

**YIELD MAXIMIZATION IN *KHARIF* GROUNDNUT  
THROUGH NUTRIENT MANAGEMENT  
PRACTICES**

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**PALB 2180**

**DEPARTMENT OF AGRONOMY  
UNIVERSITY OF AGRICULTURAL SCIENCES  
BENGALURU - 560 065**

**2014**

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*Thesis submitted to the*

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*in partial fulfillment of the requirements*

*for the award of the degree of*

***Master of Science (Agriculture)***

in

**AGRONOMY**

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**JUNE, 2014**



*Affectionaly Dedicated to  
My Beloved Parents, Brother  
and my Guide*

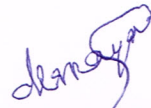


**DEPARTMENT OF AGRONOMY  
UNIVERSITY OF AGRICULTURAL SCIENCES  
GKVK, BENGALURU - 560 065**

**CERTIFICATE**

This is to certify that the thesis entitled **YIELD MAXIMIZATION IN KHARIF GROUNDNUT THROUGH NUTRIENT MANAGEMENT PRACTICES** submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY** to the University of Agricultural Sciences, Bengaluru, is a bonafide record of research work carried out by **Ms. MUNIRATHNAMMA,C.M., ID No. PALB 2180** during the period of study in this university under my guidance and supervision. This thesis has not previously formed the basis of the award of any other degree, diploma, associateship, fellowship or any other similar titles.

Bengaluru  
June, 2014

  
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**(N. JANAKIRAMAN)**

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*With regard full memories.....*

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*BENGALURU  
JUNE, 2014*

*(MUNIRATHNAMMA, C.M.)*

## Yield Maximization in *Kharif* Groundnut (*Arachis hypogaea* L.) Through Nutrient Management Practices

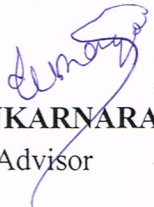
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### ABSTRACT

A field experiment entitled “Yield maximization in *Kharif* groundnut (*Arachis hypogaea* L.) through nutrient management practices” was conducted on red sandy loam soil during *kharif*, 2013 at Agricultural Research Station, Chintamani. The experiment was laid out in split plot design assigning four nutrient management practices to main plots and three foliar sprays to sub plots and replicated thrice. Application of FYM + Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> recorded significantly higher pod (1175 kg ha<sup>-1</sup>) and haulm yield (2465 kg ha<sup>-1</sup>) of groundnut as a result of higher number of pods plant<sup>-1</sup> (29.3), filled pod plant<sup>-1</sup> (21.5), total dry matter production (27.7 g plant<sup>-1</sup>) and nutrient uptake ( 93.4,11.6 ,42 kg N, P<sub>2</sub>O<sub>5</sub> ,K<sub>2</sub>O ha<sup>-1</sup> and 88.7, 25.8 g Zn ,B ha<sup>-1</sup> respectively ). Among the foliar sprays, 2 % urea spray at 30 and 60 DAS recorded significantly higher pod (1025 kg ha<sup>-1</sup>) and haulm yield (2237 kg ha<sup>-1</sup>). This was also attributed to higher dry matter production (25.9 g plant<sup>-1</sup>), number of pods plant<sup>-1</sup> (28.6), filled pod plant<sup>-1</sup> (20.9) and nutrient uptake (76.6, 8.6, 37.6 kg N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O ha<sup>-1</sup> and 71, 23.3 g Zn, B ha<sup>-1</sup> respectively). Application of FYM + Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> + foliar spray of 2 % urea at 30 and 60 DAS was found to be cost effective as it recorded higher net returns( Rs 22,522 ha<sup>-1</sup>) and B:C ratio (1.9) than other treatment combinations.

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DEPARTMENT OF AGRONOMY  
UAS, GKVK, BENGALURU-65

  
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Major Advisor

ಪೋಷಕಾಂಶಗಳ ನಿರ್ವಹಣಾ ಪದ್ಧತಿ ಮೂಲಕ ಮುಂಗಾರು ಶೇಂಗಾ ಬೆಳೆಯ ಇಳುವರಿಯನ್ನು  
ಅಧಿಕಗೊಳಿಸುವುದು


ಮುನಿರತ್ನಮ್ಮ ಸಿ. ಎಂ.

ಪ್ರಬಂಧ ಸಾರಾಂಶ

“ಪೋಷಕಾಂಶಗಳ ನಿರ್ವಹಣಾ ಪದ್ಧತಿ ಮೂಲಕ ಮುಂಗಾರು ಶೇಂಗಾ ಬೆಳೆಯ ಇಳುವರಿಯನ್ನು ಅಧಿಕಗೊಳಿಸುವುದು” ಎಂಬ ಕ್ಷೇತ್ರ ಪ್ರಯೋಗವನ್ನು ೨೦೧೩ರ ಮುಂಗಾರು ಹಂಗಾಮಿನಲ್ಲಿ ಕೃಷಿ ಸಂಶೋಧನಾ ಕೇಂದ್ರ ಚಿಂತಾಮಣಿಯ ಮರುಳು ಮಿಶ್ರಿತ ಕೆಂಪು ಗೋಡು ಮಣ್ಣಿನಲ್ಲಿ ಕೈಗೊಳ್ಳಲಾಯಿತು. ಪ್ರಯೋಗವನ್ನು ವಿಂಗಡಿತ ತಾಕು ಮಾದರಿಯಲ್ಲಿ ಕೈಗೊಂಡು ಮೂರು ಬಾರಿ ಪ್ರತಿರೂಪಿಸಲಾಯಿತು. ನಾಲ್ಕು ಪೋಷಕಾಂಶಗಳ ನಿರ್ವಹಣಾ ಉಪಚಾರಗಳನ್ನು ಮುಖ್ಯ ತಾಕುವಿನಲ್ಲೂ ಹಾಗೂ ಮೂರು ಎಲೆಗಳ ಮೇಲೆ ಪೋಷಕಾಂಶಗಳ ಸಿಂಪರಣಾ ಉಪಚಾರಗಳನ್ನು ಉಪ ತಾಕುಗಳಲ್ಲಿ ಪರೀಕ್ಷಿಸಲಾಯಿತು. ಸಂಶೋಧನಾ ಫಲಿತಾಂಶಗಳ ಪ್ರಕಾರ ಅಧಿಕ ಶೇಂಗಾ (೧೧೨೫ ಕೆ.ಜಿ./ಹೆ.) ಹಾಗೂ ದಂಟು (೨೪೬೫ ಕೆ.ಜಿ./ಹೆ.) ಇಳುವರಿಯು ಶಿಫಾರಸ್ಸು ಮಾಡಿದ ರಾಸಾಯಾನಿಕ ಗೊಬ್ಬರ (೨೫:೫೦:೨೫ ಕೆ.ಜಿ. ಸಾ.ರಂ.ಪೊ./ಹೆ) + ಕೊಟ್ಟಿಗೆ ಗೊಬ್ಬರ (೨೫ ಟನ್/ಹೆ.) + ಬೊರಾಕ್ಸ್ (೫ ಕೆ.ಜಿ./ಹೆ.) + ಸತುವಿನ ಸಲ್ಫೇಟ್ (೧೦ ಕೆ.ಜಿ./ಹೆ.) ಉಪಚಾರದಲ್ಲಿ ದಾಖಲಾಗಿದೆ. ಉಳಿದ ಇಳುವರಿ ನಿರ್ಧರಿಸುವ ಅಂಶಗಳಾದ ಹೆಚ್ಚಿನ ಶೇಂಗಾ ಸಂಖ್ಯೆ (ಪ್ರತಿ ಗಿಡಕ್ಕೆ ೨೯.೩), ಫಲಭರಿತ ಶೇಂಗಾ (೨೧.೫), ಒಟ್ಟು ಗಿಡದ ಒಣ ಪದಾರ್ಥ (೨೨.೨ ಗ್ರಾಂ/ಗಿಡ) ಹಾಗೂ ವಿವಿಧ ಪೋಷಕಾಂಶಗಳ ಹೀರುವಿಕೆ (೯೩.೪, ೧೧.೬, ೪೨ ಕೆ.ಜಿ. ಸಾ.ರಂ.ಪೊ./ಹೆ. ಹಾಗೂ ೮೮.೨, ೨೫.೮ ಗ್ರಾಂ. ಸ. ಬೊ. /ಹೆ.) ಕೂಡ ಈ ಉಪಚಾರದಲ್ಲಿ ಹೆಚ್ಚು ಇರುವುದು ಕಂಡು ಬಂದಿದೆ. ವಿವಿಧ ಪೋಷಕಾಂಶಗಳ ಸಿಂಪರಣಾ ಉಪಚಾರದಲ್ಲಿ ಶೇಕಡಾ ಎರಡರ ಯೂರಿಯಾವನ್ನು ೩೦ ಹಾಗೂ ೬೦ ದಿನಗಳಲ್ಲಿ ಸಿಂಪರಿಸಿರುವ ಉಪಚಾರವು ಅಧಿಕ ಶೇಂಗಾ (೧೦೨೫ ಕೆ.ಜಿ./ಹೆ.) ಹಾಗೂ ದಂಟು (೨೨೩೨ ಕೆ.ಜಿ./ಹೆ.) ಇಳುವರಿಯು ಕಂಡು ಬಂದಿದೆ. ಹಾಗೂ ಇದೇ ಉಪಚಾರದಲ್ಲಿ ಇಳುವರಿ ನಿರ್ಧರಿಸುವ ಅಂಶಗಳಾದ ಹೆಚ್ಚಿನ ಶೇಂಗಾ ಸಂಖ್ಯೆ (ಪ್ರತಿ ಗಿಡಕ್ಕೆ ೨೮.೬), ಫಲಭರಿತ ಶೇಂಗಾ (೨೦.೯), ಒಟ್ಟು ಗಿಡದ ಒಣ ಪದಾರ್ಥ (೨೫.೯ ಗ್ರಾಂ/ಗಿಡ) ಹಾಗೂ ವಿವಿಧ ಪೋಷಕಾಂಶಗಳ ಹೀರುವಿಕೆ (೨೬.೬, ೮.೬, ೩೨.೬ ಕೆ.ಜಿ. ಸಾ.ರಂ.ಪೊ./ಹೆ. ಹಾಗೂ ೨೧, ೨೩.೩ ಗ್ರಾಂ. ಸ. ಬೊ. /ಹೆ.) ಹೆಚ್ಚು ಇರುವುದು ಕಂಡು ಬಂದಿದೆ. ಪೋಷಕಾಂಶಗಳ ಹಾಗೂ ಸಿಂಪರಣಾ ಉಪಚಾರಗಳ ಸಂಯೋಜಿತ ಪರಿಣಾಮವನ್ನು ಅವಲೋಕಿಸಿದಾಗ ಅಧಿಕ ನಿವ್ವಳ ಲಾಭವು (ರೂ. ೨೨,೫೨೨/ಹೆ.) ಮತ್ತು ಅಧಿಕ ಲಾಭ:ವೆಚ್ಚದ ಅನುಪಾತ ಸಹ (೧.೯) ಶಿಫಾರಸ್ಸು ಮಾಡಿದ ರಾಸಾಯಾನಿಕ ಗೊಬ್ಬರ (೨೫:೫೦:೨೫ ಕೆ.ಜಿ. ಸಾ.ರಂ.ಪೊ./ಹೆ ) + ಕೊಟ್ಟಿಗೆ ಗೊಬ್ಬರ (೨೫ ಟನ್/ಹೆ.) + ಬೊರಾಕ್ಸ್ (೫ ಕೆ.ಜಿ./ಹೆ.) + ಸತುವಿನ ಸಲ್ಫೇಟ್ (೧೦ ಕೆ.ಜಿ./ಹೆ.) ಒದಗಿಸುವುದರ ಜೊತೆಗೆ ಶೇಕಡಾ ಎರಡರ ಯೂರಿಯಾವನ್ನು ಬೆಳೆಯ ೩೦ ಹಾಗೂ ೬೦ ದಿನಗಳಲ್ಲಿ ಸಿಂಪರಿಸಿರುವ ಉಪಚಾರದಲ್ಲಿ ಕಂಡುಬಂದಿದೆ.

೨೦೧೪

ಬೇಸಾಯಶಾಸ್ತ್ರ ವಿಭಾಗ  
ಗಾ.ಕೃ.ವಿ.ಕೇ., ಬೆಂಗಳೂರು

  
ಪ್ರಧಾನ ಸಲಹೆಗಾರರ ಸಹಿ  
(ಎ. ಶಂಕರನಾರಾಯಣ)

# Yield maximization in *Kharif* groundnut through nutrient management practices.



Munirathamma, C. M and Dr. V. Shankarnarayana

Department of Agronomy



## Introduction:

Groundnut (*Arachis hypogaea* L.), king of oilseeds belongs to the family Leguminosae. It is energy rich crop, mainly grown under rainfed conditions under energy starved condition. Inadequate and imbalance use of nutrients is one of the major factors responsible for low yields in groundnut. Although, chemical fertilizers are playing a crucial role to meet the nutrient requirement of the crop, integrated use of both chemical fertilizers and organic manures is needed to check the depletion of soil nutrients and enhance the yield levels.

As time growing, deficiency of micronutrients appeared due to intensive cropping, therefore it is imperative to apply those micronutrients for higher productivity in groundnut. Among the micronutrients Zn and Bo deficiency is known to exist in larger area, these micronutrients will play a key role in synthesis of protein, fat and biological N fixation. Foliar nutrition in groundnut results in efficient absorption of applied nutrients which in turn reduces the amount of fertilizer and economizing crop production. With this background the above the experiment was conducted.

## Objectives:

1. To study the effect of nutrient management practices on growth and yield of groundnut.
2. To study nutrient status of soil and plant.

## Material and methods:

Crop: Groundnut  
Variety : KCG – 2  
Spacing : 30 × 10 cm  
Location: ARS, Sericulture college, chintamani.  
Design : Split plot design  
Treatments: 12  
Replication : 3  
Gross plot size: 3.6 m × 3.0 m  
Net plot size: 3.0 m × 2.8 m  
**Treatment Details**  
**Main-plot( nutrient management):**  
M<sub>1</sub> : FYM 7.5 t ha<sup>-1</sup>  
M<sub>2</sub> : Recommended NPK (25:50:25 kg ha<sup>-1</sup>)  
M<sub>3</sub> : FYM @ 7.5 t ha<sup>-1</sup> + Rec. NPK (25:50:25 kg ha<sup>-1</sup>)  
M<sub>4</sub> : FYM + Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup>  
**Sub-plot( foliar spray):**  
S<sub>1</sub> : Absolute control (No spray)  
S<sub>2</sub> : Foliar spray of 2% urea at 30 DAS  
S<sub>3</sub> : Foliar spray of 2% urea at 30 and 60 DAS  
Treatments combinations: 12

Table 1. Effect of nutrient management practices and foliar spray on yield attributes and yield of groundnut

Treatment	No. of pods plant	Filled pods plant <sup>-1</sup>	100 kernel weight (gm)	Pod yield (kg ha <sup>-1</sup> )	kernel yield (kg ha <sup>-1</sup> )
<b>Main plot: Nutrient management (kg/ha)</b>					
M <sub>1</sub>	17.5	13.3	26.3	659	391
M <sub>2</sub>	20.9	15.5	28.1	787	487
M <sub>3</sub>	24.9	18.7	30.5	931	595
M <sub>4</sub>	29.3	21.5	33.1	1175	780
S.E.m±	1.22	1.06	0.78	45.26	30.63
CD (p=0.05)	4.24	3.68	2.78	156.61	105.99
<b>Subplot: Foliar spray</b>					
S <sub>1</sub>	18.7	14.1	27.7	745	457
S <sub>2</sub>	22.1	16.7	29.5	893	563
S <sub>3</sub>	28.7	20.9	31.3	1025	670
S.E.m±	1.18	1.06	0.66	38.76	25.97
CD (p=0.05)	3.54	2.05	1.98	116.20	77.86
<b>Interaction effect</b>					
S.E.m±	2.36	1.38	1.32	77.16	51.94
CD (p=0.05)	NS	NS	NS	NS	NS

## Results :

### Yield and yield attributes :

- The treatment M<sub>4</sub> recorded significantly higher pod yield (1175 kg ha<sup>-1</sup>) and higher number of pods plant<sup>-1</sup> (29.3), filled pods plant<sup>-1</sup> (21.7) and 100 kernel weight (33.1 g) compared to other treatments. (Table 1)
- The S<sub>3</sub> treatment recorded significantly higher pod yield (1025 kg ha<sup>-1</sup>) and higher number of pods plant<sup>-1</sup> (28.7), filled pods plant<sup>-1</sup> (20.9), 100 kernel weight (31.3g) over absolute control (S<sub>1</sub>)
- The interaction between nutrient management and foliar spray on yield and yield parameters were found non-significant.

### Nutrient uptake:

- The treatment M<sub>4</sub> recorded significantly higher N, P, K, Zn and B uptake (95.71, 11.73, 43.1 kg ha<sup>-1</sup> and 93.76, 25.81 gm ha<sup>-1</sup>, respectively) than other treatments. (Fig. 1)
- The treatment S<sub>3</sub> recorded significantly higher nitrogen 80.29 kg ha<sup>-1</sup>, phosphorus (8.05 kg ha<sup>-1</sup>), potassium (37.72 kg ha<sup>-1</sup>) and zinc (76.49 g ha<sup>-1</sup>), Boron (23.30 g ha<sup>-1</sup>) uptake compared to absolute control (51.01, 4.3, 25.83 kg ha<sup>-1</sup> NPK and 44.35, 16.50 g ha<sup>-1</sup> Zn, Bo respectively). (Fig. 2)
- The interaction between nutrient management and foliar spray on nutrient uptake were found non-significant.

## Discussion:

- Significantly higher pod yield was recorded with the application of FYM + Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup>. could be attributed to higher number of pods plant<sup>-1</sup>, filled pods plant<sup>-1</sup> and 100 kernel weight. These results are similar with the findings of Krishna murthy *et al.* (2009) and Mahapatra *et al.* (2010).
- The significantly higher pod yield of groundnut was recorded in foliar spray of 2% urea at 30 and 60 DAS, mainly due to higher yield attributes like more number of pods plant<sup>-1</sup>, filled pods plant<sup>-1</sup> and 100 kernel weight. These results are in conformity with Kuttimani *et al.* (2011) in green gram.
- Significantly higher N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O, and Zn, B uptake was recorded with application of FYM + Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup>, which might be due to steady and increased availability of nutrients to the crop due to interaction effect of major and micro nutrients. These results are in accordance with the findings Manish Kumar *et al.* (2003)
- Significantly higher N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn, B uptake was recorded in foliar spray of 2% urea at 30 and 60 DAS. Nutrients through foliar application leading to more growth, so more uptake of nutrients. The similar results are in agreement with the findings of Kuttimani *et al.* (2011) in green gram.

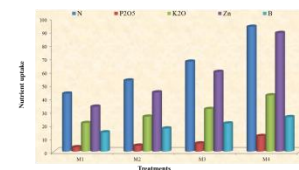


Fig. 1. N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O (kg ha<sup>-1</sup>) and Zn, Bo (g ha<sup>-1</sup>) uptake of groundnut as influenced by nutrient management practices.

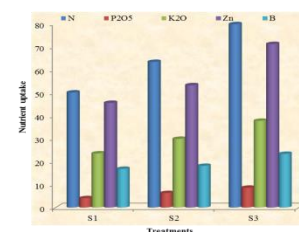


Fig. 2. N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O (kg ha<sup>-1</sup>) and Zn, Bo (g ha<sup>-1</sup>) uptake of groundnut as influenced by n foliar spray



Plate .1 General view of the experimental site

## Summary :

- The experiment was conducted at ARS, Sericulture college, Chintamani, laid out in a split plot comprising of 3 replications and 4 main and 3 sub treatments, the results are summarized as follows.
- Application of FYM + Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> recorded higher pod yield, yield attributes and higher uptake of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn, B nutrients.
  - Foliar spray of 2% urea at 30 and 60 DAS recorded higher pod yield, yield attributes and higher uptake of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn, B nutrients.

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## LIST OF ABBREVIATIONS

SYMBOL	ABBREVIATIONS
DAS	Days after sowing
S.Em	Standard error mean
C.D	Critical difference
C.V	Coefficient of variation
B C ratio	Benefit cost ratio
NS	Non significant
N	Nitrogen
P, P <sub>2</sub> O <sub>5</sub>	Phosphorus
K, K <sub>2</sub> O	Potassium
Kg ha <sup>-1</sup>	Kilogram per hectare
Q ha <sup>-1</sup>	Quintal per hectare
Cm	Centimeter
dS m <sup>-1</sup>	Desi Simons per meter
P=0.05	At 5 per cent probability
<i>Viz</i>	Namely
<i>i.e.</i>	That is
@	At the rate of
%	Per cent
g	Grams
m t	Million tones
m ha	Million hactares
NF	Normal fertilizers
FYM	Farm yard manure
t ha <sup>-1</sup>	Tonnes per hectare

## I. INTRODUCTION

Groundnut (*Arachis hypogaea* L.), king of oilseeds belongs to the family Leguminosae and is popularly called as poor man's almond. It is the world's fourth most important source of edible oil and third most important source of vegetable protein. Seed is valued both for its oil and protein content as it contains about 40-45 per cent oil, 25-30 per cent protein and it also contains 18 per cent carbohydrates, minerals and vitamins. It is a good source of all B vitamins and rich source of thiamin, riboflavin, nicotinic acid and vitamin E and minerals like copper, manganese, potassium, calcium, magnesium, zinc and selenium. By virtue of its nutritive value it is also called as wonder nut and poor man's cashew nut. It is mainly used as major edible oil in the preparation various food items and also utilized in the manufacture of soap, cosmetics, shaving cream, lubricants, etc. The haulm is also used as a nutritive dry fodder. It plays a pivotal role in the oilseed economy of India.

It occupies an area of 24.7 million hectares in the world with a total production of 33 million tonnes and an average yield of 1336 kg ha<sup>-1</sup>. Major groundnut producing countries are China (40.1%), India (16.4%), Nigeria (8.2%), U.S.A (5.9%) and Indonesia (4.1%). China and India together are the world's leading groundnut producers which accounts nearly 60 per cent of the production and 52 per cent of the cropped area. In India it occupies the first place in acreage but stands second in production after China. The area under groundnut in India was estimated to be 4.88 million hectares with a production of 5.77 million tonnes (2013). In India 70 % of the groundnut area and 75 % of the production are concentrated in the five states of Gujarat, Andhra Pradesh, Tamilnadu, Maharashtra and Karnataka. Gujarat accounts for 36 per cent of the total production of groundnut and it's the largest producer in India followed by Tamil Nadu (20.78 %), Andhra Pradesh (15.23 %), Rajasthan (8.23 %), Maharashtra (8.23 %) and Karnataka (7.82 %) (Gracy *et al.*, 2013).

In Karnataka, the area under groundnut is 0.64 million hectares with a production of 0.41 million tonnes (Anon., 2014). The major groundnut growing districts are Chitradurga, Tumkur, Dharwad, Belgaum, Bijapur, Raichur, Bellary and Bidar, Koppal, Haveri.

It is an energy rich crop, mainly grown under rainfed conditions under energy starved condition. Inadequate and imbalance use of nutrients is one of the major factors responsible for low yields in groundnut. Moreover the unbalanced and continued use of inorganic fertilizers in intensive cropping system has led to reduction in the crop yields and resulted in imbalance of nutrients in soil. Therefore, integrated use of both inorganic fertilizer and organic manures is very much essential to maintain and sustain a higher level of soil fertility and productivity.

Among micronutrients, Zn and boron deficiency is most prevalent in India. About 50% of the groundnut soils show Zn deficiencies causing considerable yield losses. Zinc is required in small concentrations but critical to allow several key plant physiological

pathways to function normally and these micro nutrients are of critical importance for sustaining higher productivity of groundnut.

Foliar application of nutrients has advantages in supplementing the nutritional requirements of groundnut. It also eliminates the problems like fixation and immobilization of nutrients and provides utilization of nutrients more efficiently and correcting deficiencies rapidly in groundnut crop. Hence foliar application has been recognized as an important method of fertilization in groundnut for getting maximum yields.

It is now well documented that the use of both organic and inorganic source of nutrient, could sustain the yield and soil fertility on long-term basis. Keeping this point in view, a field experiment entitled “**Yield maximization in *Kharif* groundnut (*Arachis hypogaea* L.) through nutrient management practices**” was conducted at Agricultural Research Station, Chintamani, during *Kharif* 2013 with the following objectives.

**Objectives of Investigation:**

1. To study the effect of nutrient management practices on growth and yield of groundnut
2. To study nutrient status of soil and plant.
3. To work out the economics of different nutrient management practices.

## II. REVIEW OF LITERATURE

The literature on the “Yield maximization in *kharif* groundnut through nutrient management practices.” has been reviewed in this chapter under the following headings.

- 2.1 Effect of FYM on growth, yield and quality of groundnut
- 2.2 Effect NPK on growth, yield and quality of groundnut
- 2.3 Effect of Zn and B on growth, yield and quality of groundnut
- 2.4 Effect of urea foliar spray on growth, yield and quality of groundnut
- 2.5 Effect of combined use of organic and inorganic fertilizer on growth, yield and quality of groundnut
- 2.6 Nutrient management on nutrient uptake and soil properties
- 2.7 Economics of groundnut under nutrient management

### 2.1 Effect of FYM on growth, yield and quality of groundnut

In fluctuating rainfall situation organic manures helps to bring the stability in crop yields by alleviating drought effects. It improves physico-chemical properties of soil, increase soil fertility status by increasing the amount of organic carbon, available N, P, K and S in the subsequent seasons. Groundnut needs good aeration in the rooting and pegging zones. Inadequate aeration results in abnormal respiration, which in turn inhibits root growth and retard metabolic functions. Use of organic manures reduces soil crusting, increase water holding capacity, hydraulic conductivity and infiltration rate besides reducing environmental pollution.

Asha *et al.* (1996) revealed that application of FYM significantly increased the number of nodules plant<sup>-1</sup>, dry weight of nodules plant<sup>-1</sup>, higher pod and haulm yield of groundnut.

In an experiment on sandy loam soils of Bangalore, application of 10 t ha<sup>-1</sup> FYM increased the available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O from 209 to 280, 77 to 119 and 243 to 298 kg ha<sup>-1</sup>, respectively (Ramamurthy and Shivashankar, 1996).

Balasubramaniyan and Palaniappan (1997) reported that application of farm yard manure @ 12.5 t ha<sup>-1</sup> resulted in higher pod yield and nutrient uptake of groundnut. Further, Balasubramaniyan (1997) found that oil yield and crude protein content in the kernel of groundnut seeds were increased with FYM and addition to enriched FYM application.

In calcareous soils at Junagadh, Gujarat, the highest pod yield in groundnuts grown during rabi was obtained with FYM applied @ 10 t ha<sup>-1</sup> (Ghosh, 1997).

Pattar *et al.* (1999) reported that significantly higher pod yield (2606 kg ha<sup>-1</sup>) and haulm yield (3752 kg ha<sup>-1</sup>) were noticed among the FYM treated plots followed by vermicompost both at 1t ha<sup>-1</sup>.

Ramaswami *et al.* (1999) reported that application of enriched FYM registered significant increase in plant height, number of pods plant<sup>-1</sup>, and pod yield, WUE and benefit cost ratio over bio digested slurry and press mud.

Sheshadri Reddy (2000) conclude that the pod yield (1765 kg ha<sup>-1</sup>), kernel yield (1212 kg ha<sup>-1</sup>) and oil yield (529 kg ha<sup>-1</sup>) were significantly higher with cow dung at 25 t ha<sup>-1</sup> which was found to be on par with other organic manure treatments.

Application of 20 t ha<sup>-1</sup> FYM, which recorded the highest pod and haulm yield of 1237 and 1883 kg ha<sup>-1</sup> respectively was significantly superior to that of control and other FYM levels (Mishra, 2000).

Rao and Shakawat (2002) revealed that application of FYM @10 t ha<sup>-1</sup> and poultry manure @ 5 t ha<sup>-1</sup> increased matured pods plant<sup>-1</sup>, pod weight plant<sup>-1</sup>, mature kernel (%) and 100 kernel weight as compared to control .

The farmers of South Saurashtra Agro-climatic zone growing *kharif* groundnut cv. GG-20 are advised to apply FYM @ 10 tones ha<sup>-1</sup> every year for getting higher pod yield and oil content (Anon., 2002 a).

The experiment was conducted in All India Co-ordinated Research Project for Dryland Agriculture at Hyderabad, revealed that application of farmyard manure at 10 t ha<sup>-1</sup> produced significantly higher pod yield of groundnut as compared to the treatment receiving no farmyard manure (Anon., 2002 b).

Application of FYM at 13 t ha<sup>-1</sup> recorded higher plant height (14.1cm), total dry matter (15.7 g plant<sup>-1</sup>), number of nodules plant<sup>-1</sup> (62.9) and pod yield (1874 kg ha<sup>-1</sup>) followed by application of urban garbage compost at 11.5 t ha<sup>-1</sup> (Ananda *et al.*, 2004).

Chandrasekarn *et al.* (2007) reported that application FYM (5 t ha<sup>-1</sup>) recorded higher number of pods plant<sup>-1</sup> (9.26), pod weight (3.75 g plant<sup>-1</sup>) and pod yield (698 kg ha<sup>-1</sup>) followed by vermicompost (1 t ha<sup>-1</sup>) application.

In a model organic farm at ARS, Balajipade , application of farm yard manure @ 10 t ha<sup>-1</sup> produced significantly higher pod yield (1000 kg ha<sup>-1</sup>) of groundnut as compared to the treatment recommended fertilizers (Anon., 2008a). Similarly, in another model organic farm at ARS, Chintamani, application of 10 t FYM ha<sup>-1</sup> increased the groundnut yields were ranging from 1200 to 1400kg ha<sup>-1</sup> (Anon., 2008 b).

The experiment conducted in ZARS, Navile, Shimoga application of farmyard manure at 5 t ha<sup>-1</sup> gave significantly higher pod yield (840 kg ha<sup>-1</sup>) of groundnut as compared to the treatment receiving no farmyard manure (Anon., 2008c).

Akbari *et al.* (2010) revealed that application of FYM @ 10 t ha<sup>-1</sup> improved plant height, number of branches, number of pods plant<sup>-1</sup>, 100 kernel weight, shelling percentage and haulm yield. Application of FYM at 15 t ha<sup>-1</sup> improved the yield

attributes, haulm yield and pod yield significantly by 7.9 per cent over control (Pareek *et al.*, 2011).

Thayamini *et al.* (2013) results showed that the increase of cattle manure (up to 15 t ha<sup>-1</sup>) combined with EM increased the number of pods, weight of pods and kernels per plant, 100-kernel weight, shelling % and total yield compared control treatment (chemical fertilizer only).

From the above literature cited it is concluded that, application of FYM and other organic manures increased the growth, yield and yield parameter of groundnut crop and related crops.

## **2.2 Effect N, P, and K on growth, yield and quality of groundnut**

The average yield of groundnut under rainfed conditions is very low. Efficient use of fertilizer, particularly of N, P and K plays an important role in enhancing the production and productivity of the crop by increasing cell division and multiplication.

Nitrogen is a component of protoplasm, proteins, nucleic acid, and chlorophyll and plays a vital role in both vegetative and reproductive phases of crop growth. Phosphorus is an important constituent of nucleoproteins, high energy components such as ATP and plays a key role in energy transfer in metabolic processes. Potassium is essential for carbohydrate metabolism and synthesis of proteins, regulation activities of various essential mineral elements, activation of various enzymes and adjustment of stomatal movement and water relations.

