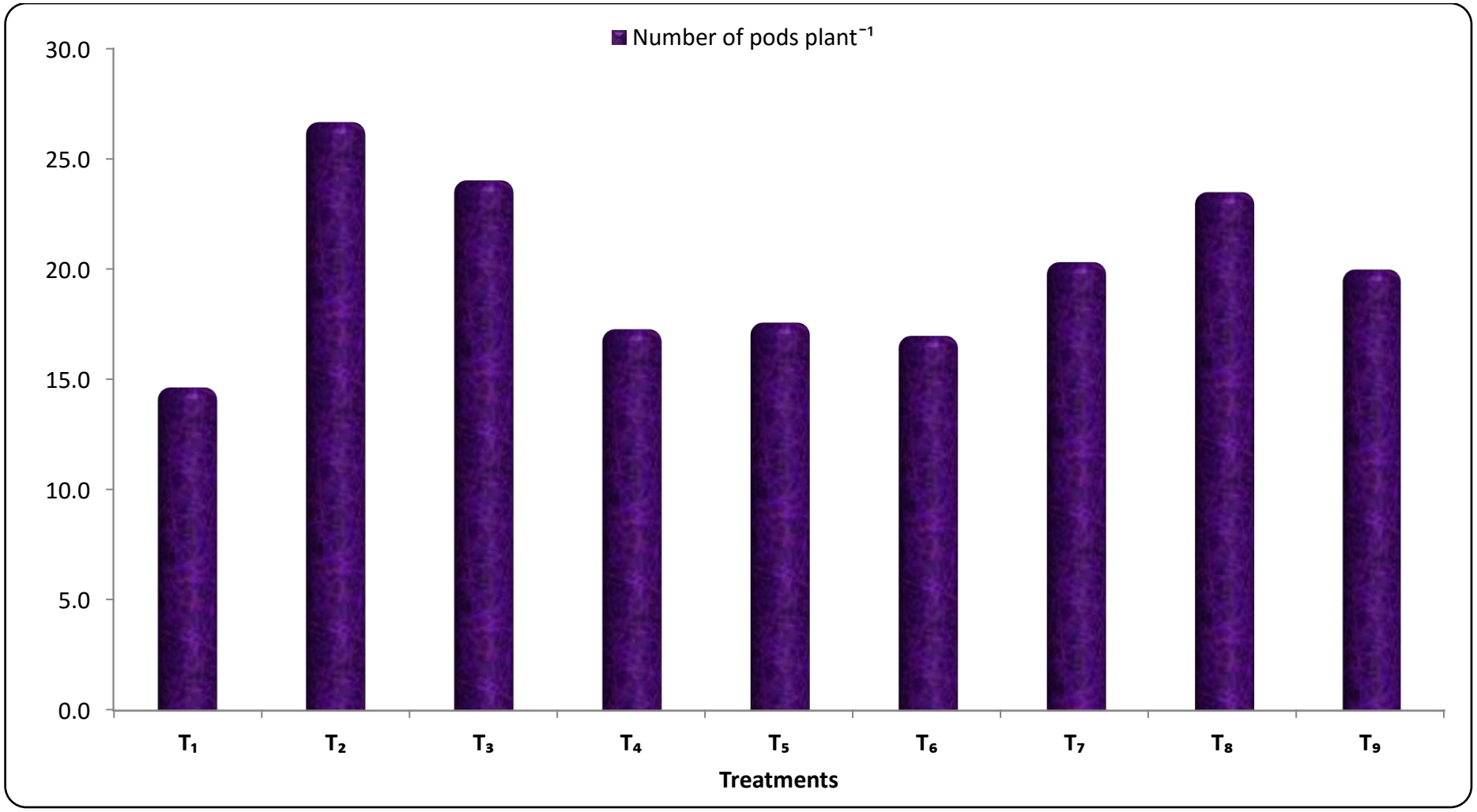


Fig. 4.5. Number of pods plant^{-1} of groundnut as influenced by various organic sources.

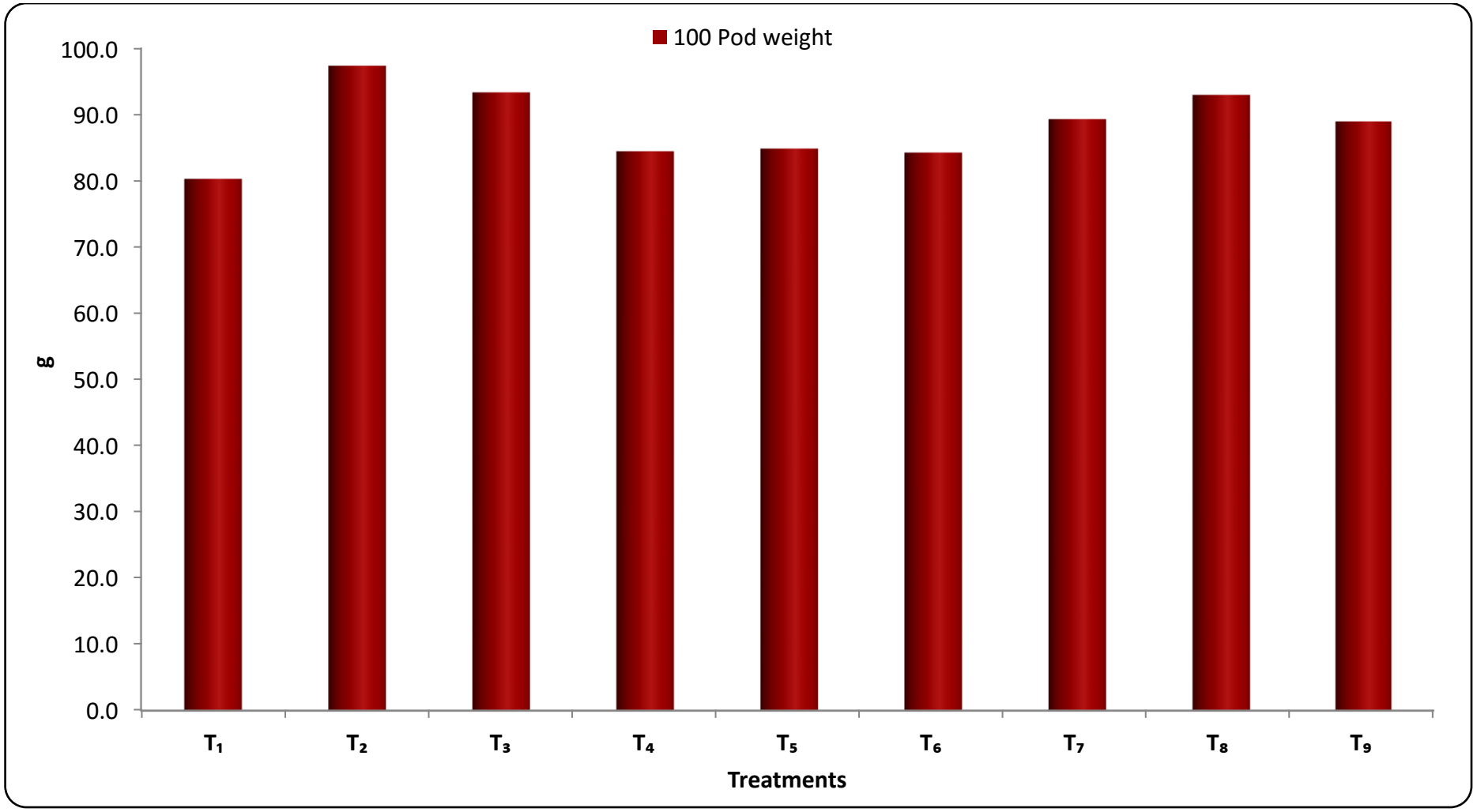


Fig. 4.6. Hundred pod weight (g) of groundnut as influenced by various organic sources.

Among the various organic sources tried for the experimental study, the supremacy of FYM might be due to better supply of macro and micro nutrients required to enhance the enzymatic activity and physiological process of plant which in turn reflected through the inflated stature of all the yield attributes of groundnut. The similar results were reported in the studies of Marimuthu *et al.* (2002), Verma and Munshi (2003) and Zalate and Padmani (2009b).

4.4 YIELD

4.4.1 Pod Yield

The pod yield of groundnut was significantly influenced by the various organic sources (Table 4.7 and Fig. 4.7).

The highest pod yield of groundnut was obtained with 100% recommended dose of nutrients through fertilizers (T_2), which was significantly superior to rest of the treatments. Among the various organic sources tried, supply of 100% N through FYM (T_3) recorded higher pod yield, which was however, comparable with 50% N through FYM + 50% N through sheep manure (T_8). The next best treatments were 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9), which were statistically on par with each other. Application of 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) were comparable among them. The lowest pod yield was registered with control (T_1).

4.4.2 Kernel Yield

Various organic sources exerted significant influence on the kernel yield of groundnut (Table 4.7).

The highest kernel yield of groundnut was recorded with 100% recommended dose of nutrients through fertilizers (T_2), which was

significantly superior to all the other treatments. The next best treatment was 100% N through FYM (T_3), which was however, comparable with 50% N through FYM + 50% N through sheep manure (T_8). These treatments were followed by 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9), which were statistically on par with each other. The kernel yield obtained with application of 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) was not statistically traceable among themselves. The lowest kernel yield was obtained with control (T_1).

Application of 100% recommended dose of nutrients through fertilizers (T_2) resulted in the highest pod and kernel yields. Application of 100% recommended dose of nutrients through fertilizers (T_2) resulted in 13.6 per cent higher pod yield compared to the next best treatment of 100% N through FYM (T_3). It is obvious that fertilizers can supply the required quantity of nutrients instantly in balanced proportion coinciding with the crop requirement. Accordingly the groundnut crop under comfortable nutrition might have produced elevated stature of growth parameters, better stature of yield attributes which in turn reflected in highest pod and kernel yields. The above mentioned results are in agreement with the findings of Sagare *et al.* (1992) and Devi *et al.* (2003).

Under organic approach, 100% N through FYM resulted in 87.9 per cent of improvement in the pod yield over control. Among the various organic manures tried, 100% N through FYM recorded on an average of 38 to 40 per cent higher pod yield over 100% N through poultry manure (1497 kg ha^{-1}) or sheep manure (1499 kg ha^{-1}) or neem cake (1487 kg ha^{-1}). In this experiment, the various organic sources differ with their nutrient (N, P & K) content and were applied on equal nitrogen basis. The results of the investigation revealed that these organic sources had significantly influenced the yield of groundnut and amongst them, 100% N through FYM

(T_3) resulted in higher pod and kernel yields of groundnut, which were however comparable with 50% N through FYM + 50% N through sheep manure (T_8). Further the combination of poultry manure or sheep manure or neem cake along with FYM proved to be better over sole application of these manures. Beneficial effect of FYM could be owing to better physical environment with improved aeration and root activity conducive for nutrient absorption. The complementary effect of these favorable conditions was reflected through higher level of biomass accrual coupled with its efficient translocation and accumulation in to the sink, which consequently resulted in higher pod and kernel yields. The results are in close confirmity with the findings of Marimuthu *et al.* (2002), Verma and Munshi (2003) and Zalate and Padmani (2009b).

All though the poultry manure, sheep manure and neem cake were nutritionally superior to FYM, higher pod yield was recorded FYM might be due the variation in the nutrient release pattern in to the soil. The lowest pod and kernel yields were obtained in control as the crop might have suffered under nutrient starvation especially nitrogen. The present investigation confirms the documented evidence of Rao and Shaktawat (2002) and Laxminarayana and Patiram (2005).

4.4.3 Haulm Yield

Various organic sources exerted significant influence on the haulm yield of groundnut (Table 4.7 and Fig. 4.7).

Application of 100% recommended dose of nutrients through fertilizers (T_2) recorded the highest haulm yield of groundnut, which was significantly higher than the other treatments tried. Among the various organic sources, supply of 100% N through FYM (T_3) proved to be better in resulting of higher haulm yield, which was however, comparable with 50% N through FYM + 50% N through sheep manure (T_8). These treatments were

Table 4.7. Pod yield, kernel yield and haulm yield (kg ha^{-1}) of groundnut as influenced by various organic sources

Treatments	Pod yield	Kernel yield	Haulm yield
T_1 : Control	1103	720	2049
T_2 : 100% RDF (20-40-50 kg N, P_2O_5 and K_2O ha^{-1})	2357	1731	3813
T_3 : 100% N through farm yard manure (FYM)	2073	1490	3375
T_4 : 100% N through poultry manure	1497	1005	2587
T_5 : 100% N through sheep manure	1499	1006	2598
T_6 : 100% N through neem cake	1487	1009	2557
T_7 : 50% N through FYM + 50% N through poultry manure	1767	1233	2997
T_8 : 50% N through FYM + 50% N through sheep manure	2070	1486	3351
T_9 : 50% N through FYM + 50% N through neem cake	1750	1222	2993
SEm±	66.2	50.8	105.6
CD (P=0.05)	200	152	319