Balasubramaniyan and Palaniappan (1996) observed that nodule number, nodule weight and pod yield in groundnut increased with split application of nitrogen and potassium at sowing and at 45 DAS. Highest mean pod yield of 3.22 t ha<sup>-1</sup> and highest net returns were obtained with the application of 25:50:25 Kg NPK per ha to groundnut Cv.Dh-3-30 at Dharwad (Agasimani, 1996).

Ponnuswamy *et al.* (1996) reported that 150 per cent of the recommended dose of K (79 kg ha<sup>-1</sup>) applied in two equal splits viz., 50 per cent at basal and remaining 50 per cent at 40 DAS gave significantly higher dry pod yield of groundnut (2383 kg ha<sup>-1</sup>). Similarly, application of potassium resulted in higher uptake of NPK and also increased the pod, kernel yield and quality parameters were also enhanced by the application of K which reflected in enhanced oil and protein content (Lakshamma *et al.*, 1996).

Mehta and Rao (1996) reported that application of 50 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> registered significantly higher number of pods per plant and 100 kernel weight. The increasing trend in pods and haulm yield was noticed up to 75 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>.

Samui and Ahasan (1997) reported that split application of phosphorus equally at sowing and at earthing up significantly increased the 100 kernel weight, number of pods plant<sup>-1</sup>, shelling per cent and pod yield in groundnut. Application 60 kg K<sub>2</sub>O ha<sup>-1</sup> recorded higher pod yield of 1.87 t ha<sup>-1</sup> and it was on par with 30 kg K<sub>2</sub>O ha<sup>-1</sup> (1.83 t ha<sup>-1</sup>) on silty

loam soil during summer season (Ghatak *et al.*, 1997). Significantly higher pod yield (2893 kg ha<sup>-1</sup>) with application of 60 kg P<sub>2</sub>O<sub>5</sub> per hectare over lower dose of 30 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (Shelke *et al.*, 1997).

Barik and Mukherjee (1997) reported that application of 40 kg N ha<sup>-1</sup> recorded higher nodulation and pod yield and as N rate increased beyond 40 kg N ha<sup>-1</sup> there was decrease in nodulation and pod yield.

Tiwari and Dhakar (1997) revealed that groundnut crop recorded increased pod yield with application of 30:80 kg N and P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>, respectively as compared to control under irrigated condition. The study concluded that application of N and P<sub>2</sub>O<sub>5</sub> up to 60:75 kg as basal dose recorded higher pod yield compared to 0:0, 30:25 and 90:75 kg N and P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (Mahalanobis and Maiti, 1998).

Barik *et al.* (1998) reported that dry matter production, LAI and plant height were increased significantly with the enhanced rate of nitrogen supply and the higher value was observed with 40 kg ha<sup>-1</sup>. The study concluded that application of 60 kg P<sub>2</sub>O<sub>5</sub> significantly increased number of pods plant<sup>-1</sup>, shelling percentage, pod yield, haulm yield, and harvest index and oil yield of groundnut (Intodia *et al.*, 1998).

Significant increase in pod yield of groundnut was observed at a fertilizer level of 30:60:30 kg NPK ha<sup>-1</sup> and increase in yield was 30 per cent higher than lower level of fertilizer doses (Vinod Kumar *et al.*, 2000).

Gogoi *et al.* (2000) compared the response of different levels of N *viz.*, 0, 20, 40, 60 and 80 kg ha<sup>-1</sup> applied to groundnut and found that increased level of N application up to 80 kg ha<sup>-1</sup> increased the number of branches, pegs, pods per plant and shelling percentage. However, significant increase in yield and yield attributes were noticed only up to application 40 kg ha<sup>-1</sup>.

Subrahmaniyan *et al.* (2000) reported that increasing dose of NPK fertilizers up to 150 per cent of the RDF (26:51:81kg NPK ha<sup>-1</sup>) recorded significantly higher plant height, more number of matured pods per plant, higher 100 kernel weight, shelling percentage, sound matured kernel percentage and pod yield of groundnut.

Antony *et al.* (2000) revealed that LAD, LAI and net assimilation rate were increased with increase in nitrogen dose in all genotypes studied and concluded that 25 kg N ha<sup>-1</sup> was necessary for optimum yield. Increasing nitrogen levels up to 60 kg ha<sup>-1</sup> significantly increased the pod yield of groundnut and it did not respond to N beyond 60 kg ha<sup>-1</sup> (Singh and Singh, 2001).

Application of NPK (20:40:20 kg ha<sup>-1</sup>) increased the groundnut pod yield by 62 per cent with more number of matured pods and shelling percentage when compared to control (Kumaran *et al.*, 2001).

Migawer *et al.* (2001) revealed that application of (15 N + 30 P + 25 K) and/or (30 N + 30 P + 50 K) were the most suitable nutrient combinations for improving growth and yield characters of peanut grown in such soil. The highest yield (2.7 and 3.1 t  $\text{ha}^{-1}$ ) with acceptable oil and protein contents were obtained when fertilized with (30N + 30P + 50K) treatment.

Mandal *et al.* (2002) reported that on an average groundnut required 60-80 kg of N, 20-25 kg of P and 80-100 kg of K to produce 2.0 to 2.5 t  $\text{ha}^{-1}$  of economic yield. Maximum pod yield of 1324 kg  $\text{ha}^{-1}$  under groundnut mono cropping was attained with application of 100 percent recommended N through inorganic source (80 kg  $\text{ha}^{-1}$ ) applied at  $\frac{1}{2}$  basal and  $\frac{1}{2}$  top dressed under arid alfisols (Anon., 2002 e).

Prakasa Rao (2004) observed that supplemental nitrogen either through soil or foliage at 50 and 70 DAS in addition to recommended dose of NPK increased the yield of groundnut.

Munda *et al.* (2004) observed increased branches per plant from 9.9 to 10.1 and number of pods per plant from 9.2 to 12.3 when 20:60:40 kg N,  $\text{P}_2\text{O}_5$  and  $\text{K}_2\text{O}$   $\text{ha}^{-1}$  was applied to groundnut as compared to control.

Veerabhadrapa *et al.* (2005) reported that three graded levels of fertilizers (no RDF, 50 % RDF and 100 % RDF) applied through soil and foliar application of nutrients at three crop growth stages (30, 45 and 60 DAS) resulted in higher pod yield.

Mirhat *et al.* (2006) observed that increasing rate of phosphorus fertilizer from 30 to 60 kg  $\text{P}_2\text{O}_5$   $\text{ha}^{-1}$  significantly increased vegetative growth, yield and its components as well as seed quality.

Hosmani and Janwade (2006) reported that recommended dose of fertilizer (100% RDF) recorded significantly highest pod yield of groundnut (22.5 q  $\text{ha}^{-1}$ ) compared to 75 per cent RDF (20.7q  $\text{ha}^{-1}$ ) and 50 per cent RDF (18.7 q  $\text{ha}^{-1}$ ).

Plant receiving 60 kg N and 39 kg P  $\text{ha}^{-1}$  had larger root system, greater photosynthetic rate and better yield contributing characters that resulted in the maximum pod yield which, however, was not significantly different from  $\text{N}_{60}\text{P}_{26}$  treatment (Hossain *et al.*, 2007).

Kuligod *et al.* (2007) reported that higher doses of fertilizer (150 per cent of recommended dose) application had resulted in increased yield (22.5 q  $\text{ha}^{-1}$ ) compared the farmer practice of manure and fertilizer application (17.7 q  $\text{ha}^{-1}$ ). Application of increasing nitrogen levels increased growth parameters, yield parameters, pod yield, haulm yield, seed protein content and NPK contents in plant (Kandil *et al.*, 2007).

Application of 34:64:108 kg NPK  $\text{ha}^{-1}$  as three splits of N and K at basal (50 per cent), flowering (25 per cent) and peg formation stage (25 per cent) and 100 per cent P as basal were found to be the optimum dose for getting the highest pod yield (Chitdeshwari

*et al.*, 2007). The study concluded that application of 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> proved beneficial in increasing growth characters, yield attributes, yield of kernel and uptake of nutrients (Kumar *et al.*, 2008).

Application of phosphorus was found beneficial in respect of plant height, number of branches plant<sup>-1</sup> and number of pods plant<sup>-1</sup> (Akbari *et al.*, 2010). It was concluded that the plant density of 95,238 plants ha<sup>-1</sup> with application of 40kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> would enhance optimum productivity of groundnut (Shiyam *et al.*, 2010).

Pareek *et al.* (2011) increasing the level of nitrogen increased the mean number of pods per plant, shelling percentage, seed and pod indices progressively up to the highest level of 60 kg ha<sup>-1</sup> applied in three splits leading to pod yield significantly higher by 1565 kg ha<sup>-1</sup> over control. The results revealed that among the different levels of NPK studied, application of 175 per cent recommended dose of fertilizers (30:60:95 kg NPK ha<sup>-1</sup>) registered significantly higher growth characters, yield parameters, yield and economic returns (Veeramani *et al.*, 2012).

Salve *et al.* (2011) reported that application of 50 and 75 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> to groundnut were at par with each other but 50 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> significantly increased plant height, number and weight of matured pods plant<sup>-1</sup>, 100 kernel weight, dry pod and haulm yields, protein and oil content and their yields as compared to application of 75 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>. Similarly, application of 30 and 45 kg K<sub>2</sub>O ha<sup>-1</sup> were found to be at par with each other but 30 kg K<sub>2</sub>O ha<sup>-1</sup> significantly increased number of branches plant<sup>-1</sup>, dry matter production plant<sup>-1</sup>, root nodules and their weight plant<sup>-1</sup> protein and oil content in kernel and their yields as compared to application of 15 kg K<sub>2</sub>O ha<sup>-1</sup>.

Naveen Kumar (2012) revealed that treatment receiving N/P ratio of 0.57 (basal application of 20 kg N, 60 kg P<sub>2</sub>O<sub>5</sub>, 25 kg K<sub>2</sub>O ha<sup>-1</sup> + foliar application of nitrogen @ 7 kg N ha<sup>-1</sup> through urea at 45 DAS and 7 kg N ha<sup>-1</sup> at 60 DAS) produced significantly higher dry pod yield (4361 kg ha<sup>-1</sup>), kernel yield (3340 kg ha<sup>-1</sup>), total number of pods (29.53 plant<sup>-1</sup>), 100 kernel weight (41.16 g), total dry matter production (39.36 g), oil content (47.17%), oil yield (1575 kg ha<sup>-1</sup>), over N/P ratio of 0.00, 0.33 and 0.50, respectively.

Application of fertilizers resulted in increase in the nutrient uptake, number of nodules per plant, dry matter production and also resulted in higher yield of groundnut.

### **2.3 Effect of Zn and B on growth, yield and quality of groundnut**

For leguminous oilseeds like groundnut and soybean, the main nutrients from fertilizer management point of view are P, K, S, Ca Fe, Zn, and B. Being legumes, these crops can meet a large part of their nitrogen needs through biological N fixation. Zinc is essential for the activity of dehydrogenase enzyme for catalysing the oxidation process. It is also known to stimulate IAA synthesis and decrease ribonuclease activity leading to more RNA content and higher protein synthesis.

Zinc is one of the essential Micronutrient for production for production of quality seeds. The role of Zn in plant metabolism and growth is well document, zinc increased the chlorophyll content in the leaves, number and weight of nodules, number of plants, pods and pod weight.

Boron plays an important role in seed quality of both legumes and cereals but more prominently in legumes, its presence in plants is being required in small quantities. This micronutrient used as seed treatment and soil application. The presence of boron in soil will improve the seed quality.

Geetha *et al.* (1996) observed that application of Ca + Zn + Mo increased the number of pods per plant and pod yield 23 to 60 percent compared to 30 percent with rhizobium treated control.

Singh and Vidya Chuadhari (1996) reported that use of zincated super phosphate in groundnut resulted in increased nodule weight , pod number and pod yield over use of ordinary super phosphate .

Tripathy *et al.* (1999) studied that soil application of zinc, boron and molybdenum singly or in combination improved nodulation and nitrogenase activity in groundnut, but the dry matter and leaf area index increased only when at least two out of three micronutrients were applied in combination. The increase in pod yield due to application of B, Zn + B, B + Mo, Mo + Zn and Zn + B + Mo over control were 20.4, 34.8, 38.9, 25.0 and 46.9, respectively.

Subramaniyan *et al.* (2001) reported that application of zinc sulphate, borax and ferrous sulphate either alone or in combination registered significant maximum values of growth, yield attributes and pod yield of groundnut over control among the different treatments combined application of zinc sulphate + borax + ferrous sulphate recorded the highest pod yield 2209 kg ha<sup>-1</sup> as compared to control. Results indicated that application of Zn produced significantly higher pod yield and haulm yield and higher 100 kernel weight in groundnut. Zinc application increased the pod yield from 11.3 to 13.1 q ha<sup>-1</sup> (Halepyati, 2001a)

Darwish *et al.* (2002) found that application of Zn (1000 mg L<sup>-1</sup> zinc sulphate) gave the highest seed, oil yields and protein percentage

Application of foliar spray with Zn (2%) slightly improved peanut yield and quality (Ali and Mowafy, 2003). The study concluded that application of micronutrients (B, Zn and Mo) showed significantly increase in yield, oil content and growth parameters of groundnut (Niranjana *et al.*, 2005). The results revealed that the combined application of Zn + B significantly increased the growth and yield of ground nut by recording a pod and haulm yield of 33.40 and 48.07 g pot<sup>-1</sup> respectively besides increasing the soil available nutrients (Singaravel *et al.*, 2006).

Meena *et al.* (2007) conducted experiment application of  $\text{ZnSO}_4$  @ 20 kg ha<sup>-1</sup> plus 0.5 per cent foliar spray along with borax @ 25 kg ha<sup>-1</sup> plus 0.25 per cent foliar spray recorded the highest pod, kernel and oil yield.

Application of 10, 2 and 4 kg ha<sup>-1</sup> of Fe, Zn and Mn, increased pods by 19.5, 13.6, and 11.7 per cent and oil yield by 20.1, 13.9 and 12.2 per cent, respectively (Singh *et al.*, 2008).

Results of the experiment showed that protein content, oil content and oil yield of groundnut was significant increased over the control due to application of boron @ 5 kg ha<sup>-1</sup> and zinc sulphate at three level 5, 10 and 20 kg ha<sup>-1</sup> either alone or in combination with borax (Nadaf *et al.*, 2013).

The total nodulation in groundnut increased with soil application of zinc sulphate up to 10.0 kg ha<sup>-1</sup>. Hence, soil application of  $\text{ZnSO}_4$  at 10.0 kg ha<sup>-1</sup> is sufficient to obtain higher nodulation across growth stages compare to control (Kamath *et al.*, 2013).

Use of Zn foliar application either at flowering or seed filling stages significantly increased number of pods plant<sup>-1</sup>, weight of pods plant<sup>-1</sup>, number of seed plant<sup>-1</sup>, weight of seeds plant<sup>-1</sup>, 100-pod weight, 100-seed weight, pod, seed and straw yield faddan<sup>-1</sup>, oil yield, seed protein content, N and K content in the seed and haulm compared to control treatment (Habbasha *et al.*, 2013). Study resulted that foliar spraying with micronutrient (Zn and B) together had the significant effect on peanut seed yield and its attributes as well as seed quality (Kader *et al.*, 2013).

Thus the micronutrients application in recommended dose either through foliar spray or soil application along with other major nutrients improved the yield and yield parameters of groundnut. There was significant improvement in yield attributes viz., pods per plant, the number of seeds per pod, 100 seed weight and the increase in pod yield (30-55%) and also improved the quality parameter of groundnut like oil content, oil yield, protein percentage and protein yield. The increased oil content might be due to application of zinc, which is involved in the activation of NADPH depends dehydrogenase enzyme besides involving in fat synthesis.

#### **2.4 Effect of urea foliar spray on growth, yield and quality of groundnut**

The interest of foliar fertilizers arose due to the multiple advantages of foliar application methods such as rapid and efficient response to the plant needs, less product needed and independence of soil conditions. It is also recognized that supplementary foliar fertilization during crop growth can improve the mineral status of plants and increase the crop yield (Elayaraja and Angayarkanni, 2005). Application of nutrients through foliar spray at appropriate stages of growth becomes important for their utilization and better performance of the crop (Anandhkrishnaveni *et al.*, 2004).

Peeran *et al.* (1970) reported that applying half of the N before sowing and the remainder as a foliar spray in 2 split doses at 4 and 6 weeks after sowing increased the average yields to 1411 kg pods (8.1 % increase) ha<sup>-1</sup> and kernel oil content to 30.27 %,

compared with 1308 kg and 29.13 %, respectively, where the full rate of N was applied to the soil before sowing; yield increases were smaller where the full N rate was applied as foliar sprays in 2 or 3 doses 1 month after sowing and subsequently at fortnightly intervals.

Increased yields of pods (up to 13 %) and of hay (up to 16 %) when four foliar fertilizer applications (10 kg N, 1 kg P, 3 kg K and 0.5 kg S ha<sup>-1</sup> application) were given, at one-week intervals (Halevy *et al.*, 1987). Study concluded that foliar application of 1% urea and 50 ppm NAA significantly influenced the specific leaf area in soybean (Kalarani, 1991)

Dwivedi and Tiwari (1991) reported that highest number of pods was obtained by spraying 2 % urea than 2 % DAP in chickpea. Results revealed that foliar spraying of 1% urea significantly increased the crop growth rate (CGR) in soybean (Salim, 1992).

In summer, application of 1.5 per cent urea and 0.5 per cent DAP increased the number of pods, seeds, length of pod and seed yield in green gram (Patel and Patel, 1994). Study concluded that foliar application of urea and triacontanol significantly increased seed yield of pigeon pea (Pujari *et al.*, 1998)

Selvam *et al.*(1999) reported that top dressing of 10 kg N ha<sup>-1</sup> to groundnut as foliar spray at 2% urea increased pod yield (2.82 t ha<sup>-1</sup>) while the same as soil application produced 2.47 t ha<sup>-1</sup>. The study concluded that foliar application of one per cent DAP + 0.5 per cent urea recorded in significantly more number of pods plant<sup>-1</sup> in irrigated black gram (Subramani *et al.*., 2002).

Foliar application of nutrients during their critical growth stages resulted in higher nutrient uptake by green gram in turn recorded higher growth and yield parameters (Anandhakrishnaveni *et al.*, 2004).

Amany (2007) studied the effect of foliar application of urea on growth and yield components of chick pea with four foliar application treatment *viz.*, 1 per cent urea sprayed at flowering , at pod set, pod filling and (control) unsprayed. among this foliar application of urea at 1 per cent during pod filling resulted in higher plant height ,number of branches, total dry weight, pods + seeds plant<sup>-1</sup>,100 seed weight (36 g), harvest index (0.45) and highest protein content in seed (25 %).

Subhamoy Gupta (2010) reported that foliar application of DAP and urea at the rate of 2 % in green gram at 25 and 45 DAS has significant increase in plant height (64.5 cm) steadily up to 60 DAS and leaf area index (5.0) and also increase in yield attributes like no. of pods m<sup>-2</sup> (404) and maximum seed yield (760.7 kg ha<sup>-1</sup>) which represented 26.8 per cent increase over basal application of fertilizers and sprayed with distilled water, respectively.

Feeding feba bean with urea (450 mg N per pot in 3 equal splits) increased the intensity of the net photosynthesis in leaves, which in turn increased plant nitrogen

accumulation and feba bean seed yield ( an average increase of 14-15 per cent for foliar feeding and 2-4 % for soil top dressing in comparison with no top dressing ). The study conducted that foliar feeding with urea was found to be more beneficial than soil top dressing, irrespective of basic dose of N (Kocon, 2010).

Mondal *et al.* (2011) studied that, foliar application of N alone or combination of N and micronutrients had significant effect on growth and yield attributes, and recorded higher leaf area ( $497\text{cm}^2$ ), specific leaf dry weight ( $10.72\text{ mg cm}^{-2}$ ), chlorophyll content and total dry matter  $\text{plant}^{-1}$  ( $10.2\text{ g}$ ) over no foliar application of nutrients in different genotypes of mung bean but did not have significant influence on grain protein which was recorded in range of 24 -25 % in all the treatments.

Venkatesh and Basu (2011) studied that of foliar application of urea at 2 per cent concentration during 60,75 and 90 DAS recorded higher growth parameters, yield attributes, quality of chick pea and recorded higher no. of pods  $\text{plant}^{-1}$ (43.7), seeds per pod and 100 seed weight with maximum seed yield ( $2828.5\text{ kg ha}^{-1}$ ) and increase in grain protein content of 17.88 to 19.31 % ( due to increased nitrogen availability for seed filling) with two sprays of 2 per cent urea at 75 DAS than no foliar spray and water spray as control .

Venkatesh *et al.* (2012) conducted experiment on effect of foliar application of nitrogenous fertilizers for improved productivity of chickpea under rainfed conditions and revealed that the highest pods per plant (45.3) were recorded in 2 % urea spray at 75 DAS which was 23.7 and 21.3 % higher than control and water spray respectively. The highest seed yield of  $2437\text{ kg ha}^{-1}$  was recorded with 2 % urea spray at 75 DAS followed by 2 % DAP spray at 75 DAS ( $2389\text{ kg ha}^{-1}$ ).

Gupta *et al.* (2011) stated that foliar application of 2 per cent urea at flowering and 10 days after flowering along with biofertilizers (Rhizobium + PSB + PGPR) resulted in higher dry weight and also higher grain yield (  $1224\text{ kg ha}^{-1}$ ) which was significantly higher over the control ( $902\text{ kg ha}^{-1}$ ) . It was mainly because of enhanced biological nitrogen fixation, availability of P and continuous supply of N through basal dose during initial stages and through foliar spray at later stages of growth in chick pea.

Kuttimani and Velayutham (2011) revealed that foliar application of nutrient solution of DAP (2 %) + sodium molybdate (0.05 % ) at 30 and 45 DAS in green gram recorded maximum partitioning co-efficient ( 49.18 %) with a dry matter production of  $1230\text{ kg ha}^{-1}$  and also increased no. of pods  $\text{plant}^{-1}$  (34) with a maximum grain yield of  $928\text{ kg}$  which was significantly superior over the no spray ( $712\text{ kg ha}^{-1}$ ).

Mohamed *et al.* (2011) studied the effect of foliar application of urea and potassium di hydrogen orthophosphate on( PDO) on feba bean and it was observed that spraying feba bean with (5 g/ L urea + 2.5 g/L PDO) recorded higher number of pods per plant (7.00), seed yield per plant (11.57g) and harvest index (47.9 %). The positive effects of foliar application with urea through improving the physiological performance

of plants and multiple advantage of foliar application method such as rapid and efficient response to plant needs, less product needed and independence of soil condition .

Foliar application of urea at 1 per cent recorded higher growth parameters like plant height( 10.25 cm), leaf area (9.84 cm<sup>2</sup>) and dry weight of shoot of 1.24 g plant<sup>-1</sup> in mung bean (khalilzadeh *et al.* , 2012).

Mondal *et al.* (2012) studied the effect of foliar application of urea on physiological characters and yield of soybean and revealed that foliar application of urea at 1.5% three times at reproductive stages may be used for getting increased seed yield in soybean (3.19 t ha<sup>-1</sup>).

## **2.5 Effect of combined use of organic and inorganic fertilizer on growth, yield and quality of groundnut**

Application of MRP + FYM + inoculation with *Aspergillus awamori* showed significantly higher test weight, number of pods plant<sup>-1</sup> and protein content in kernels (Manjaiah *et al.*, 1996). Inoculation of groundnut seed with rhizobium + 10 t FYM + 20 kg N ha<sup>-1</sup> gave higher nodule dry weight and highest seed yield ha<sup>-1</sup> (Pant and Katiyar, 1996).

Lourduraj and Rajagopal (1996) reported that the application of NPK + organic manures was recorded significantly higher pod yield of groundnut than NPK alone. At Bangalore, groundnut during summer supplied with P (25:25 rock phosphate and super phosphate), FYM @ 9 t ha<sup>-1</sup> and seed inoculation with *Aspergillus awamori* recorded the highest nodule dry weight and number (Ramesh *et al.*, 1997).

Lourduraj *et al.* (1997) reported that the application of NPK along with 5 kg borax ha<sup>-1</sup>, 25 kg ZnSO<sub>4</sub> kg ha<sup>-1</sup>, 500 kg gypsum ha<sup>-1</sup> and 1 per cent Fe<sub>2</sub>SO<sub>4</sub> increased groundnut yield and net returns.

At Jagtial ( Andra Pradesh) and Khargone ( Madhya Pradesh) centers application of FYM at 5 t ha<sup>-1</sup> along with 50 per cent RDF gave higher pod yield of groundnut (1659 kg ha<sup>-1</sup>) over the FYM at 2.5 t ha<sup>-1</sup>+ 75 per cent RDF ( 1582 kg ha<sup>-1</sup>) and crop residue 10 t ha<sup>-1</sup> + 50 per cent RDF (1246 kg ha<sup>-1</sup>) during 1996-1997 in *kharif* season (Anon., 1997).

Kumaraswamy (1997) reported that seeds produced with the treatment combination of NPK +FYM +gypsum+ ZnSO<sub>4</sub> and borax spray gave maximum seed yield and quality of groundnut.

Subramaniyan *et al.* (2000) studied that application of FYM (10 and 15 t ha<sup>-1</sup>) and NPK fertilizers (100 and 150 per cent of recommended NPK) recorded that maximum growth and yield attributes and yield. Application of FYM 15 t ha<sup>-1</sup> and 150 per cent NPK levels significantly recorded the maximum yield parameters and pod yield.

Combine application of FYM @ 20 tonnes ha<sup>-1</sup> + 100 % recommended dose of fertilizer + *Azotobacter* spp. + *Pseudomonas striata* recorded significantly higher shelling

(%), protein content and yield, oil yield, mean yield of pod and haulm as well as gross returns than the control at application (Kachot *et al.*, 2000).

Indicate significant favourable influence of combined application of organic and inorganic sources of nutrients on growth and yield attributes as well as yield of groundnut (Kumaran *et al.*, 2000).

Higher pod yield of ground nut (2015 kg ha<sup>-1</sup> and 1902 kg ha<sup>-1</sup>) in summer and rabi season, respectively was obtained with application of NPK with 12.5 t of FYM as compared to NPK alone (Kamaram *et al.*, 2001).

Halepyati (2001b) recorded highest (20.80 q ha<sup>-1</sup>) groundnut pod yield and net returns (16,038 Rs ha<sup>-1</sup>) by application of FYM (6 t ha<sup>-1</sup>) + RDF.

Nagaraj *et al.* (2001) reported that fertilizer management practices involving the application of recommended dose of fertilizer (25 kg N, 32.7 kg P<sub>2</sub>O<sub>5</sub> and 20.72 kg K<sub>2</sub>O ha<sup>-1</sup>) + FYM (7.5 t ha<sup>-1</sup>) + Vermicompost (1 t ha<sup>-1</sup>) + micronutrients (4.50 kg ha<sup>-1</sup> Fe) + 5 kg ha<sup>-1</sup> Zn + 0.25 kg ha<sup>-1</sup> Mo produced significantly higher dry pod yield of groundnut (1796 kg ha<sup>-1</sup>) compared to fertilizer management practice involving RDF only (1475 kg ha<sup>-1</sup>).

Anand (2003) reported that significantly highest pod yield (2445 kg ha<sup>-1</sup>) and haulm yield (3625 kg ha<sup>-1</sup>) were produced by the application of FYM 10 t + 25:75:37.5 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>.

Panwar and Singh (2003) reported that when half quantity of FYM (5 t ha<sup>-1</sup>) has integrated with rhizobium and PSM, the highest pod yield of 31.8 q ha<sup>-1</sup> was obtained.

Recommended practice (25:75:40 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O +10 t FYM ha<sup>-1</sup>) recorded higher pod yield, NPK uptake, agronomic efficiency and apparent nitrogen recovery compare to control (Sheshadri Reddy *et al.*, 2004).

Sheshadri Reddy *et al.* (2005) revealed that application of 25:75:40 kg N, P<sub>2</sub>O<sub>5</sub> + 10 t ha<sup>-1</sup> FYM ha<sup>-1</sup> treatment recorded significantly higher pod yield (2955 kg ha<sup>-1</sup>), haulm yield (3.77 t ha<sup>-1</sup>), oil yield (971 kg ha<sup>-1</sup>) and protein yield (486 kg ha<sup>-1</sup>) of groundnut as compared to other treatments.

100 % NPK and INM combinations have maintained higher pod yields of groundnut than 100 % organic and control plots. Results indicated that INM combination of 50 % NPK plus 4 t FYM or groundnut shell improved soil health and biological properties and maintained higher productivity of soils (Srinivasa rao *et al.*, 2006).

Kausale *et al.* (2009) revealed that nodule number, dry matter plant<sup>-1</sup>, pod and haulm yield of groundnut crop increased with application of 100 % RDF (25:50 N and P kg ha<sup>-1</sup>, 10 t FYM ha<sup>-1</sup> and rhizobium or PSB seed inoculation).

Krishna Murthy *et al.* (2009) reported the treatment with the application of recommended dose of fertilizer with vermicompost and gypsum (T9) recorded higher plant height (30.99 and 43.03 cm at 60 DAS and at harvest, respectively) number of branches per plant (7.85), number of nodules per plant (73.13), nodules dry weight (133.99 mg plant<sup>-1</sup>), number of mature pods per plant (16.17), pod yield (3211 kg ha<sup>-1</sup>) and total dry matter production at harvest (18.01g plant<sup>-1</sup>), compared to other treatments.

Mohapatra *et al.*(2010) revealed that application of FYM + 75 % RDF + Rhizobium + gypsum + boron recorded significantly higher pods plant<sup>-1</sup>, 100 pod weight resulting in higher pod (2.66 t ha<sup>-1</sup>), kernel yield (1.92 t ha<sup>-1</sup>).

The experimental results revealed that the application of NPK + Borax @ 15 kg ha<sup>-1</sup> along with composted coir pith @ 12.5 t ha<sup>-1</sup> was significant in increasing the nutrient availability, growth and yield of groundnut. The yield increase recorded with borax application @ 15 kg ha<sup>-1</sup> along with CCP was 18.47 percentage of pod and 13.71 percentage of haulm as compared to control ( Elayaraj *et al.* , 2010).

The significantly highest pod yield was recorded in treatment 20 kg ZnSo<sub>4</sub> and 5 kg Borax as soil application and 3 foliar spray of 1 % iron in addition to RDF followed by 20 kg Zn + 5 kg Borax + RDF. The per cent increase in yields by these two treatment combinations were 49.94 and 33.76 % over RDF only (Sonawane *et al.*, 2010).The results revealed that application of 125 % RDF + 5 t ha<sup>-1</sup> EC increased growth and yield attributes that led to its significantly higher productivity 2.25 and 5.00 tonne ha<sup>-1</sup> of mean pod and haulm yield (Karunakaran *et al.*, 2010).

Application of 50 per cent organic manure + 50 per cent inorganic fertilizers recorded highest pod yield of 1282 kg ha<sup>-1</sup> and also noticed the better soil physico-chemical properties (Patil *et al.*, 2010).

Results revealed that application of 100 % NPKSZn significantly enhanced the pod and haulm yields of groundnut by 25.9 and 22.4 per cent over 100 % NPK, respectively (Sharma *et al.*, 2011).

The results revealed that the combined application of inorganic fertilizer and organic manure recorded favourable effects on the quality of summer groundnut. The application of 100 per cent GRD (25:50:00 kg ha<sup>-1</sup> plus 5 t FYM ha<sup>-1</sup>) recorded the highest kernel yield, oil yield, protein yield, oil content and protein content were 28.26 q ha<sup>-1</sup>, 14.07 q ha<sup>-1</sup>, 6.94 q ha<sup>-1</sup>, 49.82 per cent and 24.56 per cent respectively of summer groundnut (Thorave *et al.*, 2011).

Singh *et al.* (2011) reported application of Lime + FYM + 50 % NPK increased growth, yield attributes, yield over other nutrient levels. Integrated use of Lime + FYM + 50 % NPK along with *Rhizobium* + PSM was the best for groundnut.

Patro *et al.* (2012) revealed that application of 100 % recommended dose of fertilizer as basal plus 50 % recommended dose of fertilizer nitrogen at 30 DAS along with FYM @ 7.5 t ha<sup>-1</sup> recorded the maximum pod yield compare to the control.

Singh *et al.* (2012) reported that application of highest tested dose of 60 kg S + 80 kg Ca ha<sup>-1</sup> with RDF + 10 t FYM ha<sup>-1</sup> confined the pod yield of groundnut (30.74 q ha<sup>-1</sup>) compared to RDF + 10 t FYM + 52.5 kg S + 70 kg Ca ha<sup>-1</sup>.

The results revealed that application of RDF + Zn, Fe 1 per cent spray and borax applied alone showed increase in root length, root nodules, dry and fresh weight of nodules, chlorophyll content, yield and quality of groundnut. However, among all the treatments application of RDF + 20 kg ZnSO<sub>4</sub> + Fe- EDTA + 5 kg ha<sup>-1</sup> borax was found to be superior over the rest of the treatment in enhancing the yield and quality of groundnut (Bangal *et al.*, 2012).

Study the effect of integrated nutrient management in groundnut (variety 'HNG-10'), application of FYM @ 8 t ha<sup>-1</sup> + 50 % RDF produced significantly higher yield, oil content, oil yield and protein content as well as N, P content and uptake by groundnut but remained at par with vermicompost @ 3 t ha<sup>-1</sup> + 50 % RDF (Lal *et al.* , 2013).

Among the levels of NPK, application of 100 % RDF+ ZnSO<sub>4</sub> @ 25 kg ha<sup>-1</sup> + boron @ 10 kg ha<sup>-1</sup> and farm yard manure @ 12.5 t ha<sup>-1</sup> recorded the highest plant height ,dry matter production and highest yield characters in the soils viz., number of pods plant<sup>-1</sup> (22.81), 100 kernel weight (43.37), shelling percentage (77.87), pod yield (3310 kg ha<sup>-1</sup>) and haulm yield (3991 kg ha<sup>-1</sup>), respectively (Kamalakaran *et al.*, 2013).

Results showed that application of NPK (20:10:25 kg ha<sup>-1</sup>) + gypsum+ zinc sulphate recorded highest pod yield of 1499 kg ha<sup>-1</sup> which was on par with NPK+ gypsum and FYM alone treated plot (Parvathi *et al.*, 2013).

Application of lime @ 500 kg ha<sup>-1</sup> + FYM @ 10 tonnes ha<sup>-1</sup> + 50 % NPK recorded highest seed yield and seed quality attributes. Seed Inoculation with Rhizobium + PSM in the presence of lime + FYM and 50 % NPK improved seed yield and nutrient uptake of groundnut (Singh *et al.*, 2013).The results clearly indicated that, 150 % NPK along with ZnSO<sub>4</sub> @ 30 kg ha<sup>-1</sup> and Borax @ 15 kg ha<sup>-1</sup> with composted coirpith application significantly recorded the higher pod yield of 2466 kg ha<sup>-1</sup> and haulm yield of 3354 kg ha<sup>-1</sup> as compared 100 % recommended NPK alone 1878 and 2663 kg ha<sup>-1</sup> of pod and haulm yield, respectively (Elayaraja , 2014).

## 2.6 Nutrient management on nutrient uptake and soil properties

Experiment on sandy loam soils of Bangalore, application of 10 t ha<sup>-1</sup> FYM increased the available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O from 209 to 280, 77 to 119 and 243 to 298 kg ha<sup>-1</sup>, respectively (Ramamurthy and Shivashankar, 1996).

Balasubramanian and Palaniappan (1997) reported that application of farmyard manure with 12.5 t ha<sup>-1</sup> resulted in higher nutrient uptake and pod yield of groundnut.

Pattar *et al.* (1998) found that application of FYM at 10 t ha<sup>-1</sup> resulted in higher organic carbon, in addition to the available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O content of soil. Similarly, Babu and Reddy (2000) found that application of farmyard manure at 10 t ha<sup>-1</sup> led to a greater accumulation of available N, P and K in soil than fertilizer treatment alone.

Gajanana *et al.* (2000) reported that continuous application of FYM (10 t ha<sup>-1</sup>) for 20 years recorded higher available N (193 kg ha<sup>-1</sup>), P<sub>2</sub>O<sub>5</sub> (141 kg ha<sup>-1</sup>) and K<sub>2</sub>O (140 kg ha<sup>-1</sup>) content in soil as compared to 161, 30 and 59 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O ha<sup>-1</sup>, respectively in plots without FYM at Bangalore.

Study revealed that with each successive increase in the dose of nitrogen up to 40 kg ha<sup>-1</sup>, the nitrogen uptake also increased significantly. However, it was at par with 60 kg ha<sup>-1</sup> (Deka *et al.*, 2001)

Significantly higher pod yield (29.52 q ha<sup>-1</sup>), oil content (51.6 %) and higher phosphorus uptake (49 kg ha<sup>-1</sup>) were obtained by application of 75 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> along with phosphorus solubilizer for summer groundnut (Ramesh and Sabale, 2001).

Sriramachandrasekharan (2002) reported higher bacterial population, available nitrogen and organic carbon in FYM treated plots than without FYM plot.

Dutta *et al.* (2003) reported that application of graded levels of potassium produced notable differences in uptake of N, P and K and the increase was significant at higher doses of potassium application (50 kg K<sub>2</sub>O ha<sup>-1</sup>). Recommended practice (25:75:40 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O + 10 t FYM ha<sup>-1</sup>) recorded higher pod yield, NPK uptake, agronomic efficiency and apparent nitrogen recovery (Sheshadri Reddy *et al.*, 2004).

Patidar and Mali (2004) revealed that application of FYM (10 t ha<sup>-1</sup>) increased the available N (9 %) and P (16 %) in soil over control.

At Bangalore, continuous application of FYM (10 t ha<sup>-1</sup>) recorded higher available N (208.5 kg ha<sup>-1</sup>) and P<sub>2</sub>O<sub>5</sub> (116.3 kg ha<sup>-1</sup>) as compared to the plots without FYM (Anon., 2005). Study reported that application of farmyard manure (15 t ha<sup>-1</sup>) influenced the microbial biomass carbon, microbial biomass nitrogen and biomass C: N ratio (Kaur *et al.*, 2005).

Sheshadri Reddy (2005) reported that application of organic manures improved organic carbon and available NPK status significantly in two seasons compared to initial soil fertility.

Sunilkumar *et al.* (2005) reported that application of FYM (10 t ha<sup>-1</sup>) increased the soil available N (220.7 kg ha<sup>-1</sup>), P<sub>2</sub>O<sub>5</sub> (18.4 kg ha<sup>-1</sup>) and K<sub>2</sub>O (270 kg ha<sup>-1</sup>) in loamy soil. Study revealed that application of FYM (20 t ha<sup>-1</sup>) showed significant increase in organic carbon, available nitrogen, phosphorous and potassium of soil (Yadav *et al.*, 2005).

Varalakshmi *et al.* (2005) reported that application of 100 per cent N through FYM recorded higher available N ( $311 \text{ kg ha}^{-1}$ ),  $\text{P}_2\text{O}_5$  ( $127 \text{ kg ha}^{-1}$ ) and  $\text{K}_2\text{O}$  ( $319 \text{ kg ha}^{-1}$ ) content in soil. Results revealed that application of farmyard manure at  $10 \text{ t ha}^{-1}$ , poultry manure at  $5 \text{ t ha}^{-1}$ , phosphorus at  $40 \text{ kg ha}^{-1}$  and gypsum at  $250 \text{ kg ha}^{-1}$  increased total uptake of all nutrients and thereby pod and haulm yield of groundnut (Rao *et al.*, 2005).

The application of  $25 \text{ kg N} + 50 \text{ kg P}_2\text{O}_5 + 40 \text{ kg K}_2\text{O ha}^{-1}$  along with Rhizobium, VAM and PSB recorded significantly higher available nitrogen  $164.1 \text{ kg ha}^{-1}$  and available phosphorus  $26.6 \text{ kg ha}^{-1}$  whereas minimum were noted with the application of RDF- NPK alone. However, this treatment also provided significantly higher NPK uptake by the crop and crop yields (pod, kernel and haulm) over rest of the treatments (Anon., 2006).

Chitdeshwari *et al.* (2007) revealed that application of  $34:64:108 \text{ kg NPK ha}^{-1}$  at a split of 50:25:25 per cent N and K at basal, flowering and peg forming stage and 100 per cent P as basal was found to be an optimum dose for getting higher pod yield and B: C ratio (1.89) with higher nutrients uptake compared to higher level of fertilizers.

The uptake of boron by pod ( $191.08 \text{ mg pot}^{-1}$ ) and haulm ( $646.17 \text{ mg pot}^{-1}$ ) was higher in groundnut crop due to application of  $15 \text{ kg boron ha}^{-1}$ . The soil available boron was also higher  $0.43 \text{ ppm}$  in the same treatment compared to initial value ( $0.17 \text{ ppm}$ ) (Srinivasan and Angayarkanni, 2007).

The study concluded that application of  $60 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$  proved beneficial in increasing growth characters, yield attributes, yield of kernel and uptake of N, P, K, S, and micronutrients like Fe, Mn, Zn and Cu (Kumar *et al.*, 2008).

Krishna Murthy *et al.* (2009) revealed that significantly higher NPK uptake of  $148.39, 12.13, 150.67 \text{ kg ha}^{-1}$  respectively was observed at harvest with combined application of recommended dose of fertilizer with vermicompost and gypsum  $\text{kg ha}^{-1}$  compared to other treatments.

Karunakaran *et al.* (2010) revealed that application of  $125 \% \text{ RDF} + 5 \text{ t ha}^{-1}$  enriched compost increased the growth and yield attributes that led to its significantly higher productivity ( $2.25 \text{ t ha}^{-1}$ ), net returns ( $15,704 \text{ ha}^{-1}$ ) and NPK uptake ( $171, 20.7$  and  $75 \text{ kg ha}^{-1}$ ) in groundnut crop besides enriching soil available nitrogen and phosphorus after harvest of groundnut.

Mohapatra *et al.* (2010) revealed that application of  $\text{FYM} + 75 \% \text{ RDF} + \text{Rhizobium} + \text{gypsum} + \text{boron}$  recorded significantly higher pods  $\text{plant}^{-1}$ , 100 pod weight resulting in higher pod ( $2.66 \text{ t ha}^{-1}$ ), kernel yield ( $1.92 \text{ t ha}^{-1}$ ) and nutrient uptake ( $151.4-17.0-58.6-0.8-0.07 \text{ kg N-P-K-S-B ha}^{-1}$ ).

Kocon (2010) reported that foliar feeding of feba bean with urea ( $450 \text{ mg N per pot}$  in 3 equal splits) was found to be more beneficial than soil top dressing, irrespective of basic dose of N and recorded higher nitrogen uptake.

Groundnut crop fertilized with FYM 3 t ha<sup>-1</sup> + Rhizobium + PSM and vermicompost 2 t ha<sup>-1</sup> + Rhizobium + PSM were found equally effective and significantly superior over control with respect to content and uptake of nitrogen, phosphorus and potassium by kernel as well as haulm. However the highest values of these parameters were recorded with FYM 6 t ha<sup>-1</sup> + Rhizobium + PSM (Zalate *et al.*, 2010).

Results revealed that application of 100 % NPKSZn significantly enhanced the pod and haulm yields of groundnut by 25.9 and 22.4 per cent over 100 % NPK, respectively. This treatment also recorded significantly higher concentration and uptake of N, P, K, S and Zn as well as improved the soil fertility status (Sharma *et al.*, 2011).

Higher leaf nitrogen content (3.46 %) was recorded with three foliar application of urea sprayed at 60, 75 and 90 DAS than the control (3.16 %) under rainfed conditions (Venkatesh and Basu, 2011).

Yadav and Choudhary (2012) studied the effect of fertility levels and foliar nutrition on profitability, nutrient content and uptake of cowpea (*Vigna unguiculata* L.walp) and concluded that foliar spray of 2 % DAP, 2 % urea and 2 % KCL resulted in higher seed yield, net returns, protein content, nitrogen, phosphorous and potassium content in seed and straw and total uptake of N,P, and K over water sprayed.

Naveen Kumar (2012) revealed that treatment receiving N/P ratio of 0.57 (basal application of 20 kg N, 60 kg P<sub>2</sub>O<sub>5</sub>, 25 kg K<sub>2</sub>O ha<sup>-1</sup> + foliar application of nitrogen @ 7 kg N ha<sup>-1</sup> through urea at 45 DAS and 7 kg N ha<sup>-1</sup> at 60 DAS) produced significantly higher uptake of nutrients (225.33 kg N, 21.33 kg P<sub>2</sub>O<sub>5</sub> and 112.31 kg K<sub>2</sub>O ha<sup>-1</sup>) and higher net monetary returns over N/P ratio of 0.00, 0.33 and 0.50.

The results clearly indicated that, 150% NPK + ZnSO<sub>4</sub> @ 30 kg ha<sup>-1</sup> + Borax @ 15 kg ha<sup>-1</sup> along with composted coirpith application significantly increased the yield and nutrients uptake by groundnut. This treatment recorded the highest pod yield of 2466 kg ha<sup>-1</sup> and haulm yield of 3354 kg ha<sup>-1</sup> which represented 31.31 and 25.95 per cent increased in pod and haulm yield, respectively over 100 per cent NPK application (Elayaraja *et al.*, 2012).

Application of lime @ 500 kg ha<sup>-1</sup> + FYM @ 10 tonnes ha<sup>-1</sup> + 50 % NPK recorded highest seed yield and seed quality attributes. Seed Inoculation with Rhizobium + PSM in the presence of lime + FYM and 50 % NPK improved seed yield and nutrient uptake of groundnut (Singh *et al.*, 2013).

## **2.7 Economics of groundnut under nutrient management**

Application of 125 % recommended NPK with organic manure to groundnut crop gave higher pod yield (1791 kg ha<sup>-1</sup>), net profit (₹ 11,349) and B: C ratio (1.67) compared to recommend NPK alone (Kavimani *et al.*, 2002).

50 % recommended dose of fertilizer, while net returns were obtained maximum when crop was fertilized with only 100 % recommended dose of fertilizer (Kachot *et al.*, 2000).

Madhiyazhagan *et al.* (2001) concluded that confectionery groundnut variety (Somnath) produced higher pod yield with good quality kernels and higher net returns with the application of farmyard manure @ 15 t ha<sup>-1</sup> with 100 per cent of recommended dose of fertilizer.

Halepyati (2001) recorded that farmyard manure at 6 t ha<sup>-1</sup> + recommended dose of fertilizers resulted in the highest net returns (Rs 16,038) yield and growth components of groundnut.

Kavimani *et al.* (2002) concluded that application of 125 % recommended NPK with organic manure to groundnut crop gave higher pod yield (1791 kg ha<sup>-1</sup>), net profit (Rs.11, 349) and B: C ratio (1.67) compared to recommend NPK alone.

Thavaprakash and Malligawad *et al.* (2002) combined application of 120:120:60 NPK kg ha<sup>-1</sup> increased the net returns (Rs 10,993 to 24,249 ha<sup>-1</sup>) over application of no nitrogen and phosphorus with 60 kg K<sub>2</sub>O ha<sup>-1</sup>.

Ananda *et al.* (2004) noticed that FYM at 13 t ha<sup>-1</sup> recorded lower cost of cultivation (Rs. 12385 ha<sup>-1</sup>), higher gross returns (Rs. 38686 ha<sup>-1</sup>), higher net returns (Rs. 26301Rs. ha<sup>-1</sup>) and higher B: C ratio followed by urban garbage compost at 11.5 t ha<sup>-1</sup>. Study revealed that application of FYM at 10 t ha<sup>-1</sup> recorded significantly higher pod yield (2785 kg ha<sup>-1</sup>) of groundnut and gross return of Rs. 31447 ha<sup>-1</sup> in pooled results followed by application of RDF compared to control (Solanki *et al.*, 2006).

Application of 100 per cent RDF recorded significantly higher net returns (Rs. 20,837 ha<sup>-1</sup>) and higher dry pod yield of groundnut compared to 75 per cent and 50 per cent RDF (Hosamani and Janawade, 2006).

Beneficial effect of FYM in conjunction with recommended dose of fertilizers may be due to the effect of organic matter in improving physical, chemical and biological environment of soil conducive to better plant growth. Further, Application of FYM at 21.9 t ha<sup>-1</sup> produced the highest DMP, pod yield and haulm yield, and gave higher net return and B: C ratio (Chandrasekaran *et al.*, 2007).

Yeledhalli *et al.* (2007) studied that application of higher level of K<sub>2</sub>O (75 kg ha<sup>-1</sup>) and Ca (50 kg ha<sup>-1</sup>) along with recommended NP gave higher net returns (Rs.17464 ha<sup>-1</sup>) and B: C ratio (2.66). The higher B: C ratio was mainly due to higher pod yield (1810 kg ha<sup>-1</sup>) and haulm yield (3515 kg ha<sup>-1</sup>).

Hosamani *et al.* (2007) studied that crop receiving dhaincha green manuring along with RDF recorded significantly higher pod yield (22.1 q ha<sup>-1</sup>), net returns (Rs. 20,548 ha<sup>-1</sup>) and B:C ratio (3.01) over rest of the treatment combinations.

Panwar and Munda (2007) revealed that maximum net returns of Rs.16,278 and B:C ratio of 1.06 was found with farmyard manure at 10 t ha<sup>-1</sup> +50 per cent recommended dose of inorganic fertilizer than 100 per cent recommended dose of inorganic fertilizer.

Chandrasekaran *et al.* (2007) studied that among the different quantities of FYM tested, application of 121.9 t ha<sup>-1</sup> (175 % recommended level of FYM) recorded the highest DMP, pod yield (2476 kg ha<sup>-1</sup>), haulm yield, net return and B: C ratio (2.87).

Sutaria *et al.* (2010) reported that effect of different fertilizer treatments on pod yield was found significant and application of 50 % N through urea + 50 % N through FYM recorded higher net return and B: C ratio.

Combining the application of FYM at 15 t ha<sup>-1</sup>, nitrogen at 60 kg ha<sup>-1</sup> in three splits and foliar spray of 1 % FeSO<sub>4</sub> integrated with 0.1 % citric acid improved (B:C ratio) and recorded the highest net returns (60,159 Rs. ha<sup>-1</sup>) that was higher by 27 % over absolute control (Pareek *et al.*, 2011).

Application of lime + FYM + 50 % NPK increased growth, yield attributes, yield, available nutrient status, highest net returns (21.910 Rs ha<sup>-1</sup>) and B: C ratio (1.23) over other nutrient levels (Singh *et al.*, 2011).

Gupta *et al.* (2011) reported that foliar application of 2 % urea at flowering and 10days after along with biofertilizers resulted maximum net returns (Rs.5608 ha<sup>-1</sup>) over control which was attributed by increased grain yield of chickpea.

Kuttimani and Velayutham (2011) stated that foliar application of nutrients solution of DAP (2 %) + sodium molybdate (0.05 %) at 30 and 45 DAS in green gram resulted in higher B: C ratio mainly due to less cost of inputs and higher net returns.

Application of 100 % recommended dose of fertilizer as basal plus 50 % recommended dose of fertilizer nitrogen at 30 DAS along with FYM @ 7.5 t ha<sup>-1</sup> recorded the maximum pod yield of 2200 kg ha<sup>-1</sup>. Similar trend was also observed in respect of maximum gross return (Rs. 48629 ha<sup>-1</sup>), net return (Rs. 23274 ha<sup>-1</sup>) and benefit-cost ratio (1.93) with the same treatment (Patro *et al.*, 2012). The maximum gross return (Rs.66, 494 ha<sup>-1</sup>) and net return (Rs.46, 356 ha<sup>-1</sup>) was recorded when farm yard manure @ 10 t ha<sup>-1</sup> along with recommended dose of inorganic fertilizer was applied. The highest B: C ratio (3.50) was recorded in inorganic fertilizer treated control (Gunri *et al.*, 2012).

The results revealed that among the different levels of NPK studied, application of 175 per cent recommended dose of fertilizers (30:60:95 kg NPK ha<sup>-1</sup>) registered significantly higher growth characters, yield parameters, yield and economic returns (Veeramani *et al.*, 2012). Study revealed that seed inoculation with Rhizobium + PSM in the presence of lime + FYM and 50% NPK improved seed yield and nutrient uptake of

groundnut. Highest net return and benefit cost ratio was observed with combined application of Rhizobium + PSM and lime + FYM + 50 % NPK (Singh *et al.*, 2013).

Results showed that application of NPK (20:10:25 kg ha<sup>-1</sup>) + gypsum + zinc sulphate recorded highest pod yield of 1499 kg ha<sup>-1</sup> which was on par with NPK + gypsum and FYM alone treated plot (Parvathi *et al.*, 2013).

### III. MATERIAL AND METHODS

The field experiment was conducted to study the effect of “Yield maximization in *Kharif* groundnut through nutrient management practices”. The details of materials used and methods adopted in the course of study are described under the following headings.

#### 3.1 Location of experimental site

A Field experiment was conducted during the *Kharif season* of 2013 at Agriculture Research Station, Sericulture College, Chintamani, which is located in the Eastern dry zone of Karnataka at 13°24' North latitude, 70°04' East longitude with an altitude of 857 m above mean sea level.

#### 3.2 Soil characters of the experimental site

The soil type of the experimental site was red sandy loam texture. Before starting the experiment, composite soil samples were collected from 0 to 15 cm soil layer and were analysed for physical and chemical properties (Table 3.1).

#### 3.3 Climatic conditions

Mean metrological data was recorded from the observatory maintained, Agricultural Research Station, Chintamani for the crop growth period during *Kharif* 2013. The normal as well as actual weather condition data *viz.*, total rainfall, temperature (maximum and minimum), relative humidity that prevailed during the crop growth period of 2013 are presented in Table 3.2

##### 3.3.1 Actual weather conditions during the year 2013

During *Kharif* 2013, the total rainfall received was 586.6 mm and the highest rainfall was received in the month of September (146.0 mm) followed by August (79.4 mm) and lowest was in the month of November (29.8 mm) during cropping season.

The rainfall during cropping period was deficit (351.4 mm) but did not interfere with the normal crop growth and yield of groundnut. The number of rainy days during growing season were 33 and the highest was in the month of September and October. The actual mean monthly maximum temperature was lesser than the normal during the crop growth period in October (28.3° C). The higher minimum temperature was in November (16.1° C) as compared to the normal temperature. Mean monthly relative humidity ranged from 79.62 per cent in July and November to 84.5 per cent during crop growth period (Table 3.2).

#### 3.4 Cropping history of the experimental site

Groundnut crop was grown in the plot during *Kharif* season of 2012 and left fallow till sowing for present investigation were taken up.

**Table 3.1. Physical and chemical properties of soil of the experimental site at ARS, Chintamani**

Particular	Values	Status	Method followed
<b>I. Physical properties</b>			
1. Coarse sand (%)	55.05		International pipette method (Piper , 1966)
2. Fine sand (%)	29.30		
3. Silt (%)	9.15		
4. Clay (%)	6.50		
5. Textural class	Sandy loam		
Bulk density (Mg/m <sup>3</sup> )	1.34		Core sampler method (Piper , 1966)
<b>II. Chemical properties</b>			
1.pH	6.95	Neutral	Potentiometric method (Jackson, 1973)
2. Organic carbon (%)	0.49	Low	Wet oxidation method (Walkley and Black, 1934)
3.Available N (kg ha <sup>-1</sup> )	265.31	Low	Alkaline permanganate method (Subbaiah and Asija,1956)
4. Available P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	23.15	Medium	Bray's extractant (Jackson ,1973)
5. Available K <sub>2</sub> O (kg ha <sup>-1</sup> )	251.67	Medium	Neutral normal ammonium acetate method (Jackson,1973)
6. Available Zn (ppm)	0.51	Low	Atomic absorption spectrophotometer (Lindsay and Norwell,1978)
7. Available B (ppm)	0.39	Low	Carmines red method (Lindsay and Norwell,1978)

**Table 3.2: Meteorological data indicating normal, actual and deviation for the experimental period during crop growth period at ARS, Chintamani**

Month	Rainfall (mm)			Mean max. temperature (°C)			Mean min. temperature (° C)			Relative Humidity (%)		
	N	A	D	N	A	D	N	A	D	N	A	D
July	94.8	52.0	-42.8	29.5	28.9	-0.6	20.2	20.2	0.0	73.4	79.3	5.9
August	123.9	79.4	-44.55	29.3	29.2	-0.1	19.8	19.9	0.1	76.9	78.4	1.5
September	83.6	146.0	62.35	29.3	28.3	-1	19.5	19.6	0.1	73.5	79.5	6.0
October	170.7	44.2	-126.5	28.6	28.3	-0.3	18.7	19.4	0.7	76.7	83.5	6.8
November	68.9	29.8	-39.1	27.5	27.6	0.1	15.9	16.1	0.2	73.0	84.5	11.5

**Note:** **N:** Normal. **A:** Actual, **D:** Deviation from normal. Normal values are average of years (Total rainfall – 1998-2012; Max. Temp. 1998-2012; Min.Temp. 2005-2012; Relative humidity 2007-2012).

### 3.5 Experimental details

The field experiment was conducted during *Kharif*, 2013 to study the yield maximization in *Kharif* groundnut through nutrient management practices on growth, yield and uptake of groundnut. The experimental details are as follows.

<b>Variety</b>	: KCG – 2 ((bunch type)
<b>Duration</b>	: 115 days
<b>Spacing</b>	: 30 × 10 cm
<b>Seed rate</b>	: 110 kg ha <sup>-1</sup>
<b>Recommended dose of fertilizers</b>	: 25:50:25 N P <sub>2</sub> O <sub>5</sub> K <sub>2</sub> O kg ha <sup>-1</sup>
<b>Season</b>	: <i>Kharif</i> , 2013
<b>Design</b>	: split plot design
<b>Treatments combinations</b>	: Twelve
<b>Replication</b>	: Three
<b>Location</b>	: ARS, Chintamani
<b>Plot size</b>	: Gross plot size: 3.6 m × 3.0 m (10.8 m <sup>2</sup> )
<b>Net plot size</b>	: 3.0 m × 2.8 m (8.4 m <sup>2</sup> )

#### 3.5.1 Treatment details

The experiment comprised of 4 main plot and 3 subplot treatments. The details of the treatments are given below.