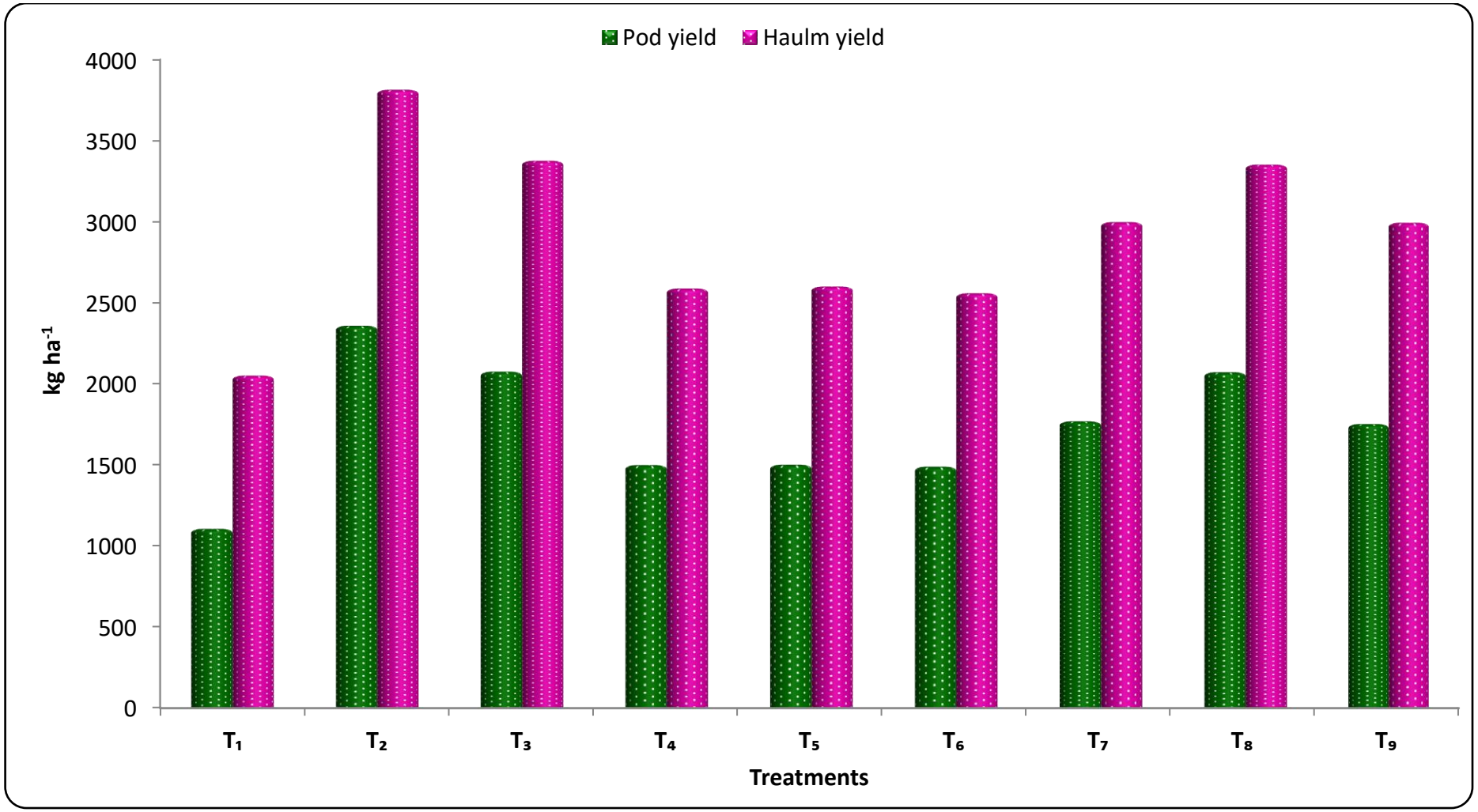


Fig. 4.7. Pod yield and haulm yield (kg ha^{-1}) of groundnut as influenced by various organic sources.

followed by 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9), which were statistically on par with each other. Application of 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) recorded comparable haulm yields. The lowest haulm yield was associated with control (T_1).

The highest haulm yield resulted with 100% recommended dose of nutrients through fertilizers (T_2) might be due to adequate and balanced nutrient supply of nutrients to the crop, which could produce the growth parameters of elevated stature. Among the varied organic sources tried for the study, 100% N through FYM (T_3) recorded higher haulm yield which was already exhibited by taller plants, larger leaf area index and higher dry matter accrual. The deflated crop growth stature under control (T_3) might have resulted in the lowest haulm yield of groundnut. The above results are in confirmity with the findings of Reddy and Moorthy (1984) and Devi *et al*. (2003).

4.5 OIL AND PROTEIN CONTENT

Organic sources failed to exert any significant influence on the oil and protein content of groundnut kernels (Table 4.8). Oil synthesis is a complex process and it is difficult to modulate its content through management practices during a single season. These findings are in agreement with the studies of Chawale *et al.* (1995) and Panwar and Munda (2007).

4.6 NUTRIENT UPTAKE AT HARVEST

Nutrient uptake by the crop was found to be significantly influenced by various organic sources. Similar trend of response was observed with respect of nitrogen, phosphorus and potassium uptake by groundnut crop (Table 4.9 and Fig. 4.8).

Table 4.8. Oil and protein content (%) of groundnut kernels as influenced by various organic sources

Treatments	Oil content	Protein content
T_1 : Control	46.7	24.3
T_2 : 100% RDF (20-40-50 kg N, P_2O_5 and K_2O ha^{-1})	47.2	25.5
T_3 : 100% N through farm yard manure (FYM)	47.2	25.3
T_4 : 100% N through poultry manure	47.3	24.4
T_5 : 100% N through sheep manure	46.7	25.0
T_6 : 100% N through neem cake	47.4	25.4
T_7 : 50% N through FYM + 50% N through poultry manure	46.8	25.0
T_8 : 50% N through FYM + 50% N through sheep manure	47.1	25.2
T_9 : 50% N through FYM + 50% N through neem cake	47.4	25.0
SEm±	0.20	0.28
CD (P=0.05)	NS	NS

The highest nutrient (N, P and K) uptake was recorded with 100% recommended dose of nutrients through fertilizers (T_2), which was distinctly superior to the other treatments. Among the organic sources tried, supply of 100% N through FYM (T_3) resulted in higher nutrient uptake, however it was comparable with 50% N through FYM + 50% N through sheep manure (T_8). Application of 50% N through FYM + 50% N through neem cake (T_9) was noticed to be on par with 50% N through FYM + 50% N through poultry manure (T_7), followed by 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) which maintained parity among them. The lowest N, P & K uptake was registered with control (T_1).