##### Main-plot:

**M<sub>1</sub>**: FYM 7.5 t ha<sup>-1</sup>

**M<sub>2</sub>**: Recommended NPK (25:50:25 kg ha<sup>-1</sup>)

**M<sub>3</sub>**: FYM @ 7.5 t ha<sup>-1</sup> + Rec. NPK (25:50:25 kg ha<sup>-1</sup>)

**M<sub>4</sub>**: FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>

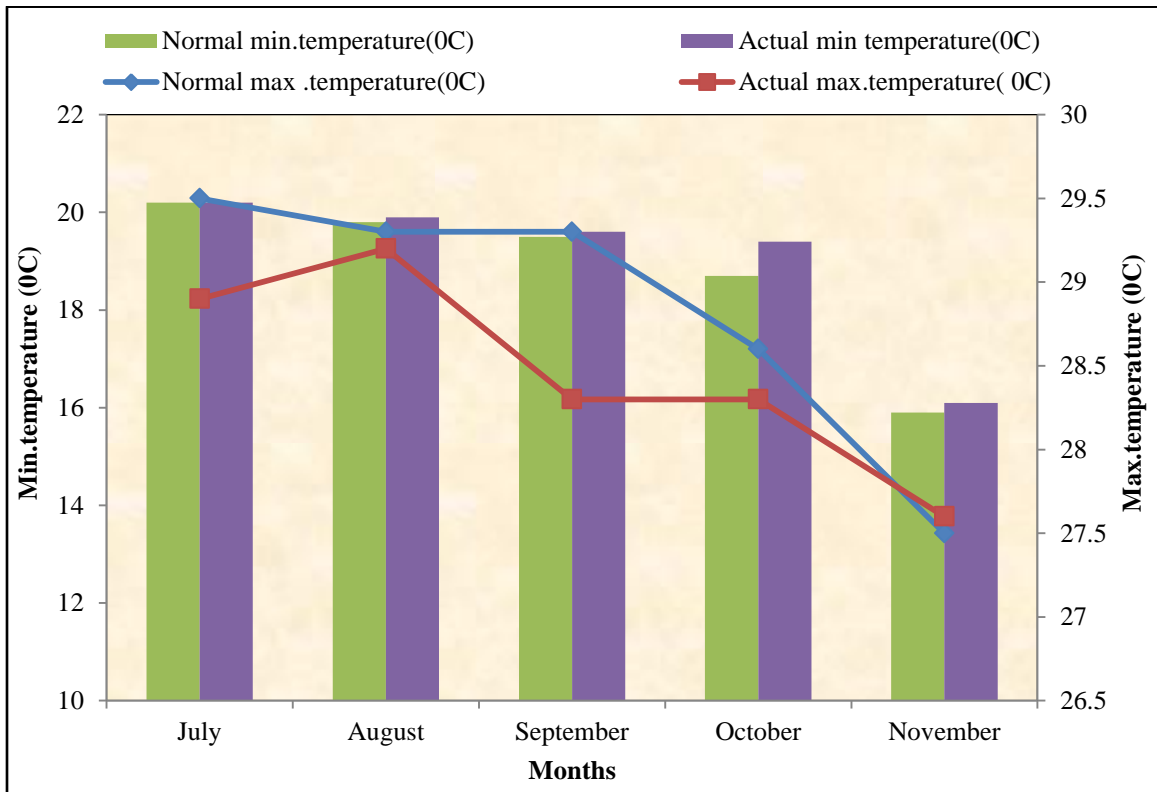
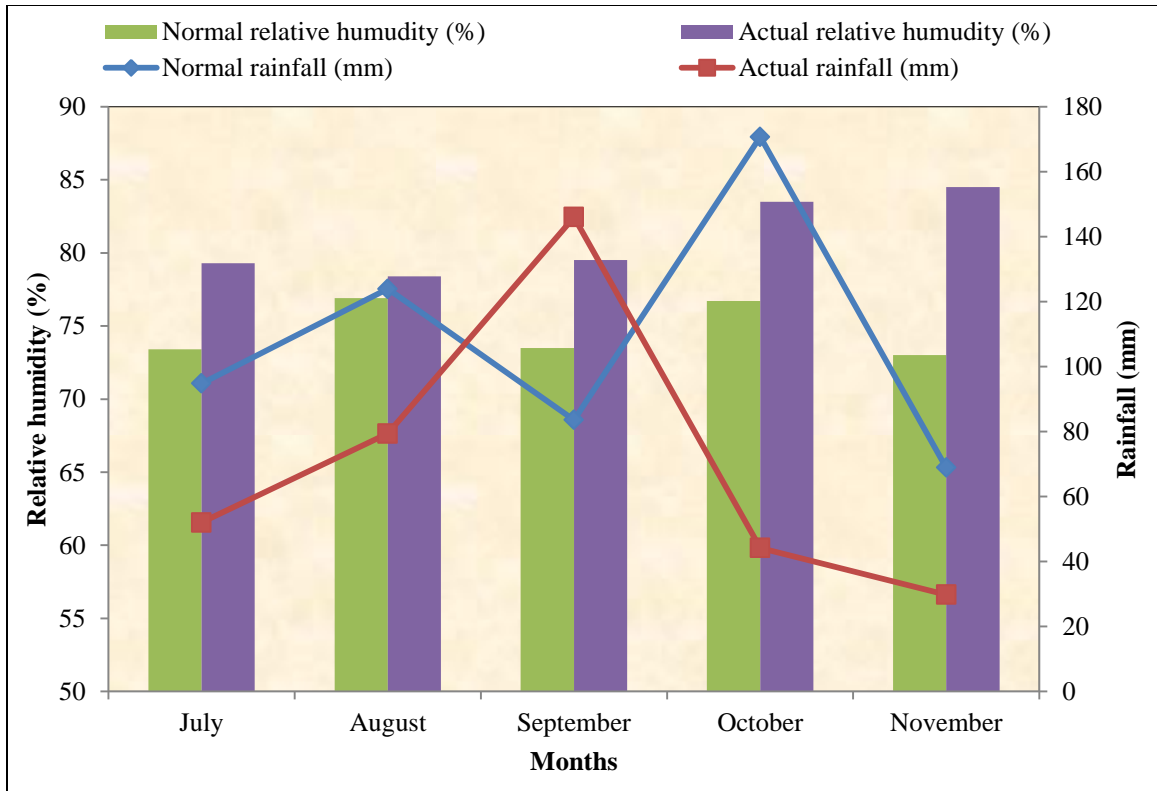
##### Sub-plot:

**S<sub>1</sub>**: Absolute control (No spray)

**S<sub>2</sub>**: Foliar spray of 2 % urea at 30 DAS

**S<sub>3</sub>**: Foliar spray of 2% urea at 30 and 60 DAS

DAS = days after sowing



**Fig. 3.1: Monthly metrological data (normal and actual) during the experimental period (July to November 2013)**

### **Treatment combination:**

**M<sub>1</sub>S<sub>1</sub>**= FYM @ 7.5 t ha<sup>-1</sup> + Absolute control (No spray)

**M<sub>1</sub>S<sub>2</sub>**= FYM @ 7.5 t ha<sup>-1</sup> + Foliar spray of 2 % urea at 30 DAS

**M<sub>1</sub>S<sub>3</sub>** = FYM @ 7.5 t ha<sup>-1</sup> + Foliar spray of 2 % urea at 30 and 60 DAS

**M<sub>2</sub>S<sub>1</sub>**= Recommended NPK (25:50:25 kg ha<sup>-1</sup>) + Absolute control (No spray)

**M<sub>2</sub>S<sub>2</sub>**= Recommended NPK (25:50:25 kg ha<sup>-1</sup>) + Foliar spray of 2 % urea at 30 DAS

**M<sub>2</sub>S<sub>3</sub>**= Recommended NPK (25:50:25 kg ha<sup>-1</sup>) + Foliar spray of 2 % urea at 30 and 60 DAS

**M<sub>3</sub>S<sub>1</sub>**= FYM @ 7.5 t ha<sup>-1</sup> + Rec. NPK (25:50:25 kg ha<sup>-1</sup>) + Absolute control (No spray)

**M<sub>3</sub>S<sub>2</sub>**= FYM @ 7.5 t ha<sup>-1</sup> + Rec. NPK (25:50:25 kg ha<sup>-1</sup>) + Foliar spray of 2 % urea at 30 DAS

**M<sub>3</sub>S<sub>3</sub>**= FYM @ 7.5 t ha<sup>-1</sup> + Rec. NPK (25:50:25 kg ha<sup>-1</sup>) + Foliar spray of 2 % urea at 30 DAS and 60 DAS

**M<sub>4</sub>S<sub>1</sub>**= FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> + Absolute control (No spray)

**M<sub>4</sub>S<sub>2</sub>**= FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> + Foliar spray of 2 % urea at 30 DAS

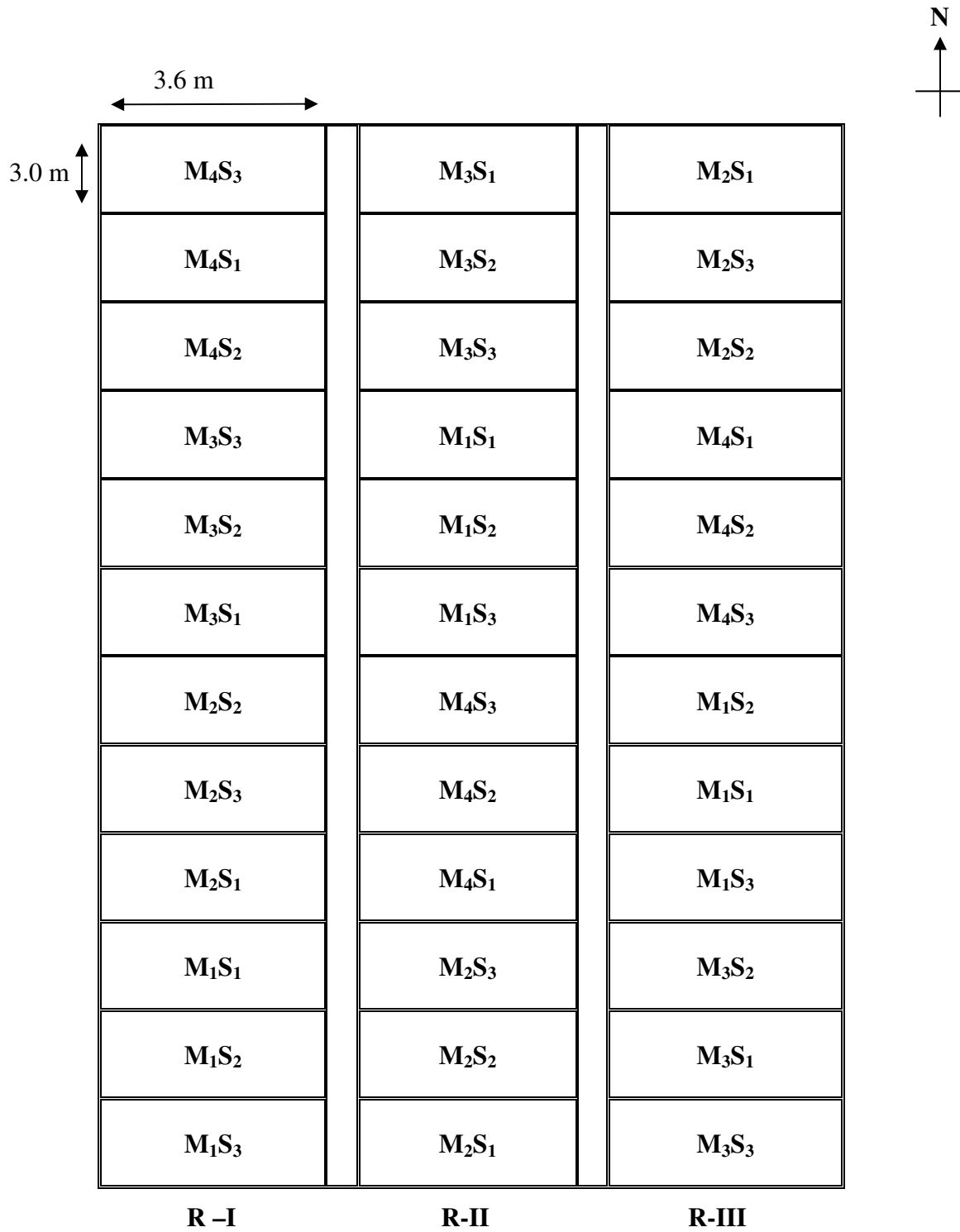
**M<sub>4</sub>S<sub>3</sub>**= FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> + Foliar spray of 2 % urea at 30 and 60 DAS

### **3.5.2 Design and layout**

The experiment was laid out in Split plot design and replicated thrice. The layout of the experiment is given in Fig. 3.1.

### **3.5.3 Salient feature of variety**

The groundnut variety used was KCG-2 (Karnataka Chintamani groundnut-2). This is a cross deviation of TAG 24 x ICGV-92257 released for cultivation from the Agricultural Research Station, Chintamani for Zone 4 (Central dry zone) and 5 (Eastern dry zone) of Karnataka state in 2010. It belongs to bunch type growth habit and seeds are bigger in size. The crop matures in 115-118 days. On an average, it yields 1600-1700 kg ha<sup>-1</sup> under rainfed condition and 2600-3000 kg ha<sup>-1</sup> under irrigated condition. Oil content varies from 39-45 %. It is resistant to foliar diseases *viz.*, leaf spots, rust and tolerant to drought.



**Fig. 3.2: Plan of layout of experiment**



**Plate 1: General view of the experiment at 30 DAS**



**Plate 2: General view of the experiment at 60 DAS**



**Plate 3: General view of the experiment at 90 DAS**

## **3.6 Cultivation practices**

### **3.6.1 Land preparation**

The land was ploughed twice with mould board plough. Then smoothed with wooden plank and harrowed twice with blade harrow to achieve fine tilth. Weeds and stubbles were removed and the land was levelled for sowing. Later, the field was demarcated and laid out as per the plan. Individual plots were prepared and levelled as per the plot size before taking up sowing operation.

### **3.6.2 Manure application**

As per treatments, calculated amount of manures at 7.5 t FYM ha<sup>-1</sup> was applied and mixed well 15 days prior to sowing.

### **3.6.3 Fertilizer application**

Fertilizers were applied as per the treatments, all the nutrients were applied in the form of straight fertilizers. Nitrogen in the form urea, phosphorus in the form single super phosphate, potassium in the form of muriate of potash and micronutrients like zinc in the form of zinc sulphate (10kg ha<sup>-1</sup>) and boron in the form borax (5 kg ha<sup>-1</sup>) and are applied in the furrows at the time of sowing and mixed well into the soil before sowing of seeds.

Foliar application of 2 % urea was applied at 30 and 60 days after sowing of the crop as per the treatments.

### **3.6.4 Seed treatment**

The groundnut seeds were treated with Rhizobium inoculum and *Trichoderma viride* were used for sowing. The seeds were sown to a depth of 4-5 cm at optimum soil moisture condition with spacing of 30cm between rows 10cm between plants and covered with soil. Subsequently after germination gap filling was done.

## **3 3.7 After care**

### **3.7.1 Intercultivation**

Intercultivation was done at 25 days after sowing. The plots were kept weed free by timely hand weeding and earthing up was done at 35 days after sowing for effective weed control and to give favourable environment for peg and pod development

### **3.7.2 Protective irrigation**

Protective irrigation was provided when the crop was suffered from moisture stress. Two protective irrigations were given during crop growth.

### **3.7.3 Plant protection measures**

During the experimental period, the crop was slightly affected by leaf miner and the suitable plant protection measures were taken up to control the pest.

### **3.7.4 Harvesting**

Crop was harvested treatment wise at physiological maturity on 22<sup>nd</sup> November. The pods were plucked from the net plot area separately and the haulm was left for drying. The harvested pods from each treatment and replication were sun dried separately. The pods were cleaned and sun dried to reduce moisture content to optimum level (8-9 %).

### **3.8 Biometric observations**

Five plants were randomly selected in each net plot and labelled them for recording biometric observation at 30, 60 and 90 DAS and at harvest. The procedure followed for various growth and yield parameters are given below.

#### **3.8.1 Observation on growth parameters**

##### **3.8.1.1 Plant height**

The plant height was measured from base of the plant to the tip of the main stem on five randomly selected tagged plants at 30, 60 and 90 DAS and at harvest. The average height of five plants was computed and expressed in centimetres.

##### **3.8.1.2 Number of primary branches per plant**

Numbers of primary branches were recorded by counting the branches in each of five plants at 30, 60 and 90 DAS and their mean was worked out and expressed as number of branches per plant.

##### **3.8.1.3 Number of leaves per plant**

The numbers of leaves per plot were recorded in each of five plants at 30, 60 and 90 DAS and at harvest and their mean were taken and expressed number of leaves plant.

The leaf area was recorded using leaf area meter (Inc/LI-COR Ltd., Nebraska USA) at 30, 60 and 90 days after sowing and at harvest. Leaf area index is the ratio of leaf area to ground area occupied by the crop plant. Leaf area index was worked out by using the following formula given by Watson, 1952. And expressed in square centimetres (cm<sup>2</sup>).

$$\text{LAI} = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Land area covered by the plant (cm}^2\text{)}}$$

##### **3.8.1.5 Dry matter accumulation and distribution**

Dry matter accumulation at 30, 60, and 90 DAS and at harvest was determined only for the above ground portion of the plant. The five plant samples selected were partitioned in to different parts like leaves, stem and total and later dried in hot air oven at 65 °C till the constant dry weight was obtained. The completely dried samples were weighed separately and weight was recorded and expressed as grams per plant.

### **3.8.1.6 Number of nodules per plant**

Five randomly selected plants were watered and pulled out without damaging the root system. The roots were carefully washed in water to remove the adhered mud and dirt. Numbers of nodules per plant were counted at 30, 60 and 90 DAS.

### **3.8.1.7 Nodule dry weight**

After recording the nodule number in each plant the nodules were manually separated from five randomly selected tagged plants and were initially dried at room temperature for five hours and then in hot air oven at 85 ° c temperature for 24 hours . The weight was recorded in electronic balance in milligrams (mg) and average was computed and expressed as nodule dry weight in milligrams per plant.

## **3.8.2 Observations on yield parameters**

### **3.8.2.1 Number of pods**

The numbers of pods were recorded by counting from each of the five randomly selected plants at harvest and the mean was expressed as number of pods per plant.

### **3.8.2.2 Number of filled pods per plant**

The number of filled pods was counted in five tagged plants and the mean was worked out and expressed as number of filled pods per plant.

### **3.8.2.3 Number of unfilled pods per plant**

The numbers of unfilled pods were counted in five randomly tagged plants and the mean number was worked out and expressed as number of unfilled pods per plant.

### **3.8.2.4 100 kernel weight**

The kernels obtained from shelled pods were mixed thoroughly and hundred seeds were counted from each net plot and the weight was recorded and expressed as grams.

### **3.8.2.5 Shelling percentage**

Two hundred and fifty grams of sun dried pods from sample of each plot was shelled manually and the shelling percentage was calculated by dividing the weight of kernels by weight of pods taken and expressed in percentage.

$$\text{Shelling (\%)} = \frac{\text{Weight of kernels (g)}}{\text{Dry weight of pods (g)}}$$

### **3.8.2.6 Pod yield**

Groundnut plants in the net plot area were harvested and after separating the pods from plant, the pods were sun dried and pod yield was recorded and expressed as pod yield in kg ha<sup>-1</sup>.

### 3.8.2.7 Kernel yield

Kernel yield was recorded from five randomly selected plants. The pod yield obtained per net plot was used for calculating kernel yield ha<sup>-1</sup>.

### 3.8.2.8 Haulm yield

The dry haulm yield from each net plot at harvest was recorded after separating the pods and complete sun drying for a period of one week and haulm yield was worked out in kg ha<sup>-1</sup>.

### 3.8.2.9 Harvest index

The harvest index of groundnut crop was calculated as per the formula given by Donald (1962).

$$\text{Harvest Index (HI)} = \frac{\text{Pod yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}}$$

## 3.9 Quality parameters

### 3.9.1 Protein content

Protein content of the kernel of groundnut was estimated as per cent nitrogen by micro kjeldhal's method (Jackson, 1973). The protein per cent in the seeds was calculated by multiplying the nitrogen content by a factor of 6.25.

$$\text{Protein content (\%)} = \% \text{ N} \times 6.25$$

### 3.9.2 Protein yield (kg ha<sup>-1</sup>)

Protein yield per hectare was worked out on the basis of seed protein content and seed yield of groundnut.

$$\text{Protein yield (kg ha}^{-1}\text{)} = \frac{\text{Kernel protein content}}{100} \times \text{Kernel yield (kg ha}^{-1}\text{)}$$

### 3.9.3 Oil content (%)

The oil content was estimated by nuclear magnetic resonance (NMR)

### 3.9.4 Oil yield (kg ha<sup>-1</sup>)

Oil yield per hectare was worked out on the basis of kernel oil content and kernel yield of groundnut

$$\text{Oil yield (kg ha}^{-1}\text{)} = \frac{\text{Kernel oil content}}{100} \times \text{Kernel yield (kg ha}^{-1}\text{)}$$

### 3.10 Soil analysis

Soil samples from 0 to 30 cm depth were collected before (one representative sample) the start of experiment and samples from each plot were collected after the harvest of the crop and analysed for pH, available nitrogen (N), available phosphorus ( $P_2O_5$ ), available potassium ( $K_2O$ ), available zinc (Zn) and available boron (Bo).

#### 3.10.1 Available NPK analysis

Soil samples were collected from 0-15 cm depth of soil, dried under shade, powdered and passed through 2 mm sieve. The samples were analyzed for available nitrogen, phosphorus, potassium, zinc and boron.

#### 3.10.2 Available nitrogen

The available nitrogen of soil was determined by alkaline potassium permanganate method as outlined by Subbaiah and Asija (1956), and expressed as  $kg\ ha^{-1}$ .

#### 3.10.3 Available phosphorus

The available phosphorus in the soil was extracted with Bray's method. The extracted phosphorus was then estimated by ascorbic acid blue colour method. The intensity of blue colour was read in spectrophotometer at a wavelength of 660 nm (Jackson, 1973). The available phosphorus was expressed as  $kg\ ha^{-1}$ .

#### 3.10.4 Available potassium

The available potassium ( $kg\ ha^{-1}$ ) of soil was determined by using neutral normal ammonium acetate extractant using a flame photometer method (Jackson, 1973) and expressed as  $kg\ ha^{-1}$ .

#### 3.10.5 Available zinc

Available Zn ( $mg\ kg^{-1}$ ) in the soil was estimated by atomic absorption spectrophotometer (Lindsay and Norwell, 1978) and expressed as  $mg\ kg^{-1}$ .

#### 3.10.6 Available boron

Available B ( $mg\ kg^{-1}$ ) in the soil was estimated by carmine red method (Lindsay and Norwell, 1978) and expressed as  $mg\ kg^{-1}$ .

### 3.11 Plant analysis

The whole plant samples collected at harvest for the dry matter estimation were ground into a fine powder using a willey mill and analysed for total N, P and K, zinc (Zn), boron (B) contents.

$$\text{Nutrient uptake} = \frac{\text{Nutrient content (\%)} \times \text{dry weight}}{100}$$

### **3.11.1 Nitrogen uptake**

Nitrogen was determined by Kjeldahl's method using digestion mixture consisting of copper sulphate, potassium sulphate and selenium catalytic mixture.

Plant samples weighing 1 g were digested in digestion flasks in micro kjeldal unit using sulphuric acid and the digestion mixture. After complete digestion, the digested materials were distilled in alkaline medium and the liberated ammonia was trapped in four per cent boric acid solution containing mixed indicator. The trapped ammonia was titrated against standard sulphuric acid (Jackson, 1973). Nitrogen content in plant samples was estimated using micro Kjeldhal method, suggested by Humphries (1956) and expressed as percentage on oven dry weight basis and same was used to compute N uptake by multiplying percentage nutrient and dry matter.

### **3.11.2 Digestion of plant samples**

One gram of plant sample was pre-digested with 5ml nitric acid and digested with di-acid mixture of nitric acid and perchloric acid (4:9). The clean digested material was made up to 50 ml volume with 6 N HCl and was used for the analysis of all elements except nitrogen.

### **3.11.3 Phosphorus uptake**

Phosphorus content in the digested plant sample was estimated by vanado-molybdo phosphoric yellow colour method in nitric acid medium and the colour intensity was measured at 460 nm wave length as outlined by Jackson (1973).

### **3.11.3 Potassium uptake**

The total K content was estimated using tri acid digestion method as suggested by Jackson (1973) by using Flame photometer and expressed in kg K<sub>2</sub>O uptake ha<sup>-1</sup>.

### **3.11.4 Zinc uptake**

The total Zn content was estimated by using atomic absorption spectrophotometry (Lindsay and Norwell, 1978).and expressed in gm Zn uptake ha<sup>-1</sup>.

### **3.11.5 Boron uptake**

The total B content was estimated using carmine red method (Lindsay and Norwell, 1978) and expressed in gm B uptake ha<sup>-1</sup>.

## **3.12 Economic analysis**

### **3.12.1 Costs**

In computing the economics, different variable cost items were considered. The cost included expenditure on land preparation, seed, manures, chemical fertilizers, plant protection chemicals, and labour charges at prevailing market prices during 2013. The labour requirement was worked out on the basis of labourers engaged for performing different field operations.

### 3.12.2 Returns

Utility of adopting different practices was computed by using following data:

**Gross returns (Rs ha<sup>-1</sup>):** Total value of the produce (both pod and haulm)  
Market price x Total yield (both pod and haulm)

**Net returns (Rs ha<sup>-1</sup>) =** Gross returns - Cost of cultivation.

**Benefit: Cost Ratio:** The Benefit Cost ratio was worked out by following method.

$$\text{B: C ratio} = \frac{\text{Gross Returns (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

### 3.13 Statistical analysis and interpretation of data

The experiment data collected on growth, yield and other aspects were subjected to Fisher's method of analysis of variance (ANOVA) as per methods outlined by Gomez and Gomez (1984). Critical difference (CD) was calculated whenever the 'F' test was found significant. The data presented with the level of significance at 5 per cent.

## IV. EXPERIMENTAL RESULTS

A field experiment entitled “Yield maximization in *kharif* groundnut through nutrient management practices” was conducted at Agricultural Research Station, Chintamani, during *kharif* season of 2013. Results of the experiment are presented in this chapter.

### 4.1 Growth parameters of groundnut as influenced by nutrient management and foliar spray.

#### 4.1.1 Plant height

Data on plant height of groundnut varied significantly due to nutrient management and foliar spray and are presented in Table 4.1.

In general, plant height increased progressively from 30 DAS to harvest and was significantly influenced by the nutrient management at all crop growth stages. At 30 days after sowing, application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> recorded significantly maximum plant height of 5.77 cm than other nutrient management practices. However it was also found on par with application of FYM +Rec. NPK (5.35cm). The lowest plant height 4.69 cm was observed in application of FYM 7.5 t ha<sup>-1</sup>. The foliar spray of 2 % urea at 30 and 60 DAS recorded numerically higher plant height of 5.27 cm and it was on par with foliar spray of 2 % urea at 30 DAS (5.23 cm), while lower plant height was noticed in absolute control (5.19 cm). The interaction effect between nutrient management and foliar spray were non-significant.

At 60 and 90 days after sowing similar trend was observed as that of plant height recorded at 30 DAS. At 60 DAS, significantly a higher plant height was recorded with the application of FYM +Rec. NPK + Borax @ 5 kg + Znso<sub>4</sub> @ 10 kg ha<sup>-1</sup> (19.75 cm) and this was found on par with application of FYM +Rec. NPK (17.81cm), the lowest plant height was recorded in application of FYM 7.5 t ha<sup>-1</sup> (13.90 cm). Among foliar spray, 2 % urea spray at 30 and 60 DAS recorded significantly higher plant height of 18.47cm but it was on par with foliar spray of 2 % urea at 30 DAS (17.15 cm), lower plant height was recorded with absolute control (14.61 cm). The interaction effect between nutrient management and foliar spray were non-significant.

At 90 days after sowing similar trend was observed as that of plant height recorded at 60 DAS. At 90 DAS, significantly a higher plant height was recorded with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> (25.53 cm) and lower plant height was noticed in application of FYM @ 7.5 t ha<sup>-1</sup> (16.25 cm). Among foliar spray, foliar spray of 2 % urea at 30 and 60 DAS recorded significantly higher plant height of 24.05 cm than foliar spray of 2 % urea at 30 DAS (20.87 cm). However, absolute control recorded significantly lower plant height (17.23 cm). The interaction effect between nutrient management practices and foliar spray were non-significant.

**Table 4.1: Plant height of groundnut at different growth stages as influenced by nutrient management and foliar spray**

Treatment	Plant height (cm)			
	30DAS	60DAS	90DAS	At harvest
<b>Main plot: Nutrient management</b>				
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup> .	4.69	13.90	16.29	17.45
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	5.13	15.53	19.31	20.53
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	5.35	17.81	21.75	22.69
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	5.77	19.75	25.53	26.91
S.Em±	0.18	0.74	0.90	0.93
CD (p=0.05)	0.65	2.55	3.12	3.23
<b>Subplot: Foliar spray</b>				
S <sub>1</sub> = Absolute control (No spray).	5.19	14.61	17.25	18.59
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	5.27	17.15	20.87	21.63
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	5.23	18.47	24.03	25.47
S.Em±	0.15	0.46	0.64	0.71
CD (p=0.05)	NS	1.39	1.92	2.15
<b>Interaction (MXS)</b>				
S.Em±	0.30	0.92	1.28	1.43
CD (p=0.05)	NS	NS	NS	NS

DAS- Days after sowing, NS – non significant

At harvest, significantly taller plants were observed in FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (26.91cm) compare to application of FYM @ 7.5 t ha<sup>-1</sup> (17.45 cm). Among foliar spray, foliar spray of 2 % urea at 30 and 60 DAS recorded significantly higher plant height of 25.47 cm than foliar spray of 2 % urea at 30 DAS (21.55 cm) and lower plant height was noticed in absolute control (18.67 cm). The interaction effect between nutrient management and foliar spray were non-significant.

#### **4.1.2 Number of primary branches per plant**

Data on number of primary branches per plant of groundnut recorded at all crop growth stages differed significantly due to nutrient management and foliar spray are presented in Table 4.2.

At 30 DAS, significantly more number of branches per plant was noticed with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (4.81) than other nutrient management practices. However, it was on par with application of FYM @ 7.5 t ha<sup>-1</sup> + Rec. NPK (4.37) compare to application of FYM @ 7.5 t ha<sup>-1</sup> (3.29). Among foliar spray, foliar spray of 2 % urea at 30 and 60 DAS produced numerically more number of branches per plant (4.25) and on par with foliar spray of 2 % urea at 30DAS (4.21), whereas, less number branches were recorded in absolute control (3.97). The interaction effect between nutrient management practices and foliar spray were found non-significant.

Number of branches recorded at 60 and 90 DAS showed similar trend as that of branch numbers recorded at 30 DAS. At 60 DAS, more number of branches per plant was noticed with application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (6.15) compared to application of FYM @ 7.5 t ha<sup>-1</sup> (4.71) The foliar spray of 2 % urea at 30 and 60 DAS produced more number of branches per plant (5.97) and was being on par with foliar spray of 2 % urea at 30 DAS (5.53). However, lower numbers of branches were noticed in absolute control (4.75). The interaction between nutrient management practices and foliar were found non-significant.

At 90 DAS, significantly more number of braches per plant were recorded with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (6.69) and was on par with FYM +Rec. NPK (5.91). While, lower number of branches recorded with the application of FYM @ 7.5 t ha<sup>-1</sup> (5.23). Significantly more number of branches per plant were recorded with the foliar spray of 2 % urea at 30 and 60 DAS (6.35) compared to absolute control (5.21) . However, it was on par with foliar spray of 2 % urea at 30 DAS (6.13).The interaction effect between nutrient management practices and foliar spray were found significant. Number of branches did not differed and same trend was observed at harvest.

#### **4.1.3 Number of leaves per plant**

Data on number of leaves per plant of groundnut recorded at differed crop growth stages differed significantly due to nutrient management practices and foliar spray and are presented in Table 4.3.

**Table 4.2: Number of branches per plant in groundnut at different growth stages as influenced by nutrient management and foliar spray**

Treatment	Number of branches			
	30DAS	60DAS	90DAS	At harvest
<b>Main plot: Nutrient management</b>				
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup> .	3.29	4.71	5.23	5.23
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	4.11	5.27	5.75	5.75
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	4.37	5.55	5.91	5.91
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	4.81	6.15	6.69	6.69
S.Em±	0.21	0.25	0.26	0.26
CD (p=0.05)	0.79	0.86	0.90	0.90
<b>Subplot: Foliar spray</b>				
S <sub>1</sub> = Absolute control (No spray).	3.97	4.75	5.21	5.21
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	4.21	5.97	6.13	6.13
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	4.25	5.53	6.35	6.35
S.Em±	0.18	0.23	0.24	0.24
CD (p=0.05)	NS	0.69	0.74	0.74
<b>Interaction (MXS)</b>				
S.Em±	0.36	0.46	0.49	0.49
CD (p=0.05)	NS	NS	NS	NS

DAS- Days after sowing, NS – non significant

**Table 4.3: Number of leaves per plant groundnut at different growth stages as influenced by nutrient management and foliar spray**

Treatment	Number of leaves			
	30DAS	60DAS	90DAS	At harvest
<b>Main plot: Nutrient management</b>				
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup> .	27.35	61.35	78.11	48.41
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	30.67	67.61	89.59	52.15
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	32.41	72.47	96.71	57.30
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	38.93	78.55	121.13	63.57
S.Em±	1.10	1.36	2.71	1.51
CD (p=0.05)	3.83	4.71	9.38	5.22
<b>Subplot: Foliar spray</b>				
S <sub>1</sub> = Absolute control (No spray).	29.21	64.75	82.79	51.25
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	32.57	73.53	94.99	55.45
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	35.23	71.70	111.39	59.37
S.Em±	0.74	0.91	2.56	1.31
CD (p=0.05)	2.22	2.74	7.70	3.90
<b>Interaction (MXS)</b>				
S.Em±	1.48	1.82	5.13	2.60
CD (p=0.05)	NS	NS	NS	NS

DAS- Days after sowing, NS – non significant

At 30 DAS, application of FYM + Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> produced more number of leaves per plant (38.93) than other nutrient management practices. However, least number of leaves was produced by FYM @ 7.5 t ha<sup>-1</sup> (27.35). At 30 DAS numerically higher numbers of leaves per plant were recorded with foliar spray of 2 % urea at 30 and 60 DAS (35.23) compared to control (29.21). Non significant interaction effects were noticed among nutrient management practices and foliar spray.

At 60 DAS, application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> recorded significantly more number of leaves per plant (78.55) whereas, least number of leaves was produced by FYM @ 7.5 t ha<sup>-1</sup> (61.35). Among foliar sprays, 2 % spray urea at 30 and 60 DAS produced more number of leaves per plant (73.53), and least number of leaves were noticed in absolute control (64.75). The interaction effect between nutrient management practices and foliar spray were found non-significant.

At 90 DAS, significantly more number of leaves per plant was recorded in FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (121.13) compared to FYM @ 7.5 t ha<sup>-1</sup> (78.11). Among foliar spray, significantly more number of leaves recorded with foliar spray of 2 % urea at 30 and 60 DAS (111.39) than foliar spray of 2 % urea at 30 DAS (94.99) and found superior over absolute control (82.79). The interaction effect between nutrient management practices and foliar spray were observed non significant.