The highest nutrient (N, P and K) uptake of groundnut was registered with 100% recommended dose of nutrients through fertilizers (T_2), which might be ascribed to the best performance of the crop under comfortable nutrition, resulting in greater absorption of nutrients coupled with higher dry matter production as compared to organic sources. The above results are in confirmity with the findings of Reddy and Moorthy (1984). Among the organic manures, 100% N through FYM (T_3) resulted in better nutrient uptake as compared to poultry manure, sheep manure and neem cake, which were higher in nutrient content. This might be due the better nutrient release pattern of FYM in to the soil there by availability to the crop. The present findings corroborates with that of Rao and Shaktawat (2002) and Laxminarayana and Patiram (2005). Though, different organic sources were applied on equal nitrogen basis, the phosphorus and potassium contents of the respective manures were considered and the remaining amounts were supplied through biophos and biopotash to meet the crop requirement. Therefore, the nitrogen, phosphorus and potassium uptake might have followed the similar trend.

Table 4.9. Nutrient uptake (kg ha^{-1}) of groundnut as influenced by various organic sources

Treatments	N uptake	P uptake	K uptake
T_1 : Control	59.1	15.0	51.6
T_2 : 100% RDF (20-40-50 kg N, P_2O_5 and K_2O ha^{-1})	97.2	30.1	75.2
T_3 : 100% N through farm yard manure (FYM)	89.1	27.2	69.3
T_4 : 100% N through poultry manure	69.4	18.5	59.1
T_5 : 100% N through sheep manure	70.1	19.2	60.3
T_6 : 100% N through neem cake	67.3	17.6	58.2
T_7 : 50% N through FYM + 50% N through poultry manure	79.1	22.5	66.2
T_8 : 50% N through FYM + 50% N through sheep manure	88.2	26.3	68.4
T_9 : 50% N through FYM + 50% N through neem cake	80.2	23.4	67.7
SEm±	2.38	0.48	1.65
CD (P=0.05)	7.1	1.4	4.9

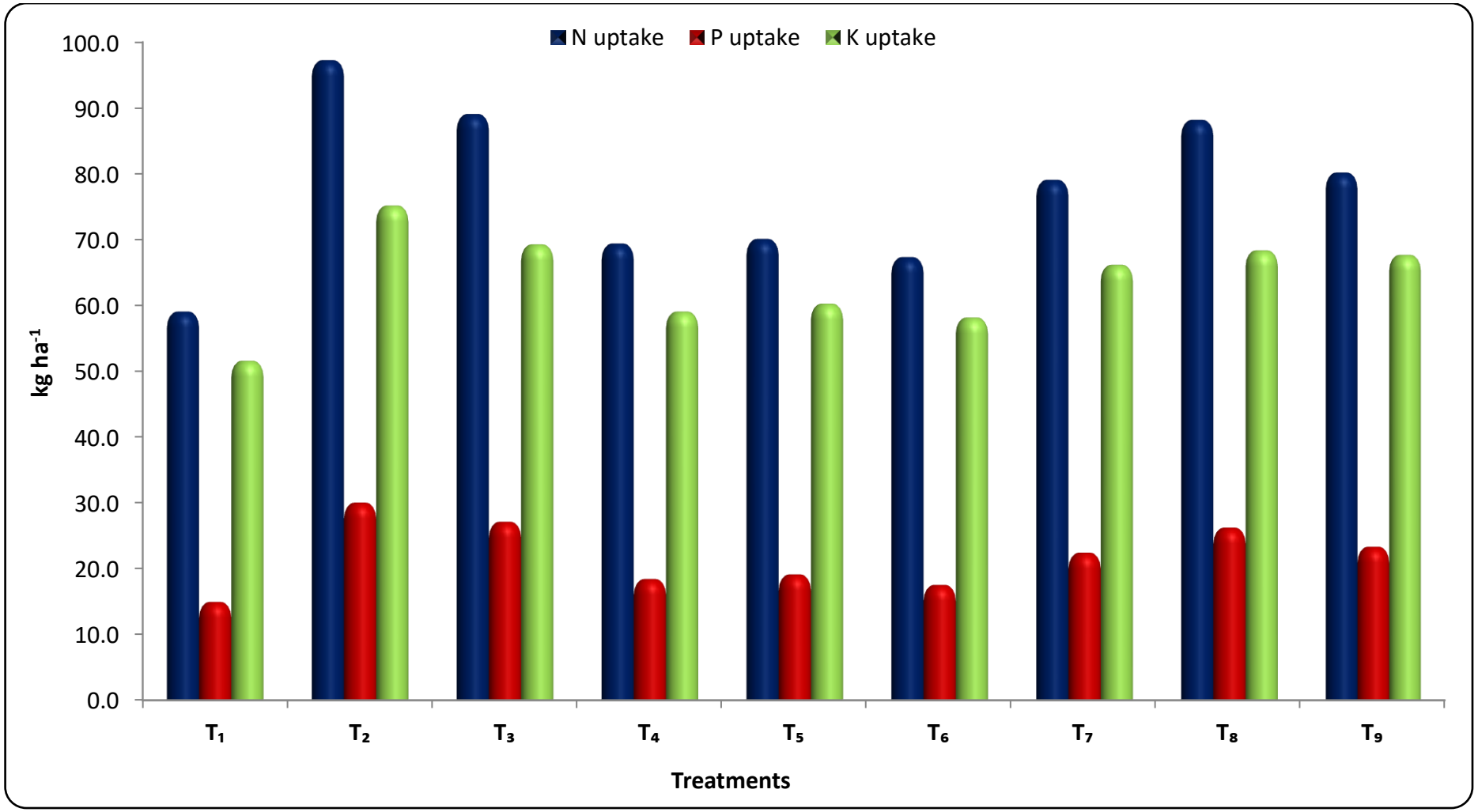


Fig. 4.8. Nutrient uptake (kg ha^{-1}) of groundnut as influenced by various organic sources.

4.7 POST-HARVEST SOIL FERTILITY STATUS

Various organic sources have exerted significant influence on the post-harvest soil nutrient status (Table 4.10 and Fig. 4.9).

4.7.1 Soil Available Nitrogen

The highest post-harvest soil available nitrogen was recorded with 100% N through neem cake (T_6), which was however comparable with 100% N through sheep manure (T_5) and poultry manure (T_4). Application of 50% N through FYM + 50% N through poultry manure (T_7), 50% N through FYM + 50% N through neem cake (T_9), 50% N through FYM + 50% N through sheep manure (T_8) and 100% N through FYM (T_3) maintained parity among them. These treatments were followed by 100% recommended dose of nutrients through fertilizers (T_2). The lowest post-harvest soil available nitrogen was found with control (T_1).

4.7.2 Soil Available Phosphorus

The highest post-harvest soil available phosphorus was recorded with 100% N through poultry manure (T_4), which was however on par with 100% N through sheep manure (T_5) and neem cake (T_6). The next higher quantity of available phosphorus was obtained with 50% N through FYM + 50% N through poultry manure (T_7), which maintained parity with 50% N through FYM + 50% N through neem cake (T_9), 50% N through FYM + 50% N through sheep manure (T_8) and 100% N through FYM (T_3). Application of 100% recommended dose of nutrients through fertilizers (T_2) recorded lesser soil available phosphorus, followed by control (T_1).

4.7.3 Soil Available Potassium

The highest post-harvest soil available potassium was noticed with 100% N through neem cake (T_6), which was however comparable with 100% N through sheep manure (T_5) and poultry manure (T_4). Application of

50% N through FYM + 50% N through poultry manure (T_7), 50% N through FYM + 50% N through neem cake (T_9), 50% N through FYM + 50% N through sheep manure (T_8) and 100% N through FYM (T_3) maintained parity among them. These treatments were followed by 100% recommended dose of nutrients through fertilizers (T_2). The lowest post-harvest soil available potassium was recorded with control (T_1).

Amongst the various organic sources tried for the study, neem cake, sheep manure and poultry manure replenished more available nitrogen and potassium to the soil than the farm yard manure. The buildup of soil available phosphorus was noticed to be higher with poultry manure as compared to other organic manures. However, all of them were applied on equal nitrogen basis and the remaining phosphorus and potassium were also supplemented through biophos and biopotash, respectively. The mineralization of organic manures and release pattern of nutrients in to the soil solution differ according to the sources. Hence, application of FYM might have enhanced the availability of nitrogen and potassium to the crop which may consequently lead to lower status in the soil after harvest as compared to other manures. Further, 100% recommended dose of nutrients through fertilizers resulted in easier release and better uptake of nutrients by the crop due to which it's post-harvest soil available nutrient status was found to be inferior over other organic manures. The non - supply of NPK through any source coupled with exhaustion of native soil nutrients by the crop might have resulted in the lowest soil available nitrogen, phosphorus and potassium in control.

Table 4.10. Post-harvest soil available Nitrogen (N), Phosphorus (P_2O_5) and Potassium (K_2O) (kg ha^{-1}) as influenced by various organic sources

Treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
T_1 : Control	135.1	21.1	130.1
T_2 : 100% RDF (20-40-50 kg N, P_2O_5 and K_2O ha^{-1})	155.4	27.1	151.2
T_3 : 100% N through farm yard manure (FYM)	176.4	33.3	172.4
T_4 : 100% N through poultry manure	198.3	45.6	200.4
T_5 : 100% N through sheep manure	199.1	44.3	203.5
T_6 : 100% N through neem cake	201.5	42.3	205.3
T_7 : 50% N through FYM + 50% N through poultry manure	179.4	36.3	178.1
T_8 : 50% N through FYM + 50% N through sheep manure	191.4	34.4	174.5
T_9 : 50% N through FYM + 50% N through neem cake	178.3	35.1	176.2
SEm±	5.34	1.17	6.18
CD (P=0.05)	16.0	3.5	18.5

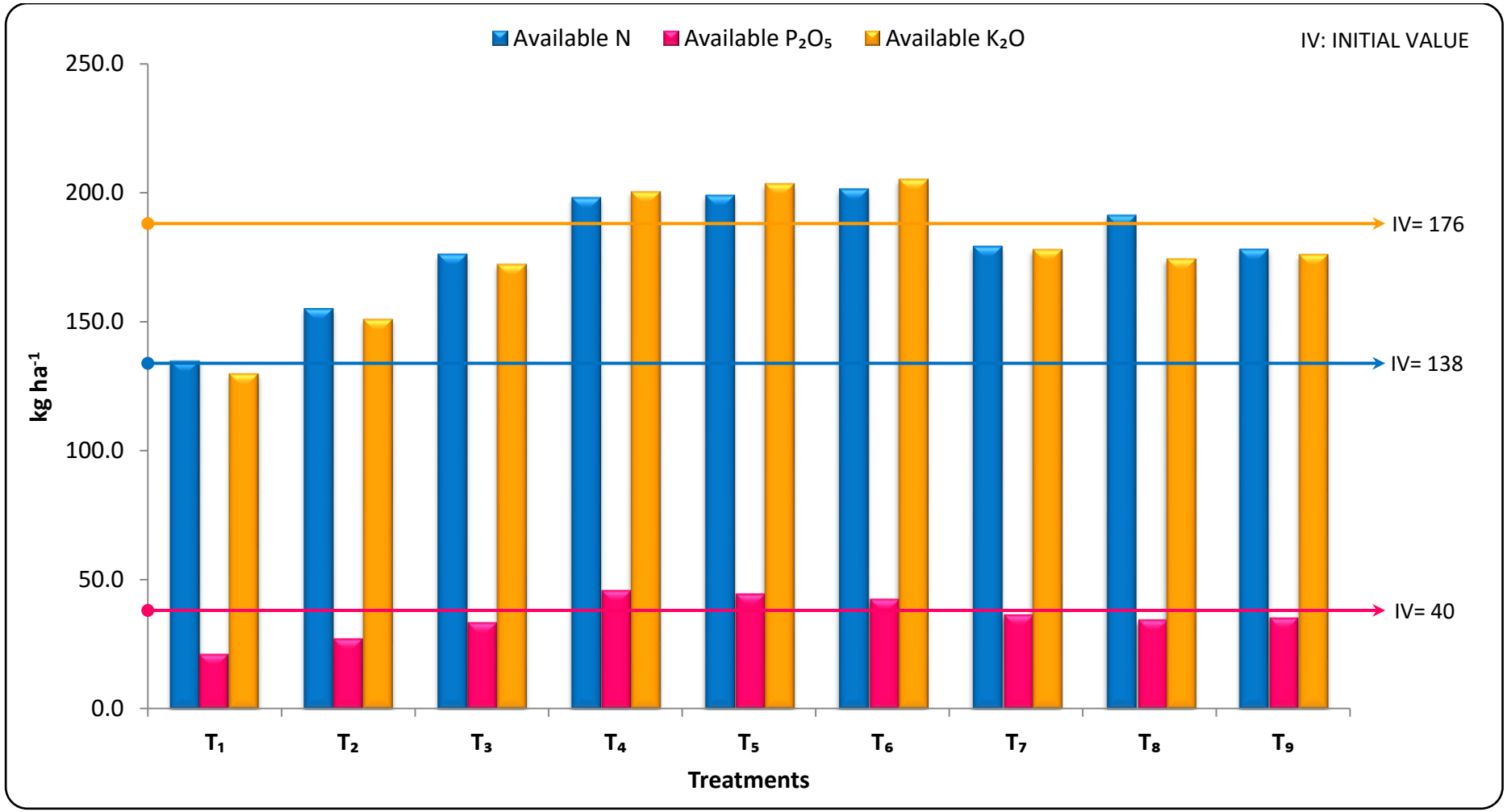


Fig. 4.9. Post-harvest soil available nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) (kg ha^{-1}) as influenced by various organic sources.