At harvest, significantly more number of leaves per plant was noticed with the application FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (63.57) than other nutrient management practices, while least number of leaves were noticed with application of FYM @ 7.5 t ha<sup>-1</sup> (48.41). Higher number of leaves was recorded with foliar spray of 2 % urea at 30 and 60 DAS (59.37) compare to absolute control (51.25). The interaction effect between nutrient management practices and foliar spray were non-significant.

#### **4.1.4 Leaf area per plant**

Data on leaf area per plant of groundnut recorded at differed crop growth stages differed significantly due to nutrient management and foliar spray and are presented in Table 4.4.

At 30 DAS, significantly higher leaf area of groundnut was recorded with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (273.1 cm<sup>2</sup> plant<sup>-1</sup>) than other nutrient management practices. Lower leaf area per plant was recorded in FYM @ 7.5 t ha<sup>-1</sup> (212.5 cm<sup>2</sup> plant<sup>-1</sup>). Numerically higher leaf area per plant was recorded in foliar spray of 2 % urea at 30 and 60 DAS (253.1 cm<sup>2</sup> plant<sup>-1</sup>) compared to absolute control (239.5 cm<sup>2</sup> plant<sup>-1</sup>). The interaction effect between nutrient management and foliar spray were observed non-significant.

Leaf area per plant recorded at 60 and 90 DAS followed similar trend as that of leaf area recorded at 30 DAS. At 60 DAS, significantly higher leaf area was recorded with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (899.3 cm<sup>2</sup> plant<sup>-1</sup>) compared to FYM @ 7.5 t ha<sup>-1</sup> (619.5cm<sup>2</sup> plant<sup>-1</sup>). Among foliar spray, foliar

**Table 4.4: Leaf area of groundnut at different growth stages as influenced by nutrient management practices and foliar spray**

Treatment	Leaf area (cm <sup>2</sup> ) per plant			
	30DAS	60DAS	90DAS	At harvest
<b>Main plot: Nutrient management</b>				
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup>	212.5	619.5	1122.9	412.35
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> )	244.9	723.1	1321.7	621.80
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> )	256.7	813.9	1546.1	743.21
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup>	273.1	899.3	1629.5	828.30
S.Em±	4.17	17.01	35.21	16.43
CD (p=0.05)	14.45	58.55	105.21	56.86
<b>Subplot: Foliar spray</b>				
S <sub>1</sub> = Absolute control (No spray).	239.5	651.5	1249.1	577.13
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	247.7	816.7	1393.3	665.75
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	253.1	823.7	1572.7	711.37
S.Em±	3.12	14.77	17.45	9.77
CD (p=0.05)	8.63	40.29	47.63	29.31
<b>Interaction (MXS)</b>				
S.Em±	9.15	33.55	84.51	19.55
CD (p=0.05)	NS	NS	NS	NS

DAS- Days after sowing, NS – non significant

spray of 2 % urea at 30 and 60 DAS produced higher leaf area ( $823.7\text{cm}^2 \text{ plant}^{-1}$ ). However, least leaf area per plant recorded in control ( $651.5 \text{ cm}^2 \text{ plant}^{-1}$ ). The interaction effect nutrient management practices found non-significant difference was noticed with the foliar spray.

At 90 DAS, significantly higher leaf area was recorded in FYM + Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> ( $1629.5 \text{ cm}^2 \text{ plant}^{-1}$ ) compared to FYM @ 7.5 t ha<sup>-1</sup> ( $1122.9 \text{ cm}^2 \text{ plant}^{-1}$ ). Foliar spray of 2 % urea at 30 and 60 DAS recorded significantly higher leaf area ( $1572.7 \text{ cm}^2 \text{ plant}^{-1}$ ) than control ( $1249.1\text{cm}^2 \text{ plant}^{-1}$ ). The interaction effect between nutrient management practices and foliar spray were found non-significant.

At harvest, significantly higher leaf area was recorded in FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> ( $828.3\text{cm}^2 \text{ plant}^{-1}$ ) compared to FYM @ 7.5 t ha<sup>-1</sup> ( $412.35 \text{ cm}^2 \text{ plant}^{-1}$ ). Foliar spray of 2 % urea at 30 and 60 DAS recorded significantly higher leaf area ( $711.37 \text{ cm}^2 \text{ plant}^{-1}$ ), however less leaf area per plant recorded in control ( $577.13 \text{ cm}^2 \text{ plant}^{-1}$ ). The interaction effect between nutrient management and foliar spray were found non-significant.

#### **4.1.5 Leaf area index (LAI)**

Data on leaf area index of groundnut varied significantly at different growth stages due to nutrient management and foliar spray and are presented in Table 4.5.

At 30 DAS, significantly the higher leaf area index was recorded in FYM + Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> (0.91) than other nutrient management practices. However, less LAI was noticed in FYM @ 7.5 t ha<sup>-1</sup> (0.70). Numerically higher LAI was noticed with foliar spray of 2 % urea at 30 and 60 DAS (0.84) compared to control (0.79). Nutrient management and foliar spray were found to be non-significant.

At 60 DAS, The application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> resulted in higher leaf area index of 2.99 compared to FYM @ 7.5 t ha<sup>-1</sup> (2.06). Significantly higher leaf area index was recorded in foliar spray of 2 % urea at 30 and 60 DAS (2.74) compared to control (2.05). The interaction effects were found non-significant for the nutrient management practices and foliar spray.

At 90 DAS, Application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> resulted in higher leaf area index of 5.43 and was being on par with FYM @ 7.5 t ha<sup>-1</sup> + Rec. NPK (5.15). However, lowest LAI recorded in FYM @ 7.5 t ha<sup>-1</sup> (3.74). Significantly higher leaf area index was recorded in foliar spray of 2 % urea at 30 and 60 DAS (5.24) compare to control (4.15). The interaction effect nutrient management and foliar spray were found non-significant.

At harvest, application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> resulted in higher leaf area index of 2.76 and found to be on par with FYM @ 7.5 t ha<sup>-1</sup> + Rec. NPK (2.47). However, less LAI was recorded with FYM @ 7.5 t ha<sup>-1</sup> (1.37). Significantly higher leaf area index was recorded in foliar spray of 2 % urea at 30 and 60

**Table 4.5: Leaf area index of groundnut at different growth stages as influenced by nutrient management and foliar spray**

Treatment	Leaf area index			
	30DAS	60DAS	90DAS	At harvest
<b>Main plot: Nutrient management</b>				
M <sub>1</sub> = FYM 7.5 t ha <sup>-1</sup> .	0.70	2.06	3.74	1.37
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	0.81	2.41	4.40	2.07
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	0.85	2.71	5.15	2.47
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	0.91	2.99	5.43	2.76
S.Em±	0.03	0.09	0.22	0.06
CD (p=0.05)	0.11	0.25	0.79	0.22
<b>Subplot: Foliar spray</b>				
S <sub>1</sub> = Absolute control (No spray).	0.79	2.05	4.15	1.92
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	0.82	2.72	4.64	2.21
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	0.84	2.74	5.24	2.37
S.Em±	0.01	0.07	0.19	0.04
CD (p=0.05)	NS	0.22	0.51	0.01
<b>Interaction (MXS)</b>				
S.Em±	0.015	0.17	0.39	0.09
CD (p=0.05)	NS	NS	NS	NS

DAS- Days after sowing, NS – non significant

DAS (2.37) compare to control (1.92). The interaction effect nutrient management practices and foliar spray were found non-significant.

#### 4.1.6 Number of root nodule per plant

Data on number of root nodule per plant of groundnut varied significantly due to nutrient management and foliar spray (Table 4.6).

At 30 DAS, more number of root nodules of 28.51 was noticed in FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> than other nutrient management practices, However, less number of nodules per plant was recorded with the application of FYM @ 7.5 t ha<sup>-1</sup> (20.89). Foliar spray of 2 % urea at 30 and 60 DAS resulted in numerically more number of root nodule 25.47 compare to control (23.71). The interaction effect between nutrient and foliar spray was found to be non-significant.

Root nodule number at 60 and 90 DAS followed same trend as that of 30 DAS. At 60 DAS, significantly more number of root nodules was noticed in FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (84.15) compared to FYM 7.5 t ha<sup>-1</sup> (57.25). Among foliar spray, 2 % urea spray at 30 and 60 DAS recorded more number of nodules (76.53). However, lesser nodules were observed in control (59.31). The interaction effect between nutrient management practices and foliar spray were found to be non-significant.

At 90 DAS, Application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> resulted in more number of nodules (45.53). However, less number of nodules were noticed in FYM @ 7.5 t ha<sup>-1</sup> (27.67). Among foliar spray, 2 % spray urea at 30 and 60 DAS produced more number of nodules (40.37) compare to control (28.95). The interaction effect between nutrient management practices and foliar spray were found non-significant.

#### 4.1.7 Root nodule weight

Root nodule weight per plant of groundnut varied significantly due to nutrient management practices and foliar spray and the data are presented in Table 4.7.

At 30 DAS, Application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> resulted in higher nodule weight per plant of 37.25 mg than other nutrient management practices, however lowest nodule weight noticed in application of FYM @ 7.5 t ha<sup>-1</sup> (24.15 mg). Among foliar spray, 2 % spray urea at 30 and 60 DAS recorded numerically maximum nodule weight (31.53) and lowest nodule weight was in control (29.21). All the interactions were found non- significant with nutrient management practices and foliar spray.

Nodule weight of groundnut recorded at 60 and 90 DAS showed similar trend as that of nodule weight recorded at 30 DAS. At 60 DAS, higher nodule weight per plant was recorded in FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (143.55 mg) compared to FYM @ 7.5 t ha<sup>-1</sup> (81.49 mg). Foliar spray of 2 % urea at 30 and 60 DAS recorded higher root nodule weight 121.3 mg compared to control (89.61 mg). The

**Table 4.6: Number of Nodules in groundnut at different growth stages as influenced by nutrient management and foliar spray**

Treatment	Number of nodules plant <sup>-1</sup>		
	30DAS	60DAS	90DAS
<b>Main plot: Nutrient management</b>			
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup> .	20.89	57.25	27.67
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	23.33	65.93	32.49
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	25.29	72.41	36.25
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	28.51	84.15	43.53
S.Em±	0.83	1.96	1.61
CD (p=0.05)	2.88	6.79	5.58
<b>Subplot: Foliar spray</b>			
S <sub>1</sub> = Absolute control (No spray).	23.71	59.31	28.95
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	25.47	73.97	35.63
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	24.34	76.53	40.37
S.Em±	0.68	1.84	1.57
CD (p=0.05)	NS	5.53	4.72
<b>Interaction (MXS)</b>			
S.Em±	1.37	3.69	3.15
CD (p=0.05)	NS	NS	NS

DAS- Days after sowing, NS – non significant

**Table 4.7: Nodule weight of groundnut at different growth stages as influenced by nutrient management and foliar spray**

Treatment	Nodule weight (mg) plant <sup>-1</sup>		
	30DAS	60DAS	90DAS
<b>Main plot: Nutrient management</b>			
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup> .	24.15	81.49	27.43
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	28.93	92.09	38.71
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	31.69	109.65	43.07
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	37.25	143.55	56.27
S.Em±	1.02	4.73	2.58
CD (p=0.05)	3.53	16.39	8.95
<b>Subplot: Foliar spray</b>			
S <sub>1</sub> = Absolute control (No spray).	29.21	89.61	35.71
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	31.53	109.35	42.25
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	30.77	121.13	46.15
S.Em±	0.97	4.47	2.38
CD (p=0.05)	NS	13.42	7.15
<b>Interaction (MXS)</b>			
S.Em±	1.88	8.95	4.77
CD (p=0.05)	NS	NS	NS

DAS- Days after sowing, NS – non significant

interaction effect between nutrient management and foliar spray were found non-significant.

At 90 DAS, higher nodule weight per plant was recorded in FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> (56.27 mg) than other nutrient management practices, However, lower nodule weight were recorded in FYM 7.5 t ha<sup>-1</sup> (27.43). Among foliar spray, foliar spray of 2 % urea at 30 and 60 DAS produced higher root nodule weight (46.15 mg) compared to control (35.71 mg). All the interactions were found non- significant nutrient management and foliar spray.

#### **4.1.8 Leaf dry weight**

Data on leaf dry weight (g) of groundnut varied significantly due to nutrient management and foliar spray (Table 4.8).

At 30 DAS, significantly higher leaf dry weight (g) per plant was recorded with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> resulted in higher leaf dry weight of 1.22 g than other nutrient management practices , However, lower leaf dry weight was observed in FYM @ 7.5 t ha<sup>-1</sup> (0.82 g). Among foliar spray, application of foliar spray of 2 % urea at 30 and 60 DAS resulted significantly higher leaf dry weight (1.05 g) compared to control (0.96 g). The interaction effect between nutrient management practices and foliar spray were found non-significant.

Leaf dry weight (g) per plant of groundnut recorded at 60 and 90 DAS showed same trend as that of leaf dry weight recorded at 30 DAS. Significantly higher leaf dry weight per plant at 60 DAS was recorded in FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> (5.85 g) compared to FYM @ 7.5 t ha<sup>-1</sup> (3.37 g). Application of foliar spray of 2 % urea at 30 and 60 DAS resulted in higher leaf dry weight per plant of 5.27 g compared to foliar control (3.83 g). The interaction effect between nutrient management and foliar spray were found to be non-significant.

At 90 DAS, among nutrient management practices, significantly higher leaf dry weight per plant was recorded with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> (7.13 g) than other nutrient management practices, whereas, less leaf dry weight was observed in FYM 7.5 t ha<sup>-1</sup> (4.31 g). 2% urea spray at 30 and 60 DAS had resulted in higher leaf dry weight per plant of 6.37 g compared to control (4.75 g). Interaction effect between nutrient management and foliar spray, were non-significant.

At harvest, significantly higher leaf dry weight per plant was recorded in application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> (7.61 g) compared to FYM @ 7.5 t ha<sup>-1</sup> (4.39g). Further, foliar spray of 2 % urea at 30 and 60 DAS recorded significantly higher leaf dry weight of 6.54 g compared to control (5.59 g). The interaction effect between nutrient management practices and foliar spray were non-significant.

**Table 4.8: Leaf dry weight of groundnut at different growth stages as influenced by nutrient management and foliar spray**

Treatment	Leaf dry weight (g plant <sup>-1</sup> )			
	30DAS	60DAS	90DAS	at harvest
Main plot: Nutrient management				
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup> .	0.82	3.37	4.31	4.39
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	0.96	4.25	5.17	5.65
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	1.05	5.03	6.09	6.73
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSO <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	1.22	5.85	7.13	7.61
S.Em±	0.033	0.19	0.30	0.33
CD (p=0.05)	0.11	0.65	1.07	1.15
Subplot: Foliar spray				
S <sub>1</sub> = Absolute control (No spray).	0.96	3.83	4.75	5.59
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	1.03	4.78	5.90	6.15
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	1.05	5.27	6.37	6.54
S.Em±	0.019	0.12	0.26	0.27
CD (p=0.05)	NS	0.37	0.078	0.82
Interaction (MXS)				
S.Em±	0.037	0.25	0.52	0.54
CD (p=0.05)	NS	NS	NS	NS

DAS- Days after sowing, NS – non significant

#### 4.1.9 Stem dry weight

Data on stem dry weight of groundnut differed significantly due to nutrient management practices and foliar spray and are presented in Table 4.9.

At 30 DAS, significantly higher stem dry weight per plant was recorded with application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (1.41g) compared to FYM @ 7.5 t ha<sup>-1</sup> (0.97g). Foliar spray of 2 % urea at 30 and 60 DAS recorded higher stem dry weight of 1.19 g compared to control (1.09 g). The interaction effect nutrient management and foliar spray were observed non-significant.

Stem dry weight (g) recorded at 60 and 90 DAS showed similar trend as that of stem dry weight recorded at 30 DAS. Application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> recorded significantly higher stem dry weight (11.75 g) , while , lower stem dry weight noticed in FYM @ 7.5 t ha<sup>-1</sup> (5.36 g). The higher stem dry weight of 9.26 g was obtained with the foliar spray of 2 % urea at 30 and 60 DAS compared to control (6.34 g). The interaction effect between nutrient management practices and foliar spray were found to be non-significant.

At 90 DAS significantly higher stem dry weight per plant was recorded in application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (17.90 g) than other nutrient management practices and lower stem dry weight was noticed in FYM @ 7.5 t ha<sup>-1</sup> (8.28 g). Further, foliar spray of 2% urea at 30 and 60 DAS resulted significantly higher stem dry weight of 16.54 g compared to control (8.82 g). The interaction effect between nutrient management practices and foliar spray were non-significant.

At harvest, significantly higher stem dry weight per plant was recorded in application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (18.34g) compared to FYM @ 7.5 t ha<sup>-1</sup> (8.66g). Further, foliar spray of 2 % urea at 30 and 60 DAS recorded significantly higher stem dry weight of 9.36 g compared to control (16.97g). The interaction effect between nutrient management practices and foliar spray were non-significant.

#### 4.1.10 Total dry matter accumulation

Data on total dry matter accumulation of groundnut differed significantly due to nutrient management and foliar spray and is presented in Table 4.10.

At 30 DAS, significantly the higher total dry matter accumulation was recorded in FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (2.65 g) than other nutrient management and lower total dry matter accumulation was noticed in FYM @ 7.5 t ha<sup>-1</sup> (1.79 g). Application of foliar spray of 2% urea at 30 and 60 DAS produced higher total dry matter accumulation (2.25 g), lower dry matter accumulation was observed in control (2.05 g). The interaction effect between nutrient management and foliar spray were found to be non-significant.

**Table 4.9: Stem dry weight of groundnut at different growth stages as influenced by nutrient management and foliar spray**

Treatment	Stem dry weight (g plant <sup>-1</sup> )			
	30DAS	60DAS	90DAS	at harvest
Main plot: Nutrient management				
M <sub>1</sub> = FYM 7.5 t ha <sup>-1</sup> .	0.97	5.36	8.28	8.66
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	1.05	7.11	10.62	10.72
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	1.12	8.58	14.14	14.38
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	1.41	11.75	17.90	18.34
S.Em±	0.067	0.32	0.45	0.51
CD (p=0.05)	0.23	1.12	1.59	1.78
Subplot: Foliar spray				
S <sub>1</sub> = Absolute control (No spray).	1.09	6.34	8.82	9.36
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	1.14	8.98	11.96	12.90
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	1.19	9.29	16.54	16.97
S.Em±	0.051	0.23	0.31	0.40
CD (p=0.05)	NS	0.71	0.92	1.01
Interaction (MXS)				
S.Em±	0.10	0.46	0.62	0.81
CD (p=0.05)	NS	NS	NS	NS

DAS- Days after sowing, NS – non significant

**Table 4.10: Total dry matter accumulation of groundnut influenced by nutrient management and foliar spray**

Treatment	Total dry matter (g plant <sup>-1</sup> )			
	30DAS	60DAS	90DAS	at harvest
<b>Main plot: Nutrient management</b>				
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup> .	1.79	8.73	12.57	13.05
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	2.01	11.35	15.79	16.37
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	2.17	13.61	20.21	21.09
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSO <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	2.65	17.27	25.17	25.89
S.Em±	0.12	0.54	0.92	0.97
CD (p=0.05)	0.43	1.89	3.20	3.35
<b>Subplot: Foliar spray</b>				
S <sub>1</sub> = Absolute control (No spray).	2.05	9.77	13.55	14.27
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	2.17	13.65	17.85	18.95
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	2.25	15.01	23.19	24.09
S.Em±	0.09	0.48	0.79	0.81
CD (p=0.05)	NS	1.46	2.39	2.55
<b>Interaction (MXS)</b>				
S.Em±	0.19	0.97	1.59	1.71
CD (p=0.05)	NS	NS	NS	NS

DAS- Days after sowing, NS – non significant

At 60 DAS, significantly the higher total dry matter accumulation was recorded in application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> resulted in higher total dry matter accumulation of 17.27 g compared to FYM 7.5 t ha<sup>-1</sup> (8.73 g). Among foliar spray, foliar spray of 2% urea at 30 and 60 DAS recorded higher dry matter accumulation (15.01g) compared to control (9.77 g). The interaction effects were found at non-significant with nutrient management practices and foliar spray.

At 90 DAS, significantly higher total dry matter accumulation was recorded in FYM + Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (25.17 g) than other nutrient management practices, However, lower total dry matter accumulation was noticed in FYM 7.5 t ha<sup>-1</sup> (12.57g). Foliar spray of 2 % urea at 30 and 60 DAS resulted in higher total dry matter accumulation 23.19 g compared to control (13.55g) Among interaction effect of nutrient management and foliar spray were found non-significant.

At harvest, significantly the higher total dry matter accumulation was recorded in FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (25.89 g) compared to application of FYM @ 7.5 t ha<sup>-1</sup> (13.05 g). Foliar spray of 2 % urea at 30 and 60 DAS resulted in higher total dry matter accumulation 25.93 g compared to control (14.27 g). Among interaction effect of nutrient management practices and foliar spray were found non-significant.

## **4.2 Yield and yield attributes of groundnut**

### **4.2.1 Number of pods per plant**

Numbers of pods per plant varied significantly due to nutrient management and foliar spray and are presented in Table 4.11.

More number of pods per plant was recorded with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (29.31) than other nutrient management practices, whereas, less number of pods per plant was observed with FYM @ 7.5 t ha<sup>-1</sup> (17.57). Among foliar spray, application of foliar spray of 2% urea at 30 and 60 DAS recorded more of pods per plant (28.67) compared to control (18.71). The interaction effect between nutrient management and foliar spray were found to be non-significant.

### **4.2.2 Number of filled pods per plant**

Data on number of filled pods per plant of groundnut differed significantly due to nutrient management and foliar spray and are presented in Table 4.11.

Significantly more number of filled pods per plants was recorded in application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (21.55) , less number of filled pods per plant noticed in FYM 7.5 t ha<sup>-1</sup> (13.30). Foliar spray of 2 % urea at 30 and 60 DAS produced more number of filled pods per plant (20.95) compared to control (14.11). The interaction effect between nutrient management and foliar spray were found to be non-significant

**Table 4.11: yield parameter of groundnut influenced by nutrient management and foliar spray**

Treatment	No. of pods per plant	No. of filled pods per plant	No. of unfilled pods per plant
<b>Main plot: Nutrient management</b>			
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup> .	17.5	13.30	4.20
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	20.9	15.57	5.33
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	24.9	18.73	6.20
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	29.3	21.55	7.75
S.Em±	1.22	0.97	0.22
CD (p=0.05)	4.24	3.36	0.78
<b>Subplot: Foliar spray</b>			
S <sub>1</sub> = Absolute control (No spray).	18.7	14.11	4.60
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	22.1	16.79	5.35
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	28.5	20.95	7.55
S.Em±	1.18	0.69	0.17
CD (p=0.05)	3.54	2.07	0.51
<b>Interaction (MXS)</b>			
S.Em±	2.36	1.38	0.34
CD (p=0.05)	NS	NS	NS

DAS- Days after sowing, NS – non significant

### 4.2.3 Unfilled pods per plant

Significantly more number of unfilled pods per plant was recorded with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (7.75) than other nutrient management practices. However less number of unfilled pods per plant was noticed in FYM 7.5 t ha<sup>-1</sup> (4.20). Among foliar spray, Foliar spray of 2 % urea at 30 and 60 DAS produced more number of unfilled pods per plant (7.55) compared to control (4.60). The interaction effect between nutrient management and foliar spray was found to be non-significant (Table 4.11).

### 4.2.4 100 kernel weight

100 kernel weight of groundnut varied significantly due to different nutrient management and foliar spray and are presented in Table 4.13.

Application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> resulted in higher 100 kernel weight of 33.1g than other nutrient management practices and found to be on par with application of FYM +Rec. NPK ( 30.5 g), However, lower 100 kernel weight was observed in FYM 7.5 t ha<sup>-1</sup> (26.3 g).Among foliar spray, application of foliar spray of 2 % urea at 30 and 60 DAS recorded higher hundred kernel weight of 31.3 g and was being on par with foliar spray of 2% urea at 30 DAS (29.5g) .while, lesser 100 kernel weight noticed in control (27.7g). The interaction effect between nutrient management and foliar spray were found to be non-significant.

### 4.2.5 Pod yield

Pod yield of groundnut differed significantly due to different nutrient management practices and foliar spray (Table 4.12).

Application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> recorded significantly higher pod yield (1175 kg ha<sup>-1</sup>) than other nutrient management practices, while, lower pod yield was noticed in FYM 7.5 t ha<sup>-1</sup> (659 kg ha<sup>-1</sup>). Foliar spray of 2 % urea at 30 and 60 DAS produced significantly pod yield (1025 kg ha<sup>-1</sup>) compared to foliar spray of 2 % urea at 30 DAS and control (745 kg ha<sup>-1</sup>). Interaction effect between nutrient management practices and foliar spray were not-significant.

### 4.2.6 Kernel yield

Data on kernel yield of groundnut differed significantly as influenced by different nutrient management and foliar spray and are presented in Table 4.13.

Application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> recorded significantly higher kernel yield (780 kg ha<sup>-1</sup>) than other nutrient management practices, However, lower kernel yield was noticed in FYM 7.5 t ha<sup>-1</sup> (391kg ha<sup>-1</sup>). Foliar spray of 2% urea at 30 and 60 DAS produced higher kernel yield (670 kg ha<sup>-1</sup>) compared to control (457 kg ha<sup>-1</sup>). Interaction effect between nutrient management and foliar spray were found non-significant.

**Table 4.12: Pod yield, haulm yield and harvest index of groundnut as influenced by nutrient management and foliar spray**

Treatment	Yield ( kg ha <sup>-1</sup> )		
	Pod	Haulm	HI
<b>Main plot: Nutrient management</b>			
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup> .	659	1705	0.38
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	787	1913	0.41
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	931	2137	0.43
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	1175	2455	0.48
S.Em±	44.16	43.04	0.027
CD (p=0.05)	152.84	148.97	NS
<b>Subplot: Foliar spray</b>			
S <sub>1</sub> = Absolute control (No spray).	745	1915	0.39
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	893	2013	0.42
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	1025	2230	0.46
S.Em±	36.08	40.71	0.017
CD (p=0.05)	108.16	122.05	NS
<b>Interaction (MXS)</b>			
S.Em±	72.16	81.42	0.031
CD (p=0.05)	NS	NS	NS

DAS- Days after sowing, NS – non significant

**Table 4.13: 100-kernel weight, shelling percentage and kernels yield of groundnut as influenced by nutrient management and foliar spray**

Treatment	100 kernel weight(g)	Shelling (%)	Kernel yield (kg ha <sup>-1</sup> )
<b>Main plot: Nutrient management</b>			
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup> .	26.3	59.37	391.0
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	28.1	61.96	487.0
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	30.5	63.91	595.0
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	33.1	67.55	780.0
S.Em±	0.78	1.41	30.63
CD (p=0.05)	2.78	4.90	105.99
<b>Subplot: Foliar spray</b>			
S <sub>1</sub> = Absolute control (No spray).	27.7	61.30	457.0
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	29.5	63.00	563.0
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	31.3	65.30	670.0
S.Em±	0.66	1.20	25.97
CD (p=0.05)	1.98	3.60	77.86
<b>Interaction (MXS)</b>			
S.Em±	1.32	2.40	51.94
CD (p=0.05)	NS	NS	NS

DAS- Days after sowing, NS – non significant

#### 4.2.7 Haulm yield

Data on haulm yield of groundnut differed significantly as influenced by different nutrient management and foliar spray and are presented in Table 4.12.

Application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> recorded significantly higher haulm yield (2465 kg ha<sup>-1</sup>) than other nutrient management practices. While, lower haulm yield recorded with the application of FYM 7.5 t ha<sup>-1</sup> (1705 kg ha<sup>-1</sup>). Foliar spray of 2 % urea at 30 and 60 DAS produced higher haulm yield (2237 kg ha<sup>-1</sup>), and lower haulm yield was recorded in control (1915 kg ha<sup>-1</sup>). Interaction effect between nutrient management and foliar spray were found non-significant.

#### 4.2.8 Shelling percentage

Shelling percentage varied significantly due to different nutrient management practices and foliar spray. Application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> resulted in higher shelling percentage of 67.55 % and on par with FYM +Rec. NPK (63.91%) and lower shelling percentage was noticed in FYM 7.5 t ha<sup>-1</sup> (59.37 %). The higher shelling percentage was recorded in foliar spray of 2 % urea at 30 and 60 DAS (65.3 %) and was found to be on par with foliar spray of 2 % urea at 30 DAS (63 %), however lower shelling percentage was observed in control (61.3 %). The interaction effect between nutrient management practices and foliar spray were found non-significant (Table 4.13).

#### 4.2.9 Harvest index (HI)

Harvest index of groundnut varied significantly due to nutrient management and foliar spray are presented in Table 4.12.

Application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> showed higher harvest index of 0.47, lower harvest index was noticed in application of FYM 7.5 t ha<sup>-1</sup> (0.38). Among foliar sprays, foliar spray of 2 % urea at 30 and 60 DAS recorded higher harvest index (0.45) compare to control (0.39). The interaction effect between nutrient management and foliar spray were to be found non-significant.

### 4.3 Quality parameters

#### 4.3.1 Oil content

Oil content of groundnut varied significantly due to different nutrient management and foliar spray (Table 4.14).

Oil content (%) of groundnut indicated that there was no significant difference among nutrient management practices. However FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> recorded numerically more oil content (40.3 %) and lower oil content observed in FYM 7.5 t ha<sup>-1</sup> (38.35 %). No significant difference among foliar spray with respect to oil content. However, foliar spray of 2 % urea at 30 and 60 DAS (39.78 %) recorded numerically higher oil content compared to control (38.69 %). The interaction effect between nutrient management and foliar spray were to be found non-significant.

**Table: 4.14: Oil content, oil yield and protein content and protein yield of groundnut kernels as influenced by nutrient management and foliar spray**

Treatment	Oil (%)	Protein (%)	Oil ( kg ha <sup>-1</sup> )	Protein ( kg ha <sup>-1</sup> )
<b>Main plot: Nutrient management</b>				
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup> .	38.35	19.57	149.95	76.51
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	38.91	20.25	186.49	98.63
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	39.53	21.51	235.21	127.95
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	40.30	22.13	314.33	172.61
S.Em±	1.08	0.95	14.02	5.30
CD (p=0.05)	NS	0.32	48.52	18.34
<b>Subplot: Foliar spray</b>				
S <sub>1</sub> = Absolute control (No spray).	38.69	19.77	176.81	90.35
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	39.35	20.89	221.55	117.61
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	39.78	21.93	266.13	148.79
S.Em±	0.89	0.75	10.84	4.17
CD (p=0.05)	NS	0.18	32.52	12.50
<b>Interaction (MXS)</b>				
S.Em±	1.79	1.50	21.69	8.34
CD (p=0.05)	NS	NS	NS	NS

DAS- Days after sowing, NS – non significant

### 4.3.2 Oil yield

Oil yield ( $\text{kg ha}^{-1}$ ) of groundnut varied significantly due to nutrient management and foliar spray and is presented in Table 4.14.

Application of FYM +Rec. NPK + Borax @ 5 kg +  $\text{ZnSO}_4$  @ 10  $\text{kg ha}^{-1}$  showed higher oil yield ( $314.33 \text{ kg ha}^{-1}$ ) than other nutrient management practices, whereas, lower oil yield was recorded with the FYM @ 7.5  $\text{t ha}^{-1}$  ( $149.95 \text{ kg ha}^{-1}$ ). Among foliar spray, 2 % urea spray at 30 and 60 DAS recorded higher oil yield (266.13), lower oil yield was noticed in control ( $176.81 \text{ kg ha}^{-1}$ ). The interaction effect between nutrient management and foliar spray were to be found non-significant.

### 4.3.3 Protein content

Protein content of groundnut varied significantly due to different nutrient management and foliar spray and is presented in Table 4.14.

Protein content of groundnut indicated that there was significant difference recorded among nutrient management practices, however, FYM +Rec. NPK + Borax @ 5 kg +  $\text{ZnSO}_4$  @ 10  $\text{kg ha}^{-1}$  recorded higher protein content (22.13 %), lower protein content was noticed in application of FYM 7.5  $\text{t ha}^{-1}$  (19.57 %). No significant difference among foliar spray with respect to protein content. However, foliar spray of 2 % urea at 30 and 60 DAS recorded numerically higher protein content (21.93 %) compared to control (19.77%). The interaction effect between nutrient management and foliar spray were to be found non-significant.

### 4.3.4 Protein yield

Protein yields ( $\text{kg ha}^{-1}$ ) of groundnut varied significantly due to nutrient management and foliar spray and are presented in Table 4.14.

Application of FYM +Rec. NPK + Borax @ 5 kg +  $\text{ZnSO}_4$  @ 10  $\text{kg ha}^{-1}$  showed higher protein yield ( $172.61 \text{ kg ha}^{-1}$ ) than other nutrient management practices. However, lower protein yield was noticed in FYM 7.5  $\text{t ha}^{-1}$  ( $76.51 \text{ kg ha}^{-1}$ ). Among foliar spray, 2 % urea spray at 30 and 60 DAS recorded higher protein yield ( $148.79 \text{ kg ha}^{-1}$ ) compared to control ( $90.35 \text{ kg ha}^{-1}$ ). The interaction effect between nutrient management and foliar spray were to be found non-significant.

## 4.4 Total nutrient uptake

### 4.4.1 Nitrogen uptake

Nitrogen uptake by groundnut at harvest varied significantly as influenced by nutrient management and foliar spray and are presented in Table 4.15.

Significantly the higher nitrogen uptake was recorded with the application of FYM +Rec. NPK + Borax @ 5 kg +  $\text{ZnSO}_4$  @ 10  $\text{kg ha}^{-1}$  ( $93.45 \text{ kg ha}^{-1}$ ) than other nutrient management practices. However, lower nutrient uptake was noticed in application FYM 7.5  $\text{t ha}^{-1}$  ( $43.37 \text{ kg ha}^{-1}$ ). Among foliar spray, foliar spray of 2 % urea

at 30 and 60 DAS recorded higher nitrogen uptake ( $79.69 \text{ kg ha}^{-1}$ ), and lower nutrient uptake was recorded in control ( $50.1 \text{ kg ha}^{-1}$ ). The interaction effect between nutrient and foliar spray were found non-significant.

#### **4.4.2 Phosphorus uptake**

Phosphorus uptake by groundnut at harvest varied significantly as influenced by nutrient management and foliar spray and are presented in Table 4.15.

Significantly higher phosphorus uptake was recorded in application of FYM +Rec. NPK + Borax @  $5 \text{ kg} + \text{ZnSO}_4 @ 10 \text{ kg ha}^{-1}$  ( $11.60 \text{ kg ha}^{-1}$ ) than other nutrient management practices. And lower phosphorous uptake was noticed with the application of FYM  $7.5 \text{ t ha}^{-1}$  ( $3.22 \text{ kg ha}^{-1}$ ). Among foliar spray, foliar spray of 2 % urea at 30 and 60 DAS recorded higher phosphorus uptake ( $8.6 \text{ kg ha}^{-1}$ ) compare to control ( $4.06 \text{ kg ha}^{-1}$ ). The interaction effect between nutrient management and foliar spray were found non-significant.

#### **4.4.3 Potassium uptake**

Potassium uptake by groundnut at harvest varied significantly as influenced by nutrient management and foliar spray and are presented in Table 4.15

Significantly higher potassium uptake was recorded in application of FYM +Rec. NPK + Borax @  $5 \text{ kg} + \text{ZnSO}_4 @ 10 \text{ kg ha}^{-1}$  ( $42.09 \text{ kg ha}^{-1}$ ) than other nutrient management practices, and lower potassium uptake was recorded in FYM  $7.5 \text{ t ha}^{-1}$  ( $21.37 \text{ kg ha}^{-1}$ ). Among foliar spray, foliar spray of 2% urea at 30 and 60 DAS recorded higher potassium uptake ( $37.69 \text{ kg ha}^{-1}$ ) compared to control ( $23.53 \text{ kg ha}^{-1}$ ). All the interactions were found non-significant with nutrient management and foliar spray.

#### **4.4.4 Zinc uptake**

Zinc uptake by groundnut at harvest differed significantly as influenced by nutrient management and foliar spray and are presented in Table 4.15

Significantly higher zinc uptake was recorded in FYM +Rec. NPK + Borax @  $5 \text{ kg} + \text{ZnSO}_4 @ 10 \text{ kg ha}^{-1}$  ( $88.79 \text{ g ha}^{-1}$ ) than other nutrient management practices. However, lower zinc uptake was observed with the application of FYM @  $7.5 \text{ t ha}^{-1}$  ( $33.6 \text{ g ha}^{-1}$ ). Among foliar spray, foliar spray of 2% urea at 30 and 60 DAS recorded higher zinc uptake ( $71.07 \text{ g ha}^{-1}$ ) compared to control ( $45.50 \text{ g ha}^{-1}$ ). The interaction effect between nutrient management and foliar spray were found significant (Table 4.16).

#### **4.4.5 Boron uptake**

Boron uptake by groundnut varied at harvest significantly as influenced by nutrient management and foliar spray and are presented in Table 4.15.

Significantly higher boron uptake was recorded in application of FYM +Rec. NPK + Borax @  $5 \text{ kg} + \text{ZnSO}_4 @ 10 \text{ kg ha}^{-1}$  ( $25.8 \text{ g ha}^{-1}$ ) than other nutrient management practices. However, lower boron uptake was recorded in FYM  $7.5 \text{ t ha}^{-1}$  ( $14.3 \text{ g ha}^{-1}$ ) and

**Table 4.15: Nitrogen, phosphorous, potassium, zinc and boron uptake by groundnut as influenced by nutrient management practices and foliar spray**

Treatment	N (Kg ha <sup>-1</sup> )	P <sub>2</sub> O <sub>5</sub> ( Kg ha <sup>-1</sup> )	K <sub>2</sub> O ( Kg ha <sup>-1</sup> )	Zn (g ha <sup>-1</sup> )	B (g ha <sup>-1</sup> )
<b>Main plot: Nutrient management</b>					
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup> .	43.37	3.22	21.37	33.60	14.35
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	53.19	4.39	26.13	44.30	17.27
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	67.33	6.08	31.85	59.62	21.03
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	93.45	11.60	42.09	88.79	25.80
S.Em±	2.11	0.30	1.02	1.45	1.09
CD (p=0.05)	7.32	1.04	3.53	5.02	3.79
<b>Subplot: Foliar spray</b>					
S <sub>1</sub> = Absolute control (No spray).	50.01	4.06	23.53	45.50	16.80
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	63.30	6.30	29.85	53.16	18.12
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	79.69	8.60	37.69	71.07	23.33
S.Em±	1.65	0.21	0.95	1.29	0.97
CD (p=0.05)	4.97	0.65	2.86	3.86	2.93
<b>Interaction (MXS)</b>					
S.Em±	3.31	0.43	1.91	2.58	1.95
CD (p=0.05)	NS	NS	NS	NS	NS

DAS- Days after sowing, NS – non significant

foliar spray of 2 % urea at 30 and 60 DAS recorded higher boron uptake ( $23.3 \text{ g ha}^{-1}$ ), and lower boron uptake was recorded in control ( $16.8 \text{ g ha}^{-1}$ ). The interaction effect between methods of nutrient management and foliar spray were found non-significant (Table 4.16).

## **4.5 Available soil nutrient status after harvest of groundnut**

### **4.5.1 Available nitrogen**

Data on available nitrogen of the soil varied significantly as influenced by nutrient management and foliar spray and are presented in Table 4.16.

The initial status of available nitrogen content of the soil was  $265.31 \text{ kg ha}^{-1}$  and it was increased at the end of crop. Significantly higher available nitrogen in soil was recorded in application of FYM  $7.5 \text{ t ha}^{-1}$  ( $271.53 \text{ kg ha}^{-1}$ ) than other nutrient management practices. However, lower available nitrogen was noticed in application of FYM + Rec. NPK + Borax @  $5 \text{ kg} + \text{ZnSo}_4 @ 10 \text{ kg ha}^{-1}$  ( $262.25 \text{ kg ha}^{-1}$ ). Among foliar spray, control (no spray) recorded higher available soil nitrogen in soil ( $268.67 \text{ kg ha}^{-1}$ ), lower available nitrogen was noticed in foliar spray of 2 % urea at 30 and 60 DAS ( $264.85 \text{ kg ha}^{-1}$ ). The interaction effect between nutrient management and foliar spray were found to be non-significant.

### **4.5.2 Available phosphorus**

Data on available phosphorus status of the soil differed significantly due to nutrient management practices and foliar spray and are presented in Table 4.16.

The initial status of available phosphorus content of the soil was  $23.15 \text{ kg ha}^{-1}$  and it increased at the end of crop. Significantly higher available phosphorus in soil was recorded in FYM  $7.5 \text{ t ha}^{-1}$  ( $29.15 \text{ kg ha}^{-1}$ ) than other nutrient management practices. However, lower available phosphorus was noticed in FYM + Rec. NPK + Borax @  $5 \text{ kg} + \text{ZnSo}_4 @ 10 \text{ kg ha}^{-1}$  ( $23.01 \text{ kg ha}^{-1}$ ). Among foliar spray, control (no spray) recorded higher available phosphorus in soil ( $27.45 \text{ kg ha}^{-1}$ ) compared foliar spray of 2 % urea at 30 and 60 DAS ( $24.67 \text{ kg ha}^{-1}$ ). Interaction between nutrient management practices and foliar spray were found non-significant.

### **4.5.3 Available potassium**

Data on available potassium status of the soil varied significantly as influenced by nutrient management and foliar spray and presented in Table 4.11.

The initial status of available potassium content of the soil was  $251.67 \text{ kg ha}^{-1}$  and it increased at end of the crop. Significantly higher available potassium in soil was recorded in application of FYM  $7.5 \text{ t ha}^{-1}$  ( $285.47 \text{ kg ha}^{-1}$ ) than other nutrient management practices, and lower available potassium was observed in application of FYM + Rec. NPK + Borax @  $5 \text{ kg} + \text{ZnSo}_4 @ 10 \text{ kg ha}^{-1}$  ( $273.31 \text{ kg ha}^{-1}$ ). Significantly higher available potassium in soil was recorded in control ( $278.17 \text{ kg ha}^{-1}$ ) compared to foliar spray of 2 % urea at 30 and 60 DAS ( $274.25 \text{ kg ha}^{-1}$ ) control. Interaction between nutrient management practices and foliar spray were found to be non-significant.

**Table 4.16: Available Nitrogen, phosphorous, potassium, zinc and boron in soil after harvest of groundnut crop as influenced by nutrient management practices and foliar spray**

Treatment	N (Kg ha <sup>-1</sup> )	P <sub>2</sub> O <sub>5</sub> ( Kg ha <sup>-1</sup> )	K <sub>2</sub> O (Kg ha <sup>-1</sup> )	Zn mg kg ha <sup>-1</sup>	B mg kg ha <sup>-1</sup>
<b>Main plot: Nutrient management</b>					
M <sub>1</sub> = FYM @ 7.5 t ha <sup>-1</sup> .	271.45	29.15	285.47	0.49	0.41
M <sub>2</sub> = Recommended NPK (25:50:25 kg ha <sup>-1</sup> ).	268.17	26.91	279.25	0.47	0.39
M <sub>3</sub> = FYM @ 7.5 t ha <sup>-1</sup> + Rec. NPK (25:50:25 kg ha <sup>-1</sup> ).	265.03	24.50	275.10	0.46	0.37
M <sub>4</sub> = FYM +Rec. NPK + Borax @ 5 kg + ZnSO <sub>4</sub> @ 10 kg ha <sup>-1</sup> .	262.25	23.35	273.31	0.45	0.35
S.Em±	2.08	1.02	2.28	1.69	1.05
CD (p=0.05)	6.12	3.53	7.92	4.79	3.61
<b>Subplot: Foliar spray</b>					
S <sub>1</sub> = Absolute control (No spray).	268.21	27.45	278.17	0.48	0.39
S <sub>2</sub> = Foliar spray of 2 % urea at 30 DAS.	266.83	25.81	275.50	0.47	0.38
S <sub>3</sub> = Foliar spray of 2% urea at 30 and 60 DAS.	264.79	24.67	274.25	0.46	0.37
S.Em±	1.26	0.83	2.17	0.97	0.86
CD (p=0.05)	3.78	2.51	5.09	2.85	2.69
<b>Interaction (MXS)</b>					
S.Em±	2.52	1.67	4.35	1.96	1.75
CD (p=0.05)	NS	NS	NS	NS	NS

DAS- Days after sowing, NS – non significant

#### **4.5.2 Available soil zinc**

Data on available zinc status of the soil differed significantly due to nutrient management and foliar spray (Table 4.11).

The initial status of available phosphorus content of the soil was  $0.51 \text{ mg kg}^{-1}$  and it decreased after harvest of the crop. Significantly higher available zinc in soil was recorded in application of FYM  $7.5 \text{ t ha}^{-1}$  ( $0.53 \text{ mg kg}^{-1}$ ) compared application FYM + Rec. NPK + Borax @  $5 \text{ kg} + \text{ZnSo}_4 @ 10 \text{ kg ha}^{-1}$  ( $0.45 \text{ mg kg}^{-1}$ ). Control (no spray) recorded higher available zinc in soil ( $0.50 \text{ mg kg}^{-1}$ ) compared to foliar spray of 2 % urea at 30 and 60 DAS ( $0.47 \text{ mg kg}^{-1}$ ). Interaction between nutrient management and foliar spray were found non-significant.

#### **4.5.1 Available soil boron**

Data on available boron of the soil varied significantly as influenced by nutrient management and foliar spray and are presented in Table 4.11.

The initial status of available boron content of the soil was  $0.39 \text{ mg kg}^{-1}$  and it was decreased after harvest of the crop. Significantly higher available boron in soil was recorded in application of FYM  $7.5 \text{ t ha}^{-1}$  ( $0.41 \text{ mg kg}^{-1}$ ) compared to FYM +Rec. NPK + Borax @  $5 \text{ kg} + \text{ZnSo}_4 @ 10 \text{ kg ha}^{-1}$  ( $0.35 \text{ ppm}$ ) Among foliar spray, higher available soil boron in soil recorded in control ( $0.39 \text{ mg kg}^{-1}$ ) compare to foliar spray of 2 % urea at 30and 60 DAS ( $0.36 \text{ mg kg}^{-1}$ ). The interaction effect between nutrient management and foliar spray were found to be non-significant.

### **4.6 Economic analysis of groundnut**

#### **4.6.1 Cost of cultivation**

Economics of groundnut as influenced by nutrient management and foliar spray are worked out and presented in Table 4.17.

Application of FYM +Rec. NPK + Borax @  $5 \text{ kg} + \text{ZnSo}_4 @ 10 \text{ kg ha}^{-1}$  with foliar spray of 2% urea at 30 and 60 DAS of groundnut cultivation recorded higher cost of cultivation (Rs.  $25,650 \text{ ha}^{-1}$ ) than other nutrient management practices, however cost of cultivation lower with application of FYM  $7.5 \text{ t ha}^{-1}$  with control (Rs.  $16,900 \text{ ha}^{-1}$ ).

#### **4.6.2 Gross returns**

The higher gross return was obtained under application of FYM +Rec. NPK + Borax @  $5 \text{ kg} + \text{ZnSo}_4 @ 10 \text{ kg ha}^{-1}$  with foliar spray of 2 % urea at 30 and 60 DAS (Rs.  $48,172 \text{ ha}^{-1}$ ) than other nutrient management practices, however application of FYM  $7.5 \text{ t ha}^{-1}$  with control recorded lower gross returns (Rs.  $26,367 \text{ ha}^{-1}$ ).

#### **4.6.3 Net returns**

Higher net return was obtained under application of FYM +Rec. NPK + Borax @  $5 \text{ kg} + \text{ZnSo}_4 @ 10 \text{ kg ha}^{-1}$  along with Foliar spray of 2% urea at 30 and 60 DAS

**Table 17: Cost of cultivation, gross returns, net returns and benefit cost ratio as influenced by nutrient management and foliar spray**

Treatment combinations	Gross returns ( Rs.ha <sup>-1</sup> )	Cost of cultivation (Rs.ha <sup>-1</sup> )	Net returns (Rs.ha <sup>-1</sup> )	B:C ratio
M <sub>1</sub> S <sub>1</sub>	26,367	16,900	9,467	1.56
M <sub>1</sub> S <sub>2</sub>	28,151	17,800	10,351	1.58
M <sub>1</sub> S <sub>3</sub>	29,884	18,600	11,284	1.61
M <sub>2</sub> S <sub>1</sub>	30,205	18,900	11,305	1.59
M <sub>2</sub> S <sub>2</sub>	32,270	20,000	12,270	1.61
M <sub>2</sub> S <sub>3</sub>	33,870	20,900	12,970	1.62
M <sub>3</sub> S <sub>1</sub>	36,995	22,700	14,295	1.63
M <sub>3</sub> S <sub>2</sub>	38,254	23,300	14,954	1.64
M <sub>3</sub> S <sub>3</sub>	41,465	24,200	17,265	1.71
M <sub>4</sub> S <sub>1</sub>	40,670	23,750	16,920	1.71
M <sub>4</sub> S <sub>2</sub>	45,075	24,850	20,225	1.81
M <sub>4</sub> S <sub>3</sub>	48,172	25.650	22,522	1.88

(Rs. 22,522 ha<sup>-1</sup>) than other nutrient management practices, FYM 7.5 t ha<sup>-1</sup> with control recorded lower net returns (Rs. 9,467 ha<sup>-1</sup>).

#### **4.6.4 Benefit to Cost ratio (B: C ratio)**

Application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> with foliar spray of 2 % urea at 30 and 60 DAS recorded higher B: C ratio (1.90) than other nutrient management practices, however application of FYM 7.5 t ha<sup>-1</sup> with control recorded lower B: C ratio( 1.56) Table (4.17).

## V. DISCUSSION

A field experiment entitled “Yield maximization in *kharif* groundnut through nutrient management practices” was conducted at Agricultural Research Station, Chintamani during *kharif* season of 2013. The salient findings of the experimental results are discussed briefly in this chapter.

### 5.1 Weather conditions during the growing seasons

Weather condition during the period of experimentation was favourable for the growth of groundnut. The fluctuations in weather conditions truly reflect on expected yield. Rainfall of 351.4 mm (from July 2013 to Nov 2013) was recorded during the period of experimentation (Table 3.2 and Fig.3.1). There was a slight decrease (351.4 mm) in yearly rainfall during 2013 compared to normal rainfall (541.9 mm). Not only actual rainfall was less compared to normal rainfall, but also rainfall distribution was uneven. Crop faced moisture deficit (drought) during the month of October and November. To overcome moisture deficit crop was supplemented with two protective irrigations. There was no much deviation in the mean monthly maximum and minimum temperature and mean sunshine hours. Slight deviation was found in case of relative humidity during crop growth period. These environmental variations were not high enough to influence crop adversely.

### 5.2 Effect of nutrient management practices on growth and yield of groundnut

Nutrient management is one such important factor which largely decides the yield of the crop produced. The economic yield of plant is an outcome of a series of integrated interactions of various biological events involving biochemical, physiological and morphological changes which take place during its development in accordance with the supply of light, water, temperature and nutrients (Donald, 1962). The yield depends on the synthesis and accumulation of photosynthates and their distribution among various plant parts. The synthesis, accumulation and translocation of photosynthates depend upon efficient photosynthetic structure as well as the extent of translocation into sink and also on plant growth and development during early stages of crop growth. The production and translocation of synthesized photosynthates depend upon mineral nutrition supplied either by soil or through foliar application. Most of the photosynthetic path ways are dependent on enzymes and coenzymes which are synthesized from mineral elements such as nitrogen, phosphorus, potassium, zinc and boron.

Significantly higher pod and haulm yield were recorded with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (1175 kg ha<sup>-1</sup> and 2455 kg ha<sup>-1</sup> respectively.) as compared to application of 7.5 t ha<sup>-1</sup> FYM (659 kg ha<sup>-1</sup> and 1705 kg ha<sup>-1</sup> respectively). It was mainly attributed to significantly higher number of pods plant<sup>-1</sup> (29.31), number of filled pods plant<sup>-1</sup> (21.55), 100 kernel weight (33.1g) and shelling percentage (67.55 %). Increased yield and yield parameters may be attributed to steady supply of nutrients throughout the crop growth period resulting in increased the nutrient availability for uptake and better utilization by the crop which in turn produced more

photosynthates and better partitioning of dry matter from source to sink. These results are in conformity with the findings of Sheshadri reddy, (2005), Chandrasekarn *et al.* (2007), Pareek *et al.* (2011), Patro *et al.* (2012) and (Elayaraja , 2014). (Kamalakaran *et al.*, 2013).

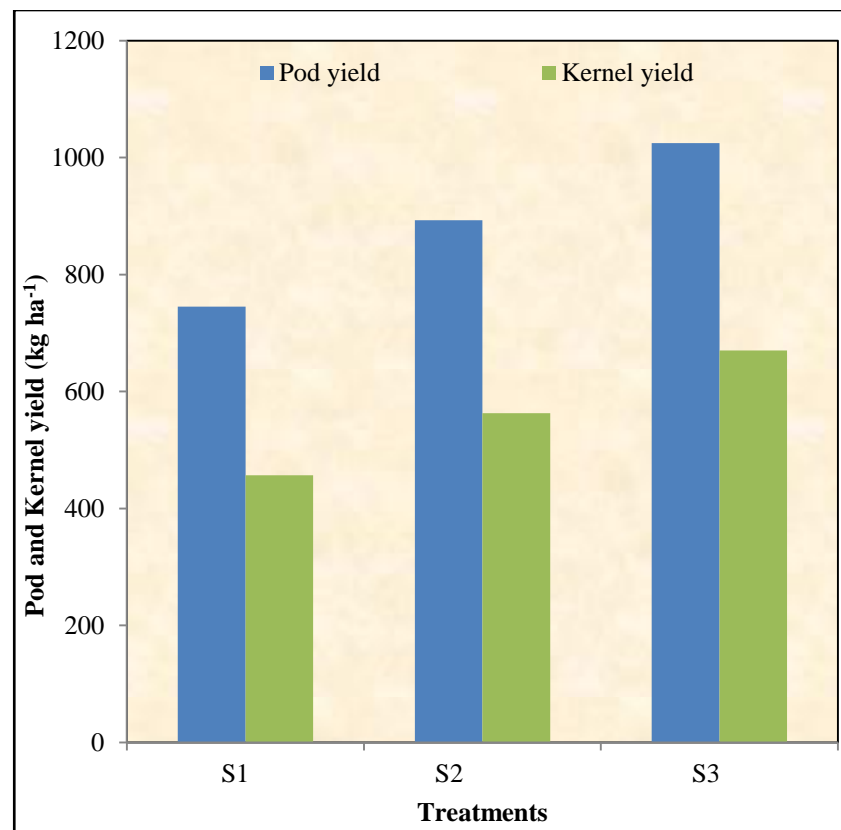
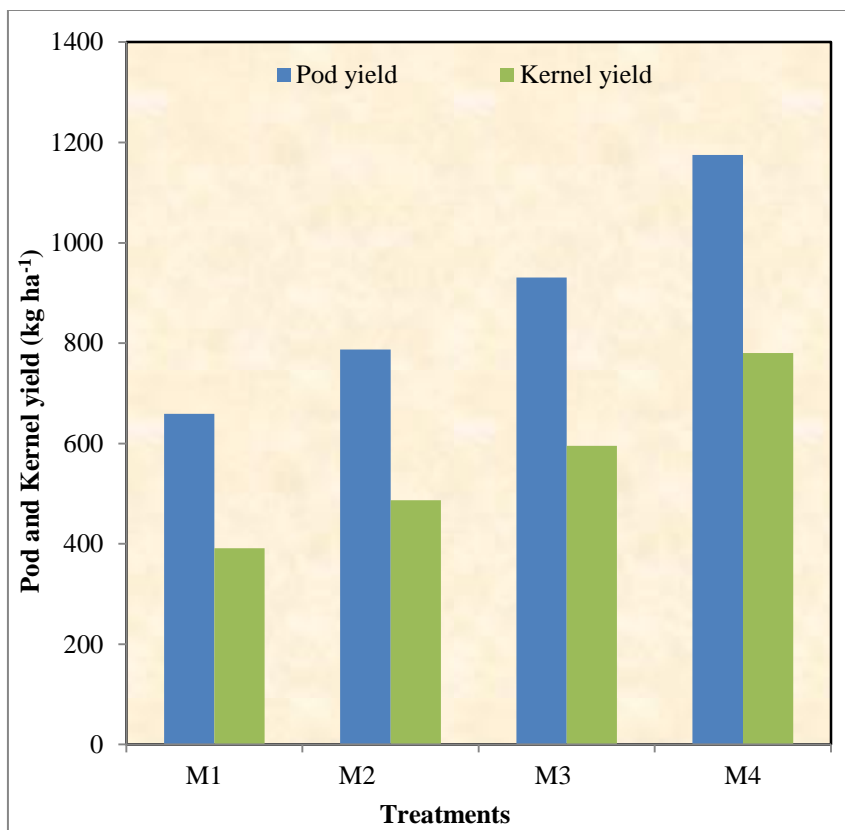
Crop yield mainly depends on yield attributing characters *viz.*, number of pod plant<sup>-1</sup>, number of filled pods plant<sup>-1</sup>, 100 kernel weight and shelling percentage, which were significantly higher with the application of FYM +Rec. NPK + Borax @ 5 kg + Znso<sub>4</sub> @ 10 kg ha<sup>-1</sup>. Improvement in yield attributes may be due to availability of sufficient and balanced nutrients in readily available form throughout the crop growth period leading to the greater photosynthesis production of metabolites and their translocation to various sinks especially the productive structures. Similar findings were reported by Mohapatra *et al.* (2010), Singh *et al.* (2011) and (Kamalakaran *et al.*, 2013).

Kernel yield was significantly higher in FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> than other nutrient management practices .It might be due to an increased shelling percentage and pod yield of groundnut ,This may be due to higher availability of nutrients during critical stages which in turn increased the translocation of photosynthates for development of pods and seed setting these findings are in agreement with the results of (Mohapatra *et.al* 2010 ) and (Singh *et.al.*, 2013).

Yield and yield attributes mainly depend on growth attributes *viz.*, plant height, branches plant<sup>-1</sup>, number of leaves plant<sup>-1</sup>, leaf area plant<sup>-1</sup>, number of nodules plant<sup>-1</sup>, dry matter production and its distribution. The highest plant height (19.75 cm, 25.53 cm and 26.91cm at 60, 90 DAS and at harvest respectively), number of primary branches per plant<sup>-1</sup> (6.15, 6.69 at 60 and 90 DAS and respectively), number of leaves plant<sup>-1</sup> (78.55 and 121.13 at 60 and 90 DAS) and number of nodules plant<sup>-1</sup> (28.51, 84.15 and 43.53 at 30, 60 and 90 DAS), (Table 4.5) were noticed with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>. This could be attributed to the better nutritional conditions that prevailed during crop growth period which lead to metabolic and physiological activity of the plant and put up more growth by assimilating more amount of nutrients. Similar results were obtained by Krishna Murthy *et al.* (2009), Akbari *et al.* (2010), Thorave *et al.* (2011), and Singh *et al.* (2011).