4.8 ECONOMICS

Gross returns, net returns and benefit - cost ratio of groundnut were significantly influenced by various organic sources furnished in (Table 4.11 and Fig 4.10).

4.8.1 Gross Returns

The highest gross returns of groundnut were obtained with 100% recommended dose of nutrients through fertilizers (T_2), which was significantly superior overall other treatments. The next higher gross returns were noticed with 100% N through FYM (T_3), which was however, comparable with 50% N through FYM + 50% N through sheep manure (T_8), followed by 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9) which were statistically on par with each other. Application of 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) had resulted in comparable gross returns. The lowest gross returns were realized with control (T_1).

4.8.2 Net Returns

The highest net returns were realized with 100% recommended dose of nutrients through fertilizers (T_2), which were significantly maximum among rest of the treatments. The next best treatment was 50% N through FYM + 50% N through sheep manure (T_8), which was however on par with the 100% N through FYM (T_3) followed by 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9) whereas the later was in parity with 100% N through poultry manure (T_4) and 100% N through sheep manure (T_5). The net returns obtained with 100% N through sheep manure (T_5) were in parity with 100% N through neem cake (T_6) and control (T_1), which resulted in the lowest net returns.

4.8.3 Benefit : Cost Ratio

The highest benefit-cost ratio was registered with 100% recommended dose of nutrients through fertilizers (T_2), which was however distinctly higher among various organic sources. The benefit-cost ratio obtained with application of 50% N through FYM + 50% N through sheep manure (T_8) and 100% N through FYM (T_3) were equivalent with each other. However, the later treatment (T_3) was in parity with 50% N through FYM + 50% N through poultry manure (T_7), which was in turn comparable with 100% N through poultry manure (T_4), control (T_1) and 50% N through FYM + 50% N through neem cake (T_9) which did not show any significant difference among them. The treatments of T_4, T_1 and T_9 were in parity with 100% N through sheep manure (T_5). The lowest benefit-cost ratio was apprehended with 100% N through neem cake (T_6).

The highest gross and net returns as well as benefit - cost ratio associated with 100% recommended dose of nutrients through fertilizers (T_2) might be due to the higher pod and haulm yields. Among the various organic sources tried in the field, the gross returns were higher with 100% N through FYM (T_3) whereas net returns and benefit cost ratio were found to be slightly higher with 50% N through FYM + 50% N through sheep manure (T_8), which were however analogous with each other. The economic returns with various organic sources were found to be lesser compared to the recommended dose of nutrients through fertilizers, this might be due to the higher cost and lesser pod and haulm yields of groundnut noticed under organic sources. Though the pod and haulm yields with application of 100% N through neem cake (T_6) were higher, the benefit cost ratio was noticed to be lower than control (T_1) due to its higher cost over all other organic manures.

Table 4.11. Gross returns, net returns (₹ ha^{-1}) and B:C ratio of groundnut as influenced by various organic sources

Treatments	Gross returns	Net returns	B : C ratio
T_1 : Control	57216	32716	2.34
T_2 : 100% RDF (20-40-50 kg N, P_2O_5 and K_2O ha^{-1})	121647	93462	4.32
T_3 : 100% N through farm yard manure (FYM)	107042	69422	2.85
T_4 : 100% N through poultry manure	77420	45148	2.40
T_5 : 100% N through sheep manure	77548	42384	2.21
T_6 : 100% N through neem cake	76891	34583	1.82
T_7 : 50% N through FYM + 50% N through poultry manure	91330	56384	2.61
T_8 : 50% N through FYM + 50% N through sheep manure	106851	70459	2.94
T_9 : 50% N through FYM + 50% N through neem cake	90493	50529	2.26
SEm±	3292	3292	0.116
CD (P=0.05)	9956	9956	0.35

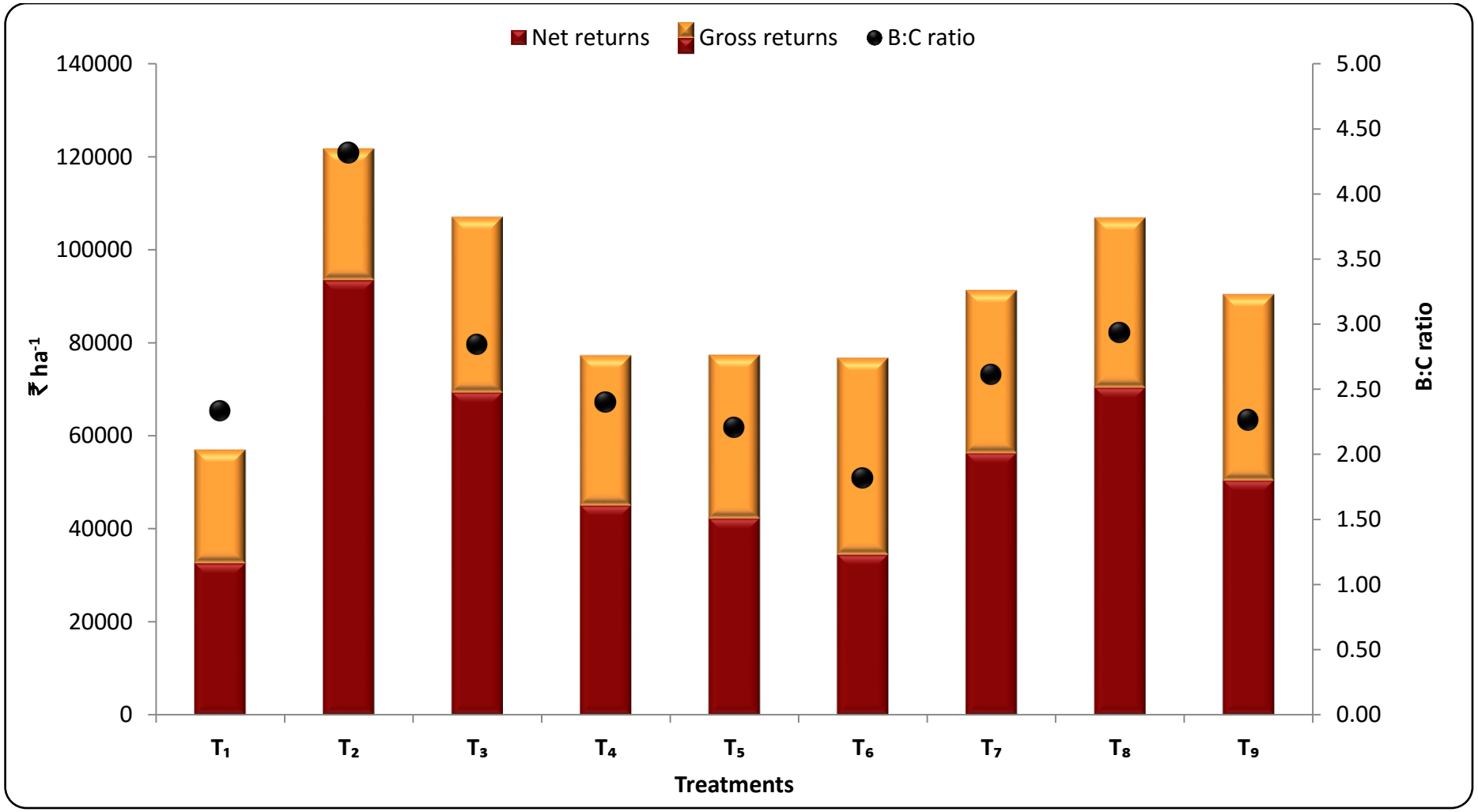


Fig. 4.10. Gross returns, net returns (₹ ha^{-1}) and B : C ratio of groundnut as influenced by various organic sources.

Chapter ~ V

Summary & Conclusions

Chapter V

SUMMARY AND CONCLUSIONS

A field experiment was conducted during *kharif*, 2015 on sandy loam soils of dryland form of S.V. Agricultural College, Tirupati, Acharya N.G. Ranga Agricultural University, Andhra Pradesh to study the **"Nutrient management for organic groundnut under rainfed condition"**. The experiment was laid out in randomized block design and replicated thrice. There were nine treatments *viz.*, Control (T_1), 100% recommended dose of nutrients through fertilizers (20-40-50 kg N, P_2O_5 and K_2O ha^{-1}) (T_2), 100% N through farm yard manure (FYM) (T_3), 100% N through poultry manure (T_4), 100% N through sheep manure (T_5), 100% N through neem cake (T_6), 50% N through FYM + 50% N through poultry manure (T_7), 50% N through FYM + 50% N through sheep manure (T_8), 50% N through FYM + 50% N through neem cake (T_9). Various organic sources were applied on equal nitrogen basis. The corresponding quantity of phosphorus and potassium supplied by those manures were considered and the remaining quantities were applied through organic sources of biophos and biopotash respectively. The salient findings of the investigation are summarized below:

Various organic sources exerted significant influence on growth parameters *viz*., plant height, leaf area index, dry matter production, total and effective number of nodules $plant^{-1}$, yield attributes *viz*., number of pods $plant^{-1}$, 100 pod weight, 100 kernel weight, kernel yield, pod yield, haulm yield, shelling percentage, nutrient uptake and post-harvest nutrient status of the soil. However, quality parameters like oil and protein content were not influenced by various organic sources.

At all the stages of observation *viz*., 25, 50, 75 DAS and at harvest, the tallest plants, highest leaf area index and dry matter production were recorded with 100% recommended dose of nutrients through fertilizers (T_2),

which was significantly superior to the organic sources tried. The next best treatment was 100% N through FYM (T_3), which was however, comparable with 50% N through FYM + 50% N through sheep manure (T_8). Supply of 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9) were statistically at par with each other, followed by 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6), which were in turn comparable among them. The deflated stature of growth parameters was noticed with control (T_1).

The highest number of total and effective nodules plant^{-1} were recorded with application of 50% N through FYM + 50% N through sheep manure (T_8), which was however comparable with 50% N through FYM + 50% N through neem cake (T_9), 100% N through FYM (T_3), 50% N through FYM + 50% N through poultry manure (T_7). Application of 100% N through poultry manure (T_4), sheep manure (T_5) and neem cake (T_6) recorded comparable number of nodules, which were noticed to be significantly superior to 100% recommended dose of nutrients through fertilizers (T_2). The lowest number of total and effective nodules plant^{-1} were registered with control (T_1).

Application of 100% recommended dose of nutrients through fertilizers (T_2) recorded the highest number of pods plant^{-1}, 100 pod weight, 100 kernel weight and shelling percentage. The next best treatment of 100% N through FYM (T_3) was comparable with 50% N through FYM + 50% N through sheep manure (T_8), followed by 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9), which were statistically on par with each other. Application of 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) were comparable among them. The deflated stature of yield attributes were registered with control (T_1).

The highest pod, kernel and haulm yields of groundnut were obtained with 100% recommended dose of nutrients through fertilizers (T_2), which was significantly superior to rest of the treatments. Among the various organic sources of nutrients tried, supply of 100% N through FYM (T_3) recorded higher pod, kernel and haulm yields, which were however, comparable with 50% N through FYM + 50% N through sheep manure (T_8). Supply of 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9) were statistically at par with each other, followed by application of 100 % N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6),which were comparable among them. The lowest pod, kernel and haulm yields were registered with control (T_1).

Organic sources failed to exert any significant influence on the oil and protein content of groundnut kernels.

The highest nitrogen, phosphorus and potassium uptake were recorded with 100% recommended dose of nutrients through fertilizers (T_2), which was distinctly superior over the other treatments. Among the organic sources tried, supply of 100% N through FYM (T_3) resulted in higher nutrient uptake, however comparable with 50% N through FYM + 50% N through sheep manure (T_8). Application of 50% N through FYM + 50% N through neem cake (T_9) were noticed to be on par with 50% N through FYM + 50% N through poultry manure (T_7) followed by 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) which inturn maintained parity among them. The lowest uptake of nutrient was registered with control (T_1).

The highest post-harvest soil available nitrogen and potassium were recorded with 100% N through neem cake (T_6) which was however comparable with100% N through sheep manure (T_5) and poultry manure (T_4). Application of 50% N through FYM + 50% N through poultry manure (T_7), 50% N through FYM + 50% N through neem cake (T_9), 50% N

through FYM + 50% N through sheep manure (T_8) and 100% N through FYM (T_3) maintained parity among them. These treatments were followed by 100% recommended dose of nutrients through fertilizers (T_2). The lowest post-harvest soil available nitrogen and potassium content was registered with control (T_1).

The highest post-harvest soil available phosphorus was recorded with 100% N through poultry manure (T_4) which was however on par with 100% N through sheep manure (T_5) and neem cake (T_6). The next higher quantity of available phosphorus was obtained with 50% N through FYM + 50% N through poultry manure (T_7), which maintained parity with 50% N through FYM + 50% N through neem cake (T_9), 50% N through FYM + 50% N through sheep manure (T_8) and 100% N through FYM (T_3). Application of 100% recommended dose of nutrients through fertilizers (T_2) resulted in lesser soil available phosphorus followed by control (T_1) which recorded the lowest content.