Root characters like nodule number and nodule dry weight were also higher with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> than in FYM 7.5 t ha<sup>-1</sup>, Integrated application of FYM and chemical fertilizers in groundnut had stimulated microbes flush and improved root growth, better source–sink relationship lead to better nodulation. Due to congenial soil physical condition created by addition of FYM, micronutrients enhance the cell division in the process of nodulation formation and development, as reported by Kausale *et al.* (2009) and Kamath *et al.* (2013), Bangal *et al.* (2012)and Sharma *et al.* (2013)

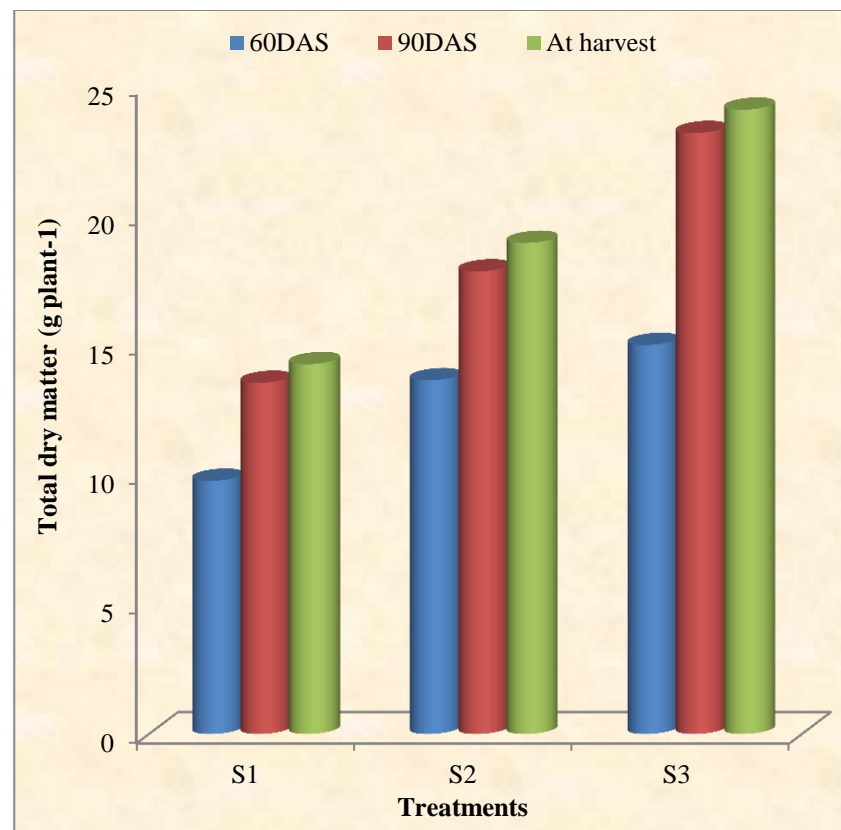
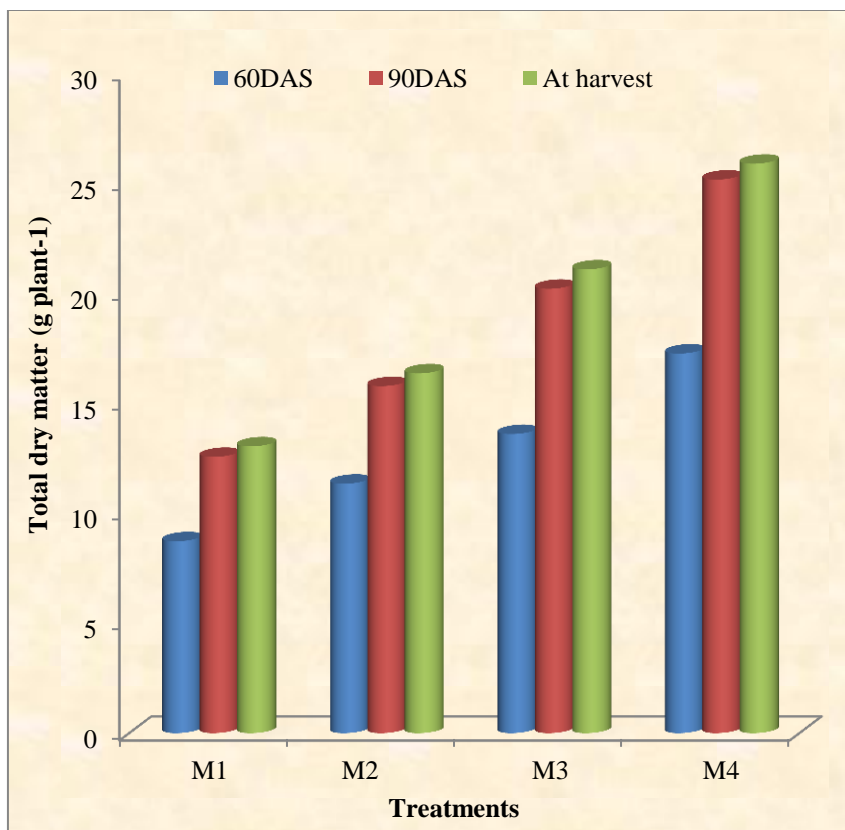
Plant growth also depends on the rate of dry matter accumulation. The dry matter accumulation reflects on the economic yield in view of the fact that vegetative parts of the plant serve as a source where as kernels are the sink. Application of FYM +Rec. NPK



**Fig. 5.1: Pod, and kernel yield of groundnut as influenced by nutrient management practices and foliar spray**

**M**<sub>1</sub>: FYM 7.5 t ha<sup>-1</sup>  
**M**<sub>2</sub>: Recommended NPK (25:50:25 kg ha<sup>-1</sup>)  
**M**<sub>3</sub>: FYM @ 7.5 t ha<sup>-1</sup> + Rec. NPK (25:50:25 kg ha<sup>-1</sup>)  
**M**<sub>4</sub>: FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup>

**S**<sub>1</sub>: Absolute control (No spray)  
**S**<sub>2</sub>: Foliar spray of 2 % urea at 30 DAS  
**S**<sub>3</sub>: Foliar spray of 2% urea at 30 and 60 DAS



**Fig. 5.2: Total dry matter accumulation of groundnut influenced by nutrient management practices and foliar spray**

**M<sub>1</sub>**: FYM 7.5 t ha<sup>-1</sup>  
**M<sub>2</sub>**: Recommended NPK (25:50:25 kg ha<sup>-1</sup>)  
**M<sub>3</sub>**: FYM @ 7.5 t ha<sup>-1</sup> + Rec. NPK (25:50:25 kg ha<sup>-1</sup>)  
**M<sub>4</sub>**: FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup>

**S<sub>1</sub>**: Absolute control (No spray)  
**S<sub>2</sub>**: Foliar spray of 2 % urea at 30 DAS  
**S<sub>3</sub>**: Foliar spray of 2% urea at 30 and 60 DAS

+ Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> recorded maximum dry matter production compared to application of FYM 7.5 t ha<sup>-1</sup>, which could be ascribed to the increase in plant growth (*i.e.* plant height, number of leaves and LAI) and cumulative effect of all these parameters on yield attributes, reported similar findings Krishna Murthy *et al.* (2009) and Elayaraj *et al.* (2010).

### **5.3 Quality parameters of groundnut as influenced by nutrient management practices**

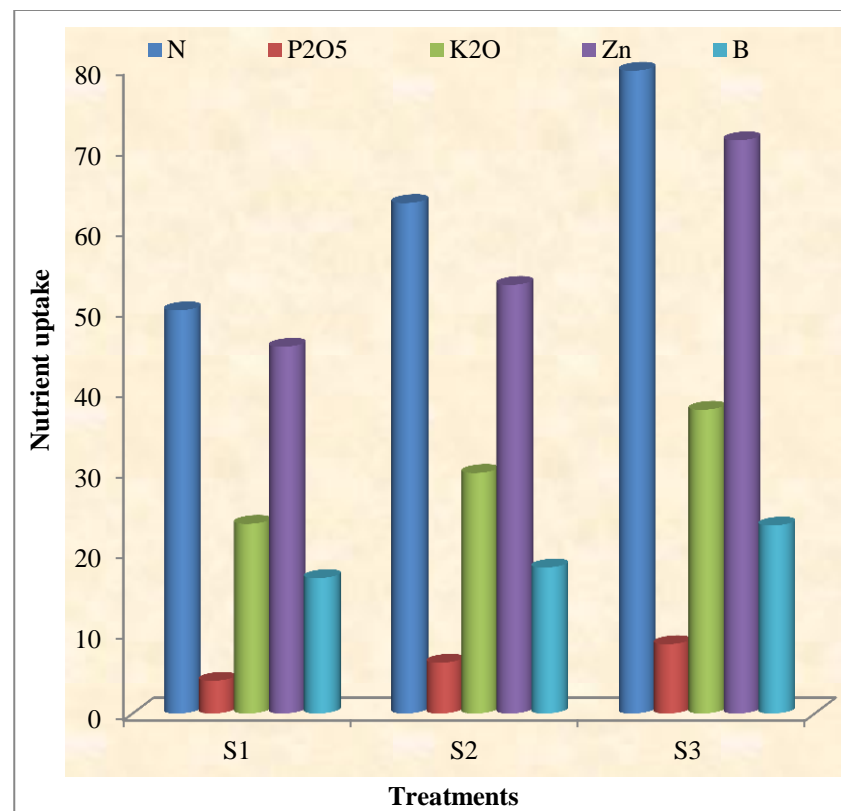
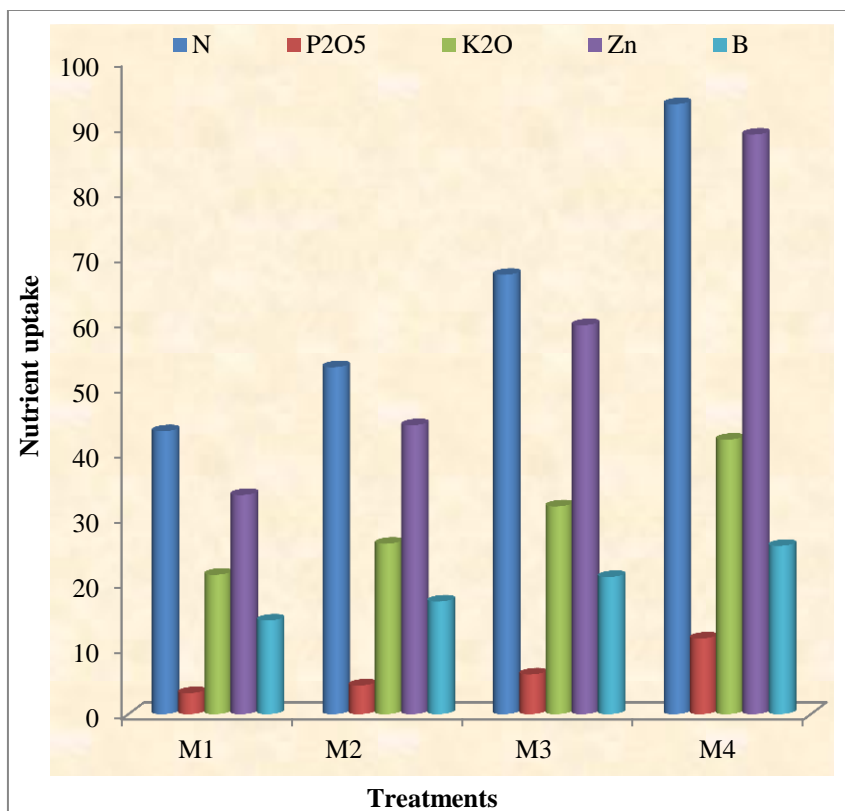
Oil percentage was not significantly influenced by nutrient management practices as it is governed by genetic factors. But application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> recorded numerically higher oil yield (149.95 kg ha<sup>-1</sup>) as compared to application of FYM 7.5 t ha<sup>-1</sup>, because of higher oil percentage and kernel yield, these results are conformity Sheshadri Reddy, *et al.* (2005), Thorave *et al.*, (2011) and Nadaf *et al.* (2013).

Protein content of kernels is the important component of quality of groundnut, significantly higher protein content was recorded with FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> compared to application of 7.5 t ha<sup>-1</sup> FYM. The reason for higher protein may be due to more availability of nutrients particularly nitrogen, it is an integral part of protein and phosphorous is structural element of certain co-enzymes involved in protein synthesis and also due to improved root nodulation and nitrogen fixation by plants as a result of zinc and boron supply as evidenced by increase in the nitrogen content of kernels. Higher protein yield may be attributed to higher kernel yield with higher protein in the seed. (Kachot *et.al*, 2000, Yadav *et al.* 2007, Lal *et al.* (2013) and Nadaf *et al.*, 2013).

### **5.4 Nutrient Uptake and soil fertility status of groundnut as influenced by nutrient management practices**

Nitrogen is a constituent of chlorophyll, proteins, enzymes, hormones, vitamins, alkaloids *etc.* Phosphorus is a constituent of sugar, phosphates, nucleotides, nucleic acids, phospholipids and co-enzymes and it also plays a major role in plant metabolism. Potassium is a most important cation not only with regard to its content in plant tissue but also its role in physiological and bio-chemical functions in imparting drought tolerance in plants and improving the quality of produce.

Significantly higher N, P, K, Zn and B uptake by soil was recorded with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> compared to FYM 7.5 t ha<sup>-1</sup>, might be due to higher dry matter production. Supply of nutrients through inorganic and organic sources to the crop, as well as reduced loss of organically supplied nutrients, increase in the availability of nutrients in soil pool as a result of better uptake of N,P,K, Zn and B by the crop. Further, improved root growth and its functional activity also helped in greater extraction of nutrients. (Sheshadri Reddy *et al.*, 2004, Srinivasan and Angayarkanni., 2007, Mohapatra *et al.*, 2010, Sharma *et al.*, 2011 and Singh *et al.*, 2013).



**Fig. 5.3: Nitrogen, phosphorous and potassium (kg ha<sup>-1</sup>), zinc and boron (g ha<sup>-1</sup>) uptake of groundnut influenced by nutrient management and foliar spray**

**M**<sub>1</sub>: FYM 7.5 t ha<sup>-1</sup>

**M**<sub>2</sub>: Recommended NPK (25:50:25 kg ha<sup>-1</sup>)

**M**<sub>3</sub>: FYM @ 7.5 t ha<sup>-1</sup> + Rec. NPK (25:50:25 kg ha<sup>-1</sup>)

**M**<sub>4</sub>: FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup>

**S**<sub>1</sub>: Absolute control (No spray)

**S**<sub>2</sub>: Foliar spray of 2 % urea at 30 DAS

**S**<sub>3</sub>: Foliar spray of 2% urea at 30 and 60 DAS

The nutrients retained in the soil after harvest of the crop mainly depends on both supply of nutrients through various sources and uptake by the crop. Addition of organic sources tends to increase organic carbon and available nitrogen, phosphorous, potassium zinc and boron content of soil. Soil organic carbon did not vary significantly among the nutrient management practices. In general, higher the uptake of nutrients by the crop lower is residual available nutrients in the soil. Further, higher the nutrients quantity supplied higher is the residual soil nutrients. However, several factors influence the uptake as well as available nutrients, Application of FYM 7.5 t ha<sup>-1</sup> recorded higher available N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and Zn, B after harvest of crop as compared to in FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup>. This could be due to higher yields obtained in the treatment which took up more nutrients leaving less available nutrients in soil. However, application of FYM 7.5 t ha<sup>-1</sup> produced lower yields hence low nutrient uptake. These results are in conformity with the findings of, Gajanana *et al.* (2000), Babu and Reddy (2000), Patidar and Mali (2004) Sunilkumar *et al.* (2005), Srinivasan and Angayarkanni., (2007), and Karunakaran *et al.* (2010).

### **5.5 Effect of foliar spray on growth and yield of groundnut**

Significantly higher pod and haulm yield were recorded with 2 % urea spray at 30 and 60 DAS (1025 kg ha<sup>-1</sup> and 2230 kg ha<sup>-1</sup>) as compared to control (745 kg ha<sup>-1</sup> and 1915 kg ha<sup>-1</sup>). Yield mainly attributed to higher yield parameters. Nitrogen through foliar application preferentially increased the metabolic processes like photosynthesis, which might have results in higher dry matter production and sink size, Similar findings were also obtained with respect to foliar nutrition by Gupta *et al.* (2011), Kuttimani and Velayutham (2011).

Yield and yield attributing characters depends on, number of pods plant<sup>-1</sup>, and number of filled pods plant<sup>-1</sup>, 100 kernel weight and shelling percentage. These results are in conformity with of Anandhakrishnaveni *et al.* (2004) and Subhamoy Gupta (2010). Kernel yield was higher in foliar spray of 2 % urea at 30 and 60 DAS (670 kg ha<sup>-1</sup>) than control, these results are conformity with the findings of Venkatesh *et al.* (2011).

Yield and its attributes also indirectly depended on growth attributes. At 90 DAS, foliar spray of 2 % urea at 30 and 60 DAS recorded higher plant height (24.03), number of branches per plant<sup>-1</sup>(6.35) and number of leaves plant<sup>-1</sup>, leaf area index. Nutrients through foliar application may lead to stimulatory effect on cell division, enlargement and the crop responses to utilizes nutrients throughout the growth period (Amany, (2007), Khalilzadeh *et al.*, 2012).

More number of leaves were recorded with the foliar spray of 2 % urea at 30 and 60 DAS, might have enhanced the synthesis of chlorophyll content of the leaves thus resulted in more number of leaves which contributing more leaf area (Mondal *et al.*, 2011 and Gupta *et al.*, 2011).

Significantly more nodule numbers with 2 % urea spray at 30 and 60 DAS compared to control, which might be due to higher N at early crop growth that would

have increased root activity by increasing the synthesis of cytokinin which would encourage more number of nodules and attribute to more nodule weight.

Plant growth also depends on the rate of dry matter accumulation. The dry matter accumulation may reflect on the economic yield in view of the fact that vegetative parts of the plant serve as a source where as kernels are the sink. Foliar spray of 2 % urea at 30 and 60 DAS recorded significantly higher dry matter production compared to control (no spray), as reported by Kocon , (2010) and Mondal *et al.* (2011).

### **5.6 Quality parameters of groundnut as influenced by foliar spray**

Among foliar spray, higher oil percentage and oil yield was recorded in foliar spray of 2 % urea at 30 and 60 DAS (39.78 % and 266.13 kg ha<sup>-1</sup> respectively) compared to control (38.69 % and 176.81 kg ha<sup>-1</sup>).

Foliar spray of 2 % urea at 30 and 60 DAS recorded higher protein content. Which could be due to higher nitrogen supply through foliar application at different crop growth stages resulted in enhancement of protein content of seeds, suggesting that hydrocarbons synthesized during photosynthetic processes are diverted to form more proteins. (Amany, (2007 ) Venkatesh and Basu 2011)

### **5.7 Nutrient Uptake and soil fertility status of groundnut as influenced by foliar spray**

Among foliar spray, 2 % urea spray at 30 and 60 DAS in groundnut recorded the higher N, P, K, Zn and B uptake compared to control (no spray). Higher uptake was mainly due to higher dry matter production and increased sink size. Application of nutrients through foliar spray during crop growth period at critical stages favoured increased nutrient availability and better nutrient uptake by the crop. Similar results were reported by Kocon, 2010, Yadav and Chaudhry 2012 in cowpea.

Foliar spray of 2 % urea at 30 and 60 DAS recorded lower available N, P, K, Zn and B in the soil after harvest of the crop as compare to control (no spray).

### **5.8 Economics of groundnut as influenced by nutrient management and foliar spray**

For successful adoption of any technology by the farmers, it should be technically feasible and economically viable. Therefore, economic analysis of any technology is foremost important. The cost of cultivation, gross returns, net returns and B: C ratios were worked out.

The higher cost of cultivation (Rs.25, 650 ha<sup>-1</sup>) was recorded with application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> along with foliar spray of 2 % urea at 30 and 60 DAS. The cost of cultivation was lower with 7.5 t ha<sup>-1</sup> FYM with absolute control (Rs 16,950) when compared to all other treatments. The higher cost of cultivation was mainly due to high input cost on fertilizers leading to combined total cost (Table 4.17).

The higher gross returns of Rs. 48,681 ha<sup>-1</sup> was recorded with the application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> along with foliar spray of 2 % urea at 30 and 60 DAS. The lower gross returns were obtained with 7.5 t ha<sup>-1</sup> FYM with absolute control (Rs. 26, 367). The increase in gross returns in these treatments was due to higher pod yield as a result of better utilization and higher nutrient availability throughout the crop growth period .

Maximum net returns of (Rs. 23,650) were found with application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> along with foliar spray of 2 % urea at 30 and 60 DAS. Higher net returns were due to higher pod yield as a result of better utilization and higher nutrient availability throughout the crop growth period. However, lower net returns were obtained with 7.5 t ha<sup>-1</sup> FYM with absolute control (Rs. 9,417) similar results are obtained by (Gunri *et al.* 2012 and Gupta *et al.* 2011).

The profitability of any crop measured in terms of profit per rupees invested (B: C ratio). Application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> with foliar spray of 2 % urea at 30 and 60 DAS given higher B: C ratio of (1.90) as compared to application 7.5 t ha<sup>-1</sup> FYM with absolute control (1.55). This was mainly due to increased gross returns as a result of higher yield and market price of groundnut. (Singh *et al.* 2013, Kuttimani and Velayutham 2011).

#### **Practical utility of results.**

- The results of present investigation indicated that application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> along with foliar spray of 2 % urea at 30 and 60 DAS has improved the yield, quality of groundnut and recorded higher net returns and B:C ratio.

#### **Future line of work**

- Study on levels of organic manure and inorganic nutrients, time of application and their interaction effects in soils need to be studied.
- Response of foliar spray of micronutrients and their effect on growth, yield and quality parameters of groundnut need to be studied.

## VI. SUMMARY

A field experiment entitled “Yield maximization in *kharif* groundnut through nutrient management practices” was conducted at Agricultural Research Station, Chintamani during *kharif* season of 2013. The salient findings of the experiment are summarized in this chapter.

The field experiment was laid out in a split plot design consisting of four main plot treatments *viz.*, FYM 7.5 t ha<sup>-1</sup>, Recommended NPK (25:50:25 kg ha<sup>-1</sup>), FYM @ 7.5 t ha<sup>-1</sup> + Rec. NPK (25:50:25 kg ha<sup>-1</sup>), FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> and three sub plot treatments *viz.*, Absolute control (No spray), Foliar spray of 2 % urea at 30 DAS, Foliar spray of 2 % urea at 30 and 60 DAS with three replications. During the course of investigation different morphological and yield parameters were recorded at 30, 60, 90 and at harvest of crop. Initial (soil) and final nutrient status (soil and plant) and quality parameters were also recorded.

- The growth parameters of groundnut varied significantly due to nutrient management and foliar spray. The growth attributes like plant height, branches per plant, leaves per plant, more leaf area per plant, nodules plant<sup>-1</sup>, dry matter production and leaf area index were higher with application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> and foliar spray of 2 % urea at 30 and 60 DAS compared to those with control (no spray) used.
- The yield parameter *viz.*, number of pods plant<sup>-1</sup> (29.3 and 28.5 pods plant<sup>-1</sup>), number of filled pods plant<sup>-1</sup> (21.55 and 20.95), hundred kernel weight (33.1g and 31.3 g), shelling percentage (67.55 % and 65.30 %) and kernel yield (780 kg ha<sup>-1</sup> and 670 kg ha<sup>-1</sup>) were significantly more with application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> and foliar spray of 2 % urea at 30 and 60 DAS, respectively.
- The higher pod yield of groundnut was recorded with application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (1175 kg ha<sup>-1</sup>) and foliar spray of 2 % urea at 30 and 60 DAS (1025 kg ha<sup>-1</sup>). However, the lowest pod yield was recorded with FYM @ 7.5 t ha<sup>-1</sup> (659 kg ha<sup>-1</sup>) and without urea spray (745 kg ha<sup>-1</sup>).
- Among different treatments, higher kernel yield was obtained by application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (780 kg ha<sup>-1</sup>) and foliar spray of 2 % urea at 30 and 60 DAS (670 kg ha<sup>-1</sup>). Whereas, lower kernel yield was recorded with application of FYM @ 7.5 t ha<sup>-1</sup> and absolute control (391 and 457 kg ha<sup>-1</sup>, respectively).
- The harvest index did not differ significantly due to FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> and foliar spray of 2 % urea at 30 and 60 DAS.
- The oil yield of ground nut was higher with application of FYM +Rec. NPK + Borax @ 5 kg + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> (314.33 kg ha<sup>-1</sup>) and foliar spray of 2 % urea at 30 and 60 DAS (149.95 kg ha<sup>-1</sup>) as compared to that with FYM @ 7.5 t ha<sup>-1</sup> (149.95 kg ha<sup>-1</sup>) and absolute control (176.81 kg ha<sup>-1</sup>).

- The protein yield of ground nut was higher with application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> (172.61 kg ha<sup>-1</sup>) and foliar spray of 2 % urea at 30 and 60 DAS (148.79 kg ha<sup>-1</sup>). While, lowest protein yield was recorded in application of FYM @ 7.5 t ha<sup>-1</sup> (76.51 kg ha<sup>-1</sup>) and in absolute control (90.35 kg ha<sup>-1</sup>).
- The higher nutrient uptake was recorded with application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> (93.45, 11.60, 42.09 kg NPK ha<sup>-1</sup> and 88.79, 25.8 g Zn, B ha<sup>-1</sup>, respectively) and Foliar spray of 2 % urea at 30 and 60 DAS (79.69, 8.60, 37.69 kg NPK ha<sup>-1</sup> and 71.07, 23.3 g Zn, B ha<sup>-1</sup>, respectively) as compared to that with FYM @ 7.5 t ha<sup>-1</sup> (43.37, 3.22, 21.37 kg NPK ha<sup>-1</sup> and 33.60, 14.35 g Zn, B ha<sup>-1</sup>, respectively) and in absolute control (50.01, 4.06, 23.53 kg NPK ha<sup>-1</sup> NPK and 45.50, 16.80 g Zn, B ha<sup>-1</sup>, respectively).
- Significantly higher available N, P, K and Zn, B in the soil after harvest was recorded with application of FYM @ 7.5 t ha<sup>-1</sup> and control (no spray). However, lower available nutrients were observed in FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> and foliar spray of 2 % urea at 30 and 60 DAS.
- Maximum gross returns, net returns and B: C ratio were obtained with application of FYM +Rec. NPK + Borax @ 5 kg + ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> with foliar spray of 2 % urea at 30 and 60 DAS. The lowest net returns were observed with application of FYM 7.5 t ha<sup>-1</sup> with absolute control.

## VII. REFERENCES

- AGASIMANI, C. A., 1996, Effect of organic and inorganic fertilizers on growth and yield of groundnut. *J. Maharashtra. Agric. Uni.*, **21**(3):470.
- AKBARI, K. N., SUTARIA, G. S., VORA, V. D., HIRPARA, D. S. AND PADMANI, D. R., 2010, Effect of periodical application of phosphorus with and without FYM on yield of groundnut on vertic ustochrepts under rainfed agriculture. *Legume Res.*, **33** (1): 64-66.
- ALI, A. AND MOWAFY, S., 2003, Effect of different levels of potassium and phosphorus fertilizers with the foliar application of zinc and boron on peanut in sandy soils. *Zagazig J. Agric. Res.*, **30**: 335-358.
- AMANY, A. B., 2007, Effect of plant density and urea foliar spray application on yield and yield components of chickpea (*Cicer arietinum*). *Res. J. Agric & Bio Sci.*, **3**(4): 220-230.
- ANAND, M. G., 2003, Experiment on utilization of organic wastes in a paddy – groundnut cropping system for sustainable production under tank fed irrigation. *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Bengaluru, Karnataka, India.
- ANANDA, M. G., REDDY, V. C. AND KALYANAMURTHY, K. N., 2004, Effect of different nutrient sources on growth and yield of groundnut. *Environ. Ecol.*, **22**(4): 631-635.
- ANANDHAKRISHNAVENI, S., PALCHAMY, A. AND MAHENDRAN, S., 2004, Effect of foliar spray of nutrients on growth and yield of greengram (*Phaseolus radiatus*). *Legume Res.*, **27**(2):149-150.
- ANNONYMOUS, 1997, *Annual Report*. AICRP on groundnut, Junagadh. Pp.2-6
- ANNONYMOUS, 2014, *Annual Report*. AICRP on groundnut, Junagadh. Pp.2-6
- ANNONYMOUS, 2008a, *Annual Report*, Model organic farm ARS, Balajipade , Directorate of Research UAS, Bangaluru, Pp. 21-22.
- ANNONYMOUS, 2008b, *Annual Report*, Model organic farm ARS, chintamani, Directorate of Research UAS, Bangaluru, Pp.14-16.
- ANNONYMOUS, 2008c, *Annual Report*, Model organic farm ZARS, Shivmoga, Directorate of Research UAS, Bangaluru , Pp.15-17.
- ANNONYMOUS, 2002a, *Annual Report*, AICRP for Dry land Agriculture, Hyderabad. Pp. 20.

- ANONYMOUS, 2002b, *Annual Report*, AICRP on groundnut, Junagadh, Pp.415-421.
- ANONYMOUS, 2002e, *Annual Report*, AICRP on groundnut, Junagadh. Pp. 415-421.
- ANONYMOUS, 2005, *Annual Report*, AICRP on small millet, UAS, Bangalore, Pp.18-20.
- ANTONY, E., DODDAMANI, M. B., ALAGAVADI, A. R. AND CHETTI, M. B., 2000, Response of groundnut genotypes to nitrogen levels and inoculation. *Annals. Agric. Res.*, **21**(2):311-313.
- ASHA, C., METHA, D. D., MALAVIA, B. B. AND KHANPARA, V. D., 1996, Response of Groundnut (*Arachis hypogaea*) to farmyard manure, phosphorus and phosphate-solubilizing micro organism. *Indian J. Agron.*, **41**(1):172-174.
- BABU AND REDDY., 2000, Effect of farm yard manure on uptake of nutrients in groundnut under sandy soils. *Andhra J. Agric. Sci.*, **32**(5): 198-206.
- BAGAL, R. S., INULKAR, B. S. AND WAGHMAREINDIAN, M.S., 2012, Effect of zinc, iron and boron on growth parameters, yield and quality of groundnut in vertisol. *Indian J. Ecol.*, **39**(2): 219-221.
- BALASUBRAMANIYAN, P., 1997, Integrated nutrient management in irrigated groundnut. *Indian J. Agron.*, **42**(4): 683-687.
- BALASUBRAMANIAN, P. AND PALANIAPPAN, S.P., 1997, Effect of combined application of bacterial inoculation along with farmyard manure on irrigated groundnut (*Arachis hypogaea* L.). *Indian J. Agron.*, **39**(1): 131-133.
- BALASUBRAMANIYAN, P. AND PALANIAPPAN, S. P., 1996, Influence of organic and inorganic manuring and split application of NK on root nodulation and pod yield of groundnut. *Madras Agric. J.*, **83**(3): 198-200.
- BARIK, A .K. AND MUKHERJEE, A. K., 1997, Effect of cropping systems and nitrogen on the oil content and nodulation in *Kharif* groundnut. *J. Oilseeds Res.*, **14**: 133-134.
- BARIK, A. K., MUKHERJEE, A. K. AND MANDAL, B. K., 1998, Growth and yield of sorghum and groundnut grown as sole and intercrop under different nitrogen regimes. *Indian J. Agron.*, **43**(1): 27-32.
- CHANDRASEKARAN, R., SOMASUNDARAM, E., AMANULLAH, M. M., NALINI, K., THIRUKKUMARAN, K. AND SATHYAMOORTHY, K., 2007, Response of Confectionery Groundnut (*Arachis hypogaea* L.) Varieties to Farm yard manure. *J. Appl. Sci. Res.*, **3**(10): 1097-1099.

- CHITDESHWARI, SELVARAJ, T. P. K. AND SHANMUGAM, P. M., 2007, Influence of levels and split application of fertilizers on the yield and nutrient uptake by groundnut. *Agril. Sci. Dig.*, **27**(2): 91-94.
- DARWISH, D.S., GHARREIB, EL-G, EL-HAWARY, M.A. AND RAFFT, O.A., 2002, Effect of some macro and micronutrients application on peanut production in a saline soil in El-Faiyum Governorate. *Egypt. J. Appl. Sci.*, **17**: 17-32.
- DEKA, N.C., DUTTA, R. AND GOGOI, P. K., 2001, Effect of lime and nitrogen on nutrient uptake and residual soil fertility in groundnut. *Legume Res.*, **24**(2): 118-120.
- DONALD, C. M., 1962, In search of yield. *J. Australian Institute Agric. Sci.*, **28**: 171-178.
- DUTTA, R., GOGOI, P. K. AND DEKA, N. C., 2003, Effect of levels of lime and potassium on nutrient uptake and residual soil fertility in groundnut. *Crop Res.*, **26**(3): 420-423.
- DWIVEDI, R. K. AND TIWARI, O. P., 1991, Effect of irrigation and nutrient spray on chickpea in rice fallows. *Indian J. Pulses Res.*, **4**(2):213-214.
- ELAYARAJ, D. AND SINGARAVEL, R., 2010, Evaluation of boron levels and organics on soil nutrients and yield of groundnut in coastal sandy soil. *Madras Agric. J.*, **97**(4-6): 142-144.
- ELAYARAJA, D. AND ANGAYARKANNI, A., 2005, Effect of foliar nutrition on the nodulation and yield of rice fallow blackgram. *Andhra Agric. J.*, **52**(3 - 4):602-604.
- ELAYARAJA, D. AND SINGARAVEL, R. 2012, Zinc and boron application on groundnut yield and nutrient uptake in coastal sandy soils. *Asian J. Soil Sci.*, **7**(1): 50-53.
- ELAYARAJA, D., 2014, Response of groundnut to zinc, boron and organics on the yield and nutrient availability in coastal sandy soil. *Internat. Res. J. Chemistry*. Vol. **5**:137-139.
- GAJANANA, G. N., SHANKAR, M. A., SOMASHEKAR, K. AND KRISHNAPPA, A. M., 2000, Importance of plant nutrient management in dryland Agriculture. Bulletin, *All India Co-ordinated Research Project on Dryland Agriculture*, UAS, Bangalore, Pp. 40-43.
- GEETHA, K. N ., SHANKAR , A. G. AND SHIVASHANKAR, K., 1996, Effect of molybdenum , zinc and calcium on productivity of groundnut (*Arachis hypogaea* Gaertn .) *J. Oilseed Res.*, **13**(2):167-172.

- GHATAK, S., SOUNDA, G., MAITRA, S., ROY, D. K., PANDA, P. K. AND SAREN, B. K., 1997, Effect of irrigation and potassium on yield attributes and yield of summer groundnut. *Indian Agriculturist.*, **41**: 203-207.
- GHOSH, P. K., 1997, An integrated approach of nitrogen management in groundnut (*Arachis hypogaea* L.). *Crop Res.*, Hissar, **13** (3): 567-568.
- GOGOI, P. K., CHOUDHURY, R. M., DUTTA, R. AND DEKA, N. C., 2000, Effect of levels of lime and nitrogen on production of groundnut (*Arachis hypogaea* L.). *Crop Res.*, **20**: 274-278.
- GOMEZ, K. A. AND GOMEZ, A. A., 1984, Statistical procedures for agricultural research (Ed.). A Willey Inter Science Publication, New York (USA).
- GRACY, C. P., JYOTI NAIK. AND NAGASHREE, N., 2013, Groundnut Prices To Hover Around MSP. Dep. Agric. Mktg. co-operation and business Management, University of Agricultural Sciences, GKVK, Bengaluru-65.
- GUNRI, S. K. AND NATH, R., 2012, Effect of organic manures, biofertilizers and biopesticides on productivity of summer groundnut (*Arachis hypogaea* L.). In red and laterite zone of West Bengal. *Legume Res.*, **35**(2):144-148.
- GUPTA, S.C., SANGEEVKUMAR AND KHANDWE, 2011, Effect of biofertilizer and foliar spray of urea on symbiotic traits, nitrogen uptake and productivity of chickpea. *J. Food legume.*, **24**(2): 155-157.
- HABBASHA, S.F., TAHA, M.H. AND JAFAR, N. A., 2013, Effect of nitrogen fertilizer levels and zinc foliar application on yield, yield attributes and some chemical traits of groundnut. *Res. J. Agric. & Biol. Sci.*, **9**(1): 1-7.
- HALEPYATI, A. S. 2001b, Conjunctive use of organic and inorganic fertilizers in rabi/ summer groundnut in UKP area. *Karnataka. J. Agric. Sci.*, **14**(2): 454-455.
- HALEPYTI, A. S., 2001a, Effect of moisture regimes and zinc levels on growth and yield of summer groundnut. *Karnataka J. Agric. Sci.*, **14**(2): 451-453.
- HALEVY, J., HARTZOOK, A. AND MARKOVITZ, T., 1987, Foliar fertilization of high-yielding peanuts during the pod-filling period. *Peanut Science*: **14**(2): 153-160.
- HOSAMANI, M. H. AND JANAWADE, A. D., 2007, Response of rabi groundnut (*Arachis hypogaea* L.) to irrigation schedules and integrated nutrient management in deep black soils of upper krishna command. *Karnataka J. Agric. Sci.*, **20**(3), 453-456.

- HOSAMANI, M. H., AND JANAWADE, A. D., 2006, Effect of irrigations and nutrient management on oil yield of groundnut and characteristics of soil. *Karnataka J. Agric. Sci.*, **19**(2): 247-252.
- HOSSAIN, M. A., HAMID, A. AND NASREEN, S., 2007, Effect of nitrogen and phosphorus fertilizer on N/P uptake and yield performance of groundnut (*Arachis hypogaea* L.). *J. Agric. Res.*, **45**(2): 119-127.
- HUMPHRIES, E.C., 1956, Mineral components and ash analysis (Ed.) In Modern methods of *plant analysis*, Springer verlag publication, Berlin. p. 468-502.
- INTODIA, S. K., MAHNOT, S. C. AND SAHU, M. P., 1998, Effect of organic manures and phosphorus on growth and yield of groundnut (*Arachis hypogaea* L.). *Crop Res.*, **5**(1): 22-26.
- JACKSON, M.L., 1967, Soil Chemical Analysis, Prentice Hall of India, Pvt. Ltd., New Delhi, p. 498.
- JACKSON, M.L., 1973, Soil Chemical Analysis, Prentice Hall of India Pvt. Ltd. New Delhi, pp. 1-492.
- KACHOT, N. C., MALAVIA, D. D., SOLANKI, R. M. AND SAGARIKA, B. K., 2001, Integrated nutrient management in rainy season groundnut. *Indian J. Agron.*, **46**(3): 516-522.
- KACHOT, N. A. AND MALIA, D. D., 2000, Integrated nutrient management for improving yield and quality of groundnut. *Extended summaries Vol-1:2<sup>nd</sup> Int. Agron. Congress*, Nov.26-30, New Delhi, India.
- KADER, E.L. AND MONA G., 2013, Effect of sulphur application and foliar spraying with zinc and boron on yield, yield components, and seed quality of peanut (*Arachis hypogaea* L.) *Res. J. of Agric. Bio Sci.*, **9**(4): 127-135.
- KALARANI, M. K., 1991. Senescence regulation in soybean [*Glycine max* (L.) Merrill]. *M.Sc. (Agri.) Thesis, Tamil Nadu Agric. Univ., Coimbatore*.
- KAMALAKANNAN, P. AND RAVICHANDRAN, M., 2013, Effect of organic and inorganic sources of nutrients on growth and yield of groundnut in two different textured soils. *Asian J. Soil Sci.*, **8**(1): 88-93.
- KAMATH, S. K. V., KRISHNAKUMAR, G., HANUMANTHAPPA, M., MAVARKAR, N. S., ANAND, M. R., 2013, Effects of methods and quantities of zinc sulphate application on nodulation in irrigated groundnut (*Arachis hypogaea* L.). *Int. J. Trop. Agric.*, **5**(14): 265-270.

- KANDIL, A. A., HALEEM, E. L., KHALAFALLAH, M. A. S., HABBASHA, E. F., HAGAZA, N. S. AND BEHAIRY, T. G., 2007, Effect of nitrogen levels and bio-fertilizers on dry matter, yield and yield attributes of groundnut. *Bullet. National. Res. Centre (Cairo)*, **32**(3): 341-359.
- KARUNAKARAN, V., RAMMOHAN, J., CHELLAMUTHU, V. AND POONGHAUZHALLAN, R., 2010, Effect of integrated nutrient management on the growth and yield of groundnut (*Arachis hypogaea* L.) in coastal region of Karaikal. *Indian J. Agron.*, **55**(2): 128-132.
- KAUR, K., KAPOOR, K. K. AND GUPTA, A. P., 2005, Impact of organic manures with or without mineral fertilizers on soil chemical and biological properties under tropical conditions. *J. Plant Nutri. Soil. Sci.*, **168**: 117-122.
- KAUSALE, S. P., SHINDE, S. B., PATEL, L. K., AND BORSE, N.S., 2009, Effect of integrated nutrient management on nodulation, dry matter accumulation and yield of summer groundnut at south Gujarat conditions. *Legume Res.*, **32** (3): 227-229.
- KAVIMANI, R., ANNADURAI, K. AND RANGARAJU, G., 2002, Spacing and nutrient management on yield maximization of irrigated groundnut. *Crop Res.*, **23**: 58-60.
- KHALILZADESH, R., MEHDI, T. AND JALAL, L., 2012, Growth characteristic of mung bean (*Vigna radiata* L.) affected by foliar application of urea and bio-organic fertilizers. *Int. J. Agri. Crop Sci.*, **4**(10):637-642.
- KOCON, A., 2010, Effect of foliar or soil top –dressing of urea on some physiological processes and seed yield of faba bean. *Polish J. Agron.*, **3**:15-19.
- KRISHANA MURTHY, R., VASUDEV, H. S., DEVAGIRI, G. M., UMASHANKAR, N. AND RAVEENDRA, H. R., 2009, Effect of integrated nutrient management of growth and yield parameters and nutrient uptake of groundnut (*Arachis hypogaea*). *Mysore J. Agric. Sci.*, **43** (4):696-699.
- KULIGOD, N. B., REVENAPPA, KULKARNI, G. M. AND UPPERI, S. N., 2007, Nutrient management for sustainable groundnut productivity in black soils of upper Krishna Canal commands. *Karnataka J. Agric. Sci.*, **20**(4): 732-734.
- KUMAR, A., MAHENDRASHARMA. AND MEHRA, R. K., 2008, Effect of phosphorus and sulphur on yield and nutrient uptake by groundnut in inceptisols. *Asian J. Soil Sci.*, **1**: 139-141.
- KUMARAN, A., SOLAIMALAI, N., RAVISANKAR AND CHANDRASEKARAN, B., 2000, Role of organic, inorganic fertilizers and gypsum application in groundnut - A REVIEW *Agric. Rev.*, **21** (3): 193-198.

- KUMARAN, S., SOLAIMALAI, A., ARULMURUGAN AND RAVISANKAR, N., 2001, Response of groundnut crop to organic and inorganic fertilizers under irrigated condition. *J. Oilseed Res.*, **18**(1):123-125.
- KUMARASWAMY, K, 1997, Influence of mother plant nutrients on seed yield and quality of groundnut TMV-2. *M.Sc. (Agri.) Thesis* , University of Agricultural Sciences, Bangalore, Karnataka, India.
- KUTTIMANI, R., AND VELAYUTHAM, A., 2011, Foliar application of nutrients enhances the yield attributes and nutrient uptake of green gram. *Agri. Sci. Digest.*, **31**(3): 202-205.
- LAKSHMAMMA, P., SHIVRAJ, A. AND RAO, L. M., 1996, Effect of cobalt, phosphorus and potassium on yield and nutrient uptake in groundnut. *Ann. Agric. Res.*, **17**(3): 335-336.
- LAL, O. B., PAREEK, B. L., YADAV, R. S., SHIVRAN, A. C. AND SHARMA, O. P., 2013, Influence of integrated nutrient management on productivity and quality of groundnut in Western Rajasthan. *Ann. Agric. Res. New Series* ., **34** (2): 156-159.
- LINDSAY, W. L AND NORWELL, W. A., 1978, Development of DTPA soil test for zinc, iron, manganese and copper . *Soil Sci. Soc . Amer. J.*, **42**: 421-428.
- LOURDURAJ, A. C. AND RAJAGOPAL, A., 1996, Irrigation and nutrient management for groundnut yield maximization. *Legume Res.*, **19**(3-4) :151-161.
- LOURDURAJ, A. C., KRISHNAN, P. K. AND GEETHLAKSHMI, V., 1997, Micronutrient fertilization in groundnut . *Madras Agric. J.*, **84**(7):362-363.
- MADHIYAZHAGAN, R., PRABHAKARAN, N. K., VENKITASWAMY, R. AND CHANDRASEKARAN, R., 2001, Response of cultivar to organic and inorganic fertilizer in groundnut. *Madras Agric. J.*, **88** (10-12): 742-744.
- MAHALANOBIS, D. AND MAITI, D., 1998, Effect of different levels of nitrogen and phosphorus on yield and yield attributes of groundnut intercropping. *J. Oilseeds Res.*, **15**(2): 371-374.
- MANDAL, K. G., GHOSH, P. K., WANJARI, R. H., HATI, K. M., BANDYOPADHYAY, K. K. AND MISRA, A. K., 2002, Practical implication of nutrient x nutrient interaction to boost oilseeds productivity in India. *Fert. Res.*, **47**(7): 13-18.
- MANJIAH, K.M., CHANNAL, H.T. AND SATYANARAYANA, T., 1996, Yield and quality of groundnut as influenced by rock phosphate organics and phosphate solubilizers. *Karnataka J. Agric. Sci.*, **9**(3): 526-528.

- MEENA, S., MALARKODI, M. AND SENTHILVALAVAN, P., 2007, Secondary and micronutrients for groundnut *Agric. Reviews*, **28**(4).
- MIGAWER, EKRAM A. AND MONA A.M., 2001, Performance of two peanut cultivars and their response to NPK fertilization in newly reclaimed loamy sand soil. *J. Agric Sci. Mansoura Univ.*, **26** (11): 6653 – 6667.
- MIRHAT, E., GOBARH, MAGDA, H., MOHAMMED. AND TAWFOK, M. M., 2006, Effect of phosphorus fertilizer and foliar spraying with zinc on growth yield and quality of groundnut under reclaimed sandy soils. *J. Appl. Sci. Res.*, **2** (8): 491-496.
- MISHRA, C.M., 2000, Effect of farmyard manure and chemical fertilizers on the yield and economics of groundnut (*Arachis hypogaea* L.) under rainfed condition. *Madras Agric. J.*, **87** (7-9): 517-518.
- MOHAMED, M. F., MOHAMED, M. H., HAMOUD, H. A. AND ZEIDAN, M. S., 2011, Effect of foliar application with urea and potassium dihydrogen orthophosphate on faba bean yield and quality in newly sandy soil. *Selcuk Tarim ve Gida Bilimeri Dergisi.*, **25**(2): 57-63.
- MOHAPATR, A. K. B. AND DIXIT, 2010, Intertared nutrient management in rainy season groundnut (*Arachis hypogaea*). *Indian. J. Agron.*, **55**(2).123-127.
- MONDAL, M. M. A., PUTEH, A. B., MALEK, M. A. AND ROY, S., 2012, Effect of foliar application of urea on physiological characters and yield of soybean. *Legume Res.*, **35**(3):202-206.
- MONDAL, M. M. A., RAHMAN, M. A., AKTER, M. B. AND FAKIR, M. S. A., 2011, Effect of foliar application of nitrogen and micronutrients on growth and yield in mung bean. *Legumes Res.*, **34**(3): 166-171.
- MUNDA, G. C., PATEL, D. P. AND ISLAM, M., 2004, Effect of macro and micronutrients on growth and yield of groundnut. *Ann. Pl. Phy*, **18**(1): 9-12. *Nat. Res. Cen. for Groundnut*, Junagadh, Gujarat. Pp. 65-66.
- NADAF, S. A., CHIDANANDAPPA, H. M. AND VENKANNA, Y., 2013, Quality parameters and oil yield of groundnut (*Arachis hypogaea* L.) as influence by soil application of zinc and boron under sandy loam texture soils of Typic Haplustalf (Shivamogga). *Res. J. Agric. Sci.*, **4**(2): 196-198.
- NAGARAJ, M. J., MALLIGAWAD, L. H. AND BIRADAR, D. P., 2001, Productivity of economics and confectionary groundnut as influenced by plant density and fertilizer management., *Karnataka. J. Agric. Sci.*, **14**(4): 932-937.

- NAVEEN KUMAR B.T., 2012, Productivity of groundnut as influenced by different nutrient ratios of nitrogen and phosphorus. M.Sc. (Agri), Thesis University of Agricultural Sciences, Dharwad.
- NIRANJANA, S. S, PRAKASH, BASAVEGOWDA, YELLADHALLI, N. A. AND CHANDRANATH, H. T., 2005, Effect of micronutrient seed treatment on growth and yield of groundnut. *Seed Res.*, **33**(2):138-141.
- PANT, L. N. AND KALIYAR, A. K., 1996, Response of groundnut (*Arachis hypogea* L.) to fertilizer nitrogen, farmyard manure and Brady rhizobium inoculation. *Agric. Sci. digest.* **16**(1):52-54.
- PANWAR, A.S.AND MUNDA, G.C., 2007, Response of groundnut (*Arachis hypogaea* L.) to organic and inorganic sources of nutrient supply under mid –hill altitude conditions. *Indian J. Agric. Sci.*, **77**(12):814-818.
- PANWAR, A. S. AND SINGH, N. P., 2003, Effect of conjunctive use of phosphorus and bio-organics on growth and yield of groundnut. *Indian J. Agron.*, **48** (3): 214-216.
- PAREEK, N. K. AND POONIA, B. L., 2011, Effect of FYM, nitrogen and foliar spray of iron on productivity and economics of irrigated groundnut in an arid region of India. *Archives. Agron. Soil Sci.* **57**(5): 523–531.
- PARVATHI, E., VENKAIKIAH, K., MUNASWAMY, V., NAIDU, M. V. S., GIRIDHARA KRISHNA, T. AND PRASAD, T. N. V. K. V., 2013, Long-term effect of manure and fertilizers on the physical and chemical properties of an alfisol under semi-arid rainfed conditions. *Internat. J. Agric. Sci.*, Vol. 3 (4), pp. 500-505.
- PATEL, J. R. AND PATEL, Z. G., 1994, Effect of foliar fertilization of nitrogen and phosphorous on growth and yield of summer green gram (*Phaseolus radiatus*). *Indian J. Agron.*, **39**(4): 578-580.
- PATIDAR, M. AND MALI, A. L., 2004, Effect of farmyard manure , fertility levels and biofertilizers on growth and yield quality of great millet . *Indian . J. Agron.*, **49**(2):117-120.
- PATIL, S. B., BALAKRISHNA REDDY, P.C., SHAKARALINGAPPA, B.C., SHARANAPPA AND BAPURAYAGOUDA B. PATIL., 2010, Effect of tillage and nutrient management practices on soil properties and yield of rainfed groundnut. *Internat. J. Agric. Sci.*, 6 (2): 408-411.
- PATRO, H., NANDA, S. S., PARIDA, D., ALIM, A. AND BEHURA, A. K., 2012, integrated nutrient management on yield maximization of irrigated groundnut. *Trends in biosciences.*, **5**(4):287-288.

- PATTAR, P. S., NADAGOUDA, V. B. AND KANNUR, V. S., 1998, Effect of organic manures and fertilizer levels on nutrient uptake and yield of groundnut. *J. Oilseed Res.*, **20**(2): 222-225.
- PATTAR, P. S., NADAGOWDA, V. B., SALAKINKOP, S. R., KANNUR, V. S., AND GADDI, A.V., 1999, Effects of Organic manures and fertilizer levels on nutrient uptake, soil nutrient status and yield of Groundnut (*Arachis hypogaea* L.). *J. Oilseeds Res.*, **16**(1): 123-127.
- PEERAN, S. N., VISWANATHAN, P. S., SIVA-SUBRAMANIAN, K. AND THIAGARAJAN, S. R., 1970, Foliar application of urea on groundnut. *Madras. Agric. J.*, **57**(2):125-127.
- PIPER, C. S., 1966, Soil and plant Analysis, *Hans Pub., Bombay* . pp: 368.
- PONNUSWAMY, K., BALAKRISHNAN, V. K. AND SANTHI, P., 1996, Exploiting the production potential of groundnut by improved nutrient management in the lower Bhavani project area, Tamil Nadu, India. *Int. Arachis News letter.*, **16**: 50-52.
- PRAKASA RAO., 2004, Integrated nutrient management in groundnut. In: National symposium on enhancing productivity of groundnut for sustaining food and nutritional security, held during October, 11-13 at
- PUJARI, B. T., GUNDAPPAGOL, R. C., PATIL, J. R., SUHAS YELSHETTY AND MANNUR, D. M., 1998, Conjunctive use of chemical fertilizers, FYM and Triacontanol on the performance of pigeon pea. *Karnataka J. Agric. Sci.*, **11**: 607-609.
- RAMAMURTHY, V. AND SHIVASHANKAR, K, 1996, Effect of organic matter and P on growth, yield and soil nutrient status of soyabean. *Indian J. Agron.*, **41**(2):247-251.
- RAMASWAMI, P. P., 1999, Recycling of agricultural and agro –industry wastes for sustainable agriculture production. *J. Indian Soc. Soil Sci.*, **47**(4):661-665.
- RAMESH, N. AND SABALE, R. N., 2001, Effect of phosphate fertilization, phosphate solubilizer and plant population on yield and quality of summer groundnut (*Arachis hypogaea* L.). *Indian J. Agron.*, **46**(1):156-161.
- RAMESH, R., SHATHAMULLAIAH, N. R., JAYADEVA, H. H. AND HIREMATH, R.R., 1997, Growth and yield of irrigated groundnut as influenced by phosphorous, farmyard manure and phosphate solubilising micro-organisms. *Current Res.*, **26**(1) :196-198.

- RAO, S. S. AND SHAKTAWAT, M. S., 2005, Effect of organic manure, phosphorus and gypsum on nutrient uptake in groundnut. *Agropedology* ., **15** (2):100-106.
- RAO, S. S. AND SHAKTAWAT, M. S., 2002, Effect of organic manure, phosphorus and gypsum on groundnut (*Arachis hypogaea*) production under rainfed condition. *Indian J. Agron.*, **48**(2): 234-241.
- SHESHADRI REDDY., 2000, Efficiency of different organic manure for sustaining crop productivity and soil fertility. *M.Sc. (Agri.) Thesis*, UAS, Bangalore.
- SHESHADRI REDDY, S., 2005, Effect of different organic manures on available NPK status and organic carbon after harvest of groundnut (*Arachis hypogaea* L.). *Crop Res.*, **30**: 26-29.
- SHESHADRI REDDY, S., SHIVARAJ, B., AND REDDY, V. C., 2004, Nutrient uptake and agronomic efficiency of groundnut as influenced by different organic manures. *Karnataka J. Agric. Sci.*, **17**(4): 670-675.
- SALIM, M. M., 1992, Effect of sowing methods and foliar nutrition with urea and some micronutrients on growth and yield of soybean. *Egyptian J. Agron.*, **17**:141-154.
- SALVE, Y.V. AND GUNJAL, B. S., 2011, Effect of different levels of phosphorus and potassium on summer groundnut (*Arachis hypogaea* L.). *Internat. J. agric. Sci.*, **7**(2): 352-355.
- SAMUI, R. C. AND AHASAN, M. A. K. M., 1997, Response of groundnut (*Arachis hypogaea* L.) to level and method of phosphorus application. *Indian. J. Agric. Sci.*, **67**(4): 164-165.
- SELVAM, V. S., RAJAN, M. S. S. AND RAO, G. N. S. N., 1999, Foliar application of urea boosts irrigated groundnut yield. *Int. Arachis newsletter.*, **6**: 12-14.
- SHARMA, S. K., JAIN, N. K. AND UPADHYAY, B., 2011, Response of groundnut (*Arachis hypogaea*.) to balanced fertilization under sub-humid southern plain zone of Rajasthan. *Legume Res.*, **34** (4): 273 -277.
- SHIYAM, J. AND OKOKOH. M, 2010, Growth and yield response of groundnut (*Arachis hypogaea* L.) to plant densities and phosphorus on an ultisol in south eastern Nigeria. *Libyan Agric. Res. Centre. J. Int.* **1** (4): 211-214,
- SHELKE, D.K., JADHAV, G.S. AND OZA, S.R., 1997, Optimization of irrigation and phosphate requirement of post monsoon groundnut under different load layout. *Indian J. Agron.*, **42**(4): 618-620.

- SINGARAVEL, R., PARASATH, V. AND ELAYARAJA, D., 2006, Effect of organics and micronutrients on the growth, yield of groundnut in coastal soil. *Internat. J. agric. Sci.*, **2** (2): 401-402.
- SINGH, A. C. AND SINGH, S. P., 2001, Growth and yield of spring sunflower and groundnut as influenced by different cropping systems and rates of nitrogen. *Ann. Pl. Soil Res.*, **3**(2): 222-225.
- SINGH, A. L. AND VIDYA CHAUDHARI., 1996, Use of zincated and boranated super phosphate and mycorrhize in groundnut grown on calcareous soil. *J. Oil seed Res.*, **13**(1) 61-65.
- SINGH, G. P., SINGH, P. L. AND PANWAR, A. S., 2011, Response of groundnut to biofertilizer, organic and inorganic sources of nutrient in north east India. *Legume Res.*, **34** (3): 196 - 201.
- SINGH, G. P., SINGH, P. L. AND PANWAR, A. S., 2013, Seed quality and nutrient uptake of groundnut (*Arachis hypogaea*) as affected by intergrated nutrient management in mid hill altitude of Meghalya, India. *Legume. Res.*, **36**(2): 147-152.
- SINGH, R. A., SINGH, P. V., SINGH, J., SINGH, D. P. AND KHAN. K., 2012, Integrated nutrient management in groundnut (*Arachis hypogaea* L.) for higher production during rainy season. *Int. J. Agric. Sci.*, **8** (1): 37- 40.
- SOLANKI, R. M., BHALU, V. B. AND JADAV, K. V., 2006, Organic farming approach for sustaining productivity of rainfed groundnut. *Ann. Agric. Res. New Series*, **27**(3): 236-239.
- SONAWANE, B. B., NAWALKAR, P. S. AND PATIL, V. D., 2010, Effect of micronutrients on growth and yield of groundnut. *J. Soils and Crops*, **20** (2): 269-273.
- SRINIVASA RAO, C., BABU, V. M., VITTAL, K.P.R., VENKATESWARLU, B., REDDY, Y.T., KUNDU, S. AND GAJBHIYE, P. N., 2006, Effect of 20 years of cropping, fertilization, farm yard manure and groundnut shells application on water retention, chemical and biological properties of alfisol and pod yields of rainfed groundnut under arid climate. *Environ. Ecol.*, **22**(4): 631-635.
- SRINIVASAN, S. AND ANGAYARKANNI., 2007, Soil available boron and uptake of boron by pod and haulm of groundnut as influenced by different levels of phosphorus and boron. *Mysore J. Agric. Sci.*, **41**(4): 441-443.
- SRIRAMACHANDRASEKHARAN, M. V., 2002, Effect of fertilizers on dehydrogenase and urease activity in soil under crop rotation. *Adv. Plant Sci.*, **15**(1): 207-212.

- SUBBAIAH, B. Y. AND ASIJA, G. L., 1956, A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.*, **25**: 259-260.
- SUBHAMOY GUPTA, KAJAL SENGUPTA AND HIRAK BANARJEE, 2010, Effect of foliar application of nutrients and brassinolide on summer green gram (*Vigna radiata*) crop. *Int. J. Tropical Agri.*, **28**: 1-2.
- SUBRAHMANYAN, K., KALAISELVAN, P. AND ARULMOZHI, N., 2000, Studies on the effect of nutrient spray and graded level of NPK fertilizers on the growth and yield of groundnut. *Int. J. Trop. Agric.*, **18**(3): 287-290.
- SUBRAHMANYAN, K. P., KALAISELVAN, G., MANICKAM, N. AND ARULMOZHI., 2001, spacing and fertilizer requirement for confectionery groundnut varieties. *Crop Res.*, **19**(2): 210-212.
- SUBRAMANI, M., SOLAIMALAI, A. AND VELAYUTHUM, A., 2002, Effect of plant population and methods of fertilizer application on yield attributes and yield of irrigated black gram. *Madras agric. J.*, **89** (4-6):305-306.
- SUNILKUMAR, CRRAWAT, SHIVADHAR AND RAI, K. S., 2005, Dry matter accumulation, nutrient uptake and changes in soil fertility status as influenced by organic and inorganic sources of nutrients to forage sorghum. *Indian J. Agric. Sci.*, **75**(1): 340-342.
- SUTARIA, G. S., RAMDEVPUTRA, M. V., AKBARI, K. N., VORA, V. D. AND PADMANI, D. R., 2010, Effect of tillage and nutrient management on yield of groundnut and soil fertility. *Legume Res.*, **33** (2): 131 – 133.
- THAVAPRAKASH, N. AND MALLIGAWAD, L. H., 2002, Effect of nitrogen and phosphorus levels and ratios on yield and economics of sunflower. *Res. Crops.*, **3**: 40-43.
- THAYAMINI H., SERAN. AND SUTHAMATHY, N., 2013, Effect of combined application of cattle manure and em on the yield and yield components of groundnut (*Arachis hypogaea* L.) *Bangladesh J. Agril. Res.*, **38**(1): 1-9.
- THORAVE, D. S., AND DHONDE, M. B., 2011, Effect of integrated nutrient management on quality parameters of summer groundnut. **17** (4): 819-822.
- TIWARY, R. B. AND DAHKAR, L. L., 1997, Productivity and economics of summer groundnut (*Arachis hypogaea*. L) as affected by irrigation, fertilizers and weed control. *Indian J. Agron.*, **41**(3): 72-76.
- TRIPATHY, S. K., PATRA, A. K. AND SAMUI, R. C., 1999, Effect of micronutrients on nodulation, growth, yield and nutrient uptake of summer groundnut (*Arachis hypogaea*). *Ann. Agric. Res.*, **20**: 439-442.

- VARALAKSHMI, L. R., SRINIVASAMURTHY, C. A. AND BHASKAR, S., 2005, Effect of integrated use of organic manures and inorganic fertilizers on organic carbon, available N, P and K in sustaining productivity of groundnut-finger millet cropping system. *J. Indian Soc. Soil Sci.*, **53**: 315-318.
- VEERABHADRAPPA, B. H. AND YELEDHALLI, N. A., 2005, Effect of soil and foliar nutrition on uptake of selected nutrients by different plant parts and nutrient ratios in groundnut. *Karnataka J. Agric. Sci.*, **18** (4):936-939.
- VEERAMANI, P. AND SUBRAHMANYAN, K., 2012, Physical and economic optimum of response model for NPK application in irrigated groundnut (*Arachis hypogaea* L.) *Madras Agric. J.*, **99** (7-9): 526-529.
- VENKATESH, M. S., BASU, P. S. AND VEDRAM, 2012, Effect of foliar application of nitrogenous fertilizers for improved productivity of chickpea under rainfed conditions. *Legume Res.*, **35**(3):231-234.
- VINOD KUMAR, B.C., GHOSE, RAVIBHAT AND KARMAKAR, S., 2000, Effect of irrigation and fertilizer on yield, water- use efficiency and nutrient uptake of summer groundnut. *Indian J. Agron.*, **45**(4): 756- 760.
- WALKELY, A. J. AND BLACK, T. A., 1934, Estimation of soil organic carbon by the chromic and titration method. *Soil Sci.*, **37**:29-38.
- WATSON, D. J., 1953, the physiological basis of variation in yield. *Adv. Agron.*, 4:101-144.
- YADAV, B. R., CHHIPA, B. R. AND YADAV, K. K., 2005, Physio-chemical properties of soil as influenced by FYM and iron application under graded levels of alkalinity. *Curr. Agric.*, **29**(1):91-95
- YADAV, L.R. AND CHOUDHARY, G.L., 2012, Effect of fertility levels and foliar nutrition on profitability, nutrient uptake of cow pea [*Vigna unguiculata* (L) WALP] *Legume Res.*, **35**(3):258-260.
- YELEDHALLI, N. A., PRAKSH, S. S., RAVI, M.V. AND NARAYANA RAO, K., 2007, Influence of different levels of potassium and calcium on available nutrients, uptake, yield and quality of groundnut in Eastern Dry Zone of Karnataka. *Mysore J. Agric. Sci.*, **41**(3):299-304.
- ZALATE, P. Y. AND PADMANI, D. R., 2010, Effect of organic manure and bio fertilizers on nutrient uptake pattern of groundnut (*Arachis hypogaea* L.) *Ecol, Env and Conservation Paper.*, **16** (4):501-504.

## APPENDIX

### Price list of inputs and Prices of out put

Sl. No.	Particulars	Unit	Cost unit <sup>-1</sup> (RS)	Unit used ha <sup>-1</sup>	cost ha <sup>-1</sup> (RS)
1	Land preparation Ploughing and harrowing	Hour	250	12	3750
2	<b>Labour</b> a) sowing (dibbling of seeds) b) fertilizer application c) weeding d) harvesting h) plucking of pods & bagging	Man day (8 hrs)	150	8 5 12 10 6	1200 750 1800 1500 900
3	<b>Inputs</b> a) Seeds b) FYM c) Bio fertilizer d) Fertilizers Urea SSP MOP ZnSO <sub>4</sub> Borax	Kg Tonne Kg Kg Kg Kg Kg	65 500 50 5.30 7.70 4.48 50.00 56.00	110 7.5 0.50 * * * * *	7150 3750 25 * * * * *
4.	Pod	Kg	42.00	*	*
5	haulm	tonnes	1000	*	*

\* - It varies according to treatment