The highest gross returns of groundnut was obtained with 100% recommended dose of nutrients through fertilizers (T_2) which was significantly superior over all other treatments. The next higher gross returns were resulted with 100% N through FYM (T_3) which was however comparable with 50% N through FYM + 50% N through sheep manure (T_8) followed by 50% N through FYM + 50% N through poultry manure (T_7) and 50% N through FYM + 50% N through neem cake (T_9) which were statistically on par with each other. Application of 100% N through sheep manure (T_5), poultry manure (T_4) and neem cake (T_6) had resulted in comparable gross returns. The lowest gross returns were realized with control (T_1).

The highest net returns and benefit cost ratio were obtained with 100% recommended dose of nutrients through fertilizers (T_2) which were significantly higher over rest of the treatments. The next best treatment was

50% N through FYM + 50% N through sheep manure (T_8) which was however on par with 100% N through FYM (T_3) followed by 50% N through FYM + 50% N through poultry manure (T_7). The lowest net returns were obtained with control (T_1), whereas the lowest benefit-cost ratio was realized with 100% N through neem cake (T_6).

Since the main aim of the study was on the scope of organic farming, the performance of groundnut with different organic manures has to be examined. Thus, keeping the best performance of groundnut crop with recommended dose of nutrients through fertilizers apart, comparison was made among various organic manures tried.

The following broad conclusions could be drawn from the present investigation.

1. Performance of groundnut in terms of productivity and economic returns were found at their best with the application of recommended dose of nutrients through fertilizers

2. Among the various organic sources tried, application of 100% N through farm yard manure found to be the best with improved crop growth stature, yield attributes and yield, which was however comparable with supply of 50% N through FYM + 50% N through sheep manure, which resulted in optimal performance of crop with higher net returns and benefit cost ratio.

3. Post-harvest soil fertility status could be improved with the application of organic manures, as 100% N through FYM as well as 50% N through FYM + 50% N through sheep manure compared to recommended dose of nutrients through fertilizers.

4. The net returns and benefit cost ratio realized with various organic sources were noticed to be lower when compared with 100% recommended dose of nutrients through fertilizers due to increased cost of cultivation.

In conclusion, the investigation revealed that higher pod yield of groundnut as well as economic returns could be realized with 100% recommended dose of nutrients through fertilizers. Among the various organic sources tried, 100% N through FYM as well as the combination of 50% N through FYM + 50% N through sheep manure were proved to be promising organic manurial practices for higher yield and economics of groundnut with maintenance of soil fertility under rainfed conditions in the present domain of study. However the economic returns under organic approach could be enhanced with premium price for the organic produce in the market after certification.

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*Original not seen

The Literature cited is as per the thesis format guidelines of Acharya N.G. Ranga Agricultural University, Guntur, Andhra Pradesh, India.

Appendices

APPENDIX – A

CALENDAR OF OPERATIONS

S. No.	Operation	Date
1.	Field preparation with tractor drawn plough	22-06-2015
2.	Removal of stubbles	23-06-2015
3.	Second ploughing, harrowing and leveling of the field	26-06-2015
4.	Layout of the experimental plot	27-06-2015
5.	Formation of bunds	29-06-2015
6.	Application of organic manures	30-06-2015
7.	Decomposition period	01-07-2015 to 14-07-15
8.	Sowing of seeds	15-07-2015
9.	First irrigation	16-07-2015
10.	Spraying of neemastram	29-07-2015
11.	Star weeding	30-07-2015
12.	First weeding	04-08-2015
13	Spraying of neemastram	13-08-2015
13.	Second weeding	20-08-2015
14.	Spraying of bramhastram	29-08-2015
15.	Second irrigation	03-09-2015
16.	Spraying of neemastram	14-09-2015
17.	Spraying of bramhastram	29-09-2015
18.	Harvesting	03-11-2015

APPENDIX – B

COST OF CULTIVATION OF GROUNDNUT EXCLUDING COST OF NUTRIENTS (₹ ha^{-1})

S. No.	Operation	Cost (₹ ha^{-1})
1.	Land preparation and leveling	3,000
2.	Seeds and sowing	12,000
3.	Weeding	3,500
4.	Irrigation	500
5.	Plant protection	500
6.	Harvesting and stripping	5,000
	Total	24,500

APPENDIX – C

COST OF INPUT AND OUTPUT

S. No.	Input/output	Cost (₹)
1.	Farm yard manure	0.5 kg^{-1}
2.	Poultry manure	0.7 kg^{-1}
3.	Sheep manure	0.6 kg^{-1}
4.	Neem cake	5.0 kg^{-1}
5.	Urea	5.8 kg^{-1}
6.	Single super phosphate	8.4 kg^{-1}
7.	Muriate of potash	16 kg^{-1}
8.	Biophos	32 kg^{-1}
9.	Biopotash	28 kg^{-1}
10.	One man day^{-1}	202
11.	Groundnut pods	50 kg^{-1}
12.	Groundnut haulms	1 kg^{-1}

* Price of the groundnut pods is as per the prevailing rate at Agricultural Market Committee, Tirupati, Chittoor district (Andhra Pradesh)

APPENDIX – D

TOTAL COST OF CULTIVATION OF GROUNDNUT (₹ ha^{-1})

S. No.	Treatment	Cost of cultivation excluding nutrients (₹ ha^{-1})	Cost of organic manures (₹ ha^{-1})	Cost of biophos (₹ ha^{-1})	Cost of biopotash (₹ ha^{-1})	Cost of Fertilizer (₹ ha^{-1})	Total cost of cultivation (₹ ha^{-1})
1.	T_1 : Control	24500	-	-	-	-	24500
2.	T_2 : 100% RDF (20-40-50 kg N, P_2O_5 and K_2O ha^{-1})	24500	-	-	-	3685	28185
3.	T_3 : 100% N through farm yard manure (FYM)	24500	2000	5120	6000	-	37620
4.	T_4 : 100% N through poultry manure	24500	1272	1600	4900	-	32272
5.	T_5 : 100% N through sheep manure	24500	1000	5344	4320	-	35164
6.	T_6 : 100% N through neem cake	24500	5260	4864	7684	-	42308
7.	T_7 : 50% N through FYM + 50% N through poultry manure	24500	1636	3360	5450	-	34946
8.	T_8 : 50% N through FYM + 50% N through sheep manure	24500	1500	5232	5160	-	36392
9.	T_9 : 50% N through FYM + 50% N through neem cake	24500	3630	4992	6842	-	39964

Plates

Plate 1. Overall view of the experimental field at flowering

Plate 2. Overall view of the experimental field at harvesting

Plate 3. Incorporation of organic manures in the experimental plots

Plate 4. Plant stature of groundnut in the control (T_1), 100% RDF (T_2) and 100% N through Farm yard manure (T_3